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NSF CAREER: Engineering Pathways for Appalachian Youth: Design Principles and Long-term Impacts of School-Industry Partnerships

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Introduction

Expanding access to engineering and skilled technical careers continues to be a national priority (Sciences et al., 2017, particularly in rural Appalachian regions where longstanding structural barriers limit students' exposure to and participation in engineering pathways (Ardoin, 2017; Carrico, 2013). Students in these communities remain underrepresented in engineering fields (Carrico, 2013), highlighting the need for targeted, context-sensitive interventions. This NSF CAREER project responds to these challenges by cultivating partnerships among educators, regional organizations, and industry partners to support the development of sustainable K–12 engineering pathways. During the past year, project activities have emphasized the delivery of professional development informed by teacher-identified needs, the strengthening of relationships among educators and regional collaborators, and the design of learning experiences that link classroom instruction to authentic engineering contexts.

Project Overview

The CAREER project was initially designed to investigate how students in rural Appalachian communities, particularly in Southwest Virginia, develop interest in engineering over time and how that interest can be supported across educational transitions. Early project goals included examining engineering career trajectories from middle school through postsecondary education and leveraging tools such as programmable microcontrollers to maintain student engagement. These efforts relied on close collaboration with regional educators and industry stakeholders. However, the COVID-19 pandemic significantly disrupted planned activities, limiting opportunities for in-person engagement and slowing relationship-building with schools.

In the years following these disruptions, the project has shifted toward rebuilding and strengthening school–university and school–industry partnerships while developing a more nuanced understanding of the educational and workforce landscape in rural Southwest Virginia. Although systemic challenges continue to complicate the creation of broad engineering and technical pathways for Appalachian youth, recent work has prioritized teacher professional development and expanded support for integrating engineering into K–12 classrooms across the region.

In response to these evolving needs and contextual constraints, the project has increasingly centered on teacher preparation and professional learning as a primary mechanism for broadening engineering pathways for Appalachian youth. Rather than focusing solely on student-facing interventions, the project now emphasizes supporting educators as key agents of change within their schools and communities. This shift led to the development of a summer professional development workshop designed to equip teachers with transferable engineering concepts, classroom-ready activities, and increased awareness of regional engineering and manufacturing careers. Building on earlier project phases, the past year's work has focused on two interconnected efforts:

1. The second iteration of an engineering professional development workshop to more explicitly reflect regional workforce priorities and local industry contexts, and
2. The continued strengthening of regional collaborations with school systems, university partners, and industry stakeholders to support sustained engagement beyond the workshop experience.

Revised Engineering Professional Development Workshop with Regional Focus

Building on insights from the initial needs assessment and evaluation of the first summer workshop, the project team redesigned the professional development experience to more explicitly reflect the educational and workforce contexts of the region surrounding the university. The revised workshop was implemented in summer 2025 as a two-day, in-person experience for 17 educators representing five school systems in Southwest Virginia. Participants taught across a range of subject areas, including science, career and technical education (CTE), and world languages, reflecting the project's continued emphasis on interdisciplinary engineering integration.

Feedback from the prior workshop indicated that teachers valued hands-on, adaptable activities, and areas of interest emerged around manufacturing and artificial intelligence, particularly given the prominence of manufacturing industries in the region and growing curiosity about how AI is shaping engineering practice. In response, the revised workshop emphasized systems thinking as an organizing framework while situating engineering content within regionally relevant manufacturing contexts. Workshop sessions incorporated hands-on activities related to advanced manufacturing, data science, artificial intelligence, and 3D printing, with explicit discussion of how these topics connect to regional industries and workforce needs.

In addition to content refinements, the workshop design placed greater emphasis on relationship-building and sustained engagement. Structured time was included for informal discussion, peer exchange, and reflection on classroom application. Former workshop participants were invited to engage with new participants, facilitating the exchange of ideas and providing informal peer mentorship throughout the workshop. These design decisions were intended to support teachers' confidence in adapting engineering activities for their own contexts while strengthening connections among participants, university partners, and regional stakeholders.

Preliminary Findings and Lessons Learned

Preliminary findings from survey responses and continued engagement across both workshop cohorts suggest that the professional development model supported tangible classroom implementation, sustained collaboration, and strengthening of school–university partnerships. Across the two cohorts, 18 teachers have remained involved with the project beyond the initial workshop experience in some capacity. These sustained partnerships extended beyond informal communication and included curriculum co-design, classroom implementation, field trips, and in-class instructional visits by the university team.

Several examples illustrate how teachers translated workshop learning into practice:

- One teacher education faculty member partnered with the project team to co-develop an activity in which preservice teachers used artificial intelligence tools to enhance lesson planning and instructional design. This extension of the workshop's AI content broadened the impact of the program by influencing future K–12 educators' approaches to instructional integration.
- Multiple teachers organized student field trips to the university's engineering laboratories following the workshop. These visits exposed approximately 85 students (grades 9–12) to engineering facilities, faculty, and postsecondary pathways, reinforcing connections between classroom learning and regional engineering careers.
- One participating teacher hosted the project team to lead a hands-on engineering design process activity in their classroom, serving approximately 30 students. This session emphasized problem definition, iterative design, and systems thinking, modeling how engineering integration can be embedded within existing curricular structures.

In addition to classroom enactment, sustained engagement also emerged within the professional learning community itself. Three teachers from the 2024 cohort returned to participate in the 2025 workshop in a peer mentorship role, supporting new participants through informal discussion and shared classroom examples. This layered participation suggests the development of a growing community of practice and signals movement beyond a one-time workshop model.

Several lessons learned regarding school–university partnership design appear to have contributed to these outcomes. First, grounding activities and examples in local contexts enhanced relevance and teacher buy-in. Second, intentionally creating space for teachers to share expertise and positioning them as valued collaborators, rather than passive recipients of professional development, strengthened relational trust. Third, providing individualized follow-up support during the academic year enabled teachers to adapt workshop concepts to their specific instructional contexts. Collectively, these design elements appear to have supported both sustained engagement and classroom-level implementation.

While these findings are preliminary and primarily reflect teacher-reported and partnership-level outcomes, they provide early evidence supporting the project's theory of change: that investing in teacher preparation, regional alignment, and sustained school–university relationships can expand engineering integration in rural classrooms and increase students' exposure to engineering pathways.

Connecting the Research and Future Directions

This year's work will continue to focus on sustaining and expanding support for rural teachers in Southwest Virginia as they integrate engineering and manufacturing concepts into their classrooms. Building on relationships established through the first two iterations of the summer professional development workshop, the project team will maintain engagement with participating educators through ongoing communication, classroom visits, and tailored follow-up support during the academic year. These interactions will inform continued refinement of professional development activities and help ensure that support remains responsive to teachers' instructional contexts.

The project will also continue to offer the summer professional development workshop, with plans to implement a third iteration that builds on prior evaluation and participant feedback. This iteration will further strengthen the project's professional development framework and serve as a model for guiding the

development of additional workshops focused on topic areas. By articulating and applying this framework, the project aims to support other faculty and partners in designing regionally relevant professional development experiences aligned with local workforce needs.

In addition to continuing work with existing partners, the project will pilot new approaches to sustained engagement by developing more intentional relationships with a nearby school system. This effort will allow the project team to explore deeper collaboration at the district level, including coordinated professional development, classroom support, and alignment with local priorities. Alongside these efforts, the project will continue to strengthen networks among educators and regional partners, supporting the growth of a community of practice and advancing long-term integration of engineering education across the region.

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