Supporting Student Success: Embedding Continuous Improvement in a Hands-on Engineering Education Program.

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Supporting Student Success: Embedding Continuous Improvement in a Hands-on Engineering Education Program

Abstract

This paper examines the implementation of a continuous improvement process for hands-on, engineering skill-building workshops delivered through the Integrated Teaching and Learning Program at the University of Colorado Boulder. We undertook this activity to support the strategic vision in our college of engineering, including enhancing co-curricular opportunities; developing innovative educational offerings; and implementing inclusive learning opportunities and practices for students, faculty, and staff. We used a Scholarship of Teaching and Learning approach, in which we included both qualitative and quantitative methods to initiate regular, structured, and scholarly evaluation of this program.

Our continuous improvement design included developing three learning objectives for a subset of our hands-on skill-building workshops, including 12 unique topics. We designed and delivered a survey to collect baseline data on student perceptions of their ability to apply engineering skills, and provided professional development to student and staff workshop instructors. This foundational work was essential to build data-informed practices. As we introduced a culture and process of continuous improvement focused specifically on growing confidence in student's engineering skills, we discovered another, unexpected yet far ranging impact–gains to morale, professionalism, and engagement among both staff and student instructors.

In Fall 2024, a team of six staff engineers and 25 student instructors delivered more than 340 skill-building workshops to over 3,600 students for 12 of the workshop topics offered by our program. Workshops have always required instructors to have strong technical expertise. Now, knowledge of *how to teach* is also critical. To reinforce the importance of learning as a social process, we introduced a Community of Practice model, in which the instructional team reflected on their work and learned from one another about how to improve the workshops and their teaching. We also offered professional development on topics like strategies to engage students in hands-on learning–particularly in cultivating a learning environment in which making mistakes is part of the learning process. Thus, we embedded risk taking, growth, and a community approach to learning. Our data collection strategy included a new survey to create a baseline, and processes and practices to analyze and act on data.

Introduction

Despite more than a half-century of research into the factors that support retention and graduation rates in engineering, degree achievement remains stagnant at approximately 60% [1]-[3]. The causes of student attrition are multifaceted and institutions are grappling with strategies to improve retention and completion rates, including those of students with high financial need, first-generation students, and community-college transfer students [4]. Quality of instruction is a known variable demonstrated to impact student outcomes [5]. One tool engineering educators have successfully adopted to improve learning outcomes and retention is the integration of active learning pedagogies, including hands-on engineering experiences [6]-[12].

Our Integrated Teaching and Learning Program (ITLP) is located at the University of Colorado Boulder, a large public research institution. Through workshops, laboratories, active learning spaces, and manufacturing and prototyping facilities, our ITLP team supports the College of Engineering and Applied Science (CEAS) in growing students' hands-on engineering skills across all disciplines in the college. In 2022, CEAS published strategic goals focused in large part on improving the quality of instruction [13]. In support of students and to help achieve college goals, our redesign aligned with key measures—including enhancing co-curricular opportunities, developing innovative educational offerings, and implementing inclusive learning experiences to benefit students.

In Fall 2024, we redesigned how we teach hands-on engineering skills and measured students' perceived growth in confidence in hands-on, technical skill-building. We developed and implemented new surveys to collect baseline metrics, practices to analyze them, and processes to share results promptly. The combination of these survey data paired with reflections from staff and student instructors contributed to a culture of data-informed continuous improvement.

By introducing a continuous improvement process in Fall 2024, we embraced practices within the Scholarship of Teaching and Learning model [14]. We included both qualitative and quantitative methods to initiate regular, structured, and data-driven evaluation of workshops taught by the ITL Program. Here, we discuss the program, the innovations, the measures, and early outcomes. Our reporting follows a scholarly process, and we discuss methods and findings from a program-redesign and evaluation lens, *not as activities of experimental research.* For this paper, we begin exploring the effect of our continuous improvement cycle on both workshop participants and instructors. This work is guided by the following research question:

> *How does a continuous improvement process affect workshop instructors—both student and staff instructors—specifically with regard to:*
> *(a) team collaboration,*
> *(b) professional development and personal satisfaction, and*
> *(c) sustaining iterative, data-informed improvements?*

Background

For more than 25 years, the Integrated Teaching and Learning Program has supported hands-on learning in the College of Engineering and Applied Science at the University of Colorado Boulder. The engineering college enrolled more than 9,600 students in Fall 2024, including ~6,500 undergraduate students, the primary attendees of these workshops. In over 34,000 square feet of lab space, students can access active learning classrooms and laboratories, workspaces housing equipment for prototyping and advanced engineering analysis, manufacturing and electronics fabrication facilities. Our team includes 25 staff and approximately 60 student staff to support 150 sections of 50 courses across ten departments and programs. The ITL program supports students doing curricular *and* co-curricular activities on campus.

One way in which our program supports hands-on learning is through teaching skill-building workshops. These workshops focus on creating a space that empowers students to apply newly learned technical skills in their hands-on engineering courses. A team of engineers, manufacturing specialists, and student staff offer approximately 1,000 skill-building workshops on 20+ topics each year to over 7,000 participants. Students take these workshops for

- required components of their coursework,
- general engineering skill building, and/or
- personal interest in the topic.

These workshops are designed with flexibility in mind, allowing faculty to integrate them into their courses as replacements or supplements to traditional lab curricula. For example, this flexibility enables first-year hands-on design courses to integrate a series of workshops into structured lab sessions while requiring additional workshops outside of class – while a junior-level materials course embeds workshops focused on material testing into class time to supplement typical material science lectures and labs. Because of their scale and reach, we chose our skill-building workshops to introduce a new continuous improvement process. This multifaceted, data-informed, and research-based process aims to: enhance instructional quality, grow a students' confidence in engineering skills, and foster a collective commitment to continuous improvement. These changes are also supported by ABET Criterion 4, which calls for continuous improvement in engineering programs.

Each workshop topic is led by an engineer, who oversees a collection of workshops related to their area of expertise. They manage the content, pedagogy, and training of student instructors. The engineers on our instructional team range from early career professionals with bachelor's degrees in biomedical and mechanical engineering to senior engineers with decades of experience in academia, some holding advanced and doctoral degrees – all sharing a common passion for engineering education. Workshops taught in class are led by a staff engineer, while evening and weekend workshops are taught by student staff. Table I offers an example of the various workshops managed by an engineer. A comprehensive summary of the 12 workshops can be seen in Appendix A.

TABLE I
SAMPLE WORKSHOP OWNERSHIP OF AN ENGINEER

Workshop Title	In Class Capacity *(Staff Instructor)*	In Class Duration *(Staff Instructor)*	Out of class capacity *(Student Staff Instructor)*	Out of class duration *(Student Staff Instructor)*	Total student instructors *(Fall 2024)*	Total sessions offered *(Fall 2024)*	Total attendees *(Fall 2024)*
Sketches & Parts *CAD - Level 1*	30	110 min.	12	90 min	2	29	608
Operating the Laser Machines *Prototyping - Level 1*	30	110 min.	15	90 min	5	52	563
Assemblies & DFM *CAD - Level 2*	*Out of class only*		10	120 min.	2	13	50
Operating the 3D Scanners *CAD - Level 1*	*Out of class only*		4	90 min	3	18	33

Methods

This improvement process is grounded in education research and follows practices of Scholarship of Teaching and Learning; it is *not* research. Our goal was program improvement, not new and generalizable knowledge. We discuss methods both to share our process and allow others to learn from and improve on our approach. In this section, we begin by framing the model where we describe the creation of workshop learning objectives, survey design, data collection and analysis processes, and the creation of a Community of Practice. Finally, we discuss how we analyzed and acted on evaluation data during the semester.

Framework

We integrated two similar frameworks to launch this project: continuous improvement and the engineering design cycle. Continuous improvement follows an iterative process known as Plan-Do-Study-Act [15], which leverages both practitioner expertise and data-driven insights to refine actions over time. The engineers on our team all embraced the familiarity of the engineering design cycle with its iterative problem-solving through planning, prototyping, testing, and revising. Each emphasizes data-informed, active engagement from stakeholders, iterative practice, context-appropriate solutions, and responsive adjustments based on earlier outcomes; thus, in practice, we merged the two, as shown in Figure 1.

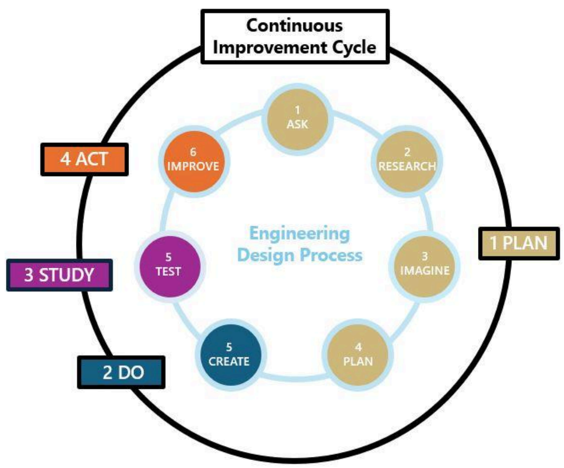


Fig. 1. Connecting the continuous improvement cycle to the engineering design process.

Identifying Learning Objectives

Drawing from the literature on backward curriculum design [16], the engineering instructional team identified three primary learning objectives for each of the 12 skill-building workshops. The survey questions mapped to the learning objectives for each workshop. In asking the entire instructional team to identify the learning objectives, we positioned the team not merely as *implementers* of predefined strategies but as *active participants* in the combined Continuous Improvement and Engineering Design cycles. Learning objectives were embedded into slide decks to identify the workshop goals for workshop attendees. Figure 2 shows an example from the Simple Circuits & Measurements Fundamentals workshop.

1. *Explain the differences between voltage, current, and resistance, and how they relate to each other.*
2. *Use a multimeter to measure voltage, current, and resistance.*
3. *Build a circuit that successfully lights up an LED.*

Fig. 2. Learning objectives for simple circuits & measurements fundamentals workshop.

In each case, we set expectations for what students should be able to do by the end of the workshop and then, in a retrospective pre-post survey [17], asked the students to reflect on their change in confidence in achieving the learning objectives.

Survey Design and Data Collection Processes

Traditionally, we have collected *summative* data from participants, i.e., macro-level data that offered perspectives on usage patterns, likes/dislikes, and frustrations with equipment or wait times. Feedback guided equipment purchases or changes in operations but did not illuminate instructional impact. Furthermore, response rates for end-of-semester surveys—our primary means of collecting user feedback--have been low. Recognizing the need for more meaningful baseline data, we chose to assess students' self-perceived growth in hands-on engineering-related skills. Research suggests that perceived confidence gains can enhance engagement, motivation, and persistence in engineering fields [18]-[21]. The primary goal of the workshops is to foster curiosity, confidence, and a willingness to apply engineering skills to open-ended design projects. Therefore, rather than assessing specific skills, we prioritized evaluating students' perceived sense of growth.

Our workshops are intentionally designed as inclusive, low-stakes learning environments where students feel empowered to explore new concepts. Introducing quizzes or assessments could create a high-pressure, test-like atmosphere that conflicts with our goal of encouraging exploration and growth. By focusing on self-assessed development, we aim to help students build the confidence to contribute effectively in team-based engineering projects regardless of their initial familiarity with the topic.

Three team members met to draft a survey tool with these goals:

- Encourage high response rates—use simple questions and a user-friendly design;
- Focus on perceived growth in confidence in engineering knowledge/skills resulting from workshop participation; and
- Collect real-time, actionable data.

The team created a *retrospective pre-post survey* to measure students' self-reported changes in confidence in skill development relative to the workshop's learning objectives. Retrospective surveys are appropriate when subjects may lack sufficient prior knowledge of a skill to accurately evaluate their baseline proficiency [22]. Priorities were to keep the survey brief and encourage high response rates, so we framed items in learner-centered language and included emojis to represent each question using audience-familiar images, as shown in Figure 3. The cognitive scale loosely aligns with Bloom's Revised Taxonomy [23] across the range from *Understanding and Applying* through *Evaluating and Creating*. Participants could also offer qualitative feedback through open-ended prompts. Students were informed that the program sought their insight to make the sessions better and were given the option not to participate. Finally, we designed the survey to be conducted on students' phones using a QR code. Our IRB deemed our survey as not needing Human Subjects review because it was designed for *quality improvement in an educational setting*, not research.

Validation

To pilot the initial survey draft, we asked student instructors to take the survey as if they were a workshop participant. This step not only helped verify that our approach was audience appropriate, it also introduced the upcoming change to the workshop process to student instructional staff. Then, the draft survey was shared with the engineer instructors, who recommended edits, including a pre/post comparison.

The final survey embedded the three learning objectives for each workshop, and asked the participants to rate their pre-workshop and post-workshop perceptions of confidence levels using this four-point scale:

1. *This is new to me; I don't know how to frame questions.* 🤔
2. *I've got this with guidance.* 🤝
3. *I've got this on my own.* 👍
4. *I could teach this to a peer.* ✨

Fig. 3. Survey Questions.

Note: Level 4, "I could teach this to a peer," is an option, not because expertise was the primary goal; rather, it subtly introduced collaboration as a value and encouraged teamwork as a personal practice.

In the Fall semester, 3,601 students attended 340 sessions of the 12 skill-building workshops discussed in this paper, and submitted 3,222 responses, a response rate of 89%. This high response rate suggests keeping the questions brief and format user friendly was a successful design choice. By the end of the first full week of workshops in the Fall 2024 semester, we already collected over 800 survey responses and needed a way to analyze and learn from the results.

Professional Development: Community of Practice

Historically our program relied on two pre-semester meetings to rapidly onboard students to support daily operations, a large portion of which is providing after-hours workshops and technical support. Additionally, the program used biweekly check-in meetings throughout the semester to complete technical training and to give feedback on program operations.
In Fall 2024, we updated our pre-semester kick-off meetings to introduce teaching techniques that engage learners and the Community of Practice (CoP) model. In a CoP, a collection of individuals who share a common purpose or interest come together to engage in collaborative activities, enabling them to learn from one another's experiences and insights [24], [25]. The engineering instructors highlighted how embracing the CoP model would enhance teaching

capabilities and increase the effectiveness of the workshops by boosting attendees' confidence in applying the skills learned.

As part of the integration of the CoP model, we introduced a four-item self-assessment (Figure 4) on student-instructor perceptions of their preparedness to deliver workshops as well as an open-ended response option for them to reflect on their workshop delivery. This was helpful because engineering instructors *did not know what the student instructors did not know*. This data helped engineers determine where additional mentorship was needed for student instructors related to teaching content.

a. *I am still learning the workshop content.*
b. *I am comfortable with the workshop content.*
c. *I am confident answering detailed Q's about the workshop content.*
d. *I want one-on-one help understanding the content.*

Fig. 4. CoP reflection answer choices for student instructors.

Biweekly meetings were updated to include the CoP model in which student instructors worked collaboratively to problem solve around how to grow as instructors. They discussed personal approaches to teaching, explored solutions to common problems of practice, and considered ways to cultivate a community where it is safe to learn and make mistakes. Within this model, our team engaged in micro-cycles of reflection and improvement, driven by regular reviews of participant feedback and collaborative discussions during CoP meetings.

At the conclusion of the Fall 2024 semester, a focus group meeting was held with engineer instructors to explore their experience with the process and outcomes of implementing continuous improvement. This meeting allowed them to reflect on what had gone well, what needed revision, and what they gained from the experience.

Data Analysis Approach

After launching the workshop surveys we discovered that an interactive data visualization tool (Appendix B) was necessary to effectively manage data volume resulting from the high survey response rate and many sessions of workshops. To process workshop participant survey responses, a Microsoft PowerBI dashboard was developed by our planning team. The PowerBI dashboard captured and displayed changes in reported confidence levels and participant feedback and could be differentiated both by instructor and workshop. Having a tool to visualize results allowed the instructional team to rapidly refine delivery methods and address content challenges based on student experiences. Analyzing feedback in almost-real time led to substantial improvement over the previous processes in which student feedback was exclusively processed at the semester's end.

These results were compiled into reports, as shown in Appendix C, that were shared during bi-weekly CoP meetings with the student instructors and used to guide discussions. In the past, biweekly meetings served as status checks and troubleshooting time; now, the meetings were used to cultivate the CoP model. Engineer instructors introduced discussions on approaches to teaching, reflections on how to address feedback, and exploration of ways to improve (see

Appendix D for discussion prompts). Each week, engineer instructors and the planning team reviewed survey feedback, developed summary reports to share with student instructors, and flagged key topics for additional attention.

Grounded Theory Approach to Evaluating Instructor Development

Our research question focused on the cognitive and non-cognitive effects of the continuous improvement process on our workshop instructors. Specifically, we sought to understand how this iterative process influenced the teaching mindset and professional development of both student and engineer instructors. The primary objective of embedding the continuous improvement process was to establish a foundation that would equip instructors with the skills to critically evaluate their teaching methods, adapt those teaching methods to better meet the needs of their audience, and develop an intrinsic commitment to continuous instructional improvement. We envisioned that this foundation would support both student and engineer instructors in various teaching contexts—whether leading structured skill-building workshops or informally mentoring students in laboratory settings.

Given the exploratory nature of our work, we did not approach analysis with a predetermined hypothesis. Instead, we adopted an analytical process loosely modeled on Grounded Theory [26], which is commonly employed to examine social contexts and dynamic interactions, such as those found in teaching environments. Unlike experimental research, Grounded Theory does not begin with a fixed hypothesis but instead allows key themes to emerge organically from the data. This approach was particularly well-suited for evaluating the impact of the continuous improvement process on our instructional team. Through a systematic review of survey responses, student-instructor reflections, and key topics from the engineer focus group, we identified patterns and themes as they emerged.

Throughout the semester, the planning team convened approximately once a month to assess and respond to data collected from the implementation of the continuous improvement process. These meetings focused on:

- Identifying emerging themes related to professional development, instructor engagement in the CoP, and improvements in teaching practices.
- Analyzing trends in workshop participant data to evaluate the impact of the continuous improvement process on workshop attendee's skill development.
- Planning necessary modifications to refine and enhance the CoP based on feedback from the instructional team.

Through this iterative cycle, the planning team continuously reviewed, interpreted, and acted upon real-time data. This process enabled us to begin forming hypotheses about the continuous improvement cycles' impact on instructional development.

At the conclusion of the semester, the planning team conducted two summative meetings with the engineer instructors. The first meeting was a focus group aimed at understanding instructors' perceptions of the continuous improvement process's impact and the value of having access to real-time aggregated workshop data. The second meeting involved a comprehensive review of participant data from all workshops to assess their effectiveness and identify areas for improvement in subsequent semesters.

To address the aspect of our research question on student instructors' growth, we analyzed data from three primary sources:

- Student-instructor reflections collected during biweekly CoP meetings.
- Qualitative feedback from independent student instructor survey reflections post workshop.
- A semester-end focus group with engineer instructors.

By triangulating data from multiple sources, we identified and validated emerging themes related to changes in student instructors' teaching and professional mindsets. Three primary themes emerged from this analysis: the impact of continuous improvement on what we teach, how we teach, and how we support instructional staff in their development.

Results and Discussion

This section describes findings from the implementation of a continuous improvement process in the ITLP's large, hands-on learning program. The findings address three key aspects related to the research question:

How does a continuous improvement process affect workshop instructors—both student and staff instructors—specifically with regard to:
(a) team collaboration,
(b) professional development and personal satisfaction, and
(c) sustaining iterative, data-informed improvements?

Effect on Instructional Team: Team Collaboration (RQ Part A)

Before implementing the continuous improvement framework, student instructors received structured training at the beginning of the semester, primarily focused on delivering workshop content as prescribed. However, they received little guidance on how to adapt their instruction to meet the unique needs of their audience. If content or delivery issues arose, the responsibility fell on student instructors to notify the engineer instructor owning the content area.

Communication between student instructors and engineering content owners was infrequent. Engineers had limited insight into student instructors' confidence levels, often assuming that workshop delivery was effective unless major issues were reported. Follow-up, when it occurred, was *reactive*—taking place only when significant challenges surfaced. Feedback loops were informal and largely driven by extreme experiences, either highly negative or exceptionally positive, rather than by consistent reflection on instructional effectiveness. As a result, potential areas for improvement and content iteration rarely existed outside of the end-of-semester updates.

With the introduction of a structured Community of Practice (CoP) and continuous improvement process, workshop training evolved beyond content delivery to include pedagogical adaptability. At the start of the semester, training was redesigned to emphasize not only what to teach but also how to assess and respond to variations in workshop attendee engagement. This shift encouraged student instructors to evaluate audience understanding and adjust their teaching strategies accordingly.

Additionally, biweekly meetings were restructured to foster an ongoing dialogue between student instructors and engineer content owners establishing a *proactive* approach. These meetings were guided by survey feedback from workshop participants, serving as a data-driven reflection tool. Instead of issues being addressed on an individual, ad hoc basis, they were now discussed within a collaborative setting where student instructors and engineers could collectively problem-solve. This iterative process empowered student instructors to take ownership of their teaching methods and encouraged a shared responsibility for instructional quality.

Furthermore, student instructors were no longer viewed solely as workshop delivery agents but as co-owners of content and pedagogy. Student instructors now had a voice in shaping workshop design and delivery, leading to greater instructional confidence and a stronger sense of agency in their roles which created a new culture of collaborative improvement.

Effect on Instructional Team: Professional Development & Personal Satisfaction (RQ Part B)

The new model contributed to both the professional development and satisfaction of staff engineers and student instructors. The increased engagement we saw when student staff were eager to receive results suggests an increase in intrinsic motivation to understand how their efforts to improve as educators impacted their audience. The continuous improvement process not only supported technical content delivery but also enhanced student instructors' roles as leaders:

- *"I feel like I effectively created personal connections with the attendees of the workshop. I had three different students come up to me after the workshop to thank me personally for the experience, which was really exciting!"*
- *"Based on feedback from previous workshops, I've adjusted my approach to teaching multimeters. I incorporated more hands-on exercises and introduced a different type of multimeter to help boost students' confidence in taking measurements."*
- *"The workshop helps me continuously work on my public speaking skills. I've seen the progress [since] last semester, and I want to keep improving."*

The increase in engagement was further evidenced by students frequently staying after biweekly CoP meetings to collaborate with engineers on refining workshop content and enhancing key concept delivery. Additionally, students proactively scheduled meetings with engineers to propose updates and improvements, demonstrating their growing investment in shaping the learning experience in workshops. Their focus extended beyond simply completing the workshop to ensuring meaningful outcomes for participants, reflecting a transition toward an outcome-driven professional mindset. Students even mentioned plans to include positive survey results on their resumes, highlighting their pride and growing confidence in their professional development.

We discovered increased personal satisfaction among both staff engineers and student instructors, despite an initial time investment to understand and integrate the continuous improvement process. Real-time feedback provided validation of the hard work, which increased morale. One engineer reflected during the focus group, “I try to keep it light by telling jokes. No one ever laughs, so I have assumed they do not like it.” However, feedback from students demonstrated that the instructor’s style was appreciated, as illustrated by one student’s comment: “I like your jokes and was LOL.”

Engineers were surprised that so many students responded to optional open prompts when they could simply have completed the radio button questions and then exited the survey. The detailed responses suggested that students valued their experience in the workshops, with the instructional team, and the opportunity to influence improvements.

Impact on Program Goals: Using Data to Build Sustainable Improvements (RQ Part C)

The new workshop survey provided a baseline assessment of the workshops’ effectiveness to address this primary question about instructional impact: *Were students leaving workshops with enough confidence in their abilities to apply their skills independently?*

As shown in Figure 5, initial results indicate that students are growing more confident in their ability to independently apply the engineering skill set, with workshop attendees self-reported confidence growing, on average from Level 2, “I’ve got this with guidance,” to Level 3, “I’ve got this on my own.”

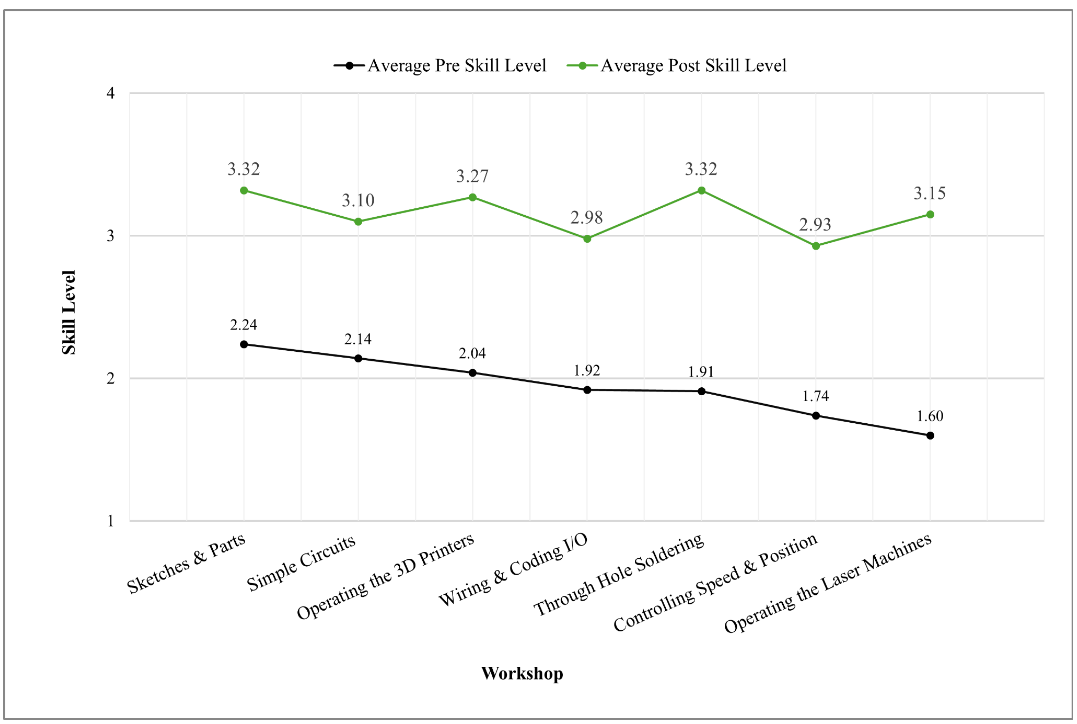


Fig. 5. Average retrospective pre- and post-workshop report of skills levels across the seven most attended workshops (1 = “This is new to me; I don’t know how to frame questions” to 4 = “I could teach this to a peer.”)

Our CoP's micro-cycles of continuous improvements appear to have fostered growth in self-assessed skills in engineering abilities. Figure 6 illustrates that early in the fall semester across all 12 workshops, the average change in students' perceived confidence in their ability was 0.96. By semester's end, the average change in confidence increased to 1.40. This trend is suggestive, not conclusive; however, we speculate that the reflective micro-cycle practices contributed to better content delivery and supported an increase in students' perceptions of their skills growth.

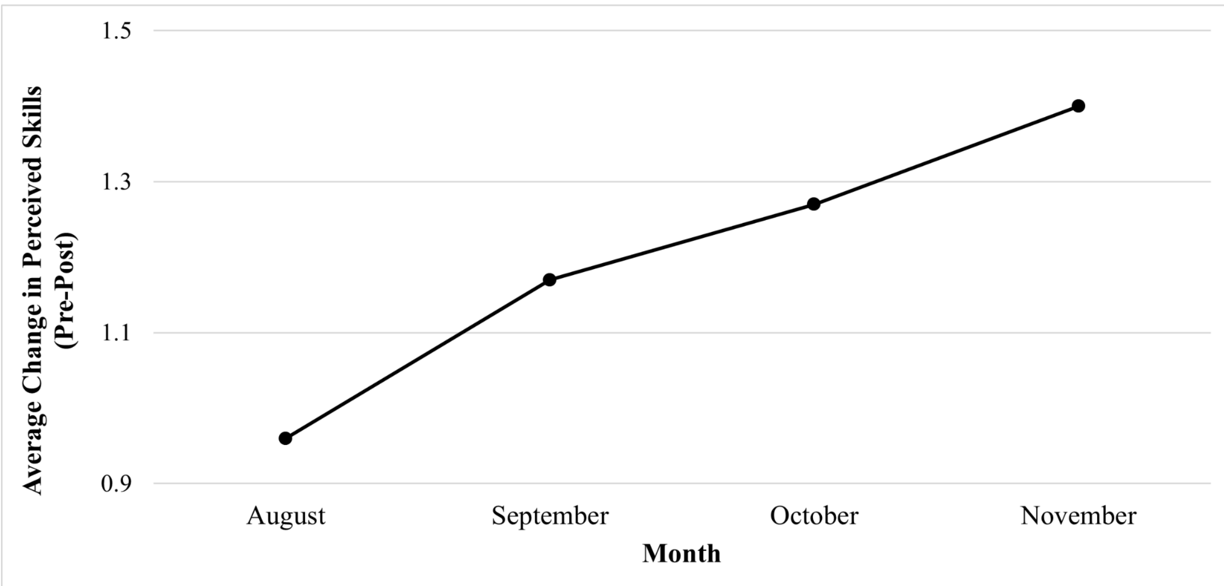


Fig. 6. Average change in perceived skill confidence development across all learning objectives and all workshops. "Change" refers to the retrospective post minus the retrospective pre-workshop skill confidence levels. Averages are plotted for each month during the continuous improvement cycles to show change over time. For Fall 2024, n=3,222.

By introducing and collaboratively implementing a continuous improvement process, we established a scalable and adaptable framework for evidence informed improvements that can be applied to other aspects of our program. This reporting is on very early analysis from the first semester of implementation of a large change. Nevertheless, we are pleased that results indicate positive change and that our community of students, student instructors, and engineer instructors all reacted favorably to the continuous improvement model.

Return on Investment

We designed this implementation to align with the College of Engineering and Applied Science's strategic vision and embed sustainable practices for instructional improvement. The work required additional staff time and effort—all in the context of higher education's volatile landscape. Our institution, like many others, has been hit by post-COVID staff turnover, so adding to workloads is not a minor consideration [27], [28]. The college also faced the "good problem" of a nearly 14% increase in first-year enrollment in Fall 2024 [29]. Given that, asking our student and staff instructors to perform their core functions and also implement a continuous improvement process was a stretch. Their engagement with the change exceeded our expectations.

The planning, design, and implementation was primarily led by four key staff. During Summer 2024, they met several times to create the survey and test it. During the fall semester, the development and refinement of data analysis and visualization tools took more staff time, some of which was built into their operational roles. However, the success of the innovation led to an unforeseen need: the instructional team wanted to engage deeply with their data—in real time and we needed better tools.

Engineer instructors received their initial data using the survey tool's built-in analysis features. Motivated by the opportunity to have timely, direct, and meaningful feedback about their work, they wanted better tools. The planning team chose a Power BI data visualization tool to streamline data insights and make them more accessible and actionable. Then the team needed guidelines for how to share data with student instructors in a constructive way. Meetings with the planning team, engineer instructors, and iterative feedback from student instructors helped us shape this practice.

Much of the implementation occurred as part of standard operations, so teasing out the precise time and effort required is imperfect. We estimate 80 staff hours were required to design, introduce, and refine this process, distributed across 32 people, both full-time staff, student staff, and a consultant. In academic-year 2024-25, the new model is expected to impact approximately 8,000 students in workshops across nearly 700 sessions. Participants experience enhanced quality of instruction, and our staff are enthusiastically engaged. We see this innovation as a win—extensive improvement to our learning environment achieved at modest investment of time and cost.

The CoP model shifted not only how instructors engage in workshops but also how they support students–and student instructors– in lab spaces. With actionable data, instructors can use meeting times more effectively; this fosters collaborative problem-solving and instructional refinement. Furthermore, we have seen a noticeable increase in motivation and engagement among instructors, who are eager to explore how to deepen their efforts. Our future focus will be on refining feedback mechanisms, and ensuring that our continuous improvement process remains both meaningful and sustainable.

Implications for Engineering Education

We were surprised with several outcomes of this work, including the high response rates from students, the substantial self-reported growth in ability and satisfaction with the workshops, the positive connections generated between students and staff, and the enthusiasm both instructional engineers and student staff displayed with implementation of this work. These outcomes *all* appear to be countertrend, in that we asked staff to do something extra during a semester when the demands on their time increased and yet their engagement with their work grew and their morale improved.

We sought to establish a baseline and wanted data from many users to improve the quality of that baseline. To that end, the survey we developed is brief, simple, and relatable; it added less than 1.5 minutes on average to students' lab time, and the vast majority of students responded. We now have baseline data on students' perceptions of their success in skill-building workshop objectives to guide future work.

Conclusion

In Fall 2024, we integrated a continuous improvement process into our ITL Program's skill-building workshops, enhancing hands-on learning opportunities for students across the college. Undeniably, implementing a continuous improvement process included hard work. It took time to research, design, implement, and analyze the impact, and yet, by basing our efforts in the sound practices of scholars and teachers before us, we had expertise to guide us. A core team of four designed most of the changes; three of those four did so within the scope of their professional roles and one consulted, periodically, paid through funds for program redesign. Because we embedded the change activities into existing team processes, the professional development time for the larger team and for the student staff was already allocated in the budget and schedule.

In particular, our experience may interest campuses which rely heavily and increasingly on student staff to support learning. Well-trained student instructors play essential roles in offering high-quality, hands-on learning experiences, yet, at the core, these staff are students. We learned that intentionally nurturing their growing capacity improved workshop quality. More than that, our Community of Practice trainings supported them to develop key professional skills, deepened their grasp of complex engineering concepts, and strengthened their teaching abilities. Finally, continuous feedback inspired greater enthusiasm and engagement among student instructors, who, for the first time, received direct, structured insights into the impact of their teaching.

Our experience demonstrates that research-informed practices can be implemented in a timely fashion and on a substantial scale *without* significant budget impact or excessive burden on people. As higher education faces many headwinds, including funding pressures, perceptions about the value of college, political pressures, and post-COVID personnel instability, one fact remains constant: students deserve to have high quality instruction and socio-affective connections as they prepare for their careers. Our experience of focusing on supporting student learning through implementation of high-quality practices offers an example of how to introduce beneficial change.

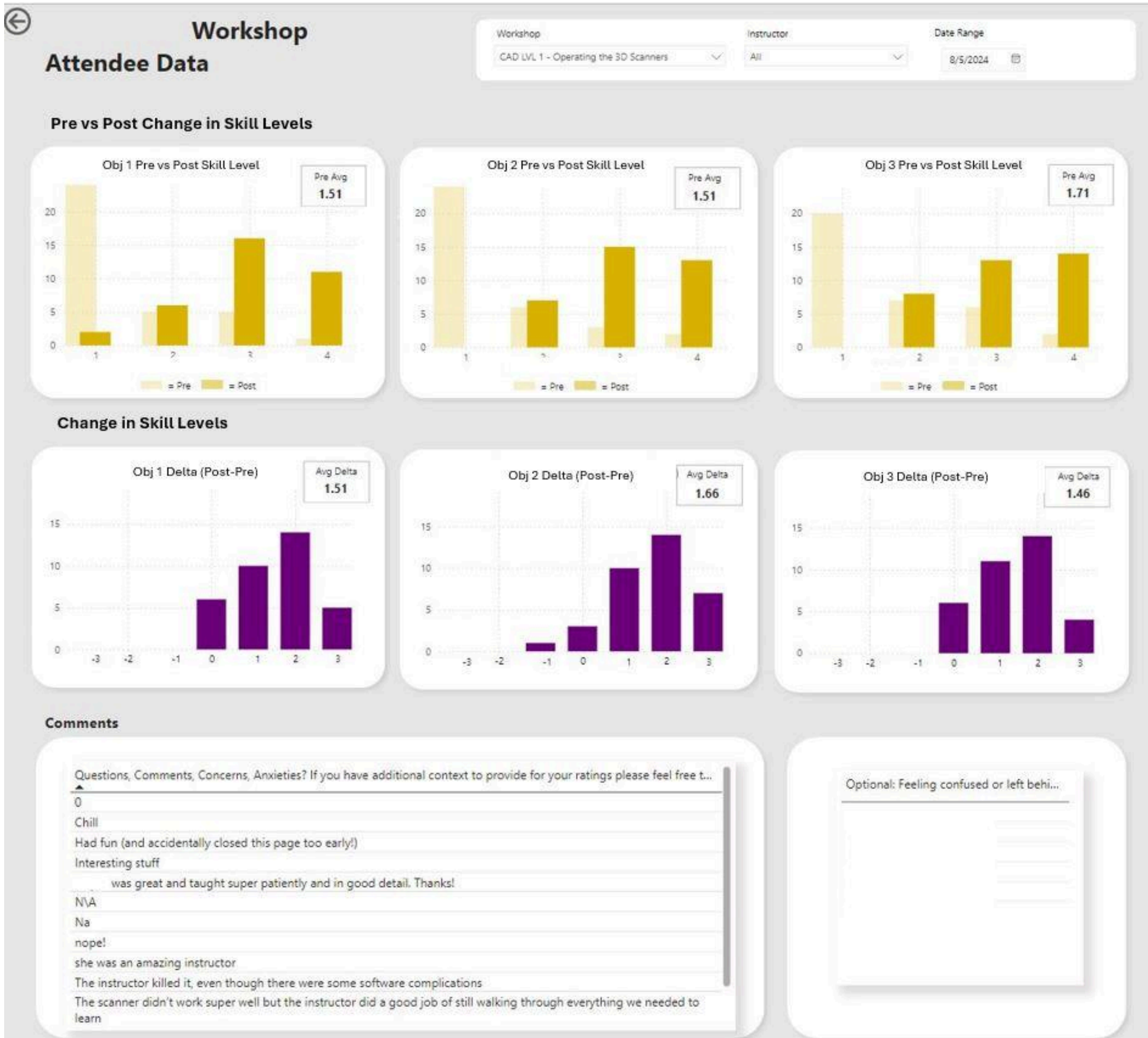
Appendix A

Comprehensive Workshop Summary

Workshop Title	In Class Capacity *(Staff Instructor)*	In Class Duration *(Staff Instructor)*	Out of class capacity *(Student Staff Instructor)*	Out of class duration *(Student Staff Instructor)*	Total student instructors *(Fall 2024)*	Total sessions offered *(Fall 2024)*	Total attendees *(Fall 2024)*
Operating the Laser Machines *Prototyping - Level 1*	30	110 min	15	90 min.	5	52	563
Operating the 3D Printers *Prototyping - Level 1*	*Out of class only*		15	90 min.	8	69	716
Wiring & Coding Inputs & Outputs *Arduino - Level 1*	30	110 min.	12	120 min.	5	29	567
Controlling Speed & Position with Motors *Arduino - Level 2*	30	110 min.	12	120 min.	4	33	389
Communication between Arduinos, Phones, & More *Arduino - Level 3*	30	110 min.	12	120 min.	2	12	47
Migrating to Smaller Microcontrollers *Arduino - Level 3*	*Out of class only*		6	120 min	2	6	9
Simple Circuits & Measurements Fundamentals *Electronics - Level 1*	30	110 min.	10	120 min.	2	23	380
Through Hole Soldering *Electronics - Level 1*	30	110 min.	10	120 min.	2	17	236
Schematic Capture & PCB Layout using Altium Designer *ECAD - Level 2*	*Out of class only*		6	120 min.	2	13	36
Sketches & Parts *CAD - Level 1*	30	110 min.	12	90 min.	2	29	608
Assemblies & DFM *CAD - Level 2*	*Out of class only*		10	120 min.	2	13	50
Operating the 3D Scanners *CAD - Level 1*	*Out of class only*		4	90 min.	3	18	33

Appendix B

Example of PowerBI Dashboard

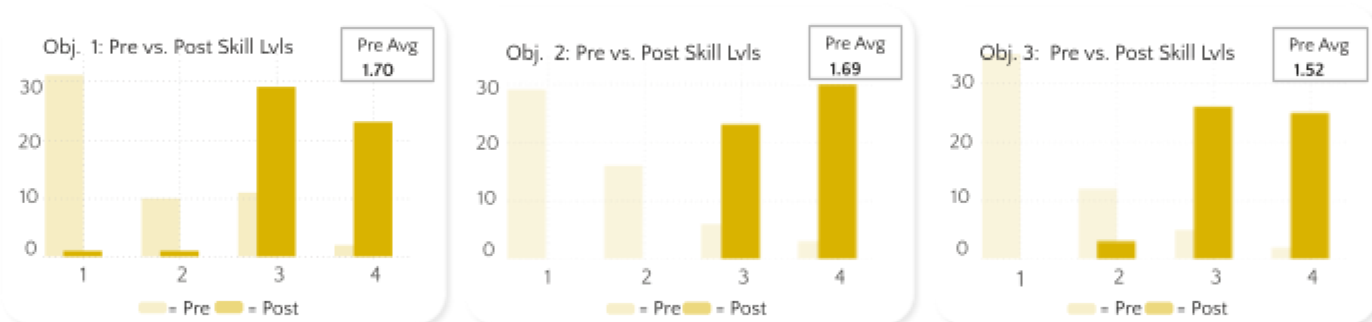


Appendix C

Example Workshop Report for Student Instructors

Soldering Workshop Report:
Self-report of skills levels is graphed for each of the three workshop objectives. Total number of workshop participants is graphed on the y-axis. The report of skills from lowest to highest (1-4) is on the x-axis. An average of the participants' perceptions of skills pre-workshop appears in the top left-hand corner.

Change in Confidence Levels:



Comments:

Questions, Comments, Concerns, Anxieties? If you have additional context to provide for your ratings please feel free to add it here.
Great workshop!!!
I thought this was a great workshop!
I was glad to be able to learn best practices, I didn't really know what to look for when soldering. Instructors were very helpful
LOVE MY INSTRUCTORS, XXXX and XXXX
Shoutout to the people working tonight (september XX, 2024 at X:XX): XXXX and someone else whose name i forgot lol. they were great. thank you :)
Suggestion: Would like to join an email list where I can get the information for these sessions more often like once a month

Appendix D

Reflection Questions for Student Instructors

1. Any initial reactions, feelings, or curiosities reviewing this data?
2. If there were objectives students regularly struggle with - why do you think students struggle in these areas? Are there *actionable things you (or the engineers) could do to support?*
    a. Ex: "I could emphasize a topic more"; "We should introduce a better demo"; "We could pause after this objective to ask questions to see where misconceptions are."
3. What is something you are proud of? (Do you have tips for others?)
    a. Ex: "I was really nervous to teach this, and I am becoming more confident"; "Students stayed later to ask questions."
4. What is one thing you are going to focus on the next time you teach to improve?
5. Where can our engineering team support you? (ex: updates to content, more training in a certain objective, more demo parts)

Acknowledgment

This work would not have been possible without the dedication, insight, and enthusiasm of the student and staff workshop instructors who participated in this continuous improvement process. Their commitment to growing as educators, cultivating inclusive spaces, and supporting their peers shaped every aspect of this project. From engaging in reflective practices and Community of Practice dialogues to integrating student feedback in real time, their willingness to lead with curiosity and care strengthened our program in meaningful and unexpected ways. We are especially grateful for their investment in creating learning environments where it is safe to make mistakes, explore new ideas, and grow both technically and professionally. Their contributions reflect the core of this initiative, and we offer our deepest appreciation for the role they played in making this work possible.

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