Engagement in Practice: Lessons Learned Partnering with Science Educators and Local Engineers in Rural Schools

Ms. Holly Larson Lesko, Department of Engineering Education, Virginia Tech
Dr. Jacob R. Grohs, Virginia Tech

Jacob Grohs is an Assistant Professor in Engineering Education at Virginia Tech with Affiliate Faculty status in Biomedical Engineering and Mechanics and the Learning Sciences and Technologies at Virginia Tech. He holds degrees in Engineering Mechanics (BS, MS) and in Educational Psychology (MAEd, PhD).

Dr. Holly M. Matusovich, Virginia Tech

Dr. Matusovich is an Associate Professor in Virginia Tech's Department of Engineering Education. She has her doctorate in Engineering Education and her strengths include qualitative and mixed methods research study design and implementation. She is/was PI/Co-PI on 10 funded research projects including a CAREER grant. She has won several Virginia Tech awards including a Dean's Award for Outstanding New Faculty. Her research expertise includes using motivation and related frameworks to study student engagement in learning, recruitment and retention in engineering programs and careers, faculty teaching practices and intersections of motivation and learning strategies.

Dr. Gary R. Kirk, School of Public & International Affairs, Virginia Tech
Dr. Cheryl Carrico P.E., Virginia Tech

Cheryl Carrico is a research faculty member for Virginia Tech. Her current research focus relates to STEM career pathways (K-12 through early career) and conceptual understanding of core engineering principles. Dr. Carrico owns a research and consulting company specializing in research evaluations and industry consulting. Dr. Carrico received her B.S. in chemical engineering from Virginia Tech, Masters of Engineering from North Carolina State University, MBA from King University, and PhD in Engineering Education from Virginia Tech. Dr. Carrico is a certified project management professional (PMP) and licensed professional engineer (P.E.).

Dr. Veronica van Montfrans

Postdoctoral Associate in the Department of Engineering Education at Virginia Tech.

Mr. Andrew L. Gillen, Virginia Tech

Andrew Gillen is a doctoral student and graduate research assistant in the Department of Engineering Education at Virginia Tech. Andrew received his B.S. in Civil Engineering with an environmental engineering concentration from Northeastern University.

Mrs. Tawni Paradise, Virginia Tech Department of Engineering Education
Sarah Anne Williams, Virginia Tech

Sarah is a PhD student in the Department of Engineering Education at Virginia Tech. She has a bachelor's degree in Aerospace Engineering from Embry-Riddle Aeronautical University and, during that time, spent a summer at Franklin W. Olin College of Engineering for an REU in engineering education. Sarah's research interests include: motivation, student and faculty metacognition, and engineering faculty self-regulated learning.

Dr. Liesl Baum, Virginia Tech

Dr. Liesl Baum is the Associate Director for Strategic Initiatives at the Center for Excellence in Teaching and Learning. She is a former middle school teacher and spent seven years teaching in Virginia public schools. Her research interests and goals are to develop a frame of mind that allows for creativity to develop among students and faculty of all levels. She works with university faculty to identify and build

teaching strategies that encourage creativity for learning. Her research and work interests remain across the full realm of education and preparing educators to design and develop teaching and learning opportunities that encourage students to take risks, inquire across multiple disciplines, and participate in grand challenges. Liesl received her B.S. in Middle Education and M.S. in Educational Technology, both from Radford University. She received her doctorate in instructional design and technology from Virginia Tech.

Engagement in Practice: Lessons Learned Partnering with Science Educators and Local Engineers in Rural Schools

Abstract:

This project, Virginia Tech Partnering with Educators and Engineers in Rural Schools (VT PEERS) focuses on the collaborative design, implementation, and study of a series of hands-on engineering activities with middle school youth in three rural communities in or near Appalachia. Launching our project has involved coordination across stakeholder groups to understand distinct values, goals, strengths and needs within these unique communities. In the first academic year, we are working with nine (9) different sixth grade science teachers across seven (7) schools in three (3) counties. The aim of this engagement-in-practice paper is to document our lessons learned in navigating the day-to-day challenges of (1) developing and facilitating curriculum at the intersection of science standards, hands-on activities, cultural relevancy, and engineering thinking, (2) collaborating with industry and university volunteers to design and deliver content in each science class, and (3) adapting to emergent needs that arise due to school, division, and community differences across three counties.

Introduction:

The focus of Virginia Tech Partnering with Educators and Engineers in Rural Schools (VT PEERS) is to collaboratively develop curriculum to support teacher-identified knowledge gaps in science standards and facilitate regular, in-class activities throughout the academic year with engineering-focused, culturally-sensitive design. The project aims for impactful and sustainable integration of the project goals with state standards of learning in the context of three unique rural schools systems. Informed by research from career choice literature, we prioritize engagement with school teachers and local professional engineers. Leveraging local expertise is especially critical in this project because family pressures and preference for local, stable jobs play considerable roles in how Appalachian youth identify possible careers [1-3].

Programatically, VT PEERS is strongly informed by the ITEST STEM Workforce Education Helix model [4] which focuses on deepening impacts of the NSF ITEST program. In accordance with the helix model and drawing upon research-informed specific needs of our target population, VT PEERS is a university-initiated partnership with school educators and industry experts local to three unique communities in rural southwestern Virginia that develops new, and adapts existing, engineering curricula for classroom-based activities. The project goals and motivation are highlighted in Figure 1.

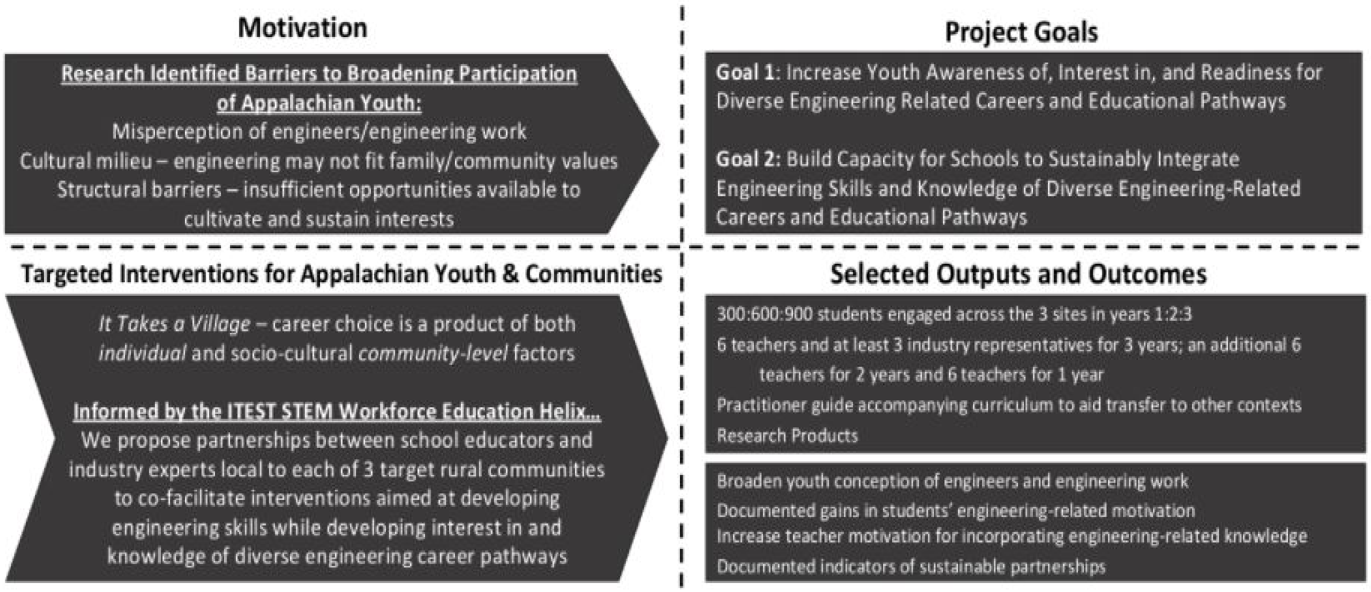

Figure 1. Project Goals and Highlights

Partner organizations were solicited by the project team and voluntarily opted to participate in a shared design-based implementation research program (DBIR). In accordance with DBIR, we balance being responsive to community-identified needs and preferences while also maintaining the research program's integrity. With a focus on serving underserved, rural communities, we also wanted to remain attentive to relevant research regarding preference for local, stable jobs, and attention to cultural relevance. This led us to reach out to advanced manufacturing facilities situated in the target communities in order to enhance the connection students and teachers feel to local engineers. Each manufacturer committed to designating several employees (professional engineers) to co-facilitate classroom activities six (6) times each academic year.

Project Design & Execution:

The administrators of our three participating rural school districts invited the 6th grade science teachers from each of their schools to participate in the program. Our original intent was to focus on one school in each district. However, in working to meet school needs, administrators requested we support all of their schools that indicated interest so that there wasn't any perceived favoritism. This resulted in seven schools and eight teachers in 24 separate class sections. These teachers, along with industry partners, the VT PEERS team, and recruited university student facilitators build and implement the curriculum which is delivered monthly, with a total of six times per academic year.

In addition, the original program design included a pre-launch summit for teachers and industry partners, with the purpose of clarifying roles and expectations and to catalyze collaboration on curriculum development. However, because this project was funded by the National Science Foundation ITEST program in June and a program manager hired as soon as possible thereafter, the summit was not feasible in advance of the first school year. To meet similar goals, the project team hosted half-day workshops in each district with interested teachers and administrators to learn about the VT PEERS program and how the in-class engagement could support the science learning objectives and schedules unique to each school. These workshops served multiple purposes. First, it offered teachers an introduction to the research component of the project. Second, sample curriculum guides were shared with teachers and school administrators in order to prompt discussion about how the day-to-day of the project might unfold. Following review of these guides, the VT PEERS team facilitated a brainstorming session to gather ideas from teachers about areas in their curriculum that they believed could most benefit from hands-on learning. Priority was placed on topics where teachers indicated students struggle conceptually such that a hands-on contextual lesson might better support understanding. In parallel with teacher workshops, the team scheduled visits with industry partners and tours of the partners' manufacturing facilities. During these visits, we reconfirmed programmatic goals and the partnership commitments that were developed months earlier as part of the grant proposal development. Due to the expansion of the number of schools participating in each targeted school system, industry partner hours and days of engagement request was increased. Unfortunately, due to misunderstandings about project needs, one local industry partner reduced the scope of their involvement. However, the VT PEERS team was able to invite and include another, larger industry in the community. Collectively, our industry partners volunteer impressive amounts of time with the project all without direct monetary benefit to the project.

A goal of the VT PEERS project is collaborative, invested curriculum development and implementation inclusive of all the program partners. While our timing of award did not allow opportunity for teachers, industry partners and our project team to physically meet and plan together prior to this pilot year, we established some collaborative methods to achieve our goals. First, we worked to include our partners through shared document editing for curriculum drafting and feedback, regular phone calls, discussions via email, as well as informal lunch conversations during the engagement days in the classrooms. Figure 2 is a graphic representation of the curriculum development inputs and flow from design to implementation. The stacked elements in Figure 2 indicate the number of school districts ("3 of SOLs & timing in each school"), the number of individual schools where classroom activities happen (7 of "Deliver Intervention") and the number of teachers (9 of "Teachers") ideally providing input, review and implementation supports.

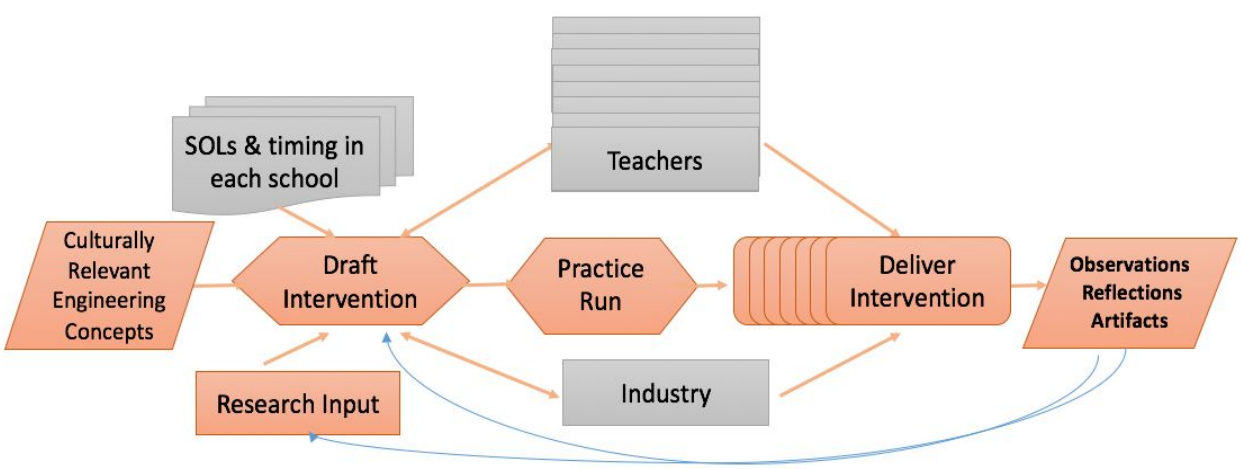

Figure 2. Curriculum development inputs and flow from design to implementation

The practice run element holds the space in the process where recruited university student facilitators receive training in the curriculum(s) for that month so they can be prepared to support the in-classroom activities. While student facilitators were not initially included in the NSF ITEST proposal, their engagement in the classroom provides extra hands to support the activities while serving as an engineering role model to the 6th grade students and teachers. All of the students volunteering for the program are pursuing degrees in engineering or science- and technology-related fields. As indicated by Figure 2, there is a loop from observations, reflections, and artifacts back to intervention design indicating a continuous improvement model that assesses and informs our ongoing work.

Ongoing project assessment data includes, but is not limited to 1) interviews with industry partners, university affiliates, teachers, and administrators, 2) student surveys, 3) student artifacts collect throughout the year, and 4) observations by a member of the VT PEERS team to provide context of the implementation.

Lessons Learned:
The intentionality of curriculum design, delivery and research protocol has led to much learning, some frustration, and a lot of thoughtful inquiry and discussion regarding the initial framing of the VT PEERS program. The integrity of the goals of the NSF ITEST proposal (as noted above in the background section of this paper) have guided curriculum design and implementation and with the addition of some tools for evaluation and templates to frame it, we are addressing cross-cutting, repeating elements (e.g., "Provides engineering/technology examples from youths' local community".) These developing key elements support deeper connections to engineering career pathways within the context of a 6th grade science curriculum.

Specific lessons, surprises and adjustments in this pilot year are bulleted below to give example and context to our year.

- One of the schools systems has a STEM education coordinator who supports the curriculum development and implementation in that school system. Her experienced eye has helped with framing curriculum goals in accessible ways for our school partners as well as students.
- Administratively, the schedules and connections to our school partners has been tricky:
    - Teachers are not generally available in the summer. While we budgeted summer stipends to compensate for teacher time, the varied school schedules and individual teacher travel schedules remain a barrier to getting everyone together physically at the same time and place.
    - Each school system has differences in administrative structure, class length and size, curriculum, teacher training and experience, and even within school systems there were differences in year-long vs. semester-long course structures. Some of these differences were anticipated, others were not. For example, while we anticipated a range of curriculum pacing, we expected all 6th grade science outcomes (at the state level) to be covered by all classes. However, we discovered that since the state standardized test is administered in 7th grade covering 6th and 7th grade objectives, some schools shuffle some outcomes between 6th and 7th grade curricula.

    - Teacher engagement with curriculum development and in-class engagement varies by teacher and by month. The different school cultures, classroom management techniques and even varying degrees of email use has required our team to prioritize individualized engagement of teachers throughout these initial months of curriculum design and implementation.
    - We strive to overcome the culture of "guest lecturer" structure where delivery of the lesson is completely by the guest while the teacher remains passive. Our project prioritizes collaborative design, development, and implementation but yet the episodic nature of our engagement mimics the "guest lecturer" engagement that is common in K12 settings. Teacher engagement varies (understandably) but we continue to work to demonstrate that we desire a collaborative structure that may be different than what they are used to.
- The industry partners are deeply engaged and willing partners beyond the classroom support.
    - An industry partner provided a suggestion for an activity regarding electron/energy transfer and was adapted as a highly successful activity in the classroom.
    - An industry partner is seeking an opportunity to bring the entire 6th grade class on a tour of their facility this spring - 200 students!
- Our community connections are developing and offer support for sustainability beyond the life of the grant
    - A local civic group interested in the VT PEERS project requested a presentation at a meeting which comprised of social services providers and county government staff where the work was met enthusiastically and with interest in deeper connections to the community and local industries
    - Student volunteers have been important to support the hands on activities as well as provide role models of engineering and educational paths for students - linking to this resource beyond the grant could support teachers in implementing the activities.
- Unexpected logistical challenges - balancing planning for research and programming activities with the limited time we have each week

Next Steps:

Year one of the VT PEERS project will wrap up in May and we are excited to have the opportunity to host a summer summit with our current 6th grade teachers, industry partners and the new 7th grade teachers we will be working with starting in the fall. This will be an opportunity to collaboratively build curriculum for next year together as well as discuss lessons learned and expectations for year two for both 6th and 7th grade teachers and students.

Through our experiences of this pilot year, we are working to design an application process for 7th grade teachers to clarify expectations that will enhance their level of engagement and input throughout the academic year. Since we are already in their schools, we will include in the application an invitation to visit the 6th grade science class when we are there to see an example of the implementation and imagine how this may work at the 7th grade level. Because we will be focused on 7th grade in the fall, we plan to discuss with our 6th grade teachers and industry partners the reframing of classroom activities for year two. While we will continue to support this work, it will not look the same as this pilot year. We want to understand what a successful year two looks like for our partners and work to support that with them.

Ultimately, the curriculum guides along with lessons learned and tips for success will be open-source so that anyone might use or adapt them to suit their purposes. While the VT PEERS program is focused on rural underserved schools in Virginia, the hands-on classroom activities are grounded pedagogically with engineering-based outcomes. These are designed with adaptation in mind for varied uses in classrooms well beyond our target population.

Acknowledgements:
This material is based upon work supported by the National Science Foundation under Grant No. 1657263. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

References:

1. Carrico, C., Matusovich, H.M., & Paretti, M.C. (2017). A Qualitative Analysis of Career Choice Pathways of College-Oriented Rural Central Appalachian High School Students. *Journal of Career Development*. https://doi.org/10.1177/0894845317725603.
2. Carrico, C., & Matusovich, H. M. (2016). A Qualitative Examination of Rural Central Appalachian High School Student Knowledge of the College Process Needed to Meet Career Goals. *Journal of Women and Minorities in Science and Engineering, 22*(3), 259-280. doi:10.1615/JWomenMinorScienEng.2016013308
3. Boynton, M., *People Not Print: Exploring Engineering Future Possible Self Development in Rural Areas of Tennessee's Cumberland Plateau*, Dissertation in *Engineering Education*. 2014, Virginia Tech: Blacksburg, VA.
4. D. Reider, K. Knestis, & J. Malyn-Smith (2016), Workforce Education Models for K-12 STEM Education Programs: Reflections on, and Implications for, the NSF ITEST Program. *Journal of Science Education and Technology*, *25*(6) p. 847-858.