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Developing Co-design Workshops with Engineering Students and their Families to promote an Engineering Identity for First-generation Students (Work in Progress)

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Work-in-Progress: Developing Co-design Workshops with Engineering Students and their Families to promote an Engineering Identity for First-generation Students

Abstract

There is a critical gap in engineering education research connecting familial support to the development of engineering identity in postsecondary settings, particularly for first-generation students as they transition into young adulthood. Current works highlight the importance of familial support reported through student perspectives, however there are few initiatives that actively engage family members in engineering experiences. This paper introduces a work-in-progress study of a family-inclusive engineering workshop for current engineering students and their families at San Francisco State University, a Minority Serving Institution (MSI). This paper reports on the details of the two-hour workshop, including the usage of LittleBits by Sphero, which aim to facilitate authentic, hands-on, design activities that simulate real-world engineering design tasks for students and their families. The paper also reports on preliminary data from researcher observations of the workshops and pre and post surveys.

Preliminary results indicate that the workshop has the potential to explore familial support systems through collaborative engineering design activities. Qualitative observations show that the workshops can encourage collaboration between families, that the low-stakes design problem can allow for play and lower creativity inhibitions, and that design divergence was impacted by the type of family relationships type, such as parents, cousins, or friends.

Introduction

Graduation outcomes for first-generation students in engineering remain significantly lower than for continuing generation students. With the rate for engineering job growth continuing to outpace the number of non-engineering jobs, it is critical we can graduate those interested in engineering careers. This requires not only preparing them well but also ensuring they feel they belong in the field of engineering for them to be retained in the field. This work-in-progress (WIP) paper reports preliminary data on a pilot engineering design workshop for engineering students and their families, looking to understand the impact of this workshop on familial support and engineering identity, both of which have been linked to increased persistence.

The impact of familial support on engineering students has been studied primarily from the perspective of the student [1], [2], [3]. Through this workshop, the research team sought to observe familial support from a holistic perspective, examining how shared participation in engineering activities shaped both students' and family members' perceptions of engineering and of the support needed through this academic journey. Previous work reports a feeling of dissonance from students, with their family's support being critical to their success, but sometimes feeling misunderstood by their families who may not have as much exposure to the field of engineering [2], [4], [5]. By having engineering students and their families engage in engineering design activities together, this work looks to understand that tension in order to help students and families strengthen their familial support structures.

By drawing on frameworks of engineering identity, particularly the roles of performance, recognition, and competence [14], the workshop introduced participants to the mindset, academic demands, collaborative culture, and support resources characteristic of undergraduate engineering programs at San Francisco State University. The design of this workshop also drew on the importance of asset-based cultural capitals including familial capital [10], to analyze the impact of belonging in engineering as first-generation students.

By bridging academic theory with practice, this workshop and future iterations aim to (a) demystify the engineering pathway for families, (b) strengthen students' engineering identity and sense of belonging, and (c) generate insights into family engagement strategies that promote persistence in engineering education at a college level. Ongoing analysis aims to explore how students and families interact within an engineering context, the influence of family involvement on student motivation, and the challenges of implementing collaborative, family-based workshops.

Related work

Family Engagement in STEM Learning

Families play a foundational role in shaping students' early interest, motivation, and confidence in STEM [6], [7]. Research in informal science education shows that when families take their children to accessible STEM environments such as museums, after-school programs, and community makerspaces, students demonstrate stronger STEM identity and more persistent engagement later on in their education [6], [7], [15]. These settings promote collaboration, curiosity, and open-ended exploration, aspects that are often limited in formal instructional spaces. However, these efforts overwhelmingly target K–12 settings, rather than college engineering environments where identity formation is still being actively developed and challenged by academic rigor. The limited involvement of families in postsecondary STEM learning suggests a largely unexplored avenue for designing supportive learning experiences that maintain family connection as students transition into higher education.

Familial Support and First-Generation Engineering Students

For first-generation and historically marginalized engineering students, family support is strongly linked to academic persistence, even when that support does not include technical engineering knowledge [4], [5]. Families frequently provide forms of social capital (support and knowledge people gain through their social relationships) through verbal encouragement and motivation, that help students overcome barriers in unfamiliar university environments [8], [9]. Yet because families are often physically and culturally removed from engineering programs, their support remains disconnected from students' day-to-day experiences in engineering spaces. Because most families of first-generation students have limited exposure to what engineering coursework involves, they often have little context for the difficulty, expectations, or norms their students navigate [2], [4], [5]. As a result, families may not be able to be fully supportive and may not be fully equipped to understand or affirm students' developing identities as engineers. Inviting families into engineering learning environments can help bridge this informational gap and strengthen mutual understanding of what it means to be an engineer.

Community Cultural Wealth and Funds of Knowledge

Asset-based frameworks such as Community Cultural Wealth [10] and Funds of Knowledge [11], [12] argue that first-generation and low-income students bring culturally rooted strengths into engineering, including creativity, caregiving skills, and practical problem-solving gained from home and work environments [11], [12]. Drawing from Yosso's Community Cultural Wealth framework, familial capital (the emotional support, cultural knowledge, and care provided by family networks) and aspirational capital (the ability to maintain hopes and long-term goals despite barriers) are critical contributors to persistence in engineering for students from under-represented backgrounds. These approaches challenge the persistent deficit narratives surrounding who "belongs" in engineering. By designing learning environments that invite students to apply their lived experiences and include their families, educators can more effectively recognize and elevate these assets to strengthen students' engineering identity.

Engineering Identity, Culture, and Inclusion

Engineering culture often focuses on individual performance and technical standards and treats stress as normal, which influences who feels seen and who is overlooked [1], [13]. Students who do not match the dominant identity of traditionally male, white/Asian, and continuing generation, often face compounded mental health pressures and barriers to belonging. Research on engineering identity emphasizes three major components: recognition (being seen by oneself and others as an engineer), interest (desire to engage in engineering), and performance/competence (belief in one's ability to do engineering successfully) [14]. Family members can influence all three dimensions, not just recognition. Through encouragement and validation, families boost recognition; through conversations, curiosity, and exposure to engineering-related ideas, families boost interest. And through emotional support and shared problem-solving, families can indirectly promote performance/competence by affirming students' abilities and helping them persist through challenges.

Gaps in Prior Research

Although prior research studies demonstrate the influence of family support on engineering persistence and identity [2], [4], [5], most do not explore family participation within postsecondary engineering learning environments. Hands-on family involvement efforts, such as makerspace-based programs described by Zimmerman et al. [6], primarily target younger learners, leaving a gap in understanding how intergenerational design activities might support engineering identity at the college level. Similarly, while asset-based literature highlights how students leverage community and familial capital [10], little is known about how families might reshape their own perceptions of engineering through shared creation. Finally, there is a lack of observational research documenting student-family dynamics such as role shifts, co-problem-solving, and engineering recognition, when students act as experts in front of their families. This pilot study begins to address these gaps by examining a family-inclusive engineering design experience within an informal, hands-on circuit-building workshop at a minority-serving institution. While multiple theoretical frameworks, including Community Cultural Wealth, Funds of Knowledge, engineering identity, and engineering culture, serve as important background and justification for the focus on familial support and asset-based context, they function primarily as conceptual grounding for this study. The primary analytical lens we will apply is Godwin's engineering identity framework, which guides the examination of how family involvement may shape recognition, interest, and performance/competence.

Methods

Workshop Design and Implementation

The workshop was designed to have an asset-based, collaborative approach to engineering design for students and family members. The first part of the workshop allowed students and families to arrive, grab coffee and pastries, sit at table with supplies, and complete an initial survey. The full agenda is listed in Table 1. The faculty researcher introduced herself to each of the families during the waiting period.

Table 1: Workshop Agenda

Time	Activity	Details
15 min	Arrival	Families arrive, check-in, grab refreshments, and complete initial survey
30 min	Introductions	Research team and families introduce themselves
15 min	Goals	Describe purpose of the activities
60 min	Engineering Design	Introduce design activity Spend time prototyping Share final prototypes with the group
15 min	Closing Surveys	Thank participants and have them complete final survey

As the three families made their way in, the research team started a presentation introducing each of the research students, all undergraduate engineering students, and the research advisor, a faculty in engineering. The team then had families introduce themselves out loud, having them share their names, role (family member or student), their hometown and a hobby or fun fact. The introductions were designed to make the space feel welcoming and have families know they were critical to our work. The research team also shared the same information in their introductions.

The team then described the goals of the activities, emphasizing that the team acknowledged the importance of drawing from personal backgrounds in engineering design to create a stronger sense of belonging for first-generation students. The team also provided a brief introduction of simple circuits (power, input, and output) and demonstrated the use of LittleBits, or lego-like circuit components.

Families had supplies at their tables including the LittleBits Kit, and arts and crafts supplies for prototyping including cardstock, scissors, pipe cleaners and tape. Once each family displayed some level of familiarity with the LittleBits through introductory prompts, we moved to the prompted design section. The prompt went as follows, “Think about your everyday life at home. What is one thing you could improve or automate to make life easier, safer, or more fun? Choose a problem you notice at home and design a creative solution for it.” The workshop at this point would follow a loosely scaffolded engineering design process that included (1) problem identification, (2) brainstorming and ideation, (3) prototyping, (4) testing and iteration, and (5) informal demonstration of each end product and which function it had fulfilled.

Overall, the workshop structure was deliberately designed to connect formal engineering education and family life, allowing participants to co-construct meaning around engineering together. By embedding engineering design within a collaborative, family-centered environment, the workshop aimed to strengthen engineering identity in hopes of helping the research team understand how familial capital can actively support persistence in undergraduate engineering pathways.

Participant Demographics

Our family-inclusive engineering workshop included three student-family groups: one student–parent pair, one student–friend pair, and one student–two cousins group. We embraced the broad definition of family, taking into consideration that students have strong social networks that may not only include immediate family members. This approach is informed by Tara Yosso's concept of familial capital, which expands the idea of family to include extended and chosen kinship networks [10]. Yosso describes familial capital as "*a commitment to community well-being...nurtured by our "extended family," which may include immediate family (living or long passed on) as well as aunts, uncles, grandparents, and friends who we might consider part of our familia* [10]." By acknowledging that first-generation students might not have immediate family members who provide direct support, but rather have "chosen family" who provide emotional and technical skills, this workshop aimed to include this broad definition of family.

Demographic data was collected through the pre-workshop survey administered during the first 10 minutes of the workshop. Participants ranged in age from 19 to 52 years old. Participants represented diverse gender identities, including male, female, and non-binary/third gender identities. In terms of race and ethnicity, participants identified as Hispanic or Latino and Asian. Primary languages reported included English and Spanish. Educational background varied, including high school completion, some college, and technical certification, associate degree, or bachelor's degree attainment.

Data Collection

Because participants did not consent for audio or video recording, the research team collected all data through field notes and surveys. This WIP paper presents preliminary findings from the researchers filed notes. During the workshop, researchers independently documented observations using personal notebooks or electronic devices. Notes focused on participant interactions, student–family dynamics, engagement with workshop activities, and emergent questions or moments of interest within each of the three student–family groups.

Following the workshop, all handwritten and electronic notes were digitized and consolidated into a secure, research-approved online folder. These notes were then prepared for qualitative analysis and uploaded into Dedoose, where they were reviewed collaboratively by the research team.

Each researcher independently reviewed the observational notes, after which the team cross-checked interpretations and shared preliminary findings to ensure consistency and credibility across analyses.

Positionality Statement

The undergraduate co-authors are engineering students engaged in engineering education research who bring lived experience navigating technical coursework alongside family expectations and support.

One co-author is a queer and trans Asian American mechanical engineering student with experience in qualitative research and STEM education studies. Their prior research experience informed the qualitative analysis process, while their work as a Learning Assistant and peer mentor in physics and engineering courses influenced the design and facilitation of the hands-on workshop activities. These experiences shaped how the workshop was structured to support collaborative learning, accessibility, and participant engagement.

Another co-author is an African American mechanical engineering student with a background in business. His recent work over the summer leading into the semester has fueled his engagement in learning how the workshop would be structured.

The senior author is an Assistant Professor of Mechanical Engineer and has a research background in engineering education, specifically design education. She brings her experience as a first-generation Latina in engineering to the development of this work.

Preliminary Results

To examine how students and family members engaged with engineering activities in practice, we conducted preliminary qualitative analysis of observational field notes collected during the workshop.

<u>Observational Notes</u>

Observational data was collected by multiple members of the research team, including the principal investigator and research assistants, who independently documented participant interactions throughout the workshop. Field notes captured moments of collaboration, problem-solving, communication, and engagement across the three student–family groups. Notes were coded in Dedoose using an iterative coding process, and analysis is ongoing. The findings presented here reflect emerging themes identified across observations rather than finalized conclusions.

<u>Collaborative Family Engagement in Engineering Design</u>

Across all three groups, observational notes highlighted frequent collaboration between students and family members during brainstorming, prototyping, and troubleshooting activities. Family members actively contributed ideas, suggested design modifications, and assisted with material use as students built and tested prototypes. Rather than observing passively, family participants engaged alongside students in shared problem-solving processes.

In several instances, collaboration evolved over time, with participants initially working independently before gradually engaging more closely with one another. Field notes described moments where family members offered functional insights or mechanical reasoning while students led assembly or experimentation. These interactions suggest that the workshop structure supported engineering as a relational and shared activity, reinforcing the role of family engagement in undergraduate engineering learning.

For example, observational notes described a parent identifying a functional issue in a circuit configuration and suggesting a modification, while the student simultaneously adjusted components and tested the prototype. In another instance, a family member recalled that a motor's rotation direction could be changed, prompting the group to revise their design approach and continue experimenting together.

In a different group, field notes captured family members assisting with material selection and organization—helping locate components, reading instruction cards aloud, and offering suggestions—while the student explained component functions and led assembly. These moments illustrate reciprocal collaboration, with family members and students contributing complementary forms of knowledge during the design process.

Reducing Intimidation Through Play, Humor, and Hands-On Experimentation

Observational notes also captured how playfulness, humor, and hands-on interaction helped reduce intimidation associated with engineering tasks. Participants frequently used humor, informal language, and laughter when encountering unexpected outcomes, errors, or unfamiliar components. These moments often coincided with experimentation, such as testing circuits, reassembling parts, or trying alternative configurations.

Hands-on materials appeared to lower barriers to participation by encouraging exploration without fear of failure. Participants handled components freely, took apart and rebuilt designs, and responded to non-working prototypes with curiosity rather than frustration. These observations suggest that playful and informal interactions may have supported a more approachable engineering environment, allowing participants to engage with engineering concepts in ways that felt accessible and low-risk.

Observational notes frequently documented humor and informal language during moments of trial and error, such as participants laughing when circuits produced unexpected sounds or movements and joking about "alchemy" or "Iron Man–like" inventions. These moments often occurred alongside hands-on experimentation, including taking apart and rebuilding circuits or swapping components to see what would happen.

In one group, participants responded to a non-working prototype by playfully suggesting alternative uses for the design and continuing to test configurations rather than abandoning the task. Field notes described participants freely handling components, disassembling circuits, and reassembling them without hesitation, suggesting that the hands-on format and playful atmosphere helped normalize experimentation and reduced fear of "doing it wrong."

Divergent Design Approaches Shaped by Relationship and Experience

While collaboration and engagement were observed across all groups, design approaches varied depending on participant relationships and prior experiences. One group consisting of cousins emphasized creativity and personal experience, frequently drawing on everyday life and humor to inspire design ideas. Another group, composed of a student and a parent, focused more heavily on mechanical functionality and component behavior, often prioritizing how individual parts operated within the system. A third group of student-friends appeared more oriented towards task completion, treating the activity similarly to an academic assignment and emphasizing functional completion over exploratory design.

These differences highlight how participants' relationships and prior exposure to engineering influenced how they approached problem identification, ideation, and prototyping. Importantly, no single approach dominated the workshop; instead, the diversity of design mindsets reflected the varied ways participants made meaning of engineering within a family-inclusive setting. For instance, observational notes from a group of cousins documented frequent references to personal and everyday experiences during brainstorming, including playful ideas inspired by household routines and humor-driven design concepts. This group prioritized creativity and aesthetic considerations alongside function, often experimenting with materials to "make it look nice" even when the prototype was already operational. In contrast, field notes from a student–parent group emphasized mechanical reasoning and functionality, with participants focusing on how sensors, motors, and power sources interacted within the system. Meanwhile, a group of student-friends appeared more focused on completing the task efficiently, treating the activity similarly to an academic assignment and prioritizing functional completion over exploratory or aesthetic refinement. Together, these examples illustrate how a family-inclusive engineering workshop can support multiple, equally valid ways of engaging with design, shaped by participants' relationships, prior experiences, and comfort with engineering practices.

Post Workshop Survey Feedback

To complement observational findings, participants also provided open-ended feedback through post-workshop survey responses. These reflections offer additional insight into participants' perceptions of the workshop experience and highlight areas of strength and opportunities for improvement. Open-ended post-workshop survey responses provided additional insight into participants' experiences and perceptions of the workshop. Participants highlighted enjoyment of teamwork, creativity, and hands-on learning, frequently describing the workshop as "fun," "hands-on," and "inclusive." Many participants valued the opportunity to spend time together while engaging in engineering-related activities. Suggestions for improvement primarily focused on logistical refinements, including the availability of additional adhesive materials (e.g., glue or tape) and, for some participants, the integration of Arduino-based kits to increase technical rigor. These reflections align with observational findings and provide practical guidance for refining future workshop iterations.

Future Work

In an effort to create a more cohesive experience in the next iteration of the workshop, the research team will incorporate lessons learned from this pilot workshop. We will ensure the design prompt provides clarity in the task for participants while still allowing creative freedom. Clearer directions could help participants have an easier time constructing prototypes than what was observed in the pilot workshop. Taking what we learned from the feedback, we plan to have a more expansive list of materials available for prototyping. Glue guns were the most requested item that we did not have available.

We also noticed several design limitations related to data collection and workshop structure. Open-ended survey responses primarily addressed materials and logistics, suggesting that future prompts could be revised to more explicitly elicit reflections on family interaction, collaboration, and learning processes. Planned workshop refinements include clearer survey instructions, expanded material options, and additional scaffolding for participants unfamiliar with digital tools. Building on these insights, our lab aims to expand this pilot model to further examine how family-inclusive engineering design experiences can support belonging, persistence, and intergenerational understanding within engineering education.

Conclusion

Family support remains a critical, though often an underexamined, contributor to the success and persistence of first-generation engineering college students. Prior research has consistently demonstrated that families provide emotional encouragement, motivation, and a sense of purpose that sustains students through demanding engineering pathways, even when family members lack direct technical knowledge of the field. However, much of the existing literature relies on retrospective accounts through interviews rather than direct observation, leaving limited insight into how families engage with engineering practices in real time.

This work-in-progress workshop begins to address that gap by examining firsthand accounts via a family-inclusive engineering design workshop. From bringing engineering students and their chosen family members into a university environment and engaging the participants through a hands-on, collaborative design activity, the workshop created an opportunity to observe how families interact with engineering processes, materials, and ways of thinking. By allowing these normally separated aspects of a student's life to be present for formal academic settings, this type of workshop gives us insights into familial support structures.

By documenting the design of a two-hour pilot workshop and examining detailed observational notes through an asset-based and familial capital framework, these preliminary results offer insights into how family inclusive engineering spaces may function and what considerations are necessary to support meaningful engagement. For students, these workshops have the potential to reinforce engineering identity, giving students opportunities to build recognition as engineers, more interest in engineering and even gain competencies in engineering, and reshape how they perceive and navigate engineering culture on campus. For families, participation may demystify engineering and open pathways for more informed and affirming support. Although preliminary, these findings underscore the promise of family inclusive approaches in engineering education. By intentionally recognizing and leveraging familial capital, engineering programs can move toward more inclusive, community-oriented learning environments that better support first-generation students throughout their academic journeys.

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