Bridging Engineering Coursework and Professional Practice through Industry and Alumni Collaboration for Hands-On Curriculum Development

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Abstract

This paper discusses the design and pilot of a multistakeholder hands-on curriculum. We partnered with alumni, industry, faculty, and undergraduate students to embed authentic professional narratives, engineering tools, and engineering practice into required undergraduate coursework. Supported by an institutional grant, we designed and piloted three curricular experiences in test and validation engineering: vibration testing, data acquisition, and material testing. To help students develop workforce-relevant skills, the new curriculum has two key goals. First, the experiences offer students opportunities to strengthen their sense of being engineers, or “engineering identity,” while also helping them see coursework as relevant to their future professional roles, or “identity-based motivation.” Second, the experiences support students in building “adaptive expertise,” or the ability to transfer existing skills to new contexts. We framed our work in a scholarship of teaching and learning approach to examine implementation and to guide iterative refinement of the curriculum model. To evaluate the impact, we collected quantitative and qualitative data via surveys, interviews, and reflections from student participants and curriculum co-developers. Results suggest that the pilot created value across stakeholder groups: students described the modules as relevant and confidence-building, student co-developers reported meaningful technical and affective learning, and alumni and industry collaborators valued the opportunity to help prepare future engineers. We will continue to iterate our approach and analysis as we examine the viability and sustainability of implementing an alumni- and industry-informed curriculum model, with interest toward scaling the model more broadly in our college.

1 | Introduction

Twenty-first century engineering graduates enter a rapidly evolving professional landscape, shaped by ceaseless technological change, a growing need for interdisciplinary collaboration, and increasingly ill-structured problems. Their success requires more than procedural fluency. Engineers must be able to navigate uncertainty and make decisions with incomplete data as they exercise professional judgment [1-5]. To support graduates’ workforce success, engineering education must provide foundational knowledge across the theoretical spectrum and also nurture curious, adaptable problem solvers. Historically, undergraduate engineering courses too often have emphasized structured, decontextualized problem solving, an approach that strengthens learners' foundational knowledge but provides few opportunities for students to practice contextual reasoning, judgment, and decision making [1, 6, 7]. The result is that many recent engineering graduates lack experience with how engineers use concepts to interpret data, reason with uncertainty, and evaluate tradeoffs—the very skills engineers are called on to exercise regularly under real-world constraints. This paper discusses the design and pilot of a hands-on curriculum model developed with contributions from students, staff, faculty, alumni, and industry. Our model embeds authentic engineering practice *directly into required undergraduate coursework*, offering students opportunities to put theory into practice.

Course delivery that over-emphasizes simplified and decontextualized problems exacerbates long-standing challenges related to student retention, motivation, and belonging in engineering [7]. When students gain expectations about professional reasoning primarily through internships, prior exposure, or social networks *rather than in class*, they may wonder if coursework is worth the effort. Not only can the lack of applied experience in class yield disengagement, but the disconnected system can also disproportionately disadvantage students with less access to informal engineering networks or early professional experiences. Those most negatively affected include community-college transfer students, women, first-generation college students, and students from racially and ethnically minoritized backgrounds [8-11].

Learning experiences that mirror authentic engineering practice help most students; gains include developing confidence in their abilities, perceiving their learning as relevant to future work, and persisting in their programs [12-15]. Fundamentally, these experiences make engineering work visible and attainable. Learning experiences that reflect the social and material contexts of professional practice support more robust ways of problem solving. Students who are positioned to contribute to meaningful engineering work can strengthen their engineering identities and sense of belonging in the field [16-19]. With that need central to our project planning, we drew on evidence-informed practices that connect theory to application, make professional engineering work *more visible within coursework*, and create more accessible pathways for students to engage authentic engineering practice. It also does so in fulfillment of a strategic college priority, to "be a teaching community that embraces and advances educational innovations" [20].

The model was implemented in the College of Engineering and Applied Science (CEAS) at University of Colorado Boulder, a large, public, research university. Specifically, the project emerged from the Integrated Teaching and Learning Program (ITLP) that supports many aspects of hands-on learning across (CEAS). We designed and piloted three modules focused on test and validation engineering: vibration testing, data acquisition, and material testing. Our goals included

- Helping students develop workforce-relevant skills,
- Providing opportunities for students to strengthen their perceptions of themselves as engineers, or their "engineering identity,"
- Fostering a context for students to build "adaptive expertise," or their ability to transfer existing skills to new contexts.

2 | Background

2.1 The Integrated Teaching & Learning Program

For more than two decades, the Integrated Teaching and Learning Program (ITLP) at the University of Colorado Boulder (CU) has supported hands-on engineering learning via laboratory experiences, active learning classrooms, prototyping and manufacturing facilities, and skill-building workshops. ITLP serves as a collaborative instructional resource for faculty and students across multiple departments as it supports both curricular and co-curricular learning. As ITLP welcomes more than four thousand undergraduate students annually, our program fills a key niche for students to develop their engineering skills, confidence, and pre-professional identity.

A hallmark of our program is its portfolio of 15 hands-on workshops where students learn and apply engineering concepts using professional tools, software, and equipment. Topics in the 60-120-minute workshops include 3D printing, laser cutting, CAD, saws and drills, circuits, soldering, and programming with Arduino. Through these workshops, faculty can integrate content into required courses, either as supplements to or as replacements for traditional laboratory activities and projects. Annually, ITLP's 25 student staff and six engineers deliver more than 1,000 workshops. The pilot we describe here builds on the concept and infrastructure of the ITLP workshops and also incorporates alumni- and industry-informed engineering scenarios and activities.

2.2 Prior Work: Embedding Continuous Improvement

Beginning in 2023, ITLP began to adopt research-based practices in the delivery and evaluation of workshops and hands-on curriculum in an effort to strengthen instructional quality and support student success. In particular, innovations enhanced our alignment with our college's strategic goals to support student retention, embed inclusive teaching practices, and build workforce preparation [21].

One innovation was introducing a continuous improvement process in a subset of the ITLP's skill-building workshops. We developed shared learning objectives, collected actionable student feedback, and supported the professional growth of student and staff workshop instructors through an ongoing Community of Practice [22]. We learned that we could

- integrate research-informed practices into a large, student-staffed teaching program,
- learn in real time the impact of experiences on student satisfaction and learning,
- improve instructional quality,
- strengthen instructor engagement,
- and support data-informed decision making.

That continuous improvement process laid the groundwork for this pilot. We wanted to test how we could more directly support students' opportunities for professional engineering practice and also strengthen persistence.

2.3 Developing Our Curriculum

This pilot began with informal networking conversations with alumni and industry partners. Their professional experience includes sports-engineering research and development, computer science, machine learning, engineering consulting, and aerospace engineering. As alumni reflected on their own early-career "lessons learned," their eagerness to support undergraduate learners became clear. One primary motivation for alumni was to help students gain facility with how engineering concepts are *applied in practice*.

What we learned from alumni echoes research findings: students and early-career engineers feel uncertain about how to apply what they know to what needs to be done in a given setting [5]. The alumni conversations prompted us to pursue a campus innovation award to design and pilot new modules for in-class and workshop use.

We conducted a literature review on adaptive expertise, engineering identity, and identity-based motivation and used this body of knowledge to frame our curriculum design. From our prior program redesign, we knew the urgent need to lighten the burden of reform for faculty. To reduce that potential implementation hurdle, we created an ecosystem of multiple stakeholders—including alumni and industry partners—to help with curriculum development and implementation [21, 22].

3 | Curriculum Design and Development

From the start, we wanted to address the pervasive complaint that engineering education differs too much from engineering work [23-26]. Engineering education research has found that collaborative, multi-stakeholder approaches to curriculum design improve both instructional quality and scalability; this is particularly true for experiential learning embedded in required courses [27-31]. To that end, we called on a multi-stakeholder design community to inform the hands-on experiences within required courses.

In our design process, student staff (who teach many of our workshops) reported on common student stumbling blocks and operational considerations in hands-on workshops. Alumni and industry partners offered authentic engineering contexts and practices. Faculty members aligned workshops with their course learning objectives as well as curricular constraints. Finally, program staff engineers supported technical accuracy and managed the oversight and development of content. Although each module differed in technical focus and the extent of stakeholder involvement, each was bounded by our goal to link foundational engineering *theory* with authentic professional *practice*.

3.1 Guiding Constructs

The design of our modules embraces well-established constructs in engineering education and learning science: adaptive expertise, engineering identity, and identity-based motivation. These constructs address how students transfer knowledge and skills to new contexts, how they come to see themselves as engineers, and why they persist through challenging learning experiences.

Adaptive Expertise

Adaptive expertise describes the human capacity to apply conceptual knowledge flexibly across contexts, particularly when the problems are ill structured, data are incomplete, and/or constraints are not fully specified [32, 33]. Research distinguishes between *routine expertise*, which emphasizes efficient execution of known procedures, and *adaptive expertise*, which emphasizes interpretation, innovation, and transfer [34, 35]. In engineering work, adaptive expertise is critical because problems rarely resemble textbook exercises and solutions must be adapted to evolving conditions [31, 33]. Learning environments that support adaptive expertise require learners to reason through uncertainty, make and justify assumptions, and connect conceptual understanding to decision-making. However, U.S. engineering education too often emphasizes routine expertise [31], to the potential detriment of early career engineers.

Engineering Identity

"Engineering identity" as a construct describes to what extent individuals take on the professional role of being an engineer and see themselves as legitimate participants in engineering and develop a sense of belonging within the profession [36-38]. Studies have shown that identity development is fostered through engagement in authentic engineering practices, opportunities to contribute meaningfully, and recognition from others that one is a capable engineer [36, 38, 39]. Engineering identity development may be delayed, constrained, or stunted when students are positioned to receive knowledge passively rather than by actively participating by practicing application of new concepts [31, 37]. Conversely, curricular experiences that make professional practice visible and attainable help students connect coursework to who they are and who they seek to become [31, 37, 39]. With this firmly in mind, we developed the model to allow students opportunities to deepen engineering identity through this curriculum.

Identity-Based Motivation

Identity-based motivation theory of learning posits how the alignment between students' tasks and their identities, either current or future, shapes motivation and persistence by influencing whether or not students perceive academic work as relevant to valued selves and future roles [39, 40]. In engineering education, identity-based motivation has been linked to persistence, particularly when students understand *why* technical content matters and *how* it connects to actual engineering work [39, 41]. When students perceive academic activities as relevant to valued future roles, they are more likely to sustain effort, particularly when they face difficulty.

Unlike introductory courses that are disconnected from “real world engineering,” in foundational, required courses that mindfully link effort and purpose, students can bolster both their engagement and resilience—a linkage that can offer powerful support to student success [39, 41, 42].

Because adaptive expertise, engineering identity, and identity-based motivation constructs offer windows into *what* students learn, *how* students learn, *how* they *see* themselves, and *why* they persist, we kept the constructs at front of mind in our design and pilots.

3.2 Principles in Practice

We piloted three modules: vibration testing, data acquisition and sensors, and material testing (Figure 1). Each module was *embedded in at least one required undergraduate course*, touching five courses in total. We intentionally varied leadership for curriculum development across the multiple stakeholders, so we could explore how different development models affect feasibility, authenticity, and the potential for successful long-term integration with coursework.

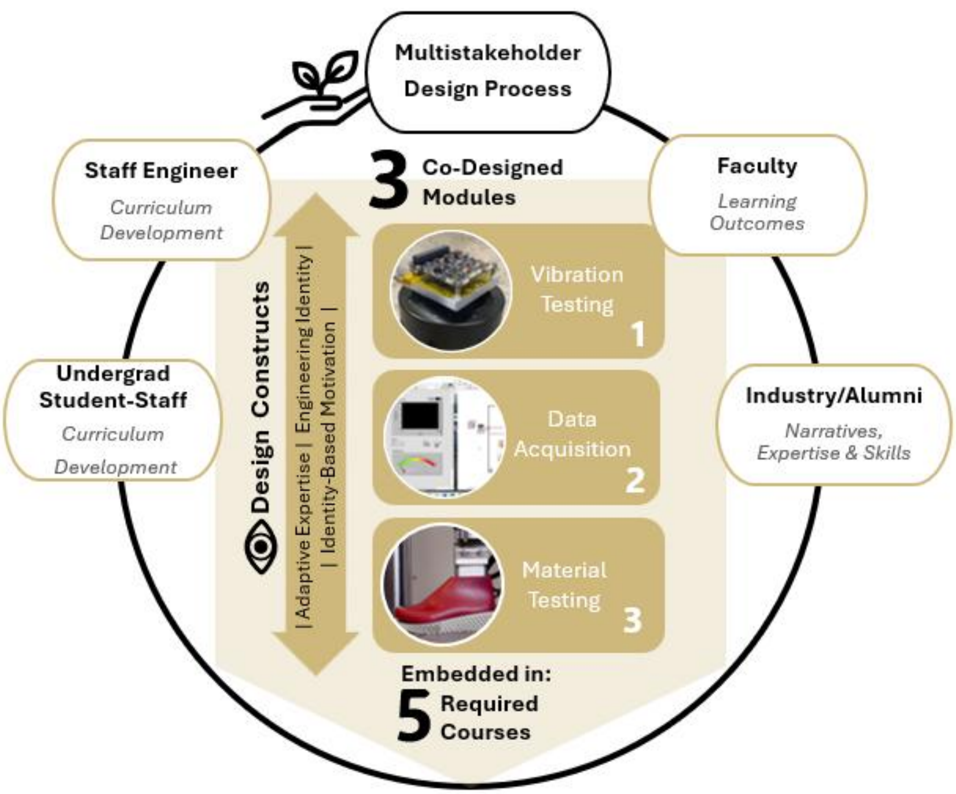

Figure 1. A diagram of the multistakeholder curriculum development model informed by adaptive expertise, engineering identity, and identity-based motivation.

Vibration Testing Module

The vibration testing team included industry partners, ITLP staff engineers, and faculty partners. The collaboration built on an existing relationship with Vibration Research, a vibration testing company from which the ITLP had purchased equipment. Their staff had already been supporting students and staff with vibration testing questions, and education was also part of their broader mission, which made them well positioned to contribute to curriculum development. The workshop topic emerged after senior-design faculty observed gaps in students' ability to translate vibration testing standards into real-world test plans. Over the summer of 2025, the industry partners and staff engineer iteratively developed the module, translating professional vibration testing practices into a two-hour hands-on workshop for students in a junior-level data analysis course and senior-level capstone courses in biomedical, aerospace, and mechanical engineering. Industry partners delivered the workshops using professional equipment, narrating how they practice engineering judgment, and allowing students to ask questions and practice with the equipment.

CubeSats are small, standardized satellites built in modular "units" and are commonly used in university and early-career aerospace contexts. To simulate real work, students were called on to practice judgement and decision making using experimental evidence. The design of the vibration testing workshop used the CubeSat to mimic the vibration environment of satellites during launch. Students could select vibration profiles, including sine, random, and shock inputs, and analyze frequency-domain data to interpret system response. Further, students were called on to justify their testing choices and to reason through uncertainty as they interpreted results. After testing the CubeSat, students practiced in a transportation scenario. They interpreted and adapted an industry-standard test plan and vibration profile. Students worked directly with industry-grade shaker systems and data-acquisition software, generated and interpreted their own data, and discussed how results would inform engineering decisions. This framed students as capable contributors engaging in the same forms of reasoning used by practicing engineers.

Because students needed to identify assumptions, make interpretations, and use knowledge transfer rather than operate solely through procedural execution, the vibration-related activities foregrounded adaptive expertise and engineering identity even as it built identity-based motivation by helping students connect technical concepts to future selves and roles in engineering.

To reinforce metacognition of their own professional growth, students were regularly prompted to connect workshop activities to their own design projects and future professional roles. Reflection supported their understanding of the relevance in engineering practice of concepts such as frequency-domain analysis. Reflection also reinforced identity-based motivation because confronting the engineering consequences of vibration testing made clear the connections between testing and reliability and safety in practice. Through the practical experiences, use of authentic equipment, and direct contact with industry engineers, students were able to deepen professional attributes known to improve success for early career engineers.

Data Acquisition and Sensors Module

The data acquisition (DAQ) and sensors module-development team comprised undergraduate workshop instructors, ITLP staff engineers, and an industry alum from National Instruments, now part of Emerson. This module was embedded in a junior-level data analysis course and used professional data acquisition hardware and software.

The viability of scaling this curricular model is one pilot objective. As proof of concept, we wanted to learn whether students across disciplines would seek to grow their skills *outside of class*. To that end, we also offered the data acquisition module as a stand-alone workshop to learn if it would attract interest and participation. We are pleased to report that students did attend the workshop, and we plan to offer it again as a stand alone experience next academic year.

Emphasizing peer-led instruction, this module focused on experimental design, sensor selection, and data interpretation. With mentoring from a staff engineer, the undergraduate students led curriculum development through a summer internship with the ITLP. They piloted the workshop multiple times before full implementation, incorporating feedback from staff engineers and an alum from Emerson who had previously worked in the ITLP and brought that teaching lens to the development of the workshop. Having student employees serve as the development and implementation leads allowed us to test a more affordable, scalable, and flexible option to delivering the workshop without requiring industry or alumni partners to be present each time it was taught.

With its emphasis on interpretation and decision-making, the DAQ workshop called on students to evaluate signal quality, consider sources of noise, and choose sampling rates and sensor placement based on the constraints of the system under study. During analysis, students connected raw data to performance evaluation. This hands-on approach reinforced that using tools such as the DAQ is not simply about *collecting measurements.* Rather, the experience of *generating evidence* to inform and support engineering decisions helped students build adaptive expertise, identity, professional judgment, and identity-based motivation.

Material Testing Module

The material testing module focused on biomechanics in a junior-level materials science course with 40 students. The testing subject was polymeric foams and footwear materials. This team comprised a fourth-year undergraduate student staff member, an ITLP staff engineer, a faculty member and two alumni with R&D experience in footwear design. The module invited students to investigate how material structure influences mechanical behavior and performance in footwear. Using cyclic compression testing, students compared two foam materials to evaluate stiffness, energy dissipation, and damping behavior. In doing so, students engaged with difficult engineering concepts by connecting microscale structure to macroscale performance, and they used experimental evidence to make design recommendations for applications such as running shoes, walking shoes, and protective packaging.

The lab supported adaptive expertise by asking students to simplify a complex human-material system using a spring-mass-damper model, interpret force-displacement behavior under cyclic loading, and justify claims about tradeoffs between cushioning, responsiveness, and impact absorption. Rather than simply following a fixed procedure, students interpreted data, reasoned across contexts, and made evidence-based decisions. The module also aimed to support engineering identity and identity-based motivation by positioning students as contributors to a realistic, materials-design problem with clear relevance to product engineering.

4 | Methods

This curriculum innovation is grounded in a translational, improvement-oriented approach. Our goal was *not* to test theory but rather to translate research-informed design principles into sustainable practice, using evidence to guide ongoing development and improvement. To that end, we planned, designed, and evaluated the curriculum and students' learning to support iterative refinement of a scalable, alumni- and industry-informed curriculum model.

Accordingly, we used a mixed-methods design in which quantitative data helped us identify patterns in how student participants responded to the modules, while qualitative data helped us examine why students and curriculum developers experienced certain outcomes. We structured data collection to capture insights across multiple implementation cycles and stakeholder groups, in alignment with a Scholarship of Teaching and Learning (SoTL) framework [43]. Note: The Material Testing module was implemented in a course one week prior to the time of this writing; thus, our results focus only on the vibration and data acquisition modules.

4.1 Participants

We gathered data from three primary stakeholder groups: undergraduate student participants, undergraduate curriculum co-developers, and alumni and industry collaborators. Sample sizes for each group are shown in Table 1. For the DAQ module, we only include data from the classroom implementation (not the out-of-class workshops) because the in-class implementation used a post-intervention survey that included the same questions as the survey used with the vibration module. Future work includes interviewing faculty who were involved in the classroom integration of the modules. From those experiencing the workshops to those designing and implementing them, these groups represent the full arc of our curriculum development process and offer complementary perspectives on learning, identity development, instructional feasibility, and the activity's relevance to professional preparation.

4.2 Evaluation & Data Sources

Table 1 summarizes the participant groups, data collection methods, and purpose of each data source. Together, these sources allowed us to examine student responses to the modules, curriculum co-developer experiences, and alumni and industry collaborator perspectives.

Table 1. Summary of participant groups, data sources, sample sizes, and response rates.

Stakeholder Group	Data Collected	Purpose of Data	Sample Size (Response Rate)
Undergraduate Student Learners	Post-workshop surveys	Measure confidence, perceived relevance, adaptive thinking	Vibration: 14 (64%) DAQ: 16 (84%)
Undergraduate Student Curriculum Co-Developers	Written reflection	Understand identity development, technical growth	Vibration: N/A DAQ: 2 (100%)
Alumni/industry partners	Semi-structured interviews	Assess engagement value, feedback on collaboration	Vibration: 1 (50%) DAQ: 1 (100%)

Students could connect to the survey with a QR code or URL and complete it on a computer or mobile device in under five minutes. The response options were a six-point Likert scale ranging from "strongly disagree" to "strongly agree." The survey also included an open-ended question that solicited other feedback on what went well or could be improved, but for this paper, we only included the quantitative survey results. We adapted six survey items from pre-existing instruments related to adaptive expertise, engineering identity, and identity-based motivation [34, 36, 39, 44-47], as shown below.

- Q1: This workshop helped me connect ideas from different courses to real engineering work.
- Q2: This workshop helped me reflect on how I learn new technical skills and manage uncertainty.
- Q3: This workshop helped me recognize that engineering problems can have multiple valid solutions.
- Q4: This workshop helped me build curiosity about the tools and concepts we used in this workshop.
- Q5: What I learned in this workshop will be useful for my future engineering work or career.
- Q6: I see myself as an engineer.

Two industry partners (not alumni) helped develop the vibrations module. Two student employees and one industry partner (an alum) played a significant role in the curriculum development process of the data acquisition module. To understand student employees' cognitive *and* non-cognitive growth, they completed a structured written reflection (Appendix A). We invited two industry partners (one from each module) to reflect by participating in semi-structured interviews (Appendix B), which we digitally recorded, transcribed, and analyzed for themes.

4.3 Data Analysis

Given our role in *design, delivery, and analysis*, we acknowledge the potential for bias or heightened sensitivity toward emerging themes. For the vibration and DAQ modules, we analyzed quantitative and/or qualitative data, depending on the data source. Again, we do not discuss analysis of the materials module here because of the timing of its implementation. For the qualitative student-employee reflections and industry and alumni partner interviews, we used an iterative thematic analysis process that began with an inductive first pass to identify emergent themes that were then interpreted by the constructs of adaptive expertise, engineering identity, and identity-based motivation. Through better understanding of how the curriculum and assessment instruments function across varied contexts, we plan to identify the design elements with the most significant impact to inform future scaling, deepened impact, and innovations.

5 | Results

5.1 Student Learners

Descriptive statistics from the vibration workshop surveys appear in Figure 2. Early findings suggest that students found the experience helpful in developing new skills, mindsets, curiosity, and relevance to their future professional contexts—we received no "Disagree" responses for any of the vibration module's survey questions. Notably, all but two participants "strongly agreed" that they see themselves as engineers, and while such positive responses might be satisfying for workshop designers, this finding limits our ability to measure precisely how the experience itself affected students across multiple levels of engineering identity.

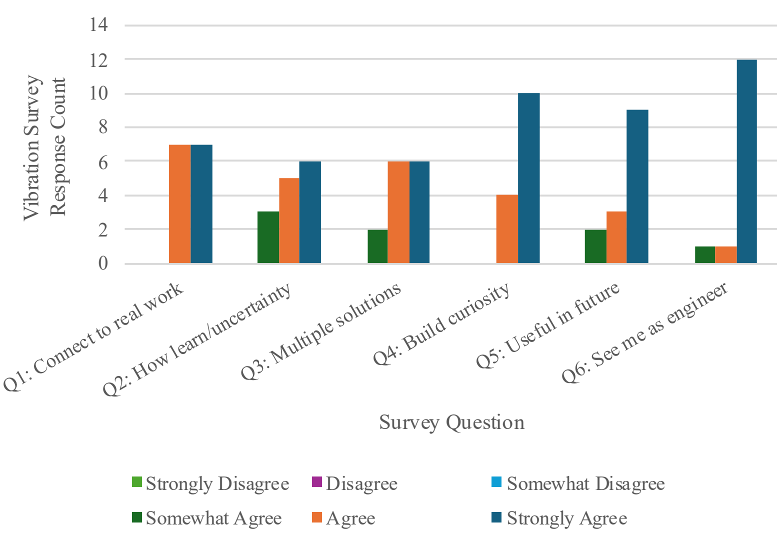

Figure 2. The survey results for the vibration module indicate that participants experienced positive cognitive and non-cognitive effects (n=14). There were no "Disagree" responses.

Descriptive statistics from the data-acquisition survey appear in Figure 3. The broadest spectrum of responses came with Question 5, about the utility of the content for future work. Question 6 inquired if students see themselves as engineers and received one "Somewhat Disagree" response.

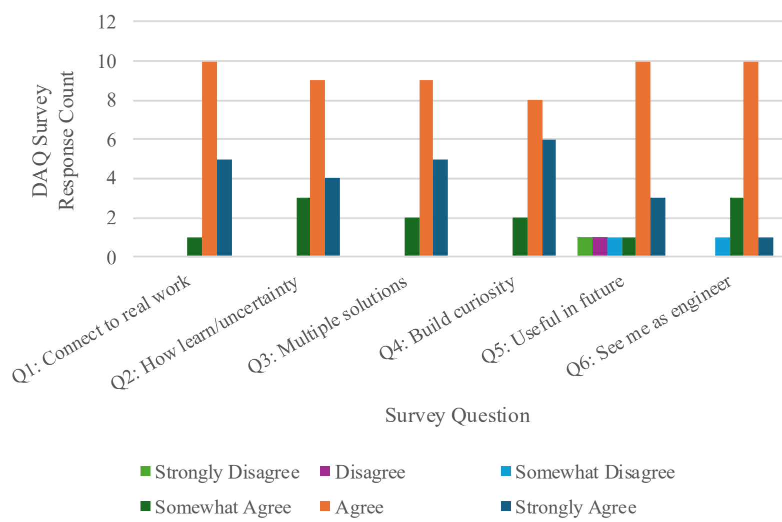

Figure 3. The DAQ module survey results suggest that module experience positively impacted student participants (n=16).

5.2 Undergraduate Curriculum Co-Developers

Written reflections from undergraduate curriculum co-developers reveal that their collaboration in developing the data acquisition workshop offered a learning experience that supported growth beyond technical content alone. The co-developers described teaching as a mechanism for deeper understanding; one explained that the activity "forced me to examine the topics at a foundational level." The second reflected that teaching had "always translated into the highest level of understanding" for them on a given topic.

While we had not specifically designed the pilots to deepen knowledge and skills of student staff, their reflections suggest that the experience of curriculum co-development did exactly that—a beneficial byproduct of our innovation. Both co-developers described revising workshop materials, drawing on their own recent experiences as learners, and making deliberate pedagogical choices to improve the material's accessibility. One student discussed the experience of learning the material "through the lens of teaching it to others." The other student emphasized that designing a strong workshop required a deeper level of understanding than simply getting a project to function, describing the process as both intellectually demanding and humbling.

Reflections indicate that this work shaped how students understood engineering and their place within it, suggesting that co-development may support engineering identity not only through technical competence, but also by broadening students' understanding of what authentic engineering work looks like. One co-developer wrote that the experience "widened my perspective of what ‘engineering’ really is” and helped them see that communication, leadership, and education also belong within engineering practice.

The co-development experience also informed future professional opportunities. One student described the workshop as a “critical factor” in obtaining an internship in a research laboratory that involved DAQ devices and LabVIEW. The other secured an opportunity with the company that produces the DAQ and LabVIEW technologies used in the workshop. While the downstream job opportunities for co-developers were not a planned-for outcome, we were pleased to discover an additional positive alignment between the co-development experience and professional engineering practice.

5.3 Alumni and Industry Co-Developers

Preliminary analysis of interviews with alumni and industry collaborators suggests that their participation was shaped by a desire to “give back” by helping students be better prepared to enter engineering work after graduation. In particular, these collaborators described wanting students to gain a clearer sense of how engineering concepts are used in practice and skills that could better position them for the workforce. For the alum, this motivation was deeply personal. She described hearing students say that they were investing substantial time and money in an engineering degree while still feeling unprepared for available jobs. She connected that concern to her own experience as a first-generation college student. Both in engineering school and after entering the workforce, she navigated through without the kinds of networks or professional access that many of her peers seemed to have. Her lived experience shaped her participation as a way of widening access to engineering careers. As she put it, “We need to do something to help these students.”

The industry collaborator emphasized that education and teaching were already central to his company’s broader mission and described a long-standing commitment to helping connect theory with practice: “[We have] always had a passion for getting that theory connected to real world [experiences].” He also described mentoring students as a rewarding part of his work. He framed his participation not simply as content delivery, but as an opportunity to help students understand what sits behind the data, how testing decisions are made, and how engineering judgment develops in applied settings.

The interviews also suggest that collaborators’ educational and professional histories shaped how they engaged. The alum revealed that her prior experiences as both a student and an early-career professional strongly influence their focus on tools and skills that were directly connected to hiring contexts, especially in LabVIEW and data acquisition. In the industry stakeholder’s interview, long experience in vibration testing appeared to shape a focus on helping students understand not only instrumentation, but also the interpretive and time-constrained nature of engineering work in practice. Taken together, interviews suggest that alumni and industry collaborators sought to bring what had been missing, difficult, or especially consequential in their own engineering pathways to the curriculum.

At the same time, these interviews revealed sustainability challenges. The alum described wanting to continue; however, large-company politics, funding structures, and competing priorities can hinder support for academic partnerships, even when there is clear enthusiasm for them. The industry partner also mentioned that competing priorities and staff budgets could influence a company's decision to collaborate on curriculum development or delivery. They also highlighted different constraints, including keeping the focus narrow so content can realistically be taught in a two-hour workshop, and striving to align the workshop delivery with student hiring cycles.

These data suggest that while multi-collaborator curriculum development holds promise, there is real complexity in coordinating different organizational realities, and these tensions must be navigated for the model to succeed.

6 | Discussion

Across groups, stakeholders valued the curriculum design process and product. In particular, collaborators appreciated the interconnections between authentic practice, evidence-based knowledge about how people learn, focus on quality of instruction, and operational feasibility. Calling on the acquired knowledge of individuals in different phases of professional expertise *and* engineering-education research yielded both expected and surprising gains.

At the heart of our interest is *how to scale authentic learning experience*. Recognizing the pressures that can hamper faculty from adopting hands-on curriculum, reliance on knowledgeable, trusted presenters who are not exclusively faculty improves our potential to scale. Delivering the modules through our student staff substantially improves the potential for expanding this approach by helping manage costs. With student staff as leaders, the workshop can be offered multiple times annually, whether in or out of class. As we called on the different world views of undergraduate developers, alumni, industry partners, and ITLP engineers, we embedded in the design process rich engagement with engineering knowledge and practice. We did so even as we *minimized additional workload for faculty*.

Data from the participants' survey results suggested that students had positive experiences for both the vibration and the DAQ modules. One especially encouraging result was that both experiences helped students build curiosity about the tools and concepts they used in the workshops (Q4), potentially introducing them to a previously unknown or unconsidered career path.

Given the strong positive skewing of results for the vibration survey, *and* that the workshop was led by industry representatives, it is surprising that students did not perceive a stronger connection between course content and real work (Q1). We anticipated more positive responses to opportunities for real-world practice. It is possible that this result reflects the fact that, typically, few students at CU Boulder take a vibration course and lack context to make the connection between what they learn in dynamics courses and vibration testing.

Few participants in the vibration survey reported a low engineering identity (Q6). On the face of it, that might seem a good problem to have, as engineering colleges generally hope for students to identify strongly with engineering as a career. Given the small sample sizes and different composition of who responded to surveys, trends and comparisons must be approached with caution, however.

The DAQ module had more variation in the responses for the engineering-identity question. A potential source of variation in response data between the workshops is that the vibration workshop was attended by many *senior design students* from multiple majors while the DAQ workshop was embedded in a *junior-level course* with mostly students from one major. This could suggest that the lens participants brought to their experiences differed substantively. Furthermore, many of the senior-design participants held the team role of testing lead. Perhaps students who self-selected into a highly technical role such as the testing lead *already had* a strong engineering identity.

Our current data does not allow us to understand our curriculum's impact on students who came to us with lower levels of engineering identity. Our work will be stronger if we identify ways to understand how it affects all students—even those who may not already strongly connect with engineering. As we mature and scale our model, we will be more likely to engage students of all levels of engineering identities.

Preliminary results suggest that students viewed these workshops as relevant and confidence-building, that undergraduate co-developers experienced deep professional learning, that industry partners valued opportunities to recruit new engineers, and that alumni derived meaning from giving back. Informal faculty feedback suggests that the modules strengthened required coursework through real-world perspectives and new hands-on lab options. Our future work will include formal faculty interviews to collect data about these experiences and inform the feasibility of continued and expanded integration.

We also plan to explore how students retained and applied workshop learning *beyond the immediate instructional context*, we plan to conduct follow-up interviews with a subset of participants. Approximately two to four months after participation, interviews will focus on

1. whether students retained specific workshop concepts or skills,

2. how they applied those concepts in later coursework or projects, and

3. how the experience influenced their confidence and understanding of engineering practice.

Future implementations and evaluation will identify both intended and unexpected outcomes of the co-development model, with the goal of articulating replicable model(s) for sustainable alumni- and industry-informed curriculum development in a hands-on engineering education program.

7 | Conclusion

This paper builds upon more than two decades of supporting hands-on learning through the Integrated Teaching and Learning Program at University of Colorado Boulder. Here, we discuss piloting a new model that integrates authentic engineering practice and professional narratives into required coursework through workshops and labs. The pilot builds on recent initiatives to enhance instructional quality and further align with college-wide strategic priorities focused on retention, inclusion, and workforce readiness. Responding to long-standing critiques in engineering education of decontextualized instruction and the persistent gap between classroom learning and engineering practice, this pilot leverages alumni and industry partnerships to help engineering students see the relevance in their curriculum and to explore a sustainable approach to distributed curriculum development. We seek alignment with faculty learning outcomes and support for meaningful student engagement.

Using collaborative design and delivery of a hands-on curriculum, this project operationalized the constructs *adaptive expertise, engineering identity, and identity-based motivation* to pilot curricula in vibration testing, data acquisition and sensors, and materials testing. We used these constructs not as abstract frameworks but rather as practical design tools to structure hands-on activities and guide the selection of realistic engineering scenarios.

Our pilot demonstrates how careful implementation of such engineering-education constructs can be achieved through co-design *without significantly increasing faculty burden,* a critical consideration as institutions grapple with how to scale applied learning in engineering education. We also believe that the use of student employees as instructors of the modules or workshops offers a cost-effective means to scale the concept more broadly in our program. By documenting our design process, stakeholder engagement strategies, and early outcomes, this paper points to a replicable framework that other institutions could adopt to make engineering education more authentic, inclusive, and professionally grounded.

Looking ahead, our aim is to continue refining this model, expanding our curriculum repository, and publishing resources on a web-based platform, so they are publicly accessible to other universities. As the model evolves, we will share findings with the broader engineering-education community through future publications, workshops, and resource repositories. We envision this work as addressing a longstanding need in engineering education: translating authentic hands-on learning as supplemental to theorical instruction. We do so by embedding it as a core classroom practice to cultivate engineering talent and build a workforce with the technical, adaptive skills, curiosity and motivation, and the interest and confidence to persist in the profession.

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Appendix A. Student Curriculum Co-Developer Reflection Prompt

Please reflect on your experience as a co-developer of the [insert workshop name] workshop. We are especially interested in the story of your experience. The prompts below are meant to guide your reflection. You do not need to answer them one by one. Specific examples and moments are especially helpful.

- Please tell the story of developing this curricular experience. What parts were exciting or difficult? How did you work through uncertainty or setbacks? Looking back, what did these challenges teach you about how you learn or solve problems?
- What did you learn through this experience about the engineering content itself, teaching or communication, and yourself as a learner or engineer?
- How, if at all, did this experience influence your confidence, motivation, or sense of belonging in engineering?
- Looking back on the project as a whole, what feels most meaningful or rewarding?
- What do you hope students who participate in the workshop you developed take away from the experience?

Appendix B. Alumni & Industry Partner Interview Questions

Interview Questions:
1. What motivated you to participate in this curriculum development experience?
2. What were you hoping to contribute or give back to the next generation of engineers?
3. How did your own undergraduate experience influence what you chose to include in the curriculum or emphasize? If so, how?
4. In what ways did this experience impact you personally or professionally?

5. What new professional or personal connections did you gain through this experience? Were there any connections you strengthened?
6. If we were to run this curriculum development process again with other alumni, what advice would you give us?