Board 336: NSF CAREER: Engineering Pathways for Appalachian Youth: Design Principles and Long-term Impacts of School-Industry Partnerships

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

Introduction

Broadening participation in the skilled technical workforce is a national priority due to increasing demand for engineers and the need for representation of the nation's rich diversity. In particular, scholars and activists call for improved education access, quality, and workforce development in rural Appalachian communities. Students from these communities face distinct challenges in accessing higher education and pursuing engineering careers. The Appalachian Regional Commission has deemed it essential to invest in preK-12 education, engage youth in community activities, and cultivate workforce opportunities in fields like advanced manufacturing. These activities are vital for strengthening economic resilience and broadening students' conceptions of what engineering is and who can do it.

Project Overview

This CAREER project originally focused on exploring engineering career pathways in rural, Appalachian communities in Southwest Virginia, building on previous efforts described in other sources. The original goals of the project sought to more deeply understand the longitudinal development of engineering interest from middle school through post-secondary education, and sought to utilize programmable microcontrollers to aid sustained engineering interest. These efforts would involve partnering with educators and industry partners in Southwest Virginia. The COVID-19 pandemic majorly disrupted programmatic efforts and halted the cultivation of relationships with educators. Work on this grant since the onset of the pandemic has focused on rebuilding school-industry and school-university partnerships and understanding the contextual nature of rural education in Southwest Virginia. Although necessary, creating engineering and technical career pathways for Appalachian youth on a large scale is difficult in the context of broader systemic issues. Previous research shows that sparking interest in engineering is not enough to inspire individuals to explore engineering as a career option. Recent efforts have honed in on meeting teachers' needs related to integrating engineering into their K-12 classrooms. The following areas of research have emerged as the primary focus of grant work in the past year:

1. Understanding teacher needs related to integrating engineering into their classrooms through relationship-building and conducting a formal needs assessment
2. Developing an institute-style professional development program
3. Meeting immediate or short-term teacher needs via:
    a. Supplying Arduino activities
    b. Developing an engineering discipline exploration opportunity for students

The following sections describe each current focus area, ending with future directions of this CAREER project.

Understanding Teacher Needs

This research area specifically focuses on identifying the needs of teachers in rural Southwest Virginia related to integrating engineering in their classrooms. The goals of this research area are twofold: 1) to meet immediate needs by providing easily-implementable engineering activities and resources that can be used in the classroom, and 2) to provide opportunities for in-depth training to strengthen educators' ability to confidently and effectively incorporate engineering into their classrooms. Through ongoing conversations with teachers and administrators, we were able to discern the types of support teachers desired. Largely, they wanted to know what their peers at other schools/in other districts were doing regarding engineering in their classrooms. They expressed that it is hard to know what they need without some sort of benchmarking mechanism or a source of inspiration. While many are eager to incorporate engineering, most do not know where to start. The second most commonly expressed sentiment is that teachers and students alike are unaware of the distinctions between engineering disciplines and unsure of the breadth of potential career paths available within engineering. These two findings are being used to inform how we move forward discovering and meeting teachers' needs.

Needs Assessment for Teachers Interested in Integrating Engineering

This ongoing research area focuses on developing and conducting a needs assessment tailored to educators who have an interest in integrating engineering concepts into their classrooms. Targeting K-12 educators, this project component is currently in progress, focusing on understanding the unique desires and challenges faced by teachers committed to incorporating engineering education. Findings will directly inform the development of a targeted professional development program and resources catering specifically to teachers interested in integrating engineering into their curriculum. We aim to enhance the effectiveness of teacher training by aligning it with the identified needs of educators seeking to integrate engineering, ensuring a more impactful educational experience for both teachers and students.

Survey participants will be recruited via email. Emails will be distributed through educator liaison networks and school and county-level administrators in the Southwest Virginia region which contains approximately 150 schools. The survey contains items related to teacher demographics, general professional development experiences and preferences, scheduling and logistics preferences for professional development opportunities, and specific interest in engineering and arts integration. Table 1 contains sample survey items from each section.

Table 1. Needs Assessment Survey Item Samples

Demographic Items
What is your role in the education sector?
How many years of teaching experience do you have?
Which subject(s) or grade level(s) do you teach? (Select all that apply)
What school district are you affiliated with?
Professional Development Preferences
When considering professional development offerings, which factors are most important to you? Please select and rank from among the following. · Cost of attendance · Content relevance · Timing · Modality · Continued support after professional development experience · Other
What timing works best for professional development opportunities? Please select and rank from among the following. · During school hours · On school breaks · After school hours · Over the summer · Ongoing semi-regular interactions (e.g., one afternoon per month; one day per quarter) · Other
Which modality do you most prefer for professional development opportunities? 1. In-person 2. Online synchronous 3. Online asynchronous (e.g., self-paced curriculum) 4. Hybrid (combination of in-person and online)
What factors hinder your ability to implement changes from professional development in your classroom? Select all that apply. 1. Lack of resources/materials

2. Limited time
3. Insufficient training/support
4. Resistance from students or colleagues
5. Other (please specify)

If Virginia Tech's Center for Educational Networks and Impacts could better support educators in our region, what are some of the opportunities or initiatives that you would like to see offered?

Professional Development Experiences and Motivation

Tell us about a professional development opportunity you found really interesting and effective. What made it interesting and effective?

Now please think about professional development experiences that haven't been as great. What do you think makes professional development less effective or interesting?

What motivates you to pursue professional development?

Which topics or areas are you most interested in for professional development (e.g., curriculum development, assessment, technology integration, leadership)?

Engineering Integration

What motivates you to integrate engineering in your classroom? Please select and rank from among the following.

- Enhancing problem-solving skills
- Fostering creativity and innovation
- Connecting STEM concepts to real-world applications
- Addressing real-world challenges through design thinking
- Meeting curriculum standards
- Other

The following are common challenges faced when integrating engineering into K-12 classrooms. Which do you anticipate being the biggest challenges in your classroom? Please select and rank from among the following.

- Lack of resources or materials
- Insufficient training or knowledge in engineering concepts
- Limited time within the curriculum
- Difficulty in aligning engineering activities with existing subjects
- Resistance from students or colleagues

- Other

Which types of professional development experience would be most beneficial to support the integration of engineering into your classroom? (Select all that apply)

1. Workshops focusing on engineering concepts and their application in education
2. Collaborative sessions with engineers or industry professionals
3. Online courses specifically tailored for integrating engineering into curriculum
4. Networking opportunities with educators experienced in teaching engineering
5. Exposure visits to engineering-related industries or institutions
6. Other (please specify)

What is your preferred modality for learning about integrating engineering into your classroom?

1. In-person workshops or sessions
2. Online webinars or courses
3. Hybrid (combination of in-person and online)
4. Reading materials or resources
5. Other (please specify)

Are there specific people, resources, or organizations you would like to be connected with to enhance your understanding of integrating engineering into your classroom?

What else would you like to share about your interest or preferences regarding professional development opportunities for engineering integration?

Arts Integration

What motivates you to integrate arts into your classroom? Please select and rank from among the following.

- Enhancing creativity and self-expression
- Encouraging critical thinking and problem-solving _
- Making learning more engaging and enjoyable
- Connecting different subjects through interdisciplinary approaches
- Supporting socio-emotional development through artistic expression
- Other

The following are common challenges faced when integrating arts into K-12 classrooms. Which do you anticipate being the biggest challenges in your classroom? Please select and rank from among the following.

- Limited resources or materials for arts education
- Lack of formal training or expertise in arts instruction
- Time constraints within the curriculum
- Difficulty in integrating arts with existing subjects
- Resistance from students or colleagues towards incorporating arts
- Other

What type of professional development experience would be most beneficial to support the integration of arts into your classroom? (Select all that apply)

1. Workshops focusing on arts integration strategies across different subjects
2. Collaborative sessions with artists or arts educators
3. Online courses specifically tailored for integrating arts into curriculum
4. Networking opportunities with educators experienced in teaching arts integration
5. Exposure visits to art-related institutions or programs
6. Other (please specify)

What is your preferred modality for learning about integrating arts into your classroom?

1. In-person workshops or sessions
2. Online webinars or courses
3. Hybrid (combination of in-person and online)
4. Reading materials or resources
5. Other (please specify)

Developing Institute-Style Professional Development Program

This research area specifically focuses on the development of an institute-style teacher professional development program informed by literature on K-12 education and an investigation of the needs of educators in the rural Appalachian region of Southwest Virginia. The program, set to be piloted in Summer 2024, will focus on broadening teacher conceptions of engineering, familiarizing teachers with the engineering industry needs of the region, and facilitating collaborative networks among educators in the region to provide a source of ongoing support. The focus on conceptions of engineering, local industry needs, and community will help teachers' ability to connect engineering skills to contexts and industries students are familiar with. Ongoing networking among educators, university liaisons, and local industry will strengthen the ability of K-12 schools to prepare their students for a wide range of relevant career paths that retain talent in the local community. This first pilot aims to identify approximately five teachers who will learn about engineering industry needs and opportunities in the Southwest Virginia region, and explore available resources to develop engineering curriculum that can be implemented in their classrooms.

Meeting Immediate or Short-Term Teacher Needs

Arduino Activities

This focus area aims to meet short-term teacher needs related to engineering activities in the classroom without incurring any additional burden, financial or otherwise. The research team has responded to more immediate needs by providing STEM kits to teachers on an as-needed basis. Using programmable Arduino microcontrollers, in alignment with the original project goals, the kits were developed to be simple, transportable, and easy to implement without prior knowledge of microcontrollers or engineering concepts. The kits, which contained microcontrollers, temperature probes, and digital read-out screens (Figure 1), allow students to explore the greenhouse effect by measuring the effect of carbon dioxide (CO2) concentration on air temperature.

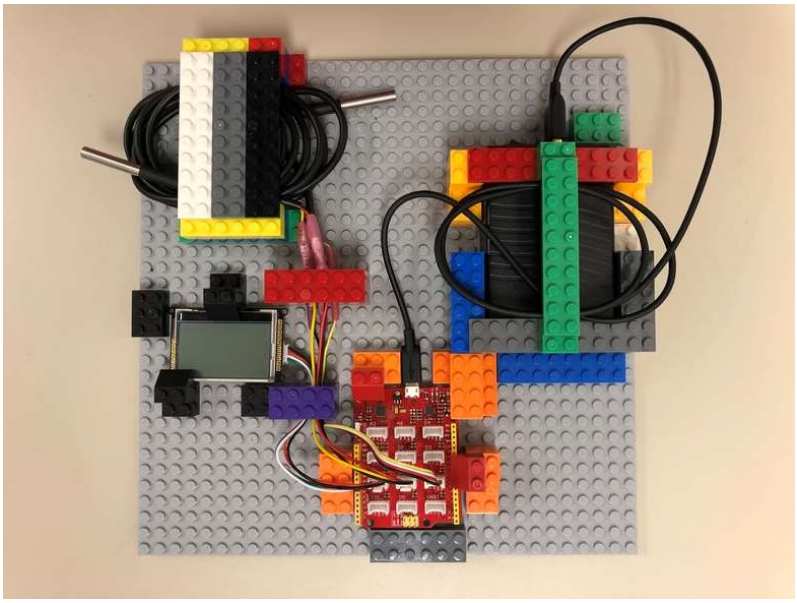

Figure 1. STEM Kit Setup

Engineering Discipline Exploration

This focus area responds directly to feedback from teachers, who emphasized the need for their students to gain more exposure to the diverse opportunities within the field of engineering. The initiative centers on college students visiting local K-12 schools, engaging with children to discuss the various engineering disciplines they can pursue in college. In many cases, students embark on major exploration only after starting college. Without a parent or a mentor who is an engineer, they often lack the exposure needed to envision themselves in an engineering profession.

This outreach effort aims to guide students toward opportunities they might be unaware of or that align closely with their interests. The objective is to introduce a broad spectrum of engineering specialties to K-12 students, thereby expanding their perceptions of what it means to be an engineer. The research team has connected with relevant partners on campus and is working to respond to this identified need in a way that strategically leverages existing events for engaging with students (e.g., local STEM nights). This will be done through the development of an informative exhibit that can be transported to various existing STEM outreach events. This effort will be a step toward making knowledge about pathways in diverse engineering fields more accessible to students who might not otherwise have the opportunity to explore these options.

Connecting the Research and Future Directions

The overarching theme threading recent research efforts in this project is the importance of understanding and overcoming the multifaceted challenges teachers face when incorporating engineering concepts and activities into their classrooms. Addressing immediate needs with

STEM kits allows teachers to expose students to engineering without imposing additional burdens, whether financial or otherwise. Future work will focus on the expansion of professional development offerings, further building networks among teachers, and establishing connections between educators and industry partners. This strategic approach seeks to raise awareness of local engineering opportunities, contributing to talent retention within the region and fostering sustainable growth in the skilled technical workforce.

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