Conference Program

2025 ASEE Illinois-Indiana Section Conference
Saturday, April 12, 2025

2025 ASEE IL-IN Section Conference – Schedule of Activities

Saturday, April 12, 2025

8:00 AM – 8:30 AM:	Sign in, breakfast (FAB 1st floor)
8:30 AM – 8:45 AM:	Conference welcome, with Dr. Doug Tougaw, B111
9:00 AM – 10:00 AM:	Paper Session #1 in J204: Global experiences, ethics, and student well-being Paper Session #2 in J206: Projects, class tools, and entrepreneurial mindset Paper Session #3 in J208: K-12, summer programs, and outreach
10:15 AM – 11:05 AM:	Workshop #1 in J213: *Psychological safety is crucial for teaming, and it can be taught!* Workshop #2 in J215: *Introduction to Entrepreneurially-Minded Learning*
11:15 AM – 12:15 PM:	Poster Session, FAB 1st floor
12:15 PM – 1:15 PM:	Lunch, FAB 1st and 2nd floor
1:30 PM – 1:50 PM:	Keynote speech, Dr. Carlotta Berry, B111
1:50 PM – 2:05 PM:	Guest speaker, Mr. Matt Ray, B111
2:05 PM – 2:20 PM:	Business meeting, announcement of awards, B111
2:30 PM – 3:30 PM:	Paper Session #4 in J204: Technology in the classroom Paper Session #5 in J206: Course and training improvements Paper Session #6 in J208: Design and capstone experiences
3:45 PM – 4:35 PM:	Workshop #3 in J213: *Implementing Critical Conciousness in Engineering Design: A Framework for Faculty* Workshop #4 in J215: *Integrating Sustainability into Engineering Curriculum Through the UN SDGs*

Paper Presentation Sessions

Session 1 (9:00 – 10:00 AM in J204)

9:00 – 9:15: Mindfulness Practices Among Engineering Students in Study Abroad Programs
Jack Ferlazzo, Julia Hopper, Ashley Schafer, Vidya Madana, Aparajita Jaiswal

9:15 – 9:30: Work in Progress: International Capstone Design: Insights from Students, Faculty, and Clients
Namita Shrestha, John Aidoo, Mitchel Daniel, Timothy Chow

9:30 – 9:45: Resisting Competently: A Mixed Methods Study of Reactions to Ethical Followership
Kyle Payne

9:45 – 10:00: Navigating Social Capital Formation: Challenges and Strategies of Cross-Cultural Kids in STEM Education
Aparajita Jaiswal, Kelsey Patton, Stephanie Bowers, Christabel K. Anumenechi

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Session 2 (9:00 – 10:00 AM in J206)

9:00 – 9:15: Work In Progress: Development of an Electromechanical Systems Integration Project for Upper-Level Engineering Students
Bradley Lane Kicklighter, P.E., Julian Ly Davis

9:15 – 9:30: Work in Progress: MATLAB Toolbox to Simplify the Solution Process for Planar Rigid Body Kinetic Problems
Simon Jones, Joseph Eichholz

9:30 – 9:45: Fun Fridays and Entrepreneurially Minded (EML) in the General Chemistry Classroom: Using Real-life Scenarios to Invigorate the First-Year Engineering Experience
Kamila Deavers, Najmus Saqib

9:45 – 10:00: Work in Progress: Photovoice Reflection at the STEM-to-HASS Inflection Point of an Entrepreneurially Minded Engineering Project
Thomas Lucas, Ph.D, Bhavana Kotla, Ph.D

Session 3 (9:00 – 10:00 AM in J208)

9:00 – 9:15: Democratizing K-6 STEAM Education with Open-Source Robotics
Carlotta A. Berry, Nicki Manion

9:15 – 9:30: Work in Progress: Evolving a 3D Printing Module developed for a 3-week STEM Summer Camp to a Semester-long Curriculum on Design and Additive Manufacturing for K-4th Grade Students – Challenges and Opportunities
Anand Nageswaran Bharath, Henry Schmidt, Jennifer Thomasson, Sydney Stewart, Deepti Gnanaseelan, Chaitali Agale, Aishwarya Vinod Ponkshe, Abhay Joshi, Sonya Ware-Meguiar

9:30 – 9:45: Assessing the Impact of an Interdisciplinary Engineering Summer Camp on Student Engagement and Interest
Umer Huzaifa, Lucia Dettori, Steven McGee, Hussain Nalwala, Dimuthu D. K. Arachchige

9:45 – 10:00: Development and Implementation of Escape Rooms for an Engineering Summer Bridge Program
Xinyu Zhang, Ryan DiBacco, James Kmetz, Joshua May

Session 4 (2:30 – 3:30 PM in J204)

2:30 – 2:45: Empowering Engineering Education with the Raspberry Pi 5
Himnish Jain, Eisha Peyyeti, Taniya Agarwal, Lawrence Angrave

2:45 – 3:00: Using Jetstream2 for Equitable Instruction of Cloud-Based Machine Learning Microservice Engineering and Deployment
Mary Loveless, Tyler Balson, Beth Plale

3:00 – 3:15: Assessing AI Integration in School Education
Maryam Ghadiri, Sotiria Koloutsou-Vakakis, Hadi Meidani, Blake Everette Johnson, Qingquan Zhang, Jiheng Jing, Elahe Soltanaghai

3:15 – 3:30: Work in Progress: Dilithium/2 = Lithium? Post-quantum signatures for undergraduate classes
Joshua Holden

Session 5 (2:30 – 3:30 PM in J206)

2:30 – 2:45: Work in Progress: Using Student Focus Groups to Improve an Undergraduate Bioengineering Transport Course
Caroline Cvetkovic, Sarah Meece, Trisha Patnaik, Divya Bendigeri

2:45 – 3:00: Work in Progress: Introducing entropy as a measure of energy dispersion to engineering sophomores
Eduardo Vitral, Allen White, Calvin Lui

3:00 – 3:15: Understanding Construction Students' Inspection of Safety Harnesses for Effective Behavioral Feedback Design in Augmented Fall Protection Training
Kwonsik Song, Joseph Ahn, Matt Ray

Session 6 (2:30 – 3:30 PM in J208)

2:30 – 2:45: A Simple Tool for Sustainability-Informed Engineering Design
Yeow Siow, William Flynn

2:45 – 3:00: Efficacy of Generative Design and Topology Optimization Compared to Traditional Design Processes Using the Case Study of a Cantilevered Beam
Quinn Fossier

3:00 – 3:15: Teaching Effective Teaming in Senior Capstone Design
Jennifer Mueller, Michelle Marincel Payne, Namita Shrestha, Jim Hanson, John Aidoo

3:15 – 3:30: Empowering Innovation: Teaching Power Strategies in Electronics and Capstone Design Projects
Suha Lasassmeh, Mary Loveless, Bryce Himebaugh

Workshops

Workshop 1 (10:15 – 11:05 AM in J213)

Title: Psychological safety is crucial for teaming, and it can be taught!
Facilitators: Michelle Marincel Payne and James Hanson
Learning Objectives:

By the end of this workshop, participants will be able to:

1. Describe the potential benefits of psychological safety on team production and value creation.
2. Explain and practice curiosity-based components of psychological safety in the context of effective teaming environments, and
3. Identify how, where, and when psychological safety attitudes can be applied in classes or teaming situations.

Description:

Teamwork is not only a pedagogical best practice, but is a required ABET outcome. This workshop targets all engineering faculty. Faculty will gain access to resources and examples of integration into engineering design courses. The framework and modules for teaching student teams to foster psychological safety are degree-agnostic; any engineering faculty member will take away ideas and practical examples of the need for teaming instruction and how to help students foster psychological safety.

Too often students say they have nothing to contribute or that teammates won't listen. Innovation, curiosity, idea-generation are stifled; students learn negative coping skills; and students miss opportunities to build leadership skills. For highest success, teams must be inclusive and efficient. Research, including Google's, demonstrates that high-performing teams actively foster psychological safety. However, engineering programs rarely teach effective teaming skills and even fewer teach skills for fostering psychological safety.

To address this gap, we developed modules to teach engineering students a framework they can use to promote psychological safety in teams. By providing examples of how to act and how to respond, students can practice effective teaming attitudes through role-play, and in this workshop participants will do the same. It is critical that we move beyond the cognitive domain of learning and into the affective domain if we value that students practice attitudes that can lead to habits. Our modules are tailored to three phases of the design process, but can be applied or adapted for any team environment. Our three modules are developed around three attitudes: (1) every idea as having potential to contribute a positive outcome, (2) questioning an idea provides valuable insight, and (3) applying the brake can be productive.

Workshop 2 (10:15 – 11:05 AM in J215)

Title: Introduction to Entrepreneurially-Minded Learning
Facilitators: Adel Alhalawani and Kosta Popovic
Learning Objectives:

By the end of this workshop, participants will be able to:

1. Describe the main pillars of Entrepreneurially Minded Learning (EML).
2. Navigate the Engineering Unleashed (EU) website and utilize the KEEN cards format to find relevant EML activities.
3. Select an activity from the provided KEEN card-decks and identify how they can implement it in their teaching in the coming academic year.

Description:

Entrepreneurial Mindset (EM) is a set of attitudes and behaviors that enhances technical education by fostering curiosity, connections, and value creation. EM as a way to scaffold learning has been adopted by a community of over 6,000 engineering faculty, staff and administrators, which is also known as the Engineering Unleashed (EU) community. In this workshop, we provide an accessible introduction to the Entrepreneurially Minded Learning (EML), starting from a foundational understanding of EM. We then demontrate how educators can access resources through the EU platform, and introduce the KEEN (the Kern Entrepreneurial Engineering Network) “cards” format for disseminating EML activities and knowledge within the EU community. Participants will explore curated decks of mini EML activities tailored to various engineering and science disciplines, enabling them to explore and integrate EML concepts in their practice with little development effort. Through interactive engagement, attendees will identify practical strategies to implement EML in their own classroom and research. We will also share insights from our experience, highlight other available resources, and discuss how EML can equip students with a unique approach to problem-solving, innovation, and creating value.

Workshop 3 (3:45 – 4:35 PM in J213)

Title: Implementing Critical Consciousness in Engineering Design: A Framework for Faculty
Facilitators: Renata A. Revelo and Joel A. Mejia
Learning Objectives:

By the end of this workshop, participants will be able to:

1. Explain the concept of critical consciousness and its relevance to engineering education.
2. Identify and implement components of intergroup dialogue to facilitate discussions around social justice in engineering design.
3. Develop ideas for incorporating critical consciousness themes into engineering design courses.

Description:

In this highly interactive special session, the presenters will engage the audience in learning about and testing out various aspects of a teaching framework that incorporates critical consciousness within engineering design education. The teaching framework was implemented at two different institutions to teach critical consciousness alongisde the engineering design process. The framework has the following components: (1) intergroup dialogue, (2) community-focused projects, (3) critical consciousness topics, and (4) engineering design process.

Workshop 4 (3:45 – 4:35 PM in J215)

Title: Integrating Sustainability into Engineering Curriculum through the UN SDGs
Facilitators: Jennifer Mueller, Mark Minster, Kelley Dugan, and Ben Mertz
Learning Objectives:

Upon completion of this workshop, participants will be able to:

1. Describe sustainability in the context of their discipline by applying relevant UN SDGs.
2. Examin existing courses taught for potential ways of incorporating sustainability or sustainable design into their course.
3. Create connections with colleagues that have similar pedagogical goals related to sustainability in education.

Description:

There are well-established challenges to incorporate learning for sustainability throughout higher education. Both faculty and curricula specialize as they advance, whereas learning for sustainability – understanding the UN SDGs, for example, or developing the sustainability competencies – requires more than specialization. Communication within and across disciplines is essential for understanding complex problems like pollution, overconsumption, environmental injustice, and declining biodiversity. Faculty sometimes feel unprepared to teach sustainability content, saying things like, “I’m not a sustainability expert” and “I don’t know what students know about sustainability already” and “I don’t know how to teach sustainability.” In addition, because curricula are tight, faculty express worries that they will not have time to teach sustainability content, which they perceive as complicated, imprecise, or inherently politicized.

Our workshop aims to provide participants with a guiding framework thorugh which they can align relevant sustainability topics to their discipline-specific curricula. With a focus on the UN SDGs, we will demonstrate how a variety of engineering disciplines can incorporate sustainability content and provide sustainability-themed course activities and assignments. By integrating content aligned with the UN SDGs, coverage of sustainability topics can be more pervasive and intentional across engineering education. Utilizing the UN SDGs provides validation for sustainability-themed curriculum, especially when faculty feel they are not experts in sustainability.

Participants can come prepared with a course in mind, but that is not necessary. We will provide an overview of sustainability in engineering education and the UN SDGs. Participants will brainstorm ideas for integrating sustainability into engineering courses and how it aligns with UN SDGs.

Posters

A Comprehensive Survey on Utilizing LLMs to Explain Math Content in College Engineering Courses
Nancy Zhang, Louis Asanaka, Lawrence Angrave, Hongye Liu, Chrysafis Vogiatzis, Pablo Robles Granda, Xiuhao Ding

Adaptation of Existing Material Testing Equipment for Tensile Testing of Additive Manufactured Materials
Jared Fulcher, Chris Martin

Analysis of STEM Student Flows through Curricular Networks: A Case Study in an Illinois Public Institution
Bonan Yang, Hannah Rachel Rondi, Syeda Zunehra Banu, Gunes Ercal

Developing a DEI in Engineering Classroom instruction Observation Instrument
Jae Jun Jong

Development of A Robotic Tour Guide Using Boston Dynamics SPOT Robot
Jared Jess, Ryan Bender, Andrew Schalk, Dr. Chris Gordon

Exploring Alternatives to Silicon in Semiconductor Applications Through VASP Simulations
Jayden Mwesige, Jared Serrano, Tally Escamilla, Tomas Jaramillo, Doruk Uçar, Isiah Ramos, Lara Herbert, Elif Ertekin

Gender Differences in Global Identity Development: Implications for Intercultural Competence in Higher Education
Vidya Madana, Aparajita Jaiswal, Sakhi Aggarwal

MERL HRI Blossom Research
Carlotta Berry, Anthony Mui

Integrating Peer-Reviewed Journals in Upper-Level Elective Courses in Undergraduate Education
Audrey Hankins, Deonisha Wright, Hailey Hofmann, Nathan Rosmarin, Namita Shrestha

Investigating Li+ Transport in Li-S Battery Electrolytes using Operando Spectroscopy
Abigail Smith, Najmus Saqib

Generative AI in CS Education: Navigating the Intersection of Student Usage and Faculty Vision
Matthew McClenahan

Paper Abstracts

Mindfulness Practices Among Engineering Students in Study Abroad Programs

Jack Ferlazzo, Julia Hopper, Ashley Schafer, Vidya Madana, Aparajita Jaiswal

Background: Engineering students face challenges with managing their workload, staying focused, and regulating emotions. Mindfulness programs can foster skills such as observation, reflection, and self-awareness, which enhance self-management. For engineering students, these practices help establish positive habits in the face of stress. This paper specifically explores mindfulness within the context of study abroad, where it becomes crucial for coping with intercultural differences and adapting to new environmental and societal norms.
Objectives: This study examines how engineering students integrate and reflect on mindfulness practices in their daily lives after participating in a week-long mindfulness module. Upon completing the module, students submitted reflections, each approximately 250-300 words in length, discussing their ability to manage emotions and stress as a result of the practices. The reflections provided insights into how these mindfulness techniques impacted students' emotional regulation and stress management skills.
Methods: The study used a case study approach to analyze the data. The qualitative data from reflection responses of 15 engineering students were evaluated using a 4-point rubric. The rubric was developed using 5 Facets of Mindfulness framework and it included following criteria: assessing skills in observation, description, awareness, non-judgment, and non-reactivity. Each reflection was scored using the rubric and sum for all the five criteria was calculated. Further median score was calculated and the participants were grouped into two categories: advanced (scores ≥ median) and moderate (scores < median). This categorization facilitated the analysis of patterns and similarities within each group, yielding key insights into how students developed mindfulness skills during the program.
Results: Students were classified into two groups based on their median mindfulness rubric scores: seven students in the moderate group and eight in the advanced group. Quantitative findings indicated that advanced participants exhibited higher proficiency in observing and describing behaviors, with the variation occurring in non-reactivity to inner experiences. Qualitative themes further revealed that moderate participants engaged with mindfulness at a surface level, often treating exercises as tasks rather than tools for self-awareness. In contrast, advanced participants demonstrated deeper engagement, using mindfulness to regulate emotions, connect with personal experiences, and develop greater self-awareness. Non-reactivity emerged as the most defining construct, with advanced students showing a stronger ability to manage internal challenges and emotional stress compared to those in the moderate group.
Conclusion: The findings of this study demonstrate that mindfulness practices significantly benefit engineering students, particularly in managing stress, enhancing self-awareness, and building emotional resilience. By fostering these skills, mindfulness not only supports well-being but also contributes to better academic performance and adaptability in diverse environments.

Work in Progress: International Capstone Design: Insights from Students, Faculty, and Clients

Namita Shrestha, John Aidoo, Mitchel Daniel, Timothy Chow

Every year since 2005, the Civil and Environmental Engineering Department at Rose-Hulman Institute of Technology has incorporated at least one international capstone design project. For each project, student teams collaborate with clients from other countries. To date, Rose-Hulman Institute of Technology has partnered with clients in 10 countries worldwide: Trinidad, Ghana, Sudan, Nepal, India, Kenya, Uganda, Pakistan, Zimbabwe, and Haiti. The unique, yearlong structure of the capstone design project provides an extended timeframe for students to gain significant design experience. These international capstone design projects have enabled students to design a wide range of structures, including churches, footbridges, community centers, resorts, five-star hotels, inland ports, and water treatment facilities for global communities. Our past assessments indicated students have successfully navigated and overcome numerous challenges within an international context, such as diverse client backgrounds, cultural differences, limited access to data, and communication barriers. Given these unique challenges, the aim of this study is to understand the impact of participation on students, faculty, and clients engaged in international capstone design projects. This study is ongoing and will continue through August 2030. We gather insights from each constituent group using online feedback surveys. Based on feedback gathered from our students, faculty technical mentors, and clients thus far, the benefits of international capstone design as part of engineering education and student development have been reaffirmed. Some of the challenges and areas of student growth associated with the international capstone projects include communication barriers, time zone differences, cultural differences, and differences in construction practices and protocols.

Resisting Competently: A Mixed Methods Study of Reactions to Ethical Followership

Kyle Payne

Shedding light on how followers navigate ethical dilemmas at work, particularly when they receive an unethical directive or request from a leader, ethical followership "reverses the lens" on ethical leadership. Rather than focusing solely on leaders' efforts to influence their followers to behave ethically, as leadership literature tends to do, this paper considers ethical leadership as co-created by leader and follower. That is, it considers what behaviors an ethical follower can use to influence leaders, peers, and other stakeholders. A few ethical follower behaviors identified through empirical research include querying, reframing, appealing, educating, negotiating, refusing, and reporting.

Building on a definition and theoretical framework for ethical followership presented at least year's ASEE Conference, this paper presents a mixed methods analysis of leaders', peers', and other stakeholders' reactions to ethical follower behaviors that examines which ethical follower behaviors are deemed most appropriate and effective to use when facing an ethical dilemma. The paper also explores leaders', peers', and other stakeholders' perceptions and emotions associated with ethical followership. Professional engineers from a variety of disciplines in the United States completed a survey on ethical follower behaviors and their reactions to them. A select group of these participants were then interviewed to explore their reactions in more depth.

For scholars, this paper enhances an emerging theory of ethical followership, clarifying how ethical follower behaviors, singularly and in combination, are understood and felt by leaders, peers, and other stakeholders. In doing so, the paper examines the potential consequences of ethical follower behaviors at individual, group, and organizational levels. For practitioners, this paper provides guidance on how to develop and support ethical followers at work. This paper can also help practitioners to prevent *unethical* followership, in which followers may participate in or condone unethical behavior, and to manage the inherent challenges of ethical leadership.

Navigating Social Capital Formation: Challenges and Strategies of Cross-Cultural Kids in STEM Education

Aparajita Jaiswal, Kelsey Patton, Stephanie Bowers, Christabel K. Anumenechi

Cross-Cultural Kids (CCKs) offer a unique perspective on social capital formation due to their hybrid cultural identities and global experiences. This study examines the experiences of STEM CCK students at a large Midwestern university, focusing on the challenges they encounter and the strategies they employ to build social networks in academic and professional settings. Through in-depth, one-on-one interviews with five CCKs, the study identifies key barriers to social integration and highlights strategies that support their academic and professional success. Findings from the study revealed that CCKs often struggle to build social capital due to difficulties in connecting with monocultural peers. Their diverse cultural backgrounds result in limited shared references, making it challenging to establish common ground. Moreover, language and cultural barriers persist even within culturally similar groups, as unfamiliarity with specific practices or dialects can lead to feelings of exclusion. Moreover, many CCKs perceive interactions with monocultural peers as superficial, contrasting with their preference for deeper, more meaningful connections informed by their global outlook. Despite these challenges, the study also found that CCKs actively develop strategies to foster strong and meaningful networks. They leverage their multicultural backgrounds to bridge cultural divides and establish connections across diverse groups. By engaging in multicultural communities, they create supportive environments that validate their hybrid identities and provide a sense of belonging. Their ability to adapt their communication styles and cultural practices enhances collaboration and conflict resolution in STEM environments. Participation in cross-cultural organizations further reinforces their identities and provides spaces where their diverse experiences are acknowledged and valued. Moreover, CCKs prioritize meaningful and authentic relationships, often seeking connections with individuals who share similar global perspectives. The findings highlight the dual nature of the CCK experience in STEM—marked by both challenges and strengths. By understanding how CCKs navigate social capital formation, educators and institutions can develop more inclusive and supportive environments that promote their academic and professional growth.

Work In Progress: Development of an Electromechanical Systems Integration Project for Upper-Level Engineering Students

Bradley Lane Kicklighter, P.E., Julian Ly Davis

Through several years of advising capstone design projects, faculty have identified key gaps in students' knowledge. Some of these include: system integration, component selection (such as motor sizing and circuit protection devices), electrical wiring, 3D printing, knowledge transfer, and awareness of standards. To address these gaps, the authors are developing an electromechanical design project. The project is aimed towards the junior-level Dynamics of Machinery course taken mostly by mechanical and manufacturing engineering students. The project will require the students to design and fabricate a mechanism to transfer an object through three prescribed positions. The mechanism will consist of a four-bar linkage, a gear train, an electrical motor, and a control circuit. Students must deliver a report including documentation of their design, identification of appropriate standards, and technical drawings.

Work in Progress: MATLAB Toolbox to Simplify the Solution Process for Planar Rigid Body Kinetic Problems

Simon Jones, Joseph Eichholz

Undergraduate dynamics curricula typically focus on the kinematics and kinetics of planar rigid body motion. Conservation of linear and angular momenta provide the solution framework, while motion is constrained by displacement and velocity boundary conditions. In general, this approach will result in systems of differential-algebraic equations (DAE), which can be challenging to interpret for students. To help simplify the interpretation, it is typical to only compute the solution at one instant in time. While this approach makes the solution more tractable, it removes the dynamic nature of the problem. Furthermore, it can require significant algebra, and therefore class time, to solve the resulting systems of equations for a single variable.

In this talk we introduce two tools written in MATLAB that 1) conveniently convert systems of differential-algebraic equations into the governing system of ordinary differential equations, and 2) will numerically solve the governing ODEs to provide a time history of all dependent variables. Consider the kinetics of a planar double pendulum. The user would input three differential equations per pendulum to account for conservation of momenta, and a total of three constraint equations to couple and ground the pendula. The DAE solver would compute the two resulting ODEs in terms of $\theta_1(t)$ and $\theta_2(t)$ and their associated derivatives, and the numerical solver would compute the time-response of the angular displacements, along with the other independent variables such as accelerations and reaction forces.

The goal of the project is to present a complete suite of analytical and software tools to allow students and faculty to analyze rigid-body motion problems of greater complexity, while reducing the time and difficulty required to simplify the DAEs to governing ODEs. Furthermore, by providing a simple means to compute the time-response of all parameters, students can better understand the motion of the system and develop intuition for dynamic systems.

Fun Fridays and Entrepreneurially Minded (EML) in the General Chemistry Classroom: Using Real-life Scenarios to Invigorate the First-Year Engineering Experience

Kamila Deavers, Najmus Saqib

Entrepreneurially Minded Learning (EML) emphasizes educating the "whole person" by supplementing traditional theory with nontechnical concepts related to curiosity, connections, and creating value (the three Cs). Integrating the EML framework has been a strong focus in curriculum changes in many engineering programs, both old and new, across the United States. Many of these changes have been infused into multidisciplinary courses that impact all engineering disciplines, which also includes first-year engineering coursework. However, a significant, if not a major, share of typical first-year engineering courses are taught by instructors from other STEM fields. Mathematics, Physics, and Chemistry are perhaps the most obvious. EML is relevant to all of these fields. General Chemistry classes are often overwhelming and stressful for first-year students because they are content-heavy and require the use of many fundamental STEM principles. Students usually memorize the exact procedure for a calculation, step by step, but do not think about how the concepts could apply beyond the specific problem. Teaching students how to think outside of the box about problems and how to apply their knowledge beyond the chemistry classroom is an important aspect of EML. This paper describes the development of a series of "Fun Fridays" activities for a General Chemistry classroom to help students develop an entrepreneurial mindset for approaching chemistry problems. These in-class activities involve solving chemistry problems in myriad real-life scenarios, while leveraging one or more of the three Cs of EML. Instead of focusing on the solution steps, the problems encourage students to think outside of the box and apply their chemistry knowledge in a broader context. Surveys were conducted at the middle and end of the semester to gauge student perceptions of the "Fun Fridays" activities. Qualitative and quantitative results from the surveys are presented in this paper. The results are limited to a single, primarily undergraduate institution with small class sizes. Incorporating these problems in General Chemistry increased student engagement in the classroom and helped them view chemistry in a broader societal context. Students were excited about Friday's activities and felt less stressed in the classroom. They left the classroom with confidence that they were able to solve different types of problems and apply the concepts they learned in general chemistry beyond the classroom. High levels of engagement in introductory chemistry courses have great potential for increasing the retention of all STEM majors, including first-year engineering students.

Work in Progress: Photovoice Reflection at the STEM-to-HASS Inflection Point of an Entrepreneurially Minded Engineering Project

Thomas Lucas, Ph.D, Bhavana Kotla, Ph.D

This paper presents preliminary findings from a photovoice reflection conducted midway through a course project focused on entrepreneurially minded and nature-inspired engineering and manufacturing. The project culminates in the creation of a podcast episode that explores the intersection of nature and technology. The reflection was assigned at a critical juncture in the project, as students must shift their perspective from STEM (Science, Technology, Engineering, and Mathematics)-focused research to HASS (Humanities, Arts, and Social Sciences)-focused activities in order to refine their narrative to appeal to a broad audience.

By employing photovoice methodology, students are encouraged to document and reflect upon their experiences and perceptions of the project thus far. Through the analysis of their photographs and accompanying narratives, this study aims to investigate three research questions. First, how do students perceive the challenges and opportunities associated with the STEM-to-HASS transition? Second, what are the students' expectations for the podcast creation process, including potential challenges and areas of concern within the HASS domain? Finally, how does photovoice as a reflective tool contribute to students' understanding of their own learning process and the project's STEM-to-HASS integration?

The anticipated outcomes of this research include a deeper understanding of the student experience during the transition phase of the project. Additionally, the findings will inform future iterations of the course, allowing for the optimization of pedagogical strategies and support mechanisms. By highlighting the value of interdisciplinary collaboration and creative expression in engineering education, this research contributes to the broader discourse on innovative approaches to teaching and learning in STEM fields and the integration of STEM-to-HASS education.

Democratizing K-6 STEAM Education with Open-Source Robotics

Carlotta A. Berry, Nicki Manion

In this paper, we examine the use of open-source robotics to democratize K-6 STEAM (science, technology, engineering, art, math) education. Robots are ideal for teaching STEAM due to the multidisciplinary nature of the platform with connections to computer science, engineering, math, humanities, arts, and social science. There are many challenges with using robotics for STEAM education including lack of appropriate knowledgebase, cost effective platforms, flexible robots, and limited learning activities. The use of a low-cost open source 3D printed platform such as the Flower∞Bots would address several of these challenges. First, since the platform is open source, the videos, tutorials, design files, code, learning activities and materials are freely available online. This provides educators with the knowledge base necessary to teach STEAM to their class. It also provides them with the ability to access, modify, and update the platform and learning activities to be flexible enough to meet their learning goals. Since the platform is half 3D printed and half commercial off the shelf parts, it is low-cost enough to scale, as necessary.

The Flower∞Bots platform, so named due to its ability to grow with the user through an infinite number of learning activities, was used to teach K-6 teachers computer science principles in professional development workshops during the 2023-2024 school year. The Lily∞Bot platform with the Micro:Bit was used to teach a Level I workshop with graphical programming to K – 5 teachers. The Lily∞Bot platform with the Arduino Uno was used to teach a Level II workshop with TinkerCad, text-based and graphical programming to 4-8 teachers. Participants built, programmed, and completed activities related to the state computing foundation and computer science standards. At the conclusion of the workshop, the participants brainstormed how to integrate these concepts into their classroom, completed a feedback survey, and attended a virtual follow up session. In the follow up session, they shared classroom artifacts based upon their participation in the professional development workshop. Preliminary results indicated that the workshops were useful and that teachers were able to make teaching artifacts for building and programming. Results will be presented and conclusions drawn regarding the ability of low-cost modular 3D printed open-source robots to democratize STEAM education.

Work in Progress: Evolving a 3D Printing Module developed for a 3-week STEM Summer Camp to a Semester-long Curriculum on Design and Additive Manufacturing for K-4th Grade Students – Challenges and Opportunities

Anand Nageswaran Bharath, Henry Schmidt, Jennifer Thomasson, Sydney Stewart, Deepti Gnanaseelan, Chaitali Agale, Aishwarya Vinod Ponkshe, Abhay Joshi, Sonya Ware-Meguiar

In collaboration with our community partner Girls Inc., Cummins employees have developed and executed an after-school Science, Technology, Engineering and Mathematics (STEM) Outreach program for kindergarten to 4th grade female students from the Franklin, Indiana Schools District to expose them to Science and Engineering concepts through Project-based Learning (PBL). One such PBL module that we developed was on 3D printing, which was originally designed to be 3-weeks long as part of an 8-week summer camp that covered multiple STEM topics. While the 3-week module was able to provide students some hands-on experience with 3D printing, 3 weeks was deemed too short a timeframe to adequately cover the fundamentals of engineering design and develop a true appreciation of additive manufacturing techniques like 3D printing. This prompted us to reevaluate the 3-week module and evolve it into a more detailed curriculum that would last an entire semester. The detailed curriculum now comprises teaching students about the basic fundamentals of engineering design such as engineering drawings and different types of views, followed by using engineering paper to produce dimensioned 2D views. After completing the tasks on engineering drawings and views, the curriculum introduces the students to a freely available web-based Computer Aided Design (CAD) tool called TinkerCad to allow them to apply the concepts they learnt to make their own 3D designs, following which the 3D designs developed by the students would be 3D printed. To incorporate Art into the curriculum so that these concepts can be reinforced in a fun way, the students were asked to design Halloween and Christmas ornaments in TinkerCad, which allows them to be creative while giving them the hands-on experience to operate CAD software. The curriculum was designed to be age-appropriate for K-4th grade students. This work-in-progress paper will describe in detail the motivation for converting a 3-week module into a full design and additive manufacturing curriculum, the lesson plan and specific tasks, and the challenges and potential opportunities in implementing this curriculum over a semester.

Assessing the Impact of an Interdisciplinary Engineering Summer Camp on Student Engagement and Interest

Umer Huzaifa, Lucia Dettori, Steven McGee, Hussain Nalwala, Dimuthu D. K. Arachchige

The objective of this summer engineering camp was to enhance student interest in engineering by providing hands-on exposure to interdisciplinary STEM concepts. Recent studies indicate a growing enthusiasm for computer science and its applications, yet a declining interest in broader engineering disciplines. To address this challenge, the engineering summer camp held at DePaul University was structured around a three-pronged approach consisting of interactive lectures, hands-on demonstrations, and practical application sessions. High school students who participated in the program reported an increased interest in computer programming, designing engineering systems, and collaborating in teambased problem-solving activities. The camp successfully fostered engagement by integrating Embedded System Design, Computer-Aided Design (CAD), and Mobile Robotics, demonstrating the real-world applications of engineering in an accessible and engaging manner.

Development and Implementation of Escape Rooms for an Engineering Summer Bridge Program

Xinyu Zhang, Ryan DiBacco, James Kmetz, Joshua May

The Academy of Engineering Success (AcES) is a cohort-based engineering summer bridge program in a public university for incoming first-year engineering students. To encourage cohort engagement, an on-campus escape room was created. This escape room was developed by teams in the Success Skills for Engineers course, primarily consisting of first-year engineering students on academic probation. The escape room design project aimed to help them reflect on past mistakes and identify future improvements to get back on track with their academic progress, as well as help future first-year engineers in avoiding mistakes during their college transition. According to the course feedback, most students enjoyed the escape room design and appreciated how their design could help incoming students. Some were so motivated that they volunteered to further optimize the escape room in collaboration with a former AcES participant (a student researcher) over the summer. Due to the budget and manpower constraints, the designed escape rooms reused existing materials and facilities, primarily using paper puzzles, making it easy to set up.

The final escape room included four sections sequentially: engineering (Arduino controlled LED circuit), math, chemistry, and academic success (campus resources). Students worked in teams of five to compete to “escape” first within a 50-minute time limit. The escape room activity was implemented in AcES and received positive feedback. AcES participants found it fun, reported increased confidence in relevant skills, and expressed higher interests in engineering after the activity. They also provided suggestions for further improvements.

This study demonstrated (1) the feasibility and positive learning experience of implementing an escape room design project in a course for students on academic probation; and (2) the feasibility and positive impact of incorporating a low-expense escape room into an engineering summer bridge program. Future iterations should explore how to balance increased hands-on interaction with budget and manpower constraints.

Empowering Engineering Education with the Raspberry Pi 5

Himnish Jain, Eisha Peyyeti, Taniya Agarwal, Lawrence Angrave

Based on findings at a large Midwest university, this work in progress paper explores the educational potential of the Raspberry Pi 5 (RPI5) in empowering engineering education, with a focus on computer science and system-level learning. The RPI5 is a cost-effective and flexible embedded device that enables university students of all skill levels to engage in a wide range of coding projects, from simple, sensor-based data logging to more complex systems projects, including client-server networking, IoT applications, and file system design. This paper presents the perspectives of an instructor, teaching assistant, and a first-year university student to share our findings on how RPI5 can bridge the gap between introductory learning and advanced systems education. To support students, a custom RPI5-based kit was developed; the component selection, cost are discussed within the context of educational goals and student environment.

From the perspective of a senior, undergraduate course assistant, who ran an honors section of a university Systems Programming course, we review strategies for fostering problem-solving and resilience in students in their work with hands-on, embedded devices. From the perspective of a first-year undergraduate, we highlight how the RPI5 can be used for an undergraduate research experience, and describe the utility of the community-driven support ecosystem provided by the Raspberry Pi Foundation, online forums, and extensive user-contributed resources.

Lastly, we evaluate the RPI5's role in promoting engagement, accessibility, and real-world skill development; we detail how the RPI5 functions as a platform that empowers instructors to innovate in teaching methodologies, while encouraging learners to gain hands-on skills to tackle technological challenges. The paper concludes with key takeaways and recommendations, and outstanding challenges for integrating the Raspberry Pi into both small and large classroom settings and advocates for its wider adoption as a transformative, educational tool.

Using Jetstream2 for Equitable Instruction of Cloud-Based Machine Learning Microservice Engineering and Deployment

Mary Loveless, Tyler Balson, Beth Plale

As the use of machine learning (ML) becomes more ubiquitous at various levels of technology, it is important for undergraduate students to know how to design, build, and deploy ML models for multiple technology platforms, from cloud-based microservices to embedded ML on microprocessors. The technical complexity of the infrastructure makes it challenging to teach the design and deployment of a containerized ML microservice in a hands-on lab setting. Simply relying on students to provide their own machines to handle each step of this process is not ideal; many students may not have machines that are powerful enough to train ML models in a reasonable amount of time, let alone host virtual machines for the containerized service. The other option is to provide this infrastructure at the institution, assigning students remote virtual machines for individual development of the service. This would require a dedicated cluster as well as administrators to set up and manage each student's environment. Both scenarios can limit equitable access to this material across institutions. The work presented here details the use of Jetstream2, a cloud computing environment provided at no cost to researchers and educators. Using this platform, students get a true hands-on experience of creating (Python) and containerizing (Docker) an ML microservice as well as deploying it on an individual virtual machine hosted on cutting-edge computing infrastructure.

Assessing AI Integration in School Education

Maryam Ghadiri, Sotiria Koloutsou-Vakakis, Hadi Meidani, Blake Everette Johnson, Qingquan Zhang, Jiheng Jing, Elahe Soltanaghai

Artificial Intelligence (AI) is increasingly influencing the educational landscape, offering new opportunities for personalized learning and administrative efficiency. This study investigates AI integration in secondary education by examining teachers' familiarity, willingness to adopt Aidriven tools, and perceived challenges. A survey was conducted among nine teachers from two high schools, covering subjects such as mathematics, history, and art. Preliminary findings indicate that while teachers acknowledge AI's potential benefits, barriers such as lack of training, privacy concerns, and institutional resistance hinder adoption. Future work includes pilot studies and codesign efforts with educators to develop an AI-based teaching assistant system (ATAS). This study also explores how lessons from secondary education may inform AI adoption in post-secondary settings, particularly in engineering and physics departments, where AI applications are becoming increasingly relevant.

Work in Progress: Dilithium/2 = Lithium? Post-quantum signatures for undergraduate classes

Joshua Holden

This paper continues the ElectroNic ExeRcises for CiphEricaL Learning (ENERCELL) project by introducing Lithium, a simplified version of the Dilithium digital signature scheme which is currently being standardized by the National Institute of standards and technology. This scheme is "post-quantum" in the sense that while it does not require a quantum computer to run, it is expected to be secure against practical quantum computers, which could be developed in the near future. No previous knowledge of quantum or postquantum cryptography is necessary for this talk or to teach Lithium in your classes. Versions of the system will be presented which are suitable for linear algebra, abstract algebra, and/or cryptography classes. (I have taught a similar system in a cryptography summer course in the past.)

Work in Progress: Using Student Focus Groups to Improve an Undergraduate Bioengineering Transport Course

Caroline Cvetkovic, Sarah Meece, Trisha Patnaik, Divya Bendigeri

Reflective teaching is a method of creating more equitable environments for students. Student reflection in particular – in various formats that can include surveys, in-class responses, interviews, and focus groups – have the potential to enhance classroom experiences, address inequities and gaps in the learning objectives, and alleviate student concerns. These reflective strategies can aid instructors in understanding students' perspectives and suggestions. Especially in traditional technical courses, informal, non-graded assessments can provide invaluable information so the instructor can promptly adjust teaching strategies and address problems by improving lesson delivery and classroom dynamics based on student feedback.

This Work in Progress paper demonstrates how various forms of reflection, including a new system of student-led focus groups, were recently implemented to improve an existing transport course at a large public institution. Transport and Flow in Bioengineering (BIOE 360) is a required junior-level lecture course that exposes students to principles of heat and mass transport in the context of bioengineering conservation principles. It requires technical problem-solving, advanced differential equations related to fluid dynamics, and a rigorous schedule of increasingly challenging content, all applied to the study of biological systems and devices. Pre-semester perceptions in Spring 2022 and Spring 2024 indicated that on average, more than 30% of students had a negative opinion and only 10% had a positive opinion of the course before it began.

The instructor first sought feedback after the completion of the semester in a series of conversational focus groups over Summer 2024. Both in-person and virtual group conversations with 10-12 participants per session were facilitated to discuss students' learning experiences, including various course aspects such as lectures, homework, classroom structure, exams, and suggestions for course improvement. Participants completed surveys before and after the sessions to help the researchers understand the focus group's impact and make recommendations to be put into practice to improve a future course offering in Spring 2025. Finally, students reflected on the impact of these experiences on creating a learning environment that increases participation, understanding of subject, and skills developed.

Though students often practice applying course material in homework problems and exams, technical engineering lectures generally lack hands-on experiences in class. The skills that students may gain from such experiential activities have the potential to solidify concepts, connect to real-world situations, increase a sense of belonging in the field, and improve equity in the classroom. The topics of heat and mass transfer, for example, lend themselves easily to applied observations; however, these concepts can be difficult to implement in a lecture setting as the classroom is a much smaller setting than a traditional laboratory, outside environment, or biological context.

Recommendations from the focus groups included connecting complex topics to areas with familiar objects or real-life relevance through experiential learning. In the next steps of this project, we will examine how integrating active learning strategies during lecture can increase students' sense of identity and belonging in the field.

Work in Progress: Introducing entropy as a measure of energy dispersion to engineering sophomores

Eduardo Vitral, Allen White, Calvin Lui

Entropy is a challenging concept to convey to undergraduate engineering students. The statistical physics background required to understand what it measures, at a fundamental level, is an obstacle for both students and instructors. However, the classical thermodynamics approach involving axiomatic second law statements, heat engines, and Carnot cycles leave students without a clear understanding of the physical meaning of entropy. In addition, many of them graduate with a misconception that entropy is a measure of disorder or chaos in an engineering system. To address this issue, we have redesigned a course on conservation principles and thermodynamics for sophomores by focusing on the core concept of entropy. The introduction starts at the molecular level and involves a few ideas from quantum and statistical mechanics. This way, energy dispersion, and, consequently, entropy can be properly communicated and understood. Images and examples used in the lecture notes rely as much as possible on classical mechanics to keep the molecular level discussion enjoyable and familiar for students and instructors. In-class activities are used as students start from the microstate Boltzmann definition of entropy and move to the more classical expression of change in entropy as a function of heat and temperature. Other lecture days are interconnected to these molecular concepts, especially on sources of irreversibility, helping students reinforce their understanding of energy dispersion. Pre-lecture and in-class quizzes are used to assess pre-conceptions and assess how well students can learn these topics, respectively. Results reveal students' preconceptions and indicate enhanced comprehension of an abstract concept at the introductory level. These suggest that, by decoupling the introduction of entropy from the foundation built for the First Law, students are able to develop an improved understanding of entropy when exposed to a molecular level discussion, avoid common misconceptions and confusion with energy.

Understanding Construction Students' Inspection of Safety Harnesses for Effective Behavioral Feedback Design in Augmented Fall Protection Training

Kwonsik Song, Joseph Ahn, Matt Ray

The proper usage of personal protective equipment (PPE) is one of the essential topics in construction safety education and training since falling from a height is the most common cause of workplace fatalities in the construction industry. Providing learners with accurate behavioral feedback during and/or after the learning activities is believed to promote the development of correct safety skills. As learners progress through their training, the feedback helps them to recognize what actions should be maintained and/or corrected to appropriately use PPE on construction sites. The integration of computer vision and augmented reality technologies into hands-on learning environments provides new opportunities to create accurate feedback messages on learners' performance in a non-invasive and timely manner. Unfortunately, despite the potential benefit of using such advanced technologies, it is still unclear how learners inspect the condition of PPE. Understanding learners' inspection process is important because this provides insights into when and what the technology-driven behavioral feedback should deliver to encourage their correct usage of PPE. Therefore, to fill the gap in literature, this research explored learners' activities regarding PPE inspection and provided useful insights for effective design of behavioral feedback messages. To achieve the research objectives, a PPE training regarding the usage of full body harness was conducted with 37 undergraduate students majoring in construction management. A brief introduction about the importance and procedure of harness usage was given to the training participants. Next, the participants were asked to use five safety harnesses with different conditions (e.g., no damage or cut on a leg strap) and were recorded using three monocular cameras to see if they took certain actions to inspect the condition of the given harnesses before wearing the harnesses. Survey data was also collected after the training to investigate whether the trainees correctly evaluate the harness condition or not. The main findings from the analysis of the collected data were twofold. First, all the construction students did not take a specific behavioral step to inspect the condition of the safety harnesses before wearing the harness. The participants completed harness inspection and wearing simultaneously. Second, the average training subject showed an inspection accuracy of 53.5%. Only 8.1% of trainees correctly inspected the condition of the given safety harnesses. These results imply that when learners practice using safety harnesses, augmented behavioral coaching can remind learners to inspect the condition of the safety harness before putting it on. Also, the automatic detection of damages on safety harnesses using computer vision technologies.

A Simple Tool for Sustainability-Informed Engineering Design

Yeow Siow, William Flynn

In engineering design courses, from introductory to senior capstone, sustainability is often an important yet loosely integrated component. For over a decade at The University of Illinois Chicago (UIC), our first-year engineering design course, ME 250, had been utilizing the Inventory of Carbon and Energy (ICE) database developed at the University of Bath, England. In particular, our students had been required to look up the ICE spreadsheet for embodied carbon and embodied energy values for various materials they intend to use, during the prototyping phase of the design process. This often resulted in major errors in calculations due to: 1). uncertainties in materials of choice versus what is available in the database, and 2). discrepancies in estimating the prototype volume or mass. Additionally, the integration was rather superficial, as it occurred after the ideation phase.

In an effort to put sustainability front and center, we developed a simple, easy-to-use, and free tool — a bill of materials (BOM) Google Sheets — that allows us to incorporate environmental ethics in the early stages of the design process.

This paper details the rationale, design principle, content, and input-output of the tool. We also discuss the scalability, limitations, and potential uses of the Google Sheets. Furthermore, we present the design methodology used in ME 250, and the revised workflow where the BOM is used to guide the design during the morphological phases, and to improve design iterations in the prototyping phase.

The new BOM was successfully implemented in the Fall 2024 semester. The instructors observed significant improvements over the previous workflow, including accuracy of the BoM output, ease of use by students, ease of verification by the instructor, and the speed at which the entire bill of materials can be generated by even inexperienced students.

Efficacy of Generative Design and Topology Optimization Compared to Traditional Design Processes Using the Case Study of a Cantilevered Beam

Quinn Fossier

Designing strong, cost-effective, and lightweight parts is often an arduous and iterative process. Recently, new technologies, such as topology optimization and generative design, promise to accelerate and even automate the lightweight part design process. This case study evaluates and compares the efficacy of topology optimization, generative design, and traditional design processes for various manufacturing processes with respect to a cantilevered beam. Utilizing Fusion 360 and online rapid prototyping services, the weight, factor of safety, and cost for a myriad of cantilever beam designs for every combination of design process and manufacturing process were assessed and ranked. It was found that parts made using generative design generally had the highest factor of safety to mass ratio and the highest factor of safety to mass ratio per dollar. However, parts designed using generative design and topology optimization consistently failed to achieve the desired factor of safety, and in particular, topology optimization was found to have limited usefulness compared to more traditional design processes. Further avenues of research to explore would be to physically manufacture and test each of the designed parts to verify the veracity of the factor of safety data and obtain more concrete part cost data.

Teaching Effective Teaming in Senior Capstone Design

Jennifer Mueller, Michelle Marincel Payne, Namita Shrestha, Jim Hanson, John Aidoo

Effective teaming is a critical skill for engineering students, especially in the context of senior capstone design projects where collaboration simulates real-world professional environments. By integrating structured team-building exercises, clear communication protocols, and conflict resolution techniques, educators can enhance students' collaborative skills. As educators, our goal is to equip students with essential teamwork skills that will translate to effective collaboration in their future engineering careers, preparing them for the complex, interdisciplinary challenges of the profession. Within the Civil and Environmental Engineering Department at Rose-Hulman Institute of Technology, we have incorporated effective teaming strategies in our capstone design curriculum through the development of a team contract, an exercise on psychological safety, and activities focused on systems thinking and conflict resolution. Additionally, we discuss methods for assessing individual contributions within a team to ensure equity and accountability through individual peer evaluation reflections. This approach of actively teaching strategies for effective teaming fosters a cohesive design process wherein all team members are encouraged to play equal roles and communicate throughout all phases of design to prepare students for the collaborative nature of professional engineering practice.

Empowering Innovation: Teaching Power Strategies in Electronics and Capstone Design Projects

Suha Lasassmeh, Mary Loveless, Bryce Himebaugh

Teaching project-based courses to engineering students such as electrical circuits, embedded systems, and capstone design presents unique opportunities to explore practical applications of power strategies in electronics projects. Selecting the appropriate power source and management techniques is critical to the success of student projects, particularly as they progress from fundamental circuit concepts to more complex systems in capstone design. This paper examines effective power strategies for electronics projects in educational settings, focusing on the integration of battery systems and advanced power calculations.

The study emphasizes the importance of teaching students how to assess power requirements, select appropriate power solutions, and optimize energy efficiency to meet project constraints. It explores practical demonstrations, hands-on labs from different courses throughout our curriculum. Capstone design projects in our program are based on real-world applications with clients from industry to engage students in designing robust power systems for diverse use cases, such as wearable devices, IoT systems, and robotics. By implementing interdisciplinary methods, including simulations and industry-standard tools, the paper highlights how power strategies are integrated into the curriculum to enhance critical thinking and problem-solving skills.

Through case studies from different courses, this work demonstrates how power strategies can influence the scalability and functionality of electronics projects. It also discusses challenges encountered by students, such as balancing power demands with size, cost, and environmental impact, and presents instructional approaches to address these challenges. The findings suggest that embedding power strategies early into project-based courses fosters innovation and prepares students for engineering careers that require a strong foundation in power management.

Poster Abstracts

A Comprehensive Survey on Utilizing LLMs to Explain Math Content in College Engineering Courses

Nancy Zhang, Louis Asanaka, Lawrence Angrave, Hongye Liu, Chrysafis Vogiatzis, Pablo Robles Granda, Xiuhao Ding

Many college engineering courses have slides containing complex equations with dense text that makes it difficult for students to understand the concept immediately. The overwhelming amount of presented information often hinders accessibility and comprehension. To make these slides more accessible to students, we aim to explore how large language models (LLMs) can be used to explain these equations in a manner that is easier for students to understand within engineering education.

We tested different LLMs including Gemini, GPT-4o, and Llama 3.2-vision on their explanations of the slide content. To ensure that each model was tested fairly, we used the same collection of class slides from various engineering courses in a large land-grant Midwest university containing equations, diagrams, and tables. Overall, each model could explain the general concept of the slides, with some nuances with high accuracy. GPT-4o was able to isolate each individual line of the equations and explain how to derive each line step-by-step. Gemini was able to provide examples and a high-level overview of the equations. Llama 3.2-vision was the least accurate of the 3 LLMs– the model was able to generally recognize what topic the slides were about, but hallucinated (as in added non-existent information) arbitrary variables and was not able to fully explain the concepts on the slides. Although LLMs were relatively weaker at explaining equations, they were more accurate with tables and diagrams. With tables and diagrams, the LLMs were able to explain the surrounding context as well as extract specific numbers from the table. With equations, LLMs would occasionally add incorrect variables and wrong numbers into the original equation from the slide. Each LLM was able to deduce the surrounding context of each table and diagram while also providing additional enrichment information. For example, when given a table with Cells and Protein data, the LLM GPT-4o stated, " This type of structured data is common in biological studies, especially in flow cytometry or similar techniques." Similar to what happened with the equations, GPT-4o and Gemini were more accurate in determining the contents of the diagram compared to Llama 3.2-vision, by being able to one-on-one reproduce the equation from the slide. To conclude, LLMs have the potential to add enrichment to class slides as well as extra explanations for the equations. LLMs do have capabilities to determine contexts from class slides, but future work should focus on making LLMs more accurate and dependable when explaining how equations are derived.

Adaptation of Existing Material Testing Equipment for Tensile Testing of Additive Manufactured Materials

Jared Fulcher, Chris Martin

The rise of additive manufacturing has drastically changed the landscape of rapid prototyping and design-development. The ease of use and relatively low cost has allowed extensive use within many academic settings. However, there has been limited incorporation of these materials into traditional undergraduate material testing laboratory courses. The goal of this study was to establish a method for integrating additive manufactured materials into an existing undergraduate material testing laboratory course. First, custom tensile testing fixtures were designed and built to perform tensile tests following ASTM D638-14 guidelines utilizing an MTS-810 tensile test machine. The fixtures consisted of static and dynamic jaws connected using socket head cap screws. The static jaw of the fixture was recessed to ensure axial alignment between the tensile load and centerline of test specimen. The specimens used in this experiment were printed using Overture polyethylene terephthalate glycol (PETG) plastic filament and a Prusa i3 MK3 FDM 3D printer. The specimens were created following ASTM D638 guidelines for Type I and Type II style specimens. Initially tests were performed on a limited number of specimens to determine correct bolt torque and displacement rate. It was found that a bolt torque of 100-in-lbf and a displacement rate of 2-in/min provided the most consistent results. Once these methods were established 16 specimens, 8 Type I and 8 Type II, were tested. The modulus of elasticity and yield strength were determined for each specimen. The results showed that for both Type I and Type II specimens the modulus of elasticity and yield strength were consistent with a standard deviation of less than 3% for each of the calculated parameters. However, it was seen that the PETG specimens, both Type I and Type II, had varying failure characteristics. Some specimens showed a 45-degree ductile tear, where others had individual fibers connected after the test reached the 5-in displacement limit. Based upon these results, future work will include the development of an additive manufactured material laboratory module, a re-design of the fixtures to incorporate dovetail grooves to improve alignment and ease of use, and investigation of alternate filament materials.

Analysis of STEM Student Flows through Curricular Networks: A Case Study in an Illinois Public Institution

Gunes Ercal, Bonan Yang

According to the National Center for Education Statistics, approximately 63% of undergraduate students at public universities complete a 4-year degree within 6 years: It is critically important to systematically analyze the problem of timely graduation and persistence using rigorous methodologies. As both engineers and university educators, of special consideration is the effect of curricular pathways on timely graduation and persistence in STEM fields which have both longer prerequisite chains and lower rates of timely graduation. In our prior work, we analyzed the densities of very long pathways across entire Course Prerequisite Networks (CPNs) of 5 regional midwestern institutions and found that indeed certain majors within engineering such as EE and ME consistently dominate the longest curricular pathways across every institution. In this work, however, we fine-tune our analysis for our institution by using actual STEM student transcript data over a 14 year period to extract both raw passing probabilities as well as conditional probabilities of passing post-requisite courses towards Bayesian network analyses. By applying a probabilistic interpretation on log-transformed shortest paths in DAGs, we identify the curricular pathways exhibiting the lowest joint passing probabilities within both types of probabilistic networks, and we compare the results to both each other and to the longest paths in the original CPN structure. Preliminary results show that the increasingly fine-tuned probabilistic models indeed enhance the original CPN structure by identifying new pathways of relevance. We present our methodologies and algorithms as well as our findings on specific curricular pathways of relevance to further the investigation of the timely graduation problem.

Developing a DEI in Engineering Classroom instruction Observation Instrument

Jae Jun Jong

One of the challenges for higher educational institutions is to broaden the engineering curriculum to address values such as diversity and inclusion (Simmons & Lord, 2019). To address the challenge, our university aims to identify a way to infuse diverse aspects of Diversity, Equity, and Inclusion (DEI) into undergraduate engineering classroom instructions. As part of this initiative we created the DEI in Engineering Classroom instruction Observation Instrument (DEI-COI). DEI-COI is an available observational checklist that can be used by observers to measure engineering instructors' DEI-related teaching behaviors in undergraduate engineering classrooms from video recorded lectures. DEI-COI is created to measure various aspects of DEI-related instructional behaviors, namely 'instruction', 'assignments', and 'general interactions' aspect, of instructors teaching undergraduate engineering courses. Observers can measure the presence or absence of both positive and negative DEI-related teaching behaviors by using DEI-COI. To evaluate DEI-COI, 70 publicly available videos were selected, which recorded undergraduate engineering course meetings in one university in the United States. The included videos came from a wide range of engineering departments, including, but not limited to aerospace engineering, bioengineering, and computer science. Trained observers scored presence or absence of DEI-related teaching behaviors by using DEI-COI for 70 prerecorded videos teaching undergraduate engineering courses. The results show that the most prominent DE-related behavior was providing tips about how to succeed on the assignments followed by instructors answering all students who had questions. It suggests that engineering instructors' DOI-related teaching behaviors mainly focus on academically supporting students. In addition, among the 10 most frequent DEI-related teaching behaviors, 9 were positive DEI-related teaching behaviors, while there was only 1 negative DEI-related teaching behavior, namely, making disparaging comments to the students. To investigate associations among the 10 most frequent DEI-related teaching behaviors, chi-squared tests were conducted. For 'instruction' aspect, the results indicate that instructors tend to link a topic to the students' interests more as they mention more positive or negative impacts of the topic. In addition, for 'assignments' aspect, the instructors tend to provide more tips regarding assignments as they talk more about flexibility around assignments. For 'general interactions' aspect, the instructors who acknowledge students' contribution positively tend to respond to all students with questions. The results indicate that DEI-COI can successfully identify and measure various aspects of engineering instructors' DEI-related teaching behaviors in undergraduate engineering classrooms. Furthermore, DEI-COI can successfully show the associations between diverse DEI-related teaching behaviors of engineering faculties teaching undergraduate engineering courses. Since DEI-COI is meant to be used by observers observing recorded undergraduate engineering classroom, usage of DEI-COI in other contexts, such as in person undergraduate engineering course observation or recorded graduate level engineering course, should be done with caution.

Development of A Robotic Tour Guide Using Boston Dynamics SPOT Robot

Jared Jess, Ryan Bender, Andrew Schalk, Dr. Chris Gordon

This project presents an innovative approach to enhancing the capabilities of a Boston Dynamics SPOT quadruped robot to serve as a robotic tour guide. Through a combination of AI, machine learning, and a custom sensor package, the project aims to establish a proof-of-concept for a Tour Guide Mode. The initiative addresses the challenge of developing interactive, AI-driven services in educational environments, specifically leveraging the platform's capabilities to autonomously provide tours. This approach employs SPOT Core I/O to implement advanced functionalities, such as Fetch Mode, facial and voice recognition, and large language model (LLM) integration for interactive voice capabilities.

This project contributes to the field of robotics in education by showcasing the application of AI and robotics in creating interactive learning experiences. Findings from this proof-of-concept phase will demonstrate the potential of integrating AI-driven autonomy into university settings, enhancing accessibility and engagement for visitors and students. Future work includes expanding tour capabilities across additional labs within the Engineering Building and incorporating a robotic arm for interactive gestures.

Exploring Alternatives to Silicon in Semiconductor Applications Through VASP Simulations

Jayden Mwesige, Jared Serrano, Tally Escamilla, Tomas Jaramillo, Doruk Uçar, Isiah Ramos, Lara Herbert, Elif Ertekin

The COVID-19 pandemic microchip shortage persists, as the production of semiconductor materials still sees occasional disruptions. The costs of cars, phones, and other complex devices fluctuated greatly due to supply chain issues, particularly in the automotive industry. The potential for synthetic elements to create a viable alternative must be considered, as the treatment of mine workers collecting critical minerals raises both ethical and health concerns. Further consideration must be made for handling of waste materials to mitigate environmental impacts and promote sustainable practices. Rare metals such as gallium and thallium, with their notable semiconductive properties, present promising potential as candidates for advanced semiconductor materials. The aim of this study is to explore a combination of elements that are sustainable and either match or surpass silicon's semiconducting abilities. The Vienna Ab initio Simulation Package (VASP) was utilized for all simulations in this work. The abundance of possible semiconductors made of two or more different elements suggest a likelihood for finding a reasonable alternative to silicon. However, sociopolitical factors may pose challenges to their practical implementation.

Gender Differences in Global Identity Development: Implications for Intercultural Competence in Higher Education

Vidya Madana, Aparajita Jaiswal, Sakhi Aggarwal

Developing a global identity has become crucial for fresh graduates. Higher Education Institutions are seeking ways to help students develop intercultural skills and prepare them for a diverse global world. Introducing intercultural skills is particularly important for first-year students, as their ability to adapt to diverse environments, such as university campuses, is tested upon enrollment. While various studies have examined programs and policies that develop intercultural competence in students, little is known about the role of demographics in understanding the intercultural competence development of first-year students. This study aims to understand the role of gender in global identity development. The study utilized the Beliefs, Events, and Values Inventory (BEVI) assessment to evaluate the global identity development of students. The survey was conducted in the first week of classes to understand the intercultural competence and worldview of incoming first-year students. A total of 2,442 first-year Technology students responded to the survey, with 1,901 identifying as male and 541 identifying as female. This study performed a gender-wise comparison for the 11 constructs of the BEVI scale that contribute to global identity. To develop a global identity, students need to demonstrate increases in Need Fulfillment, Basic Openness, Emotional Attunement, Self-Awareness, Sociocultural Openness, and Ecological and Global Resonance and decreases in Self-Certitude, Basic Determinism, and Religion and Gender Traditionalism. The analysis revealed that female students showed higher levels of Need Fulfillment, Basic Openness, Emotional Attunement, Self-Awareness, Sociocultural Openness, and Ecological and Global Resonance, with all increases being statistically significant. Female students also showed lower levels of Self-Certitude, Basic Determinism, and Religion and Gender Traditionalism compared to male students. The results of the study indicate that female students are more oriented towards developing global identities compared to male students. The findings of the study demonstrates that high level of Basic Openness and Sociocultural Openness among female students suggest they are more adaptable to diverse environments. Higher Emotional Attunement among female students indicates stronger emotional intelligence. Increased level of Self-Awareness and Ecological and Global Resonance among female students highlight a broader understanding and appreciation of global issues and sustainability. This perspective is essential for addressing global challenges and promoting responsible citizenship. Moreover, lower levels of Self-Certitude, Basic Determinism, and Religious and Gender Traditionalism among female students reflect a more progressive outlook, which can lead to greater innovation and openness to new ideas. Lastly, the higher Need Fulfillment scores among female students suggest they are better at seeking and achieving personal and professional satisfaction. By understanding these gender differences in global identity development, Higher Education Institutions can tailor their programs and support services to better meet the needs of all students. Encouraging the development of these beneficial traits across the student body can enhance overall intercultural competence and readiness for the global workforce.

MERL HRI Blossom Research

Carlotta Berry, Anthony Mui

Blossom is an open-source social robot designed by Cornell and is used to research human-robot interaction (HRI). Its goal is to be cheap and accessible for anyone to build and program, while still being highly expressive allowing children to play and learn about robots. Children can even interact with the robot through an Android app to program and create new animations using the phone's Internal Measurement Unit (IMU). Our research in the Multidisciplinary Engineering Robotics Lab (MERL) was to attach a camera to Blossom and have it use facial recognition or gesture recognition and play different animations accordingly. Then, undergraduate students would build off this design during the school year and continue adding features for more expressivity and functionality.

Integrating Peer-Reviewed Journals in Upper-Level Elective Courses in Undergraduate Education

Audrey Hankins, Deonisha Wright, Hailey Hofmann, Nathan Rosmarin, Namita Shrestha

Integrating peer-reviewed journal articles into upper-level elective courses provides a robust pedagogical strategy to engage students in critical thinking, deepen their disciplinary knowledge, and enhance research literacy. This work-in-progress study explores the qualitative impacts of incorporating scholarly articles into the undergraduate curriculum, focusing on civil engineering and biomedical engineering electives. These courses allow students greater flexibility to delve into specialized topics, making them an ideal context for this approach.

The implementation involved two rounds of student presentations. In the first round, students individually selected and presented on peer-reviewed journal articles, approved in advance by the instructor for relevance and appropriateness. The second round featured collaborative group presentations, where pairs of students introduced and analyzed a new peer-reviewed article. Each presentation was followed by a peer-led class discussion, encouraging critical engagement. Additionally, students submitted a one-page reflective summary outlining the article's key points and their insights based on the presentation.

Currently in its first year, this research employs qualitative methodology, including surveys, interviews, and focus groups, to capture student perceptions and experiences. It examines whether integrating journal articles into the curriculum promotes essential skills such as critical analysis, evidence-based reasoning, and familiarity with academic discourse. The study aims to address the following question: How does the inclusion of peer-reviewed journal articles in the undergraduate curriculum enhance student engagement, improve their ability to critically evaluate literature, and prepare them for advanced academic or professional endeavors?

Investigating Li+ Transport in Li-S Battery Electrolytes using Operando Spectroscopy

Abigail Smith, Najmus Saqib

Lithium-sulfur (Li-S) batteries have received significant attention as a promising post-lithium-ion battery technology due to their high energy density, low-cost cathode, and environmental benefits of transitioning away from rare-earth battery materials. Despite this potential, their commercialization remains elusive due to issues such as poor capacity retention and cycle stability. The underlying causes of these challenges, particularly the transport behavior and stability of lithium ions (Li+) in the electrolyte during battery operation, are not fully understood.

This study employed operando infrared spectroscopy to investigate the dynamic behavior of Li+ in optically accessible Li-S coin-cell batteries fabricated at Marian University. Operando infrared spectroscopy captures real-time transport phenomena under operating conditions, providing insights unavailable through traditional ex situ or in situ methods. By analyzing spectral data collected during controlled charge and discharge cycles, we identified key absorbance peaks of lithiated electrolyte species and subspecies, to quantify Li+ transport between the electrodes. This approach also enables the evaluation of long-term stability of Li-S batteries.

Preliminary findings suggest that operando infrared spectroscopy is a powerful tool for elucidating the complex behavior of Li+ and polysulfides within the electrolyte. These insights will inform the development of more stable and efficient Li-S batteries, potentially enabling advancements in electric vehicles and renewable energy storage systems. Additionally, this project integrates cutting-edge research with undergraduate education, offering hands-on experience in battery fabrication and electrochemical analysis for undergraduate students in the School of Engineering at Marian University, highlighting the feasibility of advanced engineering research in small academic settings common in primarily undergraduate institutions.

Generative AI in CS Education: Navigating the Intersection of Student Usage and Faculty Vision

Matthew McClenahan

Generative AI tools, such as ChatGPT, are being explored by STEM students, including those in Computer Science and Software Engineering (CS/SE) majors, for various purposes. Through a mixed-methods study at a small private STEM institution, incorporating surveys from 40 CS/SE students and 29 faculty members, along with 11 in-depth faculty interviews, this research investigates how these tools are perceived and utilized in CS/SE education. Analysis of student responses revealed seven distinct categories of tool usage, with productivity enhancement (37.5%) and learning support (35%) emerging as primary applications. Other identified uses included problem-solving assistance (15%), creativity and ideation (20%), research processing (17.5%), content creation (7.5%), and accessibility support (10%). By synthesizing student usage patterns with faculty perspectives, this study provides evidence-based insights for integrating generative AI tools into computer science courses while addressing both opportunities and potential risks to learning outcomes.

Keynote Speaker: Dr. Carlotta A. Berry

Carlotta A. Berry is a Professor in the Department of Electrical and Computer Engineering at Rose-Hulman Institute of Technology and the Dr. Lawrence J. Giacoletto Endowed Chair for Electrical and Computer Engineering. Dr. Berry is the first Black woman to earn tenure, full professor and endowed chairship at Rose-Hulman.

She has a bachelor's degree in mathematics from Spelman College, bachelor's degree in electrical engineering from Georgia Institute of Technology, master's in electrical engineering from Wayne State University, and PhD from Vanderbilt University. Her research interests are in robotics education, interface design, human-robot interaction, and increasing historically marginalized and minoritized populations in STEM (science, technology, engineering, math) fields. She is author of the textbook, "Mobile Robotics for Multidisciplinary Study" and editor for "Mitigating Bias in Machine Learning".

She has a special passion for diversifying the engineering profession by encouraging more women, marginalized and minoritized populations to pursue STEM degrees. In her role as the 2024 inaugural visiting scientist at The Children's Museum of Indianapolis, she was able to execute her mission and promote her vision for STEM. In 2020, she worked with colleagues around the world to start two nonprofit organizations, Black in Engineering and Black in Robotics. They have a mission to bring awareness to systemic racism and inequity in STEM, build community, advocate for diversity, equity, inclusion and connect with allies and sponsors. Dr. Berry also founded her business, NoireSTEMinist educational consulting, in 2020. Through her organization she does speaking engagements, workshops, consulting, performs hip hop slam poetry, gives engineering professor advice and engineering professor quizzes on social media. She also sells robots, children's books, romance novels, and other merchandise to promote diversity in STEM as part of her mission to "Make STEM and robotics for the streets".

Her strong longstanding service record has garnered her multiple accolades and awards including 2024 Know your Value Forbes 50 over 50 Innovation, 2024 ECEDHA Community Development Award, ASEE Fellow, IEEE Senior Member, 2023 IEEE Undergraduate Teaching Award, 2023 Hopper Celebration Abie Award for Educational Innovation award, 2022 Society of Women Engineers Distinguished Engineering Educator Award, 2022 Distinguished Educator Award from the American Society of Engineering Education Electrical and Computer Engineering Division, 2022 Open Source Hardware Trailblazer Fellow, 2021 TechPoint Foundation for Youth Bridge Builder award, 2018 Women and Hi Tech Leading Ligth Your Inspire Me Award and Insight Into Diversity Inspiring Women in STEM.

Guest Speaker: Mr. Matt Ray

Mr. Matt Ray serves as an Assistant Professor of Practice and Site Director in Indianapolis for the School of Construction Management Technology at Purdue Polytechnic Institute. In this role, he oversees the Construction Management undergraduate program and the online Facilities Management graduate program. He holds degrees in Architectural Technology, Construction Management, and Facilities Management, along with multiple certifications, including IFMA's Facility Management Professional (FMP), AGC's CM Lean, and BAMI-I's CTAM for asset management. With over 16 years of experience in higher education and more than 30 years in the industry, Mr. Ray has worked in design, engineering, and management for single and multifamily construction, light commercial projects, and as a design manager specializing in building components manufacturing.

As the associate site director in Indianapolis, he leads curriculum development, ensures program and student learning outcomes, fosters student engagement, and strengthens industry partnerships. Mr. Ray teaches various courses, including Construction Cost Estimating, Scheduling and Project Controls, Facilities Planning and Management, Facilities Engineering Systems, Energy Management for Buildings, Quality Control, and Financial Aspects of Facilities Management. Additionally, he is an active member of the Indianapolis Chapter of IFMA, contributing to its education committee.