Engineering Passion Projects (Resource Exchange)

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Shaylin Williams is invested in identifying ways to improve the engineering education experience for future generations of engineers. As a McNair Scholar, Shaylin worked on chemical engineering projects creating thermal barriers for food packaging and studying soil remediation. Additionally, she completed an REU project in healthcare engineering at the University of Wisconsin- Madison. She earned a master's degree in industrial and systems Engineering with a Management Systems Concentration in December 2022. Shaylin recently completed her Ph.D. in Engineering Education at Mississippi State University, using Self Determination Theory to analyze freshmen and continuing Summer Bridge students' experiences and senior engineering students' graduation plans. She previously worked on a longitudinal study researching how varying first-year experience structures affect students' engineering identities and involvement in communities of practice. Shaylin now serves as an Assistant Professor for the University of Virginia's First Year Engineering Center and is interested in learning more about what contributes to engineering students' success, how they can get the most out of their undergraduate programs, and how programs can be better designed to cater to students' needs.

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Overview

During a STEM Career Day at a local youth organization, engineering faculty asked K-12 students, "Are you interested in engineering?" Many students seemed shocked, as if engineering were a field that they could not possibly explore. This resource exchange paper describes a summer engineering enrichment program implemented in partnership with a local Boys & Girls Club serving rising 6th–9th grade students (ages 11–15). The program was conducted in summer 2025 with the primary goal to increase engineering awareness and promote design confidence by connecting engineering principles to students' existing interests, particularly sports and cosmetology. While many pre-college engineering programs emphasize robotics or pre-structured technical builds, this model positioned engineering as a problem-solving framework embedded within domains already meaningful to participants. The program was intentionally designed for adaptability within community-based settings operating with moderate resources.

Program Structure

Schedule and Staffing

- Two non-consecutive weeks
- Seven weekdays total
- 1:00–3:00 PM sessions
- ~14 students
- 1 lead instructor, 1 assistant

Students worked in teams of three to four to balance collaboration with active participation.

Instructional Flow

Each session included:

1. Brief review or design prompt
2. Targeted mini-lesson introducing relevant engineering concepts
3. Structured brainstorming (minimum five ideas before selection)
4. Prototype construction or modification
5. Testing and redesign
6. Short written or facilitated reflection

*Requiring multiple ideas prior to building was intended to discourage premature solution fixation and promote divergent thinking.

Engineering Design Framework

Students engaged in a simplified engineering design process: ask/define, research, imagine/plan, create, test, improve.

06/16/2025	Ask/Define, Research	Asked interview-style questions to learn more about their problem
06/17/2025	Research, Imagine/Plan	Researched what solutions already exist & uncover gaps
06/18/2025	Imagine/Plan	Participated in brainstorming and ideation sessions to develop alternatives
07/08/2025	Create, Test	Constructed solutions and interpreted if goals were achieved
07/09/2025	Create, Test	Constructed solutions and interpreted if goals were achieved
07/10/2025	Improve	Improved their design solutions and submitted final version for feedback
07/11/2025	*Reflect & Debrief*	Celebration and presentation of projects; debriefed for reflection and feedback

Distinguishing Features

Interest-Responsive Framing

Students completed an informal interest inventory. Sports and cosmetology emerged as dominant themes and were intentionally integrated into subsequent design challenges. Rather than treating these interests as peripheral to STEM, facilitators framed engineering concepts within familiar contexts. This approach was intended to increase perceived relevance and engagement.

Modular Materials Strategy

Students worked with smaller, modular engineering kits supplemented by low-cost consumable materials (e.g., cardboard, foam sheets, elastic bands, connectors). Compared to comprehensive, pre-packaged systems, this approach:

- Reduced initial cognitive load
- Encouraged rapid prototyping
- Increased customization
- Supported iterative redesign

Students informally reported preferring modular kits because they were easier to modify and less overwhelming.

Budget Flexibility: Approximately 15–20% of the materials budget was reserved for discretionary purchases. This allowed facilitators to respond to emergent student design ideas by acquiring additional structural or aesthetic components as needed. Built-in flexibility supported responsiveness while maintaining cost control.

Sample Multi-Session Implementation: Cosmetology-Informed Challenge

One representative activity was implemented across the seven sessions. Students were tasked with designing and prototyping a hair styling tool to improve an inefficiency within the typical cosmetology setting. The challenge leveraged students' interest in cosmetology to introduce engineering principles related to material properties, structural performance, and appropriate sizing and dimensioning.

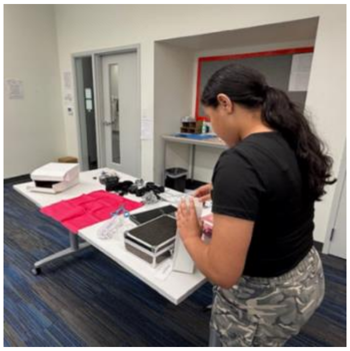

Figure 2. Fabricating designs-1

Figure 1. Fabricating designs-2

<u>Problem Description:</u>
Cosmetology is all about beauty, self-expression, and helping people feel confident—from hair and makeup to skincare and nails. But behind the scenes, cosmetologists face real challenges every day. Whether it's messy makeup storage, tools that are hard to clean, or hair products that spill easily, there's always room for smart solutions.

<u>Your challenge:</u>
Use your creativity and engineering skills to design and build a physical prototype that helps solve a real problem in the world of cosmetology.

Figure 3. Excerpt from design challenge details- given to students

Outcomes

Formal pre/post survey data collection was not completed due to organizational constraints at the host site. As such, outcomes are limited to participation metrics and qualitative observations.

- Over 80% of enrolled students attended at least six of the seven sessions.
- Most participants voluntarily presented prototypes during the culminating showcase.

Facilitators observed increased willingness to revise prototypes, greater student-led troubleshooting by later sessions, and more consistent use of engineering vocabulary during reflections. Design sketches also became more detailed over time. Future implementations will incorporate structured assessment tools to more systematically evaluate changes in engineering self-efficacy.

Figure 4. Prototyping session

<u>While the original project goal of sustained engagement in the full engineering design process across multiple weeks was not fully realized due to attendance variability, the project successfully met key outreach objectives:</u>

1. **The implementation of one-day, high-impact STEM activities proved particularly effective.**

For example, students completed introductory robotics kit activities that allowed them to design and construct functioning coloring robots. Students displayed excitement and pride when their devices successfully operated, often choosing to troubleshoot and rebuild when initial designs did not function as intended. These behaviors reflect important early indicators of engineering self-efficacy, including problem-solving persistence, willingness to iterate, and confidence in learning through failure. Informal student feedback suggested that participants developed increased openness toward STEM learning and greater confidence in their ability to attempt technical tasks.

2. **The community partner for this COEP is now also a client for UVA's School of Engineering and Applied Sciences (SEAS) student design teams, demonstrating strengthened connections with the local community.**
3. **The program lowered perceived barriers to engineering participation, introduced students to hands-on STEM experiences, and fostered positive attitudes toward experimentation and design thinking.**

Implementation Considerations

For replication in youth-serving contexts, the following components are recommended: small teams (3–4 students), daily structured reflection, flexible materials allocation (15–20% discretionary), culminating showcase, one-day experiences for optional-attendance settings, and required multi-idea brainstorming.

**Early coordination with host organizations should clarify attendance expectations, scheduling stability, space access, media permissions, and feasible evaluation strategies. Contingency planning for data collection is advisable in community-based environments.*

Ethical Considerations

Written media release permissions were obtained through the host organization prior to the inclusion of student photographs. Images are provided for contextual illustration and are not presented as evidence of efficacy.

Conclusion

This program demonstrates a feasible model for interest-responsive engineering enrichment within a short-duration, community-based summer format. By integrating student-identified interests, emphasizing iterative design, and employing flexible modular materials, the model offers a practical framework adaptable to varied resource levels. Future iterations will strengthen systematic assessment while preserving the program's identity-affirming and iterative design focus.