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Civil Engineering Accreditation Assessment in a Forced Online Learning Environment

Dr. Indumathi Jeyachandran, San Jose State University
Dr. Laura E Sullivan-Green, San Jose State University

We intend to follow up with a full paper. In this paper we describe the challenges faced in a forced online learning environment in the aspects of course delivery and assessment for ABET accreditation. The ABET assessment development and mapping process in the Civil and Environmental Engineering Department, the assessment organization is described. Further, a handbook developed to assist faculty in curricular redesign and rethinking assessment strategies for use in an online learning environment is described. This paper emphasizes the need for redesign of assessment methods for ABET accreditation in an online learning environment.

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Factors Affecting Motivation and Concentration of Engineering Students in Classrooms

Dr. Amin Malekmohammadi, California State University, Bakersfield
Mr. Robert Hernandez

Motivation, concentration and learning are highly complex aspects of student's behavior. The relationship between student concentration in a class and learning has been a prominent research topic in educational studies [1]. Motivation is an important key for student's success [2, 3]. Therefore, an aim of every learning-oriented entity is to investigate the factors that effects motivate of students to concentrate and learn better. Motivational theories, e.g. Expectancy Theory, which suggests that motivation has three main factors of expectancy, instrumentality (the perceptions of individuals as to get what they desire) and valence or Adam's Equity Theory [3] which was primarily attempts to explain relational satisfaction in terms of perceptions of fairness distributions of resources within interpersonal relationships, have been widely studied.

While student success is important at every educational level, it advances during the university years because this phase often represents the last formal education many students receive before competing for employment [6-8]. During their time at university, students develop their abilities and knowledge which make them ready for the job market. For this reason, education during these years is very important [1-2]. However, as in other levels of their educational careers, due to a lack of motivation students sometimes fail to achieve adequate learning/program outcomes [1].

In a study by Smilkstein [1], a group of college students were asked to list the stages of the learning process. The students developed a six-step process, with the number one step being motivation. Motivation was considered to be the necessary foundation on which the other steps follow and build [1, 4]. Student motivation translates to the students' willingness to participate in the learning process. But it also concerns the reasons or goals that underlie their involvement or non-involvement in academic activities. Although students may be equally motivated to perform a task, the sources of their motivation may differ. Lack of motivation leads to loss of interest or desire to learn or attend a class which consequently lead to withdraw or termination from university. Therefore, to maximize students' learning process at Higher Education Level (HE), a study into the factors that affects the motivation of students is essential.

This paper examines and presents the factors affecting motivation and concentration span of engineering students in classrooms. Our work carries out most of the recommendations of the previous works but also deviates in the sense that it is studying the motivation of the students rather than their concentration span. This project examines the results from a survey conducted among the total population of 510 students from year 1 to year 4 undergraduate students in three different universities. The students responded to a questionnaire examining the factors that motivates them to work hard on their studies.

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Development of Virtual Reality Robotics Laboratory Simulation

Dr. Ulan Dakeev, Sam Houston State University
Dr. Reg Recayi Pecen, Sam Houston State University
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Lain Edward Sowell, Sam Houston State University

Automation plays an important role in industrial manufacturing in improving the efficiency, the accuracy of tasks and preventing laborers from exposing to hazardous and dangerous situations. Since the introduction of robotic arms in manufacturing, they have been widely used in several industries and became crucial for Engineering Technology students to land a job, especially in STEM fields. Industrial robotics courses prepare students with knowledge associated with automated machinery programming and controlling. In this study, researchers have developed a Virtual Reality (VR) simulation for the robotic laboratory to provide access to the immersive robotic arm simulation, operate the arm controller remotely. This VR Robotic Arm Lab simulation is proposed to provide students with fundamental knowledge and motivation towards automation and robotics. Furthermore, the VR Lab may benefit students developing muscle memory in the operation of the robotic arm in the physical environment as well as ensure personnel and equipment safety. The outcomes of the initial hypothesis, where the students will develop fundamental knowledge in safety and efficiency in learning, will be reported at the conference. Independent sample t-Test will compare the control group with a conventional teaching method to investigate the efficiency of the proposed VR simulation application.

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An S-STEM Scholarship Program Engaging Transfer Students in the Materials Intensive Engineering Departments: Successes And Unexpected Challenges

Prof. Dwayne D Arola, University of Washington
Sandra B Maddox, University of Washington
Dr. Cara Margherio, University of Washington
Prof. Lilo Pozzo, University of Washington
Dr. Eleftheria Roumeli, University of Washington
Dr. Ismael Fajardo, City of Seattle, Department of Education and Early Learning

Through support of an S-STEM grant from the National Science Foundation, we have developed a scholarship program that is focused on students transferring from community colleges to our institution with interest in pursuing degrees in the "materials-intensive" engineering departments, i.e., Chemical Engineering, Materials Science and Engineering and Mechanical Engineering. The program builds on collaboration between the three departments and five regional partner colleges, including Edmonds College, Everett Community College, Green River College, Seattle Central College and Whatcom Community College. The overall objectives of this S-STEM program are to: i) increase the number of academically talented students from diverse backgrounds in the "materials-intensive" engineering departments at our institution, ii) increase the number of transfer students from regional community colleges in the materials-intensive departments, and iii) identify the contributions of educational experiences and unique matriculation pathways that cause disparities in the number of applicants to the three materials-intensive departments.

In addition to scholarships, the Scholars (i.e., scholarship recipients) are provided with additional opportunities that are aimed at increasing their wholistic development as materials engineers and potential for securing successful careers. Specifically, the Scholars are provided access to faculty mentoring, career development workshops, engagement with industry professionals to establish mentors, introduction to recruiters to understand how best to secure internship opportunities, as well as complementary activities. Through these opportunities the Scholars develop professional skills that are seldom attainable in a conventional engineering curriculum. In its third year, the program has provided scholarships to 44 undergraduate students and 5 graduate students and achieved a high level of diversity relative to non-Scholar control (45% of participants belong to an underrepresented minority group). Despite hardships related to the pandemic, the program has had 100% retention of the Scholars. Furthermore, both the undergraduates and graduate students met or exceeded the performance of the general student population in their respective engineering departments as indicated by GPA.

Exit surveys have been administered annually for the Scholars to rate the perceived contribution of program activities towards their total development and potential for success. Of all activities the Scholars rated their experiences with faculty mentors and seminars with previous graduates that entered graduate school and industry as the highest. These activities are very cost-effective and are being considered for universal implementation to the undergraduate programs. However, the surveys also revealed some weaknesses of the program. While students rated faculty mentorship very highly, they felt under-prepared to identify and approach faculty mentors to establish a relationship. The Scholars also felt some difficulty to connect and build community with their peers. Not surprisingly, that was exacerbated by the transition to a virtual teaching format. Most surprising, however, is that the students' sense of belonging in engineering did not improve from their introduction to the program. Those challenges were unexpected and have established the need for introducing new activities in the program, including peer mentoring and community-building exercises to elevate their sense of belonging and level of success.

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Amateur Radio and the Electrical and Computer Engineering Laboratory Curriculum: Federal Communication Commission (FCC) Amateur Radio Licenses are now available completely online for students with no cost.

Dr. Dennis Derickson, California Polytechnic State University, San Luis Obispo
Mr. Chuck Clayton Bland, Cal Poly, SLO Electrical Engineering Department
Mr. Marcel Stieber, Cal Poly Amateur Radio Club
Kevin Annik Shin-Wheeler, Cal Poly Amateur Radio Club

The Federal Communication Commission has authorized a range of frequencies to be available to the general public for radio experimentation since 1912. The amateur radio community has been active in many developments in radio science since its inception to current times. Amateur radio activities and the Electrical and Computer Engineering curriculum are well matched for hands-on laboratory experiments. The COVID-19 era in 2020-2021 has now made it easier than ever for students to get their radio license. FCC examinations are now offered completely online with multiple offerings each week starting in 2020. Online examination sessions are offered at no cost to the student in many cases.

This presentation outlines how it is easy to offer a Laboratory assignment activity for students to get their technician class FCC amateur license in the university environment. It also gives several examples of compelling laboratory activities that are associated with amateur radio.

How do students get their technician amateur radio license? The key starting point is the web site www.hamstudy.org. The hamstudy web site provides a learning environment where students can go through the 400 FCC examination questions. Flash cards are available for study that include explanations for each answer. Students typically need about 6 hours of study to become proficient at either memorizing or exercising logic for each test question. Hamstudy then provides sample 36 question practice exams to make sure that students are ready to pass the exam. A score of 26/36 is required to pass the exam. Students can then go to the hamstudy exam appointment feature to set up their online examination via ZOOM. These examination appointments are available many times a week and students should be able to find a time slot quickly that fits into their busy schedule. Getting an amateur radio license can be a key assignment as part of the university laboratory activities.

The presentation will outline several low cost laboratory experiments that use Amateur Radio to give students direct experience with the radio spectrum. RTL-SDR software defined radios and nano-VNAs were purchased by students as part of the laboratory preparation. The RTL-SDR is priced at $25 and the nano-VNA is priced at $60 from Amazon. RTL-SDR software defined radios in conjunction with SDR Sharp spectral monitoring software allow for a general purpose receiver that covers the 100 kHz to 1.5 GHz frequency range. The nano-Vector Network Analyzer provides for scattering parameter measurements and a general purpose radio frequency source at frequencies from 10 kHz to 3 GHz. Students were required to take the FCC amateur radio licensing test over the period of the laboratory. A first ”hands-on” experiment was to create a broad-band VHF and UHF discone antenna using 12 gauge wire and a BNC panel mount connector. The nano-VNA is used to verify that the antenna the student designed and built was well matched to the 50 ohm input impedance of the RTL-SDR. Students then monitored several radio services including signals from their mobile phone. A next step was to monitor the low frequency spectrum in the 0.5 to 30MHz range where ionospheric propagation is possible. A 14 MHz wire dipole antenna was created and tested with the nanoVNA. The RTL-SDR receiver is configured to receive WSJT4 weak signal transmissions on the amateur radio band at 14.074 MHz. Students were able to identify ionospheric signals transmitted from several continents even though the signal-to-noise ratio was well below 0dB. Students were able to get a wide exposure to the radio spectrum as part of this experiment series with connections to amateur radio.

The intent is to provide a poster presentation at the conference. The poster will cover the new on-line procedure for FCC amateur radio licensing. Amateur radio related ECE laboratory experiments will be demonstrated live.

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Analysis of barriers to graduation for transfer students in Aerospace Engineering

Dr. Radha Aravamudhan, San Jose State University
Dr. Maria Chierichetti, San Jose State University

This abstract will be followed by a full-paper.

The proposed study will focus on identifying the causes and implications of extended time to graduate for many transfer students in Aerospace Engineering at San Jose State University (SJSU). Community colleges where many students begin their higher education are a critical part of the engineering supply pipeline to four-year universities such as SJSU. In Fall 2021, approximately 35% of the students admitted to the College of Engineering and 21% in the Aerospace engineering department were transfer students. Analysis of data for 2015 cohort of transfer students shows that the 2-year graduation rate for transfer students in Aerospace Engineering is 20% and gradually climbs to 63% for 3 years and 83% for four years. Graduation rates of underrepresented minorities (URM) is for the same cohort is 15% in comparison to the non URM students at 23%. 91% of the non-URM students in Aerospace Engineering graduate in 5 years in comparison to only 77% of the URM students. While there are many factors that can contribute to the time to degree, a preliminary analysis of the data suggests that it is impacted by the number of courses that students transfer from their community colleges. For Fall 2015 cohort, students who graduated within 2 years or 2 years and an extra term averaged 2.6- 6 lower division courses while a junior or senior at SJSU [2]. For cohorts in 2016 and 2017 the average lower division courses taken ranged from 2.3-4.3. The courses in the junior year of the aerospace engineering program requires the completion of math, science and engineering core courses and the lack of these pre-requisites sets back many of the transfer students from graduating in 2-3 years. The most recent data from Fall 2021 Aerospace engineering transfer students' data reveals that though transfer students (from approximately 25 different community colleges) admitted to the program are typically expected to have earned enough units to reach junior standing, only 10% of the students have completed the Math and science requirements and 3% have all the required engineering core courses even though many of the community colleges offer these courses. In order to support the transfer students and URM students in particular, it is important to understand the underlying causes for challenges that students face in their transfer pathway. In this study, the researchers will use surveys, interviews and student transcripts to understand the academic experience of transfer students, identify their points of struggle and examine advising and other support structures for transfer students.

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Framework for Teaching Constructability Analysis for Design of New Construction Materials to Engineering Students

Dr. Kirsten A Davis, Boise State University

We intend to prepare a poster only (no full paper or presentation). [This is a work in progress.]

New construction materials and products are being developed all the time. The focus on green building, reducing the effects of climate change, and other environmental goals have been a recent impetus for new construction products and materials entering the market. There are also newer technologies available that facilitate the development of these products, such as 3D printing. Research done at universities is often a starting point for development of new products, but in order for the end products to be useful as construction materials, they need to be evaluated for their ability to be used successfully in an actual construction project.

Engineering students and faculty are very capable of creating new materials intended to be used in the construction industry, but often lack the expertise to analyze the materials from a constructability standpoint. This work documents the initial attempt to create a framework to teach engineering students construction related aspects that should be considered in their design of new construction materials. The work uses a case study method, with the framework focused initially on students collaborating on a research project developing a process for additive manufacturing of modular panels (wall, floor, and roof assemblies) predominantly from wood waste, utilizing a cold-setting process. This initial framework for teaching constructability analysis on the modular panel development can later be expanded to help teach students working in a more broad array of construction materials development projects.

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Pilot study on alumni-suggested improvements for the UBC civil engineering undergraduate program

Dr. Tamara Robin Etmannski, University of British Columbia, Vancouver

This abstract is intended to be for a full paper and presentation. This paper will analyze the results of a survey that is being sent out by the UBC Civil Engineering department to its alumni on the topic of suggestions for improvement of their undergraduate program. Alumni who graduated in the last fifteen years will be emailed the request to offer feedback through open-ended questions about their experience as an undergraduate. The survey data will be used by an internal team working on accreditation of the program. However, this paper will synthesis the data collected and based on the responses received explore the possibility of conducting a larger study on more narrow research questions. The goal is to see if this first set of data suggests topics connected to EDI and any possible differences in knowledge gaps across difference groups, to explore the results through an age lens to see possible difference in knowledge gaps across different generations (and assumed seniority). It could be to explore the specific feedback based on who is a practicing engineer and who is no longer practicing as well as many other different topics, depending on the responses. This paper will include the survey questions, the analysis of the coded responses, results and discussion of future work. The presentation will share this information, as well as invite group discussion on how to move forward in the creation of a more detailed study.

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Engineering Students as Knowledge Producers and Ethical Practitioners: Learning Outcomes of Wikipedia Writing in the Engineering Classroom

Helen Choi, University of Southern California

Engineering Students as Knowledge Producers and Ethical Practitioners:

Learning Outcomes of Wikipedia Writing in the Engineering Classroom

In this presentation, an instructor in the Engineering in Society Program at the USC Viterbi School of Engineering, will discuss the pedagogical implications of Wikipedia writing for engineering students. This presentation will be based on student feedback and instructor reflections from sixteen sections of an upper-division writing and communications course for engineering students from fall 2019 to fall 2021. Since fall 2019, 295 engineering students in this course have written over 100 Wikipedia articles in science and engineering with the addition of 3,781 references and over 260,000 words. These contributions have been viewed over 7 million times by Wikipedia readers all over the world.

As an open-collaboration project with hundreds of millions of volunteer editors, Wikipedia is the world's largest encyclopedia that is continually revised and expanded for accuracy and completeness. College students, who are actively acquiring research, writing, and analytical skills in their courses, are well-positioned to contribute to Wikipedia and expand the knowledge base of millions around the world. Students' positionality is leveraged in this Wikipedia group assignment, as students engage in self-reflection about their roles as knowledge consumers and their ethical responsibilities as information producers.

Student feedback about their Wikipedia group work aligns with research by rhetoric and writing scholars which notes that Wikipedia writing provides college students with extensive practice in writing and research, as well as with opportunities for collaboration with other Wikipedia editors inside and outside the classroom. Researchers also note that writing for a real-world audience provides public writing experiences that can increase student motivation to work conscientiously and accurately.

Student feedback also indicates that Wikipedia writing offered opportunities to practice digital citizenship - which was defined as the desire to contribute and ensure the accuracy and accessibility of information for the benefit of society. As this sentiment aligns with foundational principles of professional engineering ethics, such as promoting societal well-being and being honest and truthful, writing for Wikipedia may be a way for engineering students to apply ethical principals with immediacy in a highly relevant and visible context.

In this presentation, attendees will learn how Wikipedia was integrated into the writing curriculum for engineering students, examine the impact of this group project on students' perceptions about their writing, communication, and collaborative skills, and identify connections between Wikipedia writing principles and engineering ethics.

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Virtual Reality Lessons in Undergraduate Introductory STEM Courses

Prof. Chadia A. Aji, Tuskegee University
Dr. M. Javed Khan, Tuskegee University

The availability of low-cost virtual reality (VR) hardware and software provides opportunities to utilize its unique characteristics in higher education. Lessons designed for immersive learning in VR have to carefully take into consideration the affordances of virtual reality. Thus, appropriately designed VR lessons would positively impact student engagement. This paper provides details of the development of VR lessons for undergraduate students in introductory courses in five STEM disciplines. These developed lessons were implemented at an HBCU. The hardware and an off-the-shelf software for developing the VR lessons are shared. The participant attitudes and motivation to learn with the VR technology were investigated using items from validated instruments. The perceptions of the students about VR usability were also measured. Analysis of data indicates a positive impact on student attitudes and engagement with the content.

This project is supported by NSF grant # XXXXXX

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Multidimensional Engineering Design Education for Modern Applications: A Smart Grid Design Case Study

Yuri R. Rodrigues, Seattle Pacific University

The design of new services and products based on technological advancements is one of the greatest challenges in engineering. This process has been traditional performed considering reduced realities of complex system using selected economic and technological parameters designated based on a generic group of customers. Still, the massive digitalization of our modern society has significantly increased access to customers' data, allowing for the effective identification of the diverse groups consuming a respective service or product. As well, their respective needs and expectations regarding that service or product, which at times may be disregarded due to the lack of customization in the design process.

In this sense, modern solutions must be designed in ways to enable equitable access to the diverse groups they serve, i.e., all customers' groups must have their needs reasonably considered during the design process; a feature that is not achievable considering traditional design solutions based on generic data. For this, engineering design education must be expanded in ways to recognize and incorporate the multidimensional aspects involved in the customer-product/service relationship into the technical design scope.

In this perspective, this paper seeks develop a new methodology for engineering design education that ensures technically sound designs able to incorporate multidimensional perspectives required for ensuring an effective customization of services for a broad spectrum of customers' group. For this, a two-staged approach respectively focused on macro- and local-thematic is developed. First, strong theoretical analysis on macro-thematic factors are performed regarding technologies, architectures and infrastructures required for the respective engineering application design. This stage includes research and assessment on the evolution and changes of models toward a definitive design, recommendations, future vision, ongoing projects, lessons learned and trends in technology development. Next, local-thematic factors based on social, economic and regional aspects are explored toward the achievement of a multidimensional design able to model different customers' group characteristics. For this, information and communication technologies (ICT) paradigms on data identification, services sharing, and the integration of technologies are explored, including advanced metering, data-intensive computing (Big Data) and internet of things (IoT). Based on this methodology, a holistic engineering design process is achieved, enabling an effective harnessing of technological advancements toward actual needs and expectations of diverse customers' group.

To verify the proposed methodology, a case-study depicting the electric power grid modernization journey toward Smart Grids is developed. Smart grids represent electric power grids evolution into more sustainable systems with high integration between customer-utility. Based on the proposed holistic engineering design process, a successful modernization journey is designed featuring a strong common theoretical backbone, while enabling customization based on the particular needs of the diverse customers' groups served, e.g., Smart Grid projects for high-income neighborhoods are likely to be focused on service reliability, whereas for lower-income neighborhoods Smart Grid projects can be focused on tariff reduction.

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Proposed Curriculum for a Multi-Campus Educator Training Course

Dr. Christoph Johannes Sielmann P.Eng., University of British Columbia, Vancouver
Dr. Casey James Keulen, University of British Columbia, Vancouver
Ms. ANGELA Mercy RUTAKOMOZIBWA

This abstract will be followed up with a full paper submission and presentation.

In multi-campus teaching, instructors host a course at one location while concurrently teaching remote cohorts at other locations using information and communication technology (ICT). Courses taught in this format typically use specially equipped rooms with cameras, microphones, and large projection screens. When executed well, multi-campus courses provide students with a greater variety of study options, extend the reach of exceptional instructors, and offer institutions opportunities for cost savings. In some contexts, courses taught using ICT can help bridge cultural boundaries, improve cross-pollination of ideas between institutions, and bring comprehensive, sophisticated programs to rural areas.

Despite dramatic innovations in teaching and communications technology, there remain grand challenges to implementing multi-campus programs effectively. Educators, including instructors, course designers, teaching assistants (TA), and program administrators, must be prepared to overcome problems with technology, equity in learning, trust, fairness, and community building through innovative and targeted pedagogy, technology, and management. Equity in learning is particularly difficult to achieve as access to libraries, study spaces, lab equipment, and other educational resources can vary significantly between cohorts. Instructors supporting remote cohorts, often TAs, are often less experienced with direct facilitation, leading to perceivably inequitable student classroom experience. To address these challenges, a multi-campus instructional course has been developed as a training program primarily targeting HEI engineering educators to equip participants with the skills necessary to design and deliver high quality multi-campus programs.

The training course is modular, providing completion pathways for course instructors (˜10 hours), course designers (˜10 hours), TAs (˜3 hours), and program administrators (˜3 hours). Any course attendee may complete all modules with very little redundancy, resulting in approximately 14 hours of material, including learning activities. The curriculum covers introductory topics related to multi-campus instruction, course evaluation, blended learning, design considerations, remote facilitation, administration, maintenance, and additional themes. Both curricular and pedagogical topics are explored, with practical examples drawn from literature provided to highlight recommended best practices.

As implemented, the curriculum includes both self-paced asynchronous and synchronous components and is intended to be offered in conjunction with a learning management system (LMS). A complete course has been developed from the curriculum with initial delivery planned in 2022. Following a pilot launch, feedback will be analyzed on the efficacy of the training, with commensurate adjustments to the curriculum and course content applied as needed. Immediate, measurable improvements to the design and delivery of multi-campus courses within engineering programs are anticipated once multi-campus training commences. ICT-based education is technology dependent and context sensitive, where multi-campus program curricula and pedagogy must evolve continuously with the learning tools used to enable the classroom. Correspondingly, the curriculum herein proposed must adapt to remain current with technological and educational trends.

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Integrating Social and Environmental Justice into the Program Educational Objectives of California Polytechnic University San Luis Obispo's Civil and Environmental Engineering Department

Dr. Rebekah Oulton P.E., California Polytechnic State University, San Luis Obispo
Dr. Amro El Badawy, California Polytechnic State University, San Luis Obispo

After the murder of George Floyd in May 2020, an undergraduate student coalition in the Civil and Environmental Engineering (CE/ENVE) Department at [Institution] proposed that the curriculum be updated to address the topics of social and environmental justice and their role in Civil and Environmental Engineering. As a result, the CE/ENVE faculty collaborated with the student leaders to integrate social and environmental justice into the CE/ENVE program educational objectives (PEOs). PEOs reflect the goals that program graduates will achieve within a few years of graduation, reflect the mission of the Department, and provide guidance for specific student learning outcomes in the classrooms. As such, they are the principle tool for guiding lasting and significant modifications to the curriculum. As part of the student-initiated PEOs revitalization, additional educational objectives were incorporated, including: resilient, sustainable, and safe design; systems-thinking; and, inclusive communications. This paper discusses the bottom-up, student-centric process used for updating the CE/ENVE PEOs, the stakeholders involved, and the students' key contributions to the process. A comparison between the revitalized PEOs and the original PEOs are presented. The focus of the work encompasses the challenges encountered during this experience and the lessons learned. Finally, this paper outlines the CE/ENVE Department's plan to integrate the new PEOs into the curriculum, including specific examples of implementation of the PEOs into selected courses and development of appropriate metrics for student outcomes. This update of the PEOs is a critical step towards re-shaping the CE/ENVE curriculum to educate the students about social justice and its strong connection to engineering design and practice. The new PEOs will result in a modern CE/ENVE curriculum that helps students develop the knowledge and skills needed to address the contemporary challenges facing the world.

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Intellectual Mental Models of Engineering and Non-Engineering Undergraduate Students

Dr. M. Javed Khan, Tuskegee University
Prof. Chadia A. Aji, Tuskegee University

Intellectual Mental Models of Engineering and Non-Engineering Undergraduate Students

The traditional educational paradigm encourages the development of dualistic intellectual mental models of the world view. Students strive to get the correct answer as expected by the teacher. With the development of understanding of the world view and student agency, the mental models move towards multiplicity and finally to a relativistic understanding. This paper discusses this cognitive development of undergraduate students and the impact of duration of stay in college. A validated instrument was used to measure anchoring of student mental models across the spectrum of duality, multiplicity, and relativity. Data was analyzed to determine the differences between engineering and non-engineering students. The effect of the academic standing was also investigated. The influence of gender was studied. Results of these analyses are shared.

The work is supported by NSF Grant # xxxxxxxx

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Using a Pokémon Go Style Game in Introductory Computer Science Courses

Heather Marriott, Embry-Riddle Aeronautical University - Prescott

The objective of this research was to see if introductory level programming students would benefit from using an interactive Pokémon Go style mobile application. Students are notorious for using their phones all the time, even during class. The research aimed to see if this could be leveraged to the instructor's advantage by introducing a mobile application that the students could use to learn computer science material. Augmented Reality was used to add to the appeal of the app and increase student interest. The map functionality makes this an exergame with the goal of leveraging the benefits of exercise while learning. Areas of study included student perception of the enjoyment level of the application, the usefulness in learning and retaining the material, and suggestions for improvement. Based on the results of this research, the project should be expanded to incorporate content for other courses and possibly even other universities. An Augmented Reality Mobile application can be a supplement to traditional lecture materials and allow independent learning which can be especially useful during a pandemic.

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A Qualitative Study of Spatial Strategies in Blind and Low Vision Individuals

Daniel E Kane, Utah State University
Theresa Green, Utah State University - Engineering Education
Dr. Natalie L Shaheen, Illinois State University
Dr. Wade H Goodridge, Utah State University

This abstract will be followed by a full paper.

Significant work has been done to demonstrate the correlation between spatial ability and student success in STEM fields. Research has also shown that spatial ability not only predicts success in academic settings, but is also a valuable skill in STEM related professional settings. Further studies have indicated that spatial ability can develop and improve over time. It has also been shown that spatial ability is a malleable skill and can be learned through targeted interventions. For this reason, spatial ability and the implementation of spatial interventions in engineering curricula is an important aspect of engineering education research. One group that has largely been excluded from spatial ability research is blind and low vision (BLV) populations. There has been little, if any, work done to identify spatial strategies employed by BLV students in solving spatial problems.

This case study explores qualitatively investigated spatial strategies that were employed by four participants at an engineering program administered by (omitted for blind review) that was designed for BLV youth interested in STEM fields. During sessions of the program, the research team administered the Tactile Mental Cutting Test (TMCT), a fully accessible tactile adaptation of the commonly used Mental Cutting Test (MCT) to all students participating in the research. Immediately after taking the TMCT, participants at the program participated in a focused interview in which they solved a TMCT problem and discussed strategies they employed. Transcriptions of these interviews were analyzed using qualitative coding procedures.

An analysis of the data from these interviews showed that BLV students employed a wide variety of strategies as they solved spatial problems. These strategies included using geometric methods (e.g., identifying basic shapes and using symmetry) and analytical methods (e.g., ignoring non-defining features and taking measurements). Data from four of the participants was explored for further analysis. These four cases represent two high spatial performers and two low performers who provided specific details in their interview about how they solved TMCT problems. Coding results show that the two high performing participants demonstrated an ability to piece geometric shapes together and focus solely on defining features. Across all four cases, participants who had a clear strategy while solving the TMCT problems were more likely to have high spatial performance.

The results of this study demonstrate how high and low-performers use spatial strategies when solving the TMCT. Findings from this study have the potential to improve STEM-related curricula and teaching methods for BLV populations. Understanding commonly used spatial strategies in BLV populations can help teachers more effectively cater to students' needs. Findings from this study can also point to the non-visual aspects of spatial ability in sighted populations. In a broader sense, a deeper understanding of spatial strategies has the potential to encourage more BLV youth to pursue an education in STEM fields.

ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Analysis of historical student performance using engineering accreditation data to evaluate inclusive and equitable teaching practices in chemical engineering

Mr. Mohammad Hosseini, The University of British Columbia
Miss Roza Vaez Ghaemi, University of British Columbia, Vancouver
Gabriel Potvin, University of British Columbia, Vancouver

There has been a global shift in focus in engineering education from inputs (what is taught) to outcomes (what is learned). In engineering, professional skills are now considered equally important for engineers to develop than the scientific and technical content and knowledge of traditional input education models. The nature of engineering work necessitates professional skills, such as communication, teamwork, problem solving, and lifelong learning, in addition to technical proficiency in math, science and design, and this is reflected in expectations regarding engineering curricula.

This outcomes-based education model is currently mandated by the Canadian Engineering Accreditation Board (CEAB), the governing body overseeing the accreditation process of engineering programs in Canada. The CEAB introduced Graduate Attributes (GA), the abilities, knowledge areas, and professional attributes in which students must demonstrate proficiency upon graduation for a program to be accredited, meaning that its graduates are qualified to work as engineers. The monitoring of student performance progression in these GA as part of a continual curriculum improvement model is required for accreditation. This improvement process requires the collection and analysis of performance data to identify and implement meaningful program or curriculum improvements to maintain and improve student outcomes and competencies in each of these GAs.

The evaluation of specific Indicators is allocated to courses and instructors covering relevant material, and each student's performance for that indicator is assessed through relevant coursework (deliverable grades, score on specific assignment or exam questions, etc). This information has been collected each year for decades, for each cohort going through both of CHBE's accredited programs.

A high-resolution analysis of this data, collected by the Department of Chemical and Biological Engineering at the University of British Columbia, was conducted to identify any correlations or causal relationships between students' gender, status (international or domestic), performance in individual GAs, course grades, and/or overall program GPAs. Whether performance in (a) given GA indicator(s) can serve as predictors of student success or difficulty in courses, or highlight any gender or status-based performance differentials was also investigated. The results may allow for early targeted support and "real-time" program monitoring, and inform EDI-enhancing interventions and program improvements. Results of this analysis have the potential to have a significant, long-lasting impact on student equity, learning outcomes and student experience in our department.

This presentation will cover the methodology and results of this analysis, and highlight some possible future avenues of investigation or areas for targeted intervention. Results may also provide interesting insights to other engineering departments in Canada or in the US, where the ABET accreditation process a similar approach.

ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Beyond intelligence: The role of noncognitive factors in student success and student thriving

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It is well established that noncognitive factors – psychological traits, behaviors, affects and beliefs – have a significant impact on academic performance of students from elementary grades to college undergraduates. Examples of noncognitive factors include, for example, mindset, self-control, belongingness, anxiety, and study behaviors, to name a few. Previous research typically isolates a single noncognitive trait, or at most a small number of them, and study its impact on student performance. Here we present findings from the SUCCESS (Studying Underlying Characteristics of Computing and Engineering Students Success) project, in which we study a large collection of noncognitive factors and how they work in concert to support student success and thriving.

Beginning in 2016, we created the SUCCESS survey to measure a wide range of noncognitive factors that have established research evidence for their association with student success. Through exploratory and confirmatory analyses, we reduced the initial collection of factors down to 28 factors measured through a 35-min. survey instrument with evidence of reliability and validity. The constructs encompassing the 28 factors include: The Big5 personality traits, grit, engineering identity, mindset, mindfulness, meaning and purpose, belongingness, gratitude, future time perspectives of motivation, test anxiety, time and study environment, perceptions of faculty caring, self-control and student life stresses. The confirmatory factor analysis also established that these measures can account for 26% of the variance in student grades as measured by the grade point average (GPA), while standardized test scores (i.e., SAT or ACT) can explain only 10% of the variance.

Our first challenge was deciding how to use this collection of factors to characterize each student, and we took the approach of cluster analysis. Clustering revealed the emergence of four student groups, each characterized by a distinct and defining set of noncognitive factors. Our analysis found that cluster membership is strongly associated with academic performance as measured by GPA and this association persists over time.

Since most noncognitive factors are known to be malleable, we next explored how these noncognitive factors develop as students progress through their college experience, which involves both curricular and extracurricular activities, as well as other personal experiences. Among the 388 survey respondents from 2018, when they were all first-year mechanical engineering undergraduates, 48 took the survey for three consecutive years, allowing us a view of how noncognitive factors evolve. Five of the 28 factors changed significantly over time. These were: stress due to changes, reactions to stress, belongingness, engineering identity (interest), and motivation by expectancy. All five factors changed in the direction that prior research found to be negatively associated with academic success and, interestingly, all changed between the first and second years of college. We emphasize that all students in this sample are ”succeeding” academically. This collection of findings points to the need for timely, directed initiatives to support students' needs beyond curricular content, and also speaks to the role that the university should take to help students go beyond success and toward thriving.

ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Studies on teaming experience through embedding psychological safety, motivational driver, and cognitive diversity into pedagogy

Prof. Mirna Mattjik, Colorado School of Mines
Dr. Megan Sanders, Colorado School of Mines
Dr. Amy Hermundstad Nave, Colorado School of Mines
Ms. Wieke Gur, ICQ Global Asia
Mr. Muhammad Husni Mubarak Lubis , Pertamina University

This is submitted as a Work in Progress Poster Presentation:

During a series of classroom-based studies, the authors from school A used two tools to measure students' motivation and the team's psychological safety in the capstone first-year design and problem-solving course at A. Intervention through implementation of Psych Safe modules was initially done along with a modified version of the Basic Psychological Needs Scale to measure motivation (Fall 2019). The recent classroom-based study in the Spring 2021 semester utilized an industry tool published by company X and administered by company Y along with company Z. The author from school B used the same tool in the senior year capstone course, not only for student teams but also for the instructors. Outcome from the application of this tool was further discussed formally with students, facilitated by our industry partners. From this trial it was observed that most of the teams fall into the Fear/Anxiety zone. Also, teams who possess similar behavior and communication style with their instructors tend to perform better. In both cases, the effect of the pandemic lingers resulting in reduced focus and level of engagement. Potential future studies will be conducted independently by each institution, which may consist of: (1) authentic learning and assessment to encourage interaction between students beyond what is guided by the instructor; and/or (2) a qualitative study to compare focus groups between first year students and senior year students in cornerstone and capstone design respectively, for current insights on their experience in teaming without intervention. The assumption is improvement in employability skills such as teaming and collaboration give a better chance for equity in impact; because at the core, diverse perspectives and cognitive abilities should be appreciated in teams. Through this poster presentation we are seeking feedback on both potential studies.

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ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Challenges and opportunities in online engineering education online

Dr. Mory Ghomshei
Dr. Farzan Ghaffari P.Eng P.Eng., British Columbia Institute of Technology
William Oching

Challenges and opportunities in online engineering education online

Mory Ghomshei, Farzan Ghaffari, William Oching

This abstract is intended to be followed by a full paper. Corvid-19 Pandemic was a turning point in post-secondary education. Engineering education was especially impacted by the Pandemic, due to its experimental and practical components which are often difficult, if not impossible, to be effectively and efficiently delivered online. While regular lectures and courses on numerical simulation can be delivered remotely, there are major challenges in online delivering of those course components which are related to physical experiments, laboratory simulation and field-scale collaborative work . Educational software and hardware related to Virtual Reality (VR) and Augmented Reality (AR) are currently being used in most engineering programs. These tools are excellent in improving the students' perception about real-case situations but cannot replace hands-on and group experiences. While online education during the Pandemic provided an opportunity to explore new frontiers in VR and AR technologies, a major challenge is to bridge between the VR and the field reality and person-to-person interaction. This paper discuses the importance of field and human components in engineering education and proposes solutions to reduce the negative impact of online education in engineering disciplines. One suggested strategy, in case of future pandemics, will be designing safe laboratory and field experiments to complement the remote education. This paper shares examples of successful cases of bridging between online and real-field experience in the mining engineering program at BCIT.

ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Teaching Inclusive Leadership in Engineering: Theory-Based Approaches

Dr. Jannik Haruo Eikenaar, University of British Columbia
Prof. Alon Eisenstein, The University of British Columbia Okanagan

This is a workshop proposal, submitted by Dr. Jannik Eikenaar and Dr. Alon Eisenstein.

In this session, participants will be introduced (or re-introduced) to several concepts of engineering leadership, apply those concepts through a case study, and then discuss their different applications. Participants will be exposed to the diversity of thought around inclusive leadership in engineering, and they will develop, re-think, and reinforce their approaches to teaching inclusive leadership.

Objectives/Learning Outcomes

Increase familiarity with and understanding of models, frameworks, and theories of leadership in engineering contexts

Practice applying leadership concepts

Engage with others teaching similar content

Reflect on theory-based approaches to teaching inclusive leadership

Targeted audience

Educators familiar with and new to teaching theory-based inclusive engineering leadership

Activities

Learn or review leadership concepts, including leadership models (e.g., transformational, transactional), leadership frameworks (e.g., positivist, social constructivist), and engineering leadership orientations (e.g., technical mastery, organizational innovation)

Apply concepts through a case study

Discuss varying applications and connect to participants' teaching practices and contexts

Length

90 minutes

Supplies

Handout, suggested readings

Modality: in-person, online, hybrid

This workshop can be delivered in a hybrid mode:

Part 1 is a review of concepts: this can be delivered simultaneously in-person and online

Part 2 is a small-group exercise: in-person and online participants can participate with those joining in the same

mode

Part 3 is a group discussion and reflection: all participants can engage and contribute

We have delivered this workshop in an online format, and we regularly teach in hybrid modes; we are prepared to facilitate every part of the hybrid workshop.

ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Implementing a Common First-Year Engineering Curriculum in British Columbia

Dr. Brian Dick P.Eng., Vancouver Island University

Demand for engineering education has grown in recognition of its importance to the national economy; demographics and economic growth requires an expanded capacity for engineering education throughout Canada, and encouragement for students to enter the profession.

Between 2015 and 2018, a group of post-secondary institutions within BC drafted a transfer agreement, referred to as the Common First-Year Engineering Curriculum (CFYEC), that captured both the topical content and individual pathway conditions for each engineering school in the province. The agreement ensured students starting the first-year of studies at signatory college/teaching universities could transfer seamlessly into second year at any one of the engineering schools to complete their programs.

The goals of the CFYEC included:

• Recognizing the diverse learning pathways taken by students,

• Deepening community and industry partnerships (particularly in rural and semi-rural areas),

• Providing access to a broader range of engineering disciplines, and

• Improving the cost efficiency of program delivery for students, institutions, and the province.

In 2019, capacity building grants were provided to a number of college/teaching universities to support launching the CFYEC. This exercise has since been completed, and this work-in-progress paper provides qualitative survey results describing the CFYEC implementation experience at these institutions, the impact of COVID-19 on this work, and earlier indication on whether the goals of the CFYEC are being achieved.

ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Expert interviews: shifting student attitudes towards social responsibility and the role of the engineer

Dr. Gabrielle Lam, University of British Columbia, Vancouver

Background and Motivation

With the economy becoming increasingly globalized, the population of developed countries aging, and the population of undeveloped countries growing, there is a greater need for engineers to understand the complexities of the global market and of social contexts (National Academy of Engineering, 2005). This growing need calls for shifts in engineering education, such that graduates may contribute as socially responsible engineers in the workforce.

While different models have been implemented to incorporate these competencies in the engineering curriculum, each are associated with their challenges. One approach involves a designated upper-year engineering ethics course, but can give students the sense that ethics is tangential to engineering (Heckert, 2000). Another approach incorporates ethics courses throughout all levels of the curriculum; this has been criticized for its shallow exploration of engineering ethics (Heckert, 2000). A final approach involves integrating engineering ethics within technical courses, so that students explore the social context of engineering (Manion and Kam, 2000; Lathem et al., 2011). An effective model to integrate engineering ethics and an exploration of social impacts with technical engineering content would therefore be important for the development of responsible engineering graduates.

Study Objectives

The aim of this study is to characterize changes in student attitudes towards social responsibility and the role of engineers during the early stages of their educational program. It is hypothesized that student engagement with a series of expert interview videos, which highlight perspectives from professional engineers, will enhance their appreciation of the role of the engineer, as well as engineering impacts on the society, environment and economy.

Methods

At the start and end of the study, participants will complete a questionnaire gauging their perceived level of understanding of the role of the engineer, and the impacts of engineering on the society, environment and economy. A mixed methods approach will be used to analyze responses collected. Throughout the study, participants will view and annotate five expert interview videos. Their comments and responses to defined questions will be analyzed to identify themes in student attitudes. Clusters of students may be identified based on their program of study, number of video annotations submitted, and time spent viewing the videos. At the end of the study, participants will also complete an open-ended reflection about potential changes in their attitudes regarding the role of the engineer, and implications for their current studies and future careers.

ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Development of a precollege engineering outreach program during the COVID pandemic

Dr. Claire Yan P.Eng., University of British Columbia, Okanagan

I intend to follow up with a full paper.

Precollege STEM outreach activities have been a common practice to help high school students gain diverse perspectives of STEM university education and career paths [1, 2, 3]. This paper describes the development of a new engineering outreach program, Engineering 11, by the School of Engineering, University of British Columbia, Okanagan (UBC Okanagan) through collaboration with the Central Okanagan School District (SD 23). Engineering 11 consists of several modules covering a wide range of engineering disciplines and subjects, such as civil, environmental, mechanical, biomedical and electrical engineering, and engineering ethics, aiming to provide senior high school students an opportunity to explore the many disciplines of engineering and career pathways. The course is designed to be taught collaboratively by a physics teacher of SD 23 and faculty and graduate students from UBC Okanagan School of Engineering. Since the spring of 2020, the course has been offered to two cohorts of grades 11 and 12 students in Kelowna Senior Secondary (KSS) in two consecutive years, in the format of in-person and online teaching (in response to the COVID pandemic). Both pre- and post- surveys have been conducted to the cohorts to assess the impact of the program on their attitudes towards engineering and their choices of university majors. This paper presents details on the curriculum development and delivery model (pre- and during the COVID pandemic). The survey results demonstrate that, in general, many students have gained a better understanding of engineering through this outreach program and are more excited about engineering careers. The survey results also reveals the challenges of maintaining a high momentum of the program due to the restrictions from the COVID pandemic.

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ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Impacts of Students' Academic-Performance Trajectories on their Final Academic Success

Mr. Shahab Boumi, University of Central Florida
Prof. Adan Ernesto Vela

Many studies in the field of education analytics have identified student grade point averages (GPA) as an important indicator and predictor of students' final academic outcomes (graduate or halt). And while semester-to-semester fluctuations in GPA are considered normal, significant changes in academic performance may warrant more thorough investigation and consideration, particularly with regards to final academic outcomes. However, such an approach is challenging due to the difficulties of representing complex academic trajectories over an academic career. In this full paper, we apply a Hidden Markov Model (HMM) to provide a standard and intuitive classification over students' academic-performance levels, which leads to a compact representation of academic-performance trajectories. Next, we explore the relationship between different academic-performance trajectories and their correspondence to final academic success. Based on student transcript data from University of Central XXX, our proposed HMM is trained using sequences of students' course grades for each semester. Through the HMM, our analysis follows the expected finding that higher academic performance levels correlate with lower halt rates. However, in this paper, we identify that there exist many scenarios in which both improving or worsening academic-performance trajectories actually correlate to higher graduation rates. This counter-intuitive finding is made possible through the proposed and developed HMM model.

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An Active Learning Experiment for Algorithm Bias Instruction

Shalini Ramachandran
Sheree Fu, California State University, Los Angeles
Dr. steven matthew cutchin

In this paper, we discuss our ongoing instruction on algorithm bias to computer science students at three higher educational institutions. We have instructed students about algorithm bias at three universities, with varying demographics, two public and one private. Algorithm bias is a persistent problem in the technology industry and negatively impacts people based on gender, race, and other categories. As systems that determine outcomes for health, employment, education, and incarceration become automated, the impact of machine-based bias can be felt by large segments in society. We are interested in teaching computer students about algorithm bias as many of them are going to become programmers of automated systems and search engines. Awareness of the concept of algorithm bias can be a first step in training future practitioners on the importance of developing non-biased computer systems. Our project started in 2019. We are a computer science professor and two engineering librarians. Initially, we used a lecture-based module to present content about algorithm bias to students. Based on evaluating our initial deployment, we are currently adding active learning components to our lesson plan. Our paper presents our latest instruction which asks students to generate three questions about algorithm bias based on Arthur Costa's three levels of questions. Level 1 requires one to gather information; Level 2 requires one to process the information; and Level 3 requires one to apply the information. Students are asked to generate their own questions so they engage dynamically with the information on algorithm bias presented to them, including specific case studies of racial or gender-based bias. Many of our students are first generation students from disadvantaged groups and have experience with real-life bias. Subsequently, we find that the case studies presented engage students. Asking students to create questions, especially Level 3 questions, can empower them to draw from their lived experiences and apply those experiences to prepare them for their professional endeavors. The active learning aspect of the instruction will help students retain the concepts introduced in the lesson. We will present our most recent teaching outcomes in combination with results from previous instruction.

ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Work in Progress: Developing Disambiguation Methods for Large-Scale Educational Network Data

Mr. Adam Steven Weaver, Utah State University
Mr. Jack Elliott, Utah State University

This work in progress paper presents for review ongoing efforts developing and disambiguating large-scale interaction networks to improve engineering education research. Upon completion, we will present this work as a final paper at the ASEE Annual Conference 2023.

The potential for social interactions to enhance engineering education is well founded in social learning theories, and research confirms many engineering students rely on their social networks in coursework, for persistence in engineering, and even as a part of their career choices. When decomposed, these networks are comprised of a variety of individuals, including peers, family members, etc. In addition, these networks vary significantly in size and traits (e.g., interaction frequency, reason for development, communication type). Because understanding should precede application, educators must develop a broad understanding of students' interactions before they can effectively foster the growth of positive networks.

Social Network Analysis (SNA) is a well-suited research method that quantitatively maps traditionally qualitative social networks, enabling the numerical representation of ties (interactions) between actors (individuals in a network). Further, researchers may plot these networks in graphs called sociograms. Together, these methods allow researchers to conduct statistical and visual analysis of relationships between networks and traits—like sub-network homophily vs. student grades. However, the difficulties associated with gathering accurate interaction data have veered those using SNA for engineering education toward oversimplified social environments. For example, researchers often observe students' online interactions, where they can collect participant information concurrent with interaction data. Similarly, studies in face-to-face contexts are typically bounded to single classrooms, which confines the number of participants' observed ties. Examining these easily monitored environments is a critical first step towards deploying SNA in educational fields but bars a complete depiction of students' actual social networks. Hence, educators hoping to analyze authentic social networks will find existing research insufficient.

To better understand these networks, our research group is currently conducting an SNA study comparing all participating freshmen and sophomore engineering students' peer interactions to academic outcomes at a large, public land-grant university. This study produced over a thousand survey responses, and because the interaction data is open response, we found difficulty attributing many names to their correct nodes. Therefore, this paper presents our recommendations for best practices and ongoing efforts in disambiguating large scale educational network data. To begin, we organized the overarching network development task into discrete stages to filter responses according to unique name-ambiguity circumstances. These stages begin with simple spelling checks and end with a sub-network comparison process. To complete these stages, our first iteration relied on manual substitution, which yielded a best estimate of the complete network. This strategy proved effective in matching many ambiguous names with the correct node, but also highlighted procedures that we can refine through modern clustering methods. Therefore, we present a faster, automated approach using agglomerative hierarchical clustering. The results of this study demonstrate first steps toward more efficient and repeatable disambiguation methods for educational network data.

ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Structuring equity and inclusion into access to undergraduate research opportunities

Dr. Agnes Germaine d'Entremont P.Eng., University of British Columbia, Vancouver
Jennifer Pelletier, University of British Columbia

Research skills are central to many aspects of engineering but are sometimes stereotyped as being for people who are "clever, bright, reserved, socially clumsy" or unlike ordinary people [1], and incompatible with non-masculine identities [1]. Supporting institutional strategic goals to broaden access to undergraduate student research [2], our department created a cohort-based, course-supported summer research program, with goals to:

1. Interest students in research.

2. Create an equitable application and acceptance process based on skills important to research, de-emphasizing or eliminating aspects like GPA, experience, or reference letters that may have a disproportionate impact on some groups of students.

3. Support students by providing summer research skill courses, training their mentors, and providing cross-cohort social/learning opportunities.

In this paper, we will focus on the program aspects outside of the two summer courses.

Several approaches were used to increase understanding of and interest in research among undergraduate mechanical engineering students. The second-year cohort was given a research talk by a course instructor, with the explicit goal of exposing them to the idea and the reach of research. The third year lab course was restructured to introduce experimental design, then challenge students to design their own experiments to answer their own research questions; these students were surveyed to capture changes in belonging and self-efficacy related to research [3,4]. All students were invited to information sessions about the summer program.

Past research has suggested that GPA, standardized tests, and other commonly used metrics may not be successful at differentiating between the highest- and lowest-ranked graduate students [5], and can replicate bias against underrepresented groups of students [6]. We created a rubric for assessing applicants that would de-emphasize grades and emphasize critical research skills (as determined through consultation with departmental faculty). Rubric level descriptions were created for each of: perseverance, intrinsic motivation, curiosity, navigating uncertainty, and articulating ideas. Students were asked short essay-style questions to draw out examples. A minimum GPA of 76% was required for consideration, and GPA served as a sixth, equally-weighted criteria. Blind assessment of applicants was done by a committee to reduce the impact of biases. Selected students were matched with supervisors/projects based on student preference.

Thirty eight students applied, and thirteen were accepted (GPAs: 79.5% to 90.9%; one withdrew for family reasons). Gender and international/domestic ratios matched the overall departmental undergraduate population better in the cohort program than in the group of summer research students hired through other competitive mechanisms.

Initial results suggest that students within the department have a better understanding of research and their potential interest in it following our interventions, and that the assessment rubric identified excellent students having a range of GPAs, while reducing the impact of systematic biases.

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ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Beyond the Vanishing Point: Using Future Self Theory and Student-Alumni Interviews to Expand Student Perspectives on Engineering Education and Engineering Work

Dr. Harly Ramsey, University of Southern California
Yee Lan Elaine Wong

Ocular Odyssey: Perspectives on Engineering Education and Engineering beyond the Vanishing Point

This paper describes a co-curricular project, Ocular Odyssey, at a large research university on the west coast, and it contextualizes the project in terms of enlarging both engineering education and engineering.

The premise of Ocular Odyssey is simple: current engineering students interview alumni who reflect on life transformative aspects of their education; these interviews are curated into a series of videos shared on the project's website.

Just as the ocular vanishing point presents a convergence of lines where a road, for instance, disappears into the horizon, students may confront a vanishing point when imagining their professional journey beyond education. While each student will have their own unique professional future and the unseen multiplicity of potential paths for this journey, or Odyssey, are to be celebrated, hearing stories of those who have traveled the same educational path can inspire and motivate students. Indeed, in the midst of their educational journey, students may not realize the life transformative nature of their education. As alumni reflect on the educational path they share with current students and impart their transformative experiences, students' imaginations can expand to see their current self from the perspective of their future self. This future-self perspective is supported by narrative theory, and in essence the interviews and curated videos are a narrative project—making sense of the past, present, and future through storytelling and shared cultural (in this case engineering education) touch points.

Student self-reflexivity is promoted through a series of faculty led seminar-style workshops. The students engage with assigned texts and discuss short-term and long-term perspectives and the alignment of personal and professional values; students are also coached on interviewing skills. This dual focus—philosophical and practical—enriches students' ability to thoughtfully interview the alumni and promotes self-efficacy.

Ultimately, the goal of the Ocular Odyssey project is to broaden engineering education by facilitating students' exploration of their engineering identities in terms of character, agency, and purpose; this co-curricular experience contextualizes professional competencies achieved through traditional coursework. Through broadening their educational experience, students gain self-awareness of their professional identity and may forge new paths. The alumni, too, benefit through the process of narrating their journey. The videos are posted online to increase the scope of impact.

Both the presentation and the paper will provide examples from the project and present workshop materials so other engineering educators can implement similar projects.

ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Implementing community-engaged learning (CEL) in a second-year engineering design course

Dr. Jonathan Verrett P.Eng., University of British Columbia, Vancouver
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This is intended to be submitted as a full paper

Community engaged learning (CEL) involves students interacting with community groups through a partnership which provides benefits to the community group and furthers student learning. In partnership with the Centre for Community Engaged Learning (CCEL) at [University name redacted] a CEL project was integrated into a second-year chemical engineering design course.

The course consisted of 125 students and has 3 hours of lecture and 2 hours of tutorial per week. Tutorial sessions are used for students to work in teams of 4-5 students on a number of design deliverables for the first nine weeks of the term. Following this, teams were then assigned to work on a CEL project during the tutorial sessions for the last 3 weeks of the term. Teams and design deliverables are coordinated with a communications course occurring the same term. Students submit project documents to both courses and receive feedback and a grade from each course.

Initially a number of potential partners were approached for developing the CEL project. In the end the project focused on sustainability at [University name redacted] and specifically the [program name redacted] program which creates partnerships between students, faculty, staff and community partners. The project focused on assessing greenhouse gas (GHG) emissions from food delivery services to student residences. A project was selected based on a number of criteria. Notably the project had to be relevant to engineering training, it also had to be something implementable by a large number of teams (in this case 27). Other items explored included waste audits at food service sites and campus transportation data collection.

Students were familiarized to the specific project by reading a news article related to the issue to be studied. Students were then individually surveyed on their opinions on CEL before the project was presented (pre survey). In the first tutorial session students were presented with a background and rationale for the study. Data collection locations, being certain residences, and the rationale for these choices were shared with the students. Students then chose a location and time to collect data. Expected project outcomes were also discussed and students were expected to produce a 1000-1200 word memo report outlining their data collection and GHG emissions assessment.

Following the project, students completed another individual survey and self-reflection exercise (post survey). This study will present details on setting up the CEL project as well as data from student surveys. The discussion will focus on CEL project implementation from the instructional side and student reception as well as suggestions moving forward.

ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Using Discourse Analysis to Investigate Conversations during Engineering Brainstorming Activities

Dr. Benjamin David Lutz, California Polytechnic State University, San Luis Obispo
Aimee Tai Chiem, California Polytechnic State University, San Luis Obispo
Ms. Christianna Bethel

Brainstorming is a crucial component of the engineering design process and the activities and conversations that take place during conceptual ideation can have significant downstream impacts on the design process and influence the outcomes of the overall project. While researchers have focused on the outcomes of brainstorming and the ideas that student teams generate, the role of discourse and conversation during these activities remains relatively underexplored. The purpose of this paper is to provide a codebook that can be used to analyze the discourse of engineering teams during conceptual brainstorming activities. The use of discourse analysis can offer a deeper understanding of how engineering students interact with one another, and the ways different kinds of discourse can lead to different ideation outcomes.

We recruited mechanical engineering students from a large public university to participate in brainstorming sessions typical of preliminary or conceptual design phases. Each group was given the same task of collaborating for 45 minutes to create as many ideas as possible for wheelchair-accessible playground equipment and experiences. We combined existing research with emergent findings from our own data to develop a codebook that characterizes the range of "discursive moves" that engineering students use during collaborative brainstorming. Our codebook identified 11 different kinds of utterances that occurred during conceptual brainstorming activities. These codes capture instances in which students offered new ideas, as well as the ways students reacted to, built upon, and more generally engaged with these ideas. Further, when applicable, these 11 "discursive moves" were broken down using subcodes to identify the specific nature of a given comment or utterance.

Our findings offer a useful framework for characterizing discourse during engineering brainstorming activities. We can use these codes to count the number and kind of utterances made by each student during brainstorming and explore relationships between the nature of the dialogue on one hand and ideation effectiveness on the other. Analysis is ongoing and is currently being used to explore differences across teams of varying gender compositions. The frequency of these code occurrences can also be compared to other factors within ideation to gain a greater understanding of how intergroup interactions affect various aspects of engineering design. With this, educators will be able to better support both creativity and equity within their classrooms and promote effective design skills through student interactions.

ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Leadership development in co-curricular student groups: a phenomenographic study

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Tasnia Naim Anika, University of British Columbia, Vancouver

This is intended to be submitted as a full paper

Leadership development has long been a topic of educational interest [1]. Specifically in engineering there have been calls to supplement technical skill development with social, organizational, and professional skill development [2]. Intercultural and equity driven competencies are an important part of this development [3]. Giving students an ability to recognize the different ways they can be leaders allows them to engage more deeply in experiential learning and leadership opportunities, as well as achieve better outcomes after graduation [4]. This study will seek to understand how student leadership development currently occurs for engineers at [University name redacted] with a focus on diversity and inclusivity in co-curricular settings. The goal of this work is to inform the enhancement of co-curricular student leadership development opportunities.

A phenomenography framework was used to guide this study. Phenomenography seeks to describe differing understandings of reality [5]. Given the focus of this study on diversity and inclusion this framework was used in order to capture the differing perspectives of study participants. Semi-structured Interviews were selected as a means to gather data. Participants were recruited through professional networks. Recruitment and interviews were run by a 4th year student. Recruitment aimed to recruit participants of diverse genders and ethnicities. Participants were selected in their 3rd or 4th year of study as they would likely have had more opportunities to potentially participate in co-curricular student groups. Eight participants were interviewed in total. Following interviews, transcripts were produced and analyzed using a thematic coding. This paper will present the study development as well as findings from the interviews.

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ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Community engaged learning (CEL) in co-curricular student groups (full paper)

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Siba Saleh, University of British Columbia, Vancouver

Community engaged learning (CEL) can be defined as a form of experiential learning where students collaborate with members of the broader community in support of learning goals. The process usually incorporates reflection as a key component. CEL has been shown to be highly impactful in shaping educational experiences of students in university [1]. However, it can also be resource intensive, necessarily taking time and effort to cultivate community partners and establish strong relationships. Both [University name redacted] Campuses have undertaken studies on experiential learning, including CEL [2,3]. Both of these studies have recommended support to equip students, faculty and staff to respectfully engage community partners. With this in mind this study seeks to understand current community engagement strategies used by engineering students in co-curricular student groups.

This study first assessed co-curricular student groups where engagement with the community was strongly aligned with the goals of the student group. A survey was selected as the best means of collecting data from a variety of members (executive and non-executive) within each student group. The survey posed questions on whether student group members were involved in CEL projects. The survey also asked about strategies students would have used when developing CEL projects. If the members had not engaged in CEL projects, the survey questions focused on whether students were interested in pursuing CEL projects and what strategies would be used to pursue these anticipated projects. Survey results were analyzed and the practices of different student groups around CEL were characterized. These results are presented and a discussion around potential supports for improving CEL in student groups is discussed.

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ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Interdisciplinary engineering capstone course sequence designed for career preparation

Dr. James Gordon Walker, Seattle Pacific University, College of Arts and Sciences, Engineering Department
Gina Howe P.E., Seattle Pacific University
Dr. Melani Plett, Seattle Pacific University

This abstract is intended to be fleshed out into a full paper for the conference. Our engineering senior design year-long capstone course sequence is designed to mimic a high technology incubator and involve students working in interdisciplinary, diverse teams to implement a design project while developing professional skills. This paper will describe the course sequence including the design process, teaming guidance, project ideation, professional skills development; and grading/assessment methods.

Modeled after practices in industry, this course sequence includes design sprints, project management, risk assessments and mitigation, formal design reviews by the course instructors, and presentations to industry professionals. Each cross-functional team includes a mix of electrical, computer, and mechanical engineers. All teams consist of students of different ethnicities, genders, and ages. Teams are formed with diversity in mind, but also based on each student's expressed project-type interest. The instructors then lead the students through problem identification, project ideation, and development into an appropriately scaled design that is both challenging and doable. Much of the course is focused on team building and processes, conflict management, and both team and individual reflection on team performance. The instructors emphasize the value of diversity, such as the need for each student's voice to be sought, heard, and respected. The professional skills developed in the course include project management, both formal and informal presentations to varied audiences, formal documentation, budgeting, business cases, and dealing with ethical issues around their specific project. The students are assessed using performance evaluation methods from industry as to whether they meet expectations, exceed expectations, or fall short of expectations. Quarterly meetings are held with each team and with each student individually around team performance and lessons learned. The students are also invited to formally evaluate themselves around the ABET objectives. The meetings with individual students may involve an improvement plan where there is a perceived area of weakness. The student's final grade is a combination of these performance metrics on both their team assignments and individual assignments. The comprehensive nature of this course sequence allows for equity of contribution and grading in that students have multiple ways to shine depending on their strengths. Some excel at project management, some at leading, some at theoretical details, some at fabrication and implementation, etc.

We assess the course sequence itself in several ways: student feedback, our industrial advisory board's feedback after interacting with the teams multiple times, faculty observation, and observations of student projects and presentations by STEM faculty at our university's in-house research and design conference. While it is a struggle to keep the workload manageable, employers and alumni frequently remark that this sequence prepares the students well for their future careers.

ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Environmental Sustainability: More than an Afterthought in Biomedical Engineering Curriculum

Dr. negar Harandi, The University of British Columbia
Dr. Jenna Usprech P.Eng., University of British Columbia, Vancouver
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Prof. Calvin Kuo P.Eng., University of British Columbia, Vancouver
Ms. Laia Shpeller, University of British Columbia

For presentation only.

Background: The undergraduate Biomedical engineering program at [redacted] is a newly accredited program that integrates expertise from several engineering disciplines with biology and anatomy to provide students with the depth and breadth needed to improve human health. Traditionally, design in this field prioritizes human safety without consideration of environmental sustainability. With a growing awareness of the devastating effects of climate change, there is pressing demand for better integration of environmental sustainability in the biomedical engineering curriculum.

Two common mechanisms to integrate sustainability into engineering programs exist [1,2]. Vertical integration introduces content in a single course while horizontal weaves content throughout the curriculum. Horizontal integration is believed to yield "broader, deeper, and more connected knowledge" from students, since sustainability is not taught in isolation from engineering fundamentals, nor is it at risk for being considered an afterthought [2]. To achieve horizontal integration, the objective of this work is to identify the needs and resources for teaching sustainability and how best to integrate sustainability in the curriculum.

Method: We distributed separate student and faculty surveys within the biomedical engineering program at [redacted]. The student survey assessed the self-reported importance, knowledge of, and confidence in, applying environmental sustainability topics and processes in biomedical engineering design tasks. Data were gathered using a Likert scale (1 = strongly disagree, 5 = strongly agree) and aggregated by year in the program. The survey also asked students where in the curriculum they learned about sustainability and where they identified gaps. The faculty survey additionally focused on faculty members' knowledge of environmental sustainability teaching resources in biomedical engineering, and their expertise in creating such resources in the future.

Results: The student and faculty surveys recorded 105 and 9 responses respectively (approximately 25% of each population). Students and faculty overwhelmingly considered environmental sustainability an important topic in biomedical engineering (Likert scores 4.440.78 and 4.430.73, respectively). Interestingly, students considered themselves more knowledgeable on sustainability topics (2.861.10) in biomedical engineering than faculty (2.000.53). Students were also more confident in applying sustainability processes in their careers (3.231.10), which increased with their year level in the program. In contrast, students described minimal exposure to environmental sustainability content in the curriculum, and faculty reported a lack of teaching resources.

Discussion: Survey results depict a clear need for greater integration of sustainability in our biomedical engineering curriculum. Open-ended responses suggested that design courses are ideally suited to integrate environmental sustainability and create a coherent knowledge-base and skill set throughout the curriculum. We recognize that understanding the student-perceived overconfidence in applying sustainability to design, when there was a recognition of the lack of formal training in the curriculum, is multifaceted. We hypothesize that students assume prioritizing environmental sustainability is simple, and minimal effort can lead to a positive environmental impact. Thus, design instructors in the program are currently working on developing a plan to horizontally integrate environmental sustainability throughout the curriculum [2].

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ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Exploring the Ethical Perceptions of First Year Engineering Students: Public Welfare Beliefs, Ethical Behavior, and Professional Values

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In the engineering ethics education literature, there has recently been an increasing interest in the longitudinal studies of engineering students' moral development. Understanding how first year engineering students perceive ethics can provide baseline information critical for understanding their moral development during their whole engineering learning journey. Existing studies have mainly examined how first year engineering students perceived the structure and elements of ethics curricula, personal ethical beliefs, pregiven ethics scenarios, institutional ethical climate, and certain political ideas (e.g., fairness, political involvement). Complementary to the existing studies, our project surveyed how first year engineering students perceived public welfare beliefs, examples of (un-)ethical behavior in engineering, and professional ethical values. More specifically, we adopted the well-known instrument developed by Erin Cech to assess how students perceived public welfare beliefs. An important goal of replicating Cech's work is to examine whether students from a different cohort (e.g., 18 years after the cohort in Cech's study; a much more specialized institution than the institutions in Cech's study) have changed their public welfare beliefs. We invite engineering educators to carefully examine how temporality might matter when considering the connections between previously conducted studies with their own ongoing projects. Our survey also asked students to provide an example of unethical behavior in engineering and possible ethical problems they may anticipate in their future careers. Finally, we asked students to list three most important values for defining a good engineer. Such a question on professional ethical values responds to a gap in the engineering ethics literature that engineering students' perceptions of professional virtues and values are not sufficiently addressed (especially among first year students). This paper is part of a much larger project that compares how students develop moral reasoning and intuition longitudinally across three cultures: United States, Netherlands, and China. We are hoping that findings in this paper can be useful for engineering educators to reflect on and design subsequent ethics education programs that are more responsive to students' backgrounds and needs when they start their first year in engineering programs.

ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Lessons learned the collaborative creation of an OER textbook

Dr. Daniel W Baker PhD P.E., Colorado State University
Prof. Eric Davishahl, Whatcom Community College

Open educational resource (OER) textbooks offer multiple advantages to students and teaching faculty: no cost, wide availability, and the opportunity to customize learning content. While many topics have numerous options of well-vetted textbooks, engineering is behind the curve in creating OER content. Given the lack of viable OER textbooks for Engineering Mechanics: Statics, our team of nine authors worked for over two years to plan, create, and deliver an OER Statics Textbook (full name inserted post-review). In addition to sharing lessons learned from our journey, this presentation contrasts the results of student surveys from three time periods: before the book's creation, during the Fall 2020 pilot, and from subsequent semesters using the book as a primary text.

ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Cultivating Community through Student Engagement

Ms. Jill Davishahl, Western Washington University
Miss Asaki Nelson
Emilia Mediavilla
Leo Shibata
Mr. Nathan Radu Winney

This presentation will detail the development of a series of student engagement opportunities that were designed to increase student sense of belonging by building community and creating connections for first-year engineering students. Student sense of belonging to a department or program is positively associated with student motivation, self-worth, and academic success. A recent survey of engineering and design students at ABC university showed that pre-major students, people of color, and non-male identifying students have a significantly lower sense of belonging in the department than their counterparts. With a focus on increasing belonging through engagement, the department created a peer support and engagement program that aims to connect students across disciplines and build social networks for engineering students. This new student-led program, called the Student Engagement Liaison (SEL) program, uses the department makerspace to host a variety of engagement activities including non-technical workshops, DIY themed events, and discussions centered around topics related to inclusion and equity. Program activities are designed to appeal to pre-major students, are open to students of all ability levels, and require no prior experience with tools, equipment, or the makerspace. The SEL team, which consists of major-level students, designs and creates activities that provide opportunities for first year students to connect in an informal learning environment allowing them to focus on building relationships with their peers rather than on developing technical proficiencies. The activities and events are designed to encourage the development of basic skills, create shared experiences in the department makerspace, and to provide opportunities for students to connect with one another. Emphasis is placed on the development of an inclusive learning environment with a focus on providing opportunities for first year students to work in department spaces and to connect with the larger community of students. The authors will share details related to the events themselves along with their personal reflections on the challenges and successes of creating student engagement opportunities. In addition, the authors will share how they developed and executed accessible and inclusive events designed for students of varying ability levels with diverse interests. By creating and hosting activities designed to support, connect, and engage all students, the SEL team aims to increase students' sense of belonging and connectedness in engineering program, with emphasis on supporting the first-year students.

ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Guiding First-year Students through the Design Process in Linked Computer Aided Design and Technical Writing Courses

Dr. Matthew J Haslam, Embry-Riddle Aeronautical University - Prescott

The authors plan to submit a complete paper.

At the recommendation of the College of Engineering Industrial Advisory Board, faculty at _____ University began integrating communication instruction with the senior capstone design classes in 2003. This effort was formalized in 2013 when a one-semester Speech class was replaced with a two-semester Advanced Technical Communication class that is co-taught with the capstone classes.

For these co-taught courses, a communication instructor and an engineering instructor work in tandem to guide student teams through the year-long design process. Teams report on their progress and results through technical reports and presentations modeled after those used in industry.

The authors, who co-teach a mechanical engineering senior capstone design class, have observed that students come to the class unprepared for the open-ended, team-based work expected. While students have learned to solve a variety of teacher-provided engineering problems, they have not learned to follow an engineering process to identify and formulate a real-world problem and to apply their problem-solving skills to that problem.

Moreover, students have worked in project teams in earlier classes, but these projects are smaller in scope than the two-semester capstone projects. The students also have little experience preparing documents and presentations as a team.

To address these deficiencies, the authors initiated a first-year "cornerstone" design experience that combines a first-year Computer Aided Design (CAD) class with a Technical Report Writing class to mimic the capstone experience. Each student is tasked with identifying a real-world problem and writing a Request for Proposal (RFP) that defines the problem and identifies top-level requirements. A subset of these problems is selected, and teams are assigned to solve the problems through the remainder of the semester.

Each team conducts trade studies and presents their selected concepts in a Conceptual Design Review. The teams write a proposal that is responsive to the RFP. As their design matures, they present a Preliminary Design Review where they are expected to have complete CAD models of the design. The team project culminates with a Critical Design Review where they must show full compliance with the design requirements. The CDR is accompanied by a complete drawing package suitable for manufacturing.

Students learn the SolidWorks CAD modeling tools, formal drawing standards, and design for manufacturability. They also learn to form and communicate evidence-based technical arguments as they develop skills for writing documents and making presentations as a team.

Initial results of these linked courses are promising. The students indicated in an anonymous, mid-semester survey that they value this combined approach. They believe they are learning the design, teamwork, and communication skills they will need in their future careers, and they appreciate learning these skills in the context of an engineering problem. The authors have also observed improvements in the team-based writing and presentations.

Despite the successes, the authors have recognized multiples challenges that will be addressed in the next offering of the linked courses.

ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Categorizing student interactions with manipulatives in statics

Dr. Kathryn Mary Rupe, Western Washington University
Prof. Eric Davishahl, Whatcom Community College

This work in progress paper describes ongoing work to understand the ways in which students make use of manipulatives to develop their representational competence and deepen their conceptual understanding of course content. Representational competence refers to the fluency with which a subject expert can move between different representations of a concept (e.g. mathematical, symbolic, graphical, 2D vs. 3D, pictorial) as appropriate for communication, reasoning, and problem solving.

Several hands-on activities for engineering statics have been designed and implemented in face-to-face courses since fall 2016. In the transition to online learning in response to the COVID-19 pandemic, modeling kits were sent home to students so they could work on the activities at their own pace and complete the associated activity sheets. An assignment following the vector activities required students to create videotaped or written reflections with annotated pictures using the models to explain their thinking around key concepts. Students made connections between abstract symbolic representations and their physical models to explain concepts such as a general 3D unit vector, the difference between spherical coordinate angles and coordinate direction angles, and the meaning of decomposing a vector into components perpendicular and parallel to a line.

The video and written data analyzed to inform the design of think-aloud exercises in one-on-one semi-structured interviews between researchers and students that are currently in progress. This paper presents initial work analyzing and discussing themes that emerged from the initial video and written analysis and plans for the subsequent think-aloud interviews, all focused on the specific attributes of the models that students use to make sense of course concepts. The ultimate goal of this work is to develop some general guidelines for the design of manipulatives to support student learning in a variety of STEM topics.

ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Results of an Introductory STEM Research Internship Program for Underrepresented Community College Students

Prof. Nicholas Patrick Langhoff, Skyline College

This abstract is to be followed by a full paper. Retention and commitment to educational goals continues to be a challenge in the STEM fields, even more so for underrepresented students due to a variety of factors. Recently this issue has only become increasingly challenging as result of the Covid-19 pandemic, with students facing isolating conditions and a general lack of peer-to-peer engagement and support, which leaves students looking for even more encouragement to strengthen commitment and strive. Through a Title V grant from the Department of Education Developing Hispanic Serving Institutions (DHSI) Program, XXXX College, a Hispanic-serving community college in Northern California developed the STEM Pathways project, a collaborative multi-institution project that addresses barriers to student success using high-impact educational practices that have been shown to enhance interest, increase participation, and improve outcomes for underrepresented minority students in STEM. One of the top recommendations to address retention in STEM programs is to engage students in research experiences within the first two years of college. To this end, one of the main components of the STEM Pathways project is an internship preparation program that provides multiple exposures to undergraduate research opportunities. This paper focuses on the development and results of the STEM Pathways Research Scholars Program: a two-week introduction to research internship experience. Held during the winter break, the program introduces freshmen and rising sophomores to scientific research along with a variety of topics and skills such as applying for internships; introduction to the research process; university laboratory tours; conducting literature review; the university transfer process for community college students; technical presentation skills; and project-specific topics including experimental methods, instrumentation and metrology, and data acquisition and statistical error analysis. The paper provides a detailed description of the program curriculum including engineering-oriented projects and summarizes results from three years of implementation of the program from 2019-2022. Key findings are shared on program outcomes relating to changes in students' engagement in their academics, pursuing and obtaining further internships, transfer preparedness and post-transfer successes, teamwork ability, and sense of self-efficacy. A model is shared for other colleges looking to implement similar programs.

ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

A Simple Yet Pedagogically Comprehensive Undergraduate Laboratory Exercise in Fluid Dynamics

Dr. Daniel J Keene, Seattle Pacific University

This work will be shared with the community through a presentation only (no full paper) format. Fluid dynamics is among if not chief of the most challenging subjects in an undergraduate mechanical engineering curriculum due to the complexity and breadth of its content. Perhaps for this reason, the course topics are often presented in a sequential fashion which students then proceed to compartmentalize rather than synthesize into a deeper understanding of the subject. To help students combat this tendency, an approachable but pedagogically rich hands-on laboratory exercise has been developed that integrates the topics of conservation of mass, conservation of linear momentum, the Bernoulli equation, and dimensionless groups. The apparatus involves a cylindrical container with a circular hole in the center of its bottom surface which upon being unplugged allows the fluid initially contained therein to drain by the action of gravity. The entire apparatus hangs from a force sensor to measure how the support force changes over time during this drainage event. A theoretical dynamic model for the support force is developed by applying the aforementioned topics and then used as a framework for interpreting the experimental results. Because this event is transient, students cannot follow their usual habit of making the steady state assumption when developing the mathematical model. Furthermore, the concept of the quasi-steady state approximation is introduced and comparison with the experimental results which allows students to see both its utility and its limitations. The diameter of the hole is varied to explore its impact on how quickly the fluid will drain from the container and a scale analysis of the differential equation model previously developed is used to identify the characteristic time scale for this system to foster connections with the students' intuition. This characteristic time scale also allows results for every hole diameter to be plotted using dimensionless variables so that they can be visualized on a single plot in a more compact and insightful manner. Ultimately, through a hands-on investigation of this one physical system, students are able to move beyond articulating a simple qualitative explanation to developing a complex quantitative predictive model that draws on multiple key course topics.

ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Practical Experience from Online Learning Tool Development

Mr. Wesley Curl, California Polytechnic State University, San Luis Obispo
Prof. Eric Davishahl, Whatcom Community College
Dr. Brian P. Self, California Polytechnic State University, San Luis Obispo

This paper is a work in progress.

Web-based learning tools have reached a new relevance as teaching and learning activities have moved online in the context of the COVID pandemic. Being forced to rely entirely on them, some educators have become reluctant to go back to a world entirely unreliant on them. It has become apparent that virtual instructional tools can offer advantages over certain kinds of in-person learning for some learners, skills, and/or topics. In addition, the pandemic put the inadequacy of present online tools and infrastructure into sharp relief. The combination of these factors has necessitated the development of new online tools to fill the gap, and with such development comes new experience, ethoses, and strategies to make the development of virtual educational tools even easier

This paper shares lessons learned from development work on these tools. The author has developed prototype instructional tools for engineering and physics courses. The tools are all in the form of web applications, written in PHP and javascript, which connect to a single SQL database backend. The structure of these applications varies widely: some are essentially multiple choice tests administered online, while others are more adaptive, attempting to complement what the students know. As such, these web applications, while similar in their coding environments, offer remarkably different objectives in the process of their construction.

In addition to these web applications, physical hands-on manipulatives are being recreated (and expanded upon) in small educational simulations developed in Unity, a 3D gaming development engine. These simulations are more technically challenging and conceptually difficult, and so their development has been often inconsistent. The development of these tools has been quite different from the tools of the preceding paragraph, and, as a result, they afforded different organizational and design techniques.

It is at the confluence of these organizational differences that common threads begin to emerge. Various strategies exist to maximize the productivity of educational tool programmers, as well as to keep lines of communication open between programmers and the educators they work with. Limitations also emerge as to what the programmers can and cannot easily accomplish, as well as unexpected new avenues to make excellent educational tools. It is the author's hope to provide a useful guide as to some of these strategies, limitations, and opportunities that have come up in producing virtual educational tools.

ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Impact of student problem creation on self-reported confidence in mechanics

Mr. Michael Sekatchev, University of British Columbia
Mr. John Graeme Dockrill, University of British Columbia, Vancouver
Dr. Agnes Germaine d'Entremont P.Eng., University of British Columbia, Vancouver

(We intend to follow up with a full paper). Learning in engineering science courses typically involves solving textbook-style questions (given a problem statement, with one correct answer). As part of a project developing practice problems for students, we anecdotally noted that creation of problems deepended content understanding for the student problem developers. Problem creation could be an effective part of the engineering science teaching and learning toolbox. There is evidence of learning gains with student-created problems in immunology (Shakurnia 2018), general pathology and pathophysiology (Herroro 2019). Within the field of engineering, there are mixed results, with a study in the field of electrical engineering showing no effect on student learning (Algarni, 2021), and a study in manufacturing engineering showing significant improvement in learning (Brink 2004). No studies have examined the effectiveness of student problem creation in engineering mechanics, however. We seek to determine whether creating their own practice problems improves students' self-reported understanding of dynamics, and is viewed as an effective studying strategy.

In this cohort study, we will use primarily quantitative methods to assess self-reported confidence and understanding of mechanics topics related to problem-creation activities within two populations. For the first population, a group of 135 students from a second-year dynamics course will be sent a pre-survey assessing their understanding of topics in dynamics, whether or not they create their own practice problems to aid with studying, and why they do or do not create practice problems. Students will be asked to develop their own practice textbook-style problem with a full solution as an optional bonus assignment. A second post-survey will ask students (both those who submitted problems and those who didn't) to repeat a self-evaluation of their understanding, and ask whether or not they plan to incorporate problem creation into their regular studying habits (and why or why not). Finally, a third separate survey will be sent out to 13 current and previous members of our open mechanics homework problem project (an ongoing 2-year project where students create ˜50-100 problems each per work term), to evaluate whether creating their own problems improved their understanding of dynamics and/or statics, and whether they have since implemented problem creation into their studying.

From the results from our pre and post surveys, we will measure any changes in the students' self-reported confidence in the concepts behind their question before and after they have completed it. We will also measure any change in whether the students would consider creating problems as part of their regular study practices. For the OER Mechanics survey, we will assess if students observed a change in self-reported confidence in the topics they created homework problems in.

The results of this study can help inform whether student creation of problems could be used as an effective learning tool in engineering mechanics courses.

ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Hands-On Activity for Conceptual Understanding of Rigid Body Kinematics

Troy Cristobal, California Polytechnic State University, San Luis Obispo
Ms. Eileen W. Rossman, California Polytechnic State University, San Luis Obispo
Dr. Brian P. Self, California Polytechnic State University, San Luis Obispo

This Full, Work-in-Progress paper will outline various approaches used to aid in student learning of rigid body kinematics. Oftentimes students encounter difficulty visualizing dynamics problems due to the limitations of 2D diagrams presented in textbooks. The natural intuition that engineering students have for dynamic situations may be going unused when strictly solving textbook problems by hand. Our research team is exploring a blend of prediction-based concept questions and physical models for hands-on rigid body kinematics activities. Initially students are tested on their current understanding of dynamics principles with concept questions. Gaps in student understanding are identified from these problem sets, and supplemental information and questions are assigned to emphasize the primary principles that were misunderstood. After students have independently gained a foundational understanding of the dynamics principles at hand, physical models are supplied to groups of students along with prediction-based questions to allow students to test their intuition and build a deeper comprehension of the dynamics principles by simulating scenarios with the physical model. 3D printed kits are specifically used for slider crank and 4-bar linkage models. With these kits students may be asked to predict the directions of linear or angular velocities and accelerations of specific points or links on the model. The physical model is intended to illustrate how the system moves. These activities are executed in groups, so students are given the opportunity to communicate with classmates to come to a well discussed consensus on why their predictions were either correct or incorrect. In addition to group activities with physical models, online simulations are also being developed to provide students with an additional outlet for exploring rigid body kinematics. With a 3D virtual model of the slider and crank or 4-bar linkage, students can observe the movements of these models with the inclusion of velocity or acceleration plots as another tool for validating or correcting student predictions. In the future, we will have students perform think-alouds to help us further develop and refine these activities.

ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Using Learning Assistants and the Concept Warehouse During Virtual Instruction

Dr. Brian P. Self, California Polytechnic State University, San Luis Obispo
Prof. Dominic J Dal Bello, Allan Hancock College

Full paper

Creating an interactive learning environment during emergency virtual instruction was a challenge for many instructors. Using physical demonstrations, hands-on investigations, and gaging student understanding were all more difficult over Zoom. We also wanted to find ways to promote active learning, as well as build a sense of community in our classrooms. To do this, several of us utilized Learning Assistants and administered concept questions and instructional tools using the Concept Warehouse.

Learning Assistants are specially trained undergraduate students who serve a different role than a teaching assistant or grader. They take a pedagogy course and participate in a weekly planning/training session with the instructor. Their job is not to answer questions and explain course materials, but to ask probing questions and help students develop their own reasoning patterns.

At both a two-year and a four-year institution, we asked concept questions using the Concept Warehouse (CW), a free online repository of concept questions, instructional tools (eg, virtual labs), and concept inventories. The CW has thousands of concept questions, or ConcepTests, in topics such as thermodynamics, mass transfer, statics, and dynamics. Instructors can sign up for a free account, and can also upload their own questions.

Instructors utilized the LAs in a variety of ways. In one scenario, students typically were placed into breakout rooms of 3-4 students and assigned 2-3 ConcepTests. The LAs would move from room to room to see how the students were doing and guide them to correct scientific reasoning. Towards the end of class, the students went back into their same breakout rooms to solve a traditional homework-style problem. Again, the LAs would visit the different breakout room to provide guidance on problem solving approaches.

A second implementation of the LA model was to hold required sessions outside of the regular class time. During some of these, the LAs would help the students through a series of ConcepTests. Some weeks, however, there were online versions of hands-on Inquiry-Based Learning Activities. The LAs would again visit different breakout rooms, but also bring the group back together to lead discussions on the physical scenarios that were being explored. For example, in the Spool Activity, students were asked to predict the direction of the acceleration and of the friction force when pulling the string on a spool in different directions. The LAs visited the breakout rooms, then brought everyone back together for discussion. Then three other scenarios (pulling the spool thread in different directions) were investigated. Participants were given credit for just participating in the activities.

ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Adaptive Learning Modules to Promote Conceptual Understanding in Mechanics

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Ms. Eileen W. Rossman, California Polytechnic State University, San Luis Obispo
Emily Flores, California Polytechnic State University San Luis Obispo

Students who struggle with mechanics principles can often work through problems without a strong conceptual understanding of the underlying principles behind them. As a result, our team is conducting research, user group interviews, wireframing, and designing Adaptive Learning Modules (ALMs) to help students develop the foundational understanding of these underlying concepts.

Our Adaptive Learning Modules are centered on the students' understanding and progress. Currently, our learning modules have the following format: student engagement, a short lecture video, a coupled multiple response (CMR) question, supplemental instruction videos, an instructional intervention, a summative assessment, and a survey. The student engagement portion of the module will mostly be done through a video format to inspire and/ or motivate our students to see the different possibilities and roles in which they can apply their knowledge after graduation. This is especially helpful for our marginalized and first-generation students to see people with similar identities in their respective fields. The engagement portion is followed by a short lecture video on the given topic. Then, students will be given the CMR to gauge their understanding. Based on those answers, they will be given a Supplemental Instruction module to make sure they are prepared for the upcoming Instructional Tool.

Our Instructional Tools are developed in the following format: warm-up, cases, and survey. The warm-ups were created to give researchers a baseline to the student's understanding before engaging with the instructional tool. Once the warm-up questions are completed the students are given a series of case questions that build off one another. The cases are in the following format: prediction questions, confidence questions, simulation and/or video, questions, and finally a conceptual check. This format allows the students to engage in critical thinking and reflection by going through a prediction phase for students to use their current understanding of the topic to predict the movement of the given problem. Students are then able to reflect on their answers and their understanding through the simulation and or video demonstrations of the given problems. The confidence questions allow us to see how students are feeling as they progress through the instructional tool, and the final conceptual check allows us to see whether the students also feel more comfortable and confident in their understanding of the underlying principles. Once, the students complete the cases they are then given a final survey to give us feedback on the questions, videos, and simulations. Our adaptive learning modules go through an iterative process as we receive more survey responses to ensure that we are providing enough support to our students.

Currently, our team has completed one module on velocity and acceleration and is working on ones on Newton's second law and on Coriolis accelerations.

ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Equity Diversity and Inclusion Applied to Undergraduate Research

Dr. Maira Monteiro, Seattle Pacific University

Equity Diversity and Inclusion Applied to Undergraduate Research

Maíra R. Monteiro, Seattle Pacific University, Seattle, United States

Given the rapid growth and development of engineering technologies, requirements for a reliable skilled workforce, and need for groundbreaking innovators and effective leaders, the next generations of undergraduate Science, Technology, Engineering and Mathematics (STEM) students must be provided with a well-rounded education subjected to high academic standards and delivering life-long learning skills. These skills are directly related to the scientific research process, which is represented by a structured and organized method used to achieve defined objectives. Through the scientific research process, one is responsible to answer four main questions, i.e., ”What is the problem being addressed?”; ”Why is this problem relevant?”; ”How can you solve this problem?”; ”What are the proposed solution results?”. For this, 1) First, in the preliminary stage, one must clearly define the problem to be addressed (what); 2) Next, the motivation describing the importance of this topic compared to what is discussed in the literature should be developed (why); 3) Following, a clear and reproduceable method, or methodology, for successfully tackling this problem must be established (how); and 4) Finally, results depicting the contributions/improvements of the proposed solution compared to the literature must be presented (results).

Based on these perspectives, scientific research experience can significantly assist undergraduate students' development of analytical problem-solving skills, and foster their eagerness to learn, understand, and develop new methods to address on going and future problems they will likely face during their professional lives. In addition, from this perspective, considering the current requirements of engineering students, fostering student interest and participation in scientific research initiation can bring significant benefits to their training and professional journey. Then, the development of courses fully focused on research, as well as the blending of research aspects STEM courses can significantly assist students' education.

In this sense, this work seeks to develop a new methodology for introducing research curriculum in undergraduate engineering students' education, where different students' abilities can be improved. For this, a structured-learner centered design associated with active learning tools, and diversified processes seeking to ensure an equitable, diverse and inclusive (EDI) environment is employed. The proposed methodology is verified employing a case-study representative of a real industrial application problem where students must develop their solution based on the scientific method steps. Through this case-study students are exposed to hands-on research experience, encouraging them to discover the excitement that can be found in the real-world applications of research, while simultaneously highlighting the importance of diversity, as each individual opinions and experiences bring uniqueness to their solution.

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Bringing Social Justice Rhetoric and Deliberation into the Engineering Writing Classroom: the case of Amazon ”cubicle activists”

Dr. Elizabeth Fife, University of Southern California

The tech industry has seen a growth in employee protest activity against both internal policies for workers, but also expressions of concern over wider social issues including US immigration policy, climate change, personal privacy, and military contracts. Companies including Microsoft, IBM, Tableau, Salesforce, Facebook, Google and Amazon have had a variety of responses to manage a growth in social justice related petitions, walk-outs, and protests from employees, that have ranged from firing individuals to meeting demands at least in part. Study of these activities in the engineering writing classroom has multiple benefits in terms of developing student's sense of deliberate purpose, persuasive communication skills and understanding of their ethical boundaries within the field of engineering. This paper reports on the results of using a case study of Amazon's ”cubicle activists” who organized to protest their companies lack of serious involvement in addressing climate change. Students at the Master's level have engaged with this case and written reflective papers to identify ethical dilemmas and pathways to change within current global structures. Additionally, the paper makes a case for bringing social justice issues of relevance to engineering students in the writing classroom

Motivation:

Lucena and Leydens (2015) have described the ”socio-technical” constructs of engineering concepts, models and systems, noting that social justice dimensions related to implementation and creation are often invisible or are considered separately in engineering courses. As social justice rhetoric and actions are not often integrated into engineering courses, there are few opportunities for prompting engagement and consideration of the human element behind the products of technology (Scott & Welch, 2014). Further, according to Mignolo, (2011), the poverty, inequities, commodification, etc. behind progress and globalization are rarely discussed as causes. and are usually only offered up as the solution.

Use of stand-alone case studies are increasingly incorporated into engineering communication courses as a teaching tool to encourage broad thinking of ethics and societal impact of technologies. Case studies based on real world events can be tools to engage engineering students as discussion can be grounded in concrete scenarios as a vehicle for introducing abstract ethical principles (Bockman, J., R., & Couture, B., 1984, and Boehrer, J. 1990.).

Employee Activism in Context of Amazon's Protest Activities

Employee-driven efforts for social justice have occurred in the past, for example in the 1990s gay and lesbian workers sought to attain benefits for domestic partners, given the lack of legal protections (Chishi & Bolter, 2019). Such activity tends to be supported by shifts in public opinion. However, the current wave of protest activity from within companies is largely focused on national and global social issues that are intertwined with company policies and products.

Instructional Notes for this Case

Students can view this case through various lenses to support deeper analysis of the case and assessment of the rhetorical moves of various actors and underlying context. Success factors and overall sustainability of tech employee activism can also be explored as this framework allows for generalizability and hence, wider application beyond the case of Amazon.

Amazon's Workplace Activists

In general terms the capabilities, demographics and circumstances of high-tech employee protesters are an important key to understanding the emergence and continued effort. The makeup of high-tech employees tend to be the

Millennial generation, who according to reports tend to feel strongly that their employers should be involved in addressing societal issues.

Given that graduating engineering students often purport to care about the ethics of the company they work for, efforts have been made to demonstrate progressive values and openness as a company recruitment tool; having recruited employees that actually care about these things, leading companies such as Amazon have facilitated the employee activism they now are facing. The communications of Amazon's employee activists indicate that the intended audience is within the company, (management and other employees) and protest moves externally when leadership does not pay attention.

Communication Strategies

The use of the company's own mission statements and training creeds have been effectively used to show a gulf between stated values and actual practice. Turning the tables on a company by arguing for change using their own core principles has allowed protesters to make powerful points for the audience they are seeking to influence: executives in the company as well as other fellow employees. The company's core values around customer-centricity have been questioned by protesters who note that customers might have higher priorities than one-day delivery, and Amazon should consider this.

Technological Affordances

Adept use of online communication to mobile and encourage participation and then to broadcast results has been a critical underpinning of high-tech employee activism. Maiorescu (2017) highlights the use of social networking platforms by employee activists in tech fields to engage, solidify identity and organize in contrast to the minimal and ineffective use of social networking in IBM. Social communication tools that make it possible to network inside a company and externally are notable features of current efforts of employee activists.

Outcomes

Considered one of "America's most trusted brands" Amazon employees are pushing the company to earn its reputation and uphold a higher standard of corporate responsibility. While protester influence thus far could be characterized as incremental, rather than transformative, discussion and analysis of this case has a three-fold purpose. First, it is intended to help students delineate the rhetorical and situational capacities behind social justice protest in the workplace. Second, students can explore an imagined future alignment of public advocacy for environmental and societal justice, matched with public (customer) concern for the environment and other social issues. This linkage has provided fuel for employee protests in the past such as gay rights, and thus could provide a the "boundary-spanning" drive for cubicle activists to move their company's agenda. Finally, case analysis of Amazon contributes to integration of the social and technical context of engineering efforts.

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Work-in-Progress: Successful Transfer and Retention (STAR) Program at Cal State LA

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This is an abstract submitted for presentation only.

Helping community college students complete their undergraduate education is a national priority and particularly important for students pursuing engineering and engineering technology degrees. Current studies pointed out that only about 25 percent of community college students transfer to a four-year institution, with about one in six completing a bachelor's degree within six years (Jenkins & Fink, 2016). Well-known challenges encountered by pre-transfer students include lack of student support, remedial coursework requirements, navigating the transfer process, and failure to transfer. At four-year institutions, post-transfer challenges often include loss of credits during transfer, post-transfer academic shock, and loss of academic momentum (Xu et al., 2020). For engineering and engineering technology majors, rigid pre-requisite curricular requirements often lead to remarkably high transfer unit losses and increased time to degree due to pre-requisites that have not been met pre-transfer.

Community Colleges in Los Angeles serve many students from low-income families and underserved communities. Therefore, strengthening community college transfer pathways to bachelor's degrees is an important strategy for addressing equity concerns in higher education. In June 2022, with the sponsorship from College Futures Foundation, California State University Los Angeles initiated the Successful Transfer and Retention (STAR) Program in the College of Engineering, Computer Science, and Technology (ECST). The goal of the STAR program is to create new baccalaureate pathways with integrated pre and post-transfer support through peer mentoring to increase transfer student success.

This presentation will introduce the STAR program features and the work-in-progress during the first year with the broader engineering education community. We will show how the STAR program can establish a collaborative support network to enhance student-transfer capacity. In particular, the progress of the following key activities will be presented: 1) development of new guided pathways to prepare transfer students for careers in engineering and engineering technology, with a focus on providing direction for students in career education or technical vocational programs at 2-year schools to obtain BS degrees; 2) development of the STAR peer mentoring program to support pre-transfer student navigation of the pathways; 3) creation of a supportive peer community structure to strengthen the sense of belonging among post-transfer students and to accelerate their degree progress. The presentation will also share what we have learned from our transfer students and community college partners about specific challenges for regional transfer students in the era of the Covid-19 pandemic, as well as ways to cultivate cross-college collaboration.

References:

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Xu, D., Solanki, S., & Harlow, A. (2020). Stepping-Stones or Roadblocks? The Impact of Two-Year College Entry on Baccalaureate Attainment and Labor Market Outcomes. American Enterprise Institute

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The Experience of Equity in Higher Education Institutions in Rural Areas

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The intent of this abstract is to prepare a presentation on the experience of equity in higher education institutions specifically in rural areas. Current scholarship supports the goal of equity in obtaining a college degree, especially to support marginalized communities' upward mobility. Simultaneously, there are extensive efforts on science, technology, engineering, and mathematics (STEM) outreach, specifically to increase the representation of people with those degrees, which is also an equity issue. However, much of the scholarship is limited to the context of urban areas while overlooking rural areas. The purpose of this presentation is to share preliminary findings about the experience of equity work in higher education institutions located in rural areas. The project will contrast three institutions – a state university, a Hispanic Serving Institution, and a private institution located on a Native American reservation. The larger project will have interviewed 3 - 5 individuals from each of the three institutions. We anticipate that these rural-based insights on equity work in higher education will serve as inspiration for, and also as an anchor to conversation about, equity work in higher education institutions in rural areas more broadly."