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Paper ID #45218

Partnering with Rural K-12 Schools in Southwest Virginia to Broaden Participation in Engineering

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Partnering with Rural K-12 Schools in Southwest Virginia to Broaden Participation in Engineering

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February 10, 2025

2025 CoNECD Conference

Hi everyone! Today, we are going to be talking about an effort we've implemented with our colleagues to support rural K-12 teachers in Southwest Virginia in integrating engineering into their curriculum, which involves surveying and interviewing K-12 teachers about their perceptions of effective and ineffective professional development opportunities, as well as what they want to know about engineering and incorporating it into their curriculum, developing and facilitating a two-day professional development workshop for some teachers over the summer, and maintaining the relationships formed during the workshop over the course of the school year.

Background

VIRGINIA TECH

Students from rural Appalachian communities are underrepresented in higher education generally [1] and engineering specifically [2]

Engineering solutions require diverse perspectives and experiences [e.g., 3]

Rural communities have attributes that would be valuable to engineering: ingenuity, resourcefulness, familism, and community unity [4]

K-12 teachers have misconceptions of engineering [5] and do not feel prepared to teach engineering [6] → professional development opportunities can help [7, 8]

Teachers in rural areas can have difficulties accessing professional development opportunities and training related to science and engineering concepts [7, 9]

Supporting rural teachers in integrating engineering into their classrooms → broaden rural students' perceptions of what engineering is and who can be an engineer → more rural students interested in pursuing engineering

First, a little background for the study. Previous research has shown that students from rural Appalachian communities are underrepresented in higher education and engineering. This is specifically problematic for the engineering field as the most effective solutions require a diverse set of experiences and perspectives, yet rural students' perspectives and experiences are not well represented in the field despite likely bringing valuable assets to the field. For instance, rural communities have specific characteristics, such as ingenuity, resourcefulness, familism, and community unity, that are vital to the engineering design process. At the same time, K-12 teachers tend to have several misconceptions of engineering, including that creativity is not important to the process and that there is a hierarchy among science and engineering, and they do not feel prepared to teach engineering. Thus, professional development opportunities providing teachers with the content knowledge of engineering may help improve these teachers' conceptions of the field and self-efficacy in incorporating engineering into their curriculum, making them more likely to incorporate engineering into their curriculum. However, teachers in rural areas can have difficulties accessing professional development opportunities and training related to science and engineering concepts due to their geographic location. This makes it important to provide engineering education professional development opportunities specifically targeted toward rural K-12 teachers since supporting rural teachers in integrating engineering in their curriculum could lead to an increase in the number of these teachers teaching engineering, which in turn could lead more students to become interested in engineering as this integration could broaden rural students' perceptions of what engineering is and who can be an engineer.

Previous Project

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Partnered with 22 6th-8th science teachers across 7 schools in Bedford, Giles, and Smyth Counties in Southwest Virginia

Industry Partners: fostek Celanese Universal Fibers

Collaborative Curriculum: Created hands-on engineering activities (e.g., Testing and Troubleshooting Flashlights, Water Filtration, Microcontroller Lab Kits, Mountain Road Repair, etc.)

1900 middle school students participated in activities over the course of the project

NSF Award: Community-Engaged Engineering Interventions with Appalachian Youth (DRL-1657263)

VT PEERS
Partnering with Educators and Engineers in Rural Schools

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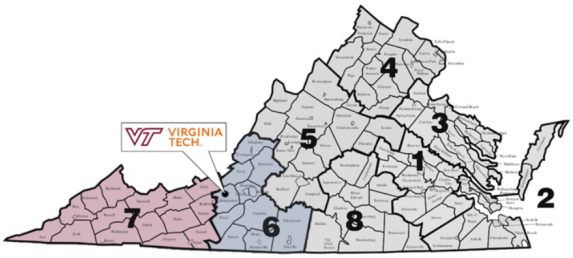
The current project was informed by previous NSF-funded research, referred to as the VT PEERS project, where a partnership with middle school science teachers, industry professionals from three local engineering companies, Fostek Corporation, Celanese Corporation, and Universal Fibers, and university representatives from Virginia Tech was established to create hands-on engineering activities for middle school students in three counties in Southwest Virginia. Representatives from all three entities co-created some culturally relevant engineering activities tailored to the region and rural areas. For instance, one activity required students to think about how they would fix damaged mountain roads and design possible solutions. This aligns with where students live because the region is located in the Appalachian Mountains. Some industry professionals and graduate student volunteers would go into the middle school classrooms and help facilitate the engineering activities. Roughly 1900 middle school students participated in these activities over the course of the two and a half year project.

Current Research Goals

1. Build multi-faceted understanding of engineering pathways for rural youth from middle school, into and through high school, and into post-graduation decisions

2. Cultivate a community of practice with high school educators from rural Southwest Virginia (SWVA) at the intersection of systems thinking, data science, generative artificial intelligence (AI), and/or programmable microcontrollers



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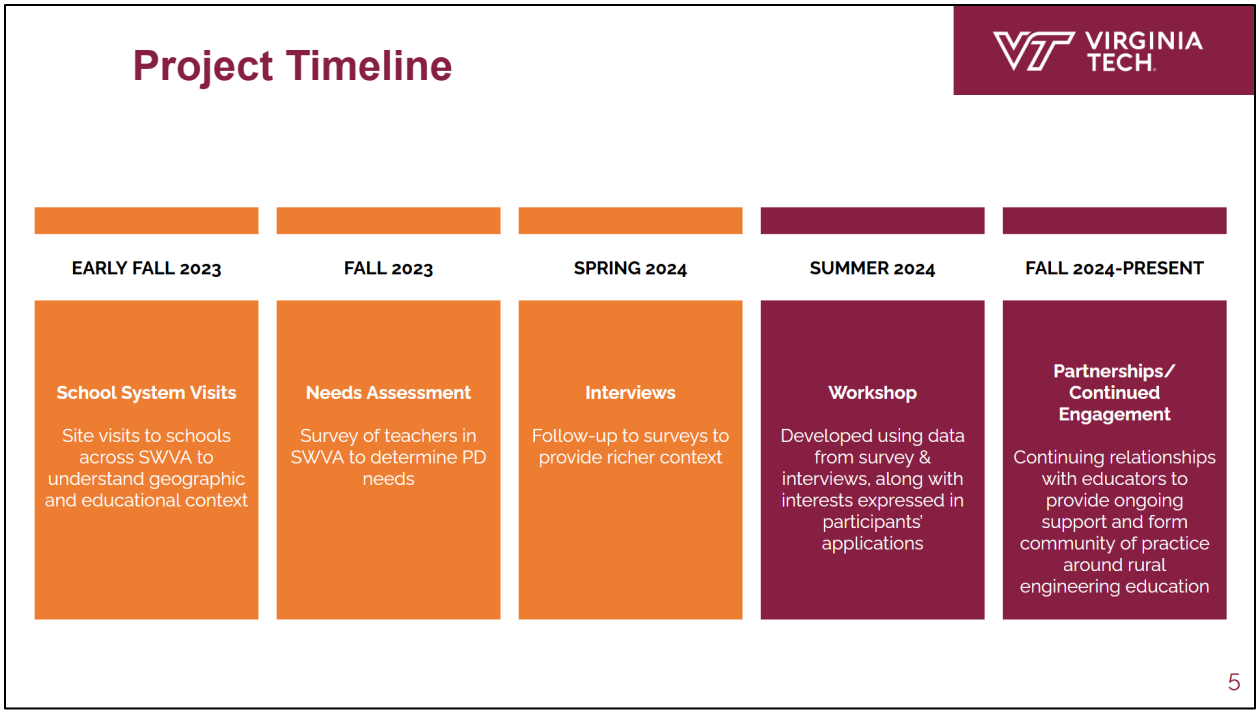
This grant was awarded a few months before the COVID-19 pandemic. The original plan for this project was to follow the middle school students in two out of the three counties from the first project into high school and examine how their interest in engineering was influenced by these engineering activities. However, when the pandemic started, the outreach engineering activities needed to be put on hold, and the project was put on pause. The initial approach was to wait it out and see what happened with the state of K-12 education with respect to the pandemic. However, during this time period, there were changes in school administrators, which meant that any of the existing relationships and partnerships that had been previously established were disrupted. Because of all of these changes, the project's goals needed to be reimagined. We decided to move away from only creating partnerships with schools from two counties to focusing on schools in rural areas in the Southwest Virginia region, which we define as Virginia's Department of Education's regions 6 and 7. Now, our project aims to address the following two research goals: [goals are listed on the slide].



This is an overview of the project's timeline. In early Fall 2023, one of our research team members participated in site visits to various schools across the Southwest Virginia region to gain an understanding of the geographic and K-12 educational context of the region. Later on in the fall of 2023, a survey was sent to K-12 teachers and administrators in Southwest Virginia to get a sense of the region's teachers' general professional development (PD) needs and needs related to integrating engineering content into their curriculum. This past spring, interviews with some of the survey respondents were conducted to gain a deeper understanding of these needs and to provide more context. Using the survey and interview data, we developed and facilitated a two-day professional development workshop over this past summer for some teachers who teach in rural schools in the southwest Virginia region. Following this workshop, partnerships with some of these teachers were established and we provided ongoing support to these teachers while they were working on integrating engineering into their curriculum throughout the school year. We'll go into more detail about the needs assessment, interviews, workshop, and partnerships during the rest of the presentation.

Needs Assessment: Methods

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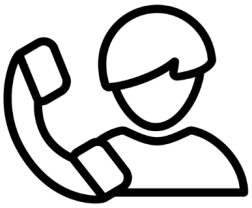
General PD Needs

Online Survey

- Prior PD experiences
- General PD preferences
- Interest in engineering integration

Engineering-Specific Needs



Phone Interviews

- Specific topic areas for PD
- Further discussion of engineering integration interests
- What does successful PD look like?

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To ensure our professional development program was tailored to the needs of teachers, we began with a comprehensive needs assessment. This assessment was conducted in two phases:. First, we distributed a survey to teachers across Virginia Department of Education's Regions 6 and 7. This was followed by in-depth interviews with selected participants. In total, we gathered input from 68 teachers and administers representing a diverse range of subjects, grade levels, and school systems. The data we collected helped shape the content and structure of our workshop, ensuring that it addressed the real challenges teachers face in this region.

Needs Assessment: Results

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68 survey responses | 8 interviews | 8 school systems | all grade levels + admin

Effective PD

- Has a tangible takeaway
- Is relevant / has a real-life application
- Is topic specific

Ineffective PD

- Is not engaging
- Is not relevant / too general / cannot be implemented (e.g., learning about technology that is not available to teachers)
- Does not provide necessary materials / resources

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In the needs assessment, we asked several general questions about educators' prior experiences with professional development and their desires for future PD opportunities. The needs assessment revealed several key elements that make PD successful in the eyes of educators, including tangible takeaways, relevance/applicability, and topic-specific. Teachers expressed a strong need for professional development that is directly applicable to their classrooms & the subjects they teach, and that respected the constraints they operate under. Teachers mentioned that if PD is too general or cannot be implemented, it is not useful.

Access Challenges in Rural Areas

…and how we addressed them

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Cost of Attendance

- All expenses paid by VT
- $500 stipend
- VT PEERS Quarter zip

Geographic Constraints

- Workshop was held in SWVA region on Virginia Tech's campus

Timing of PD

- Early June, right after end of school for local school districts

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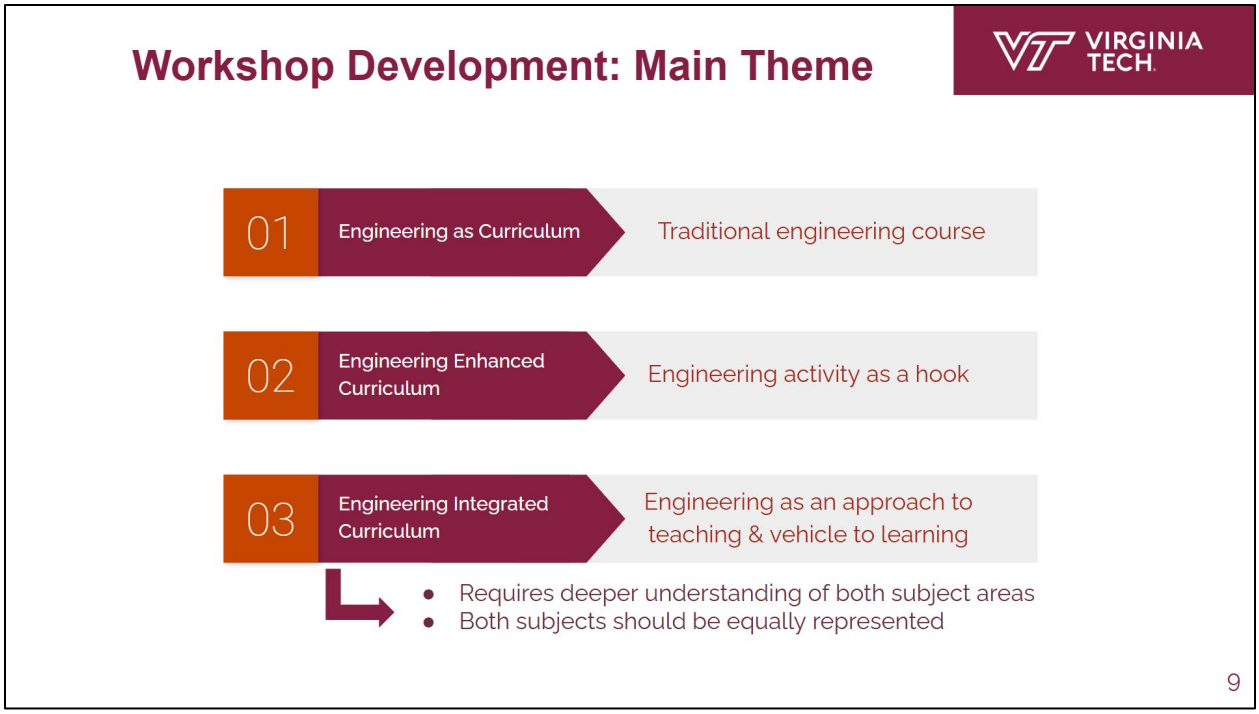
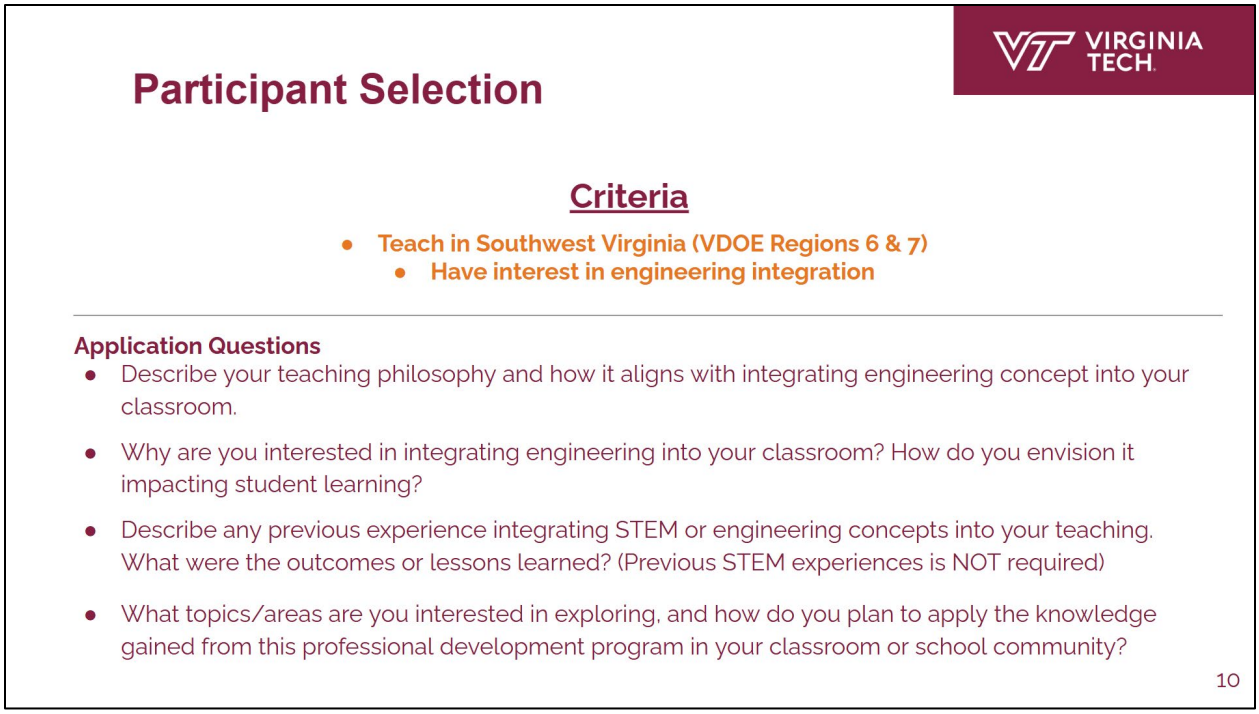
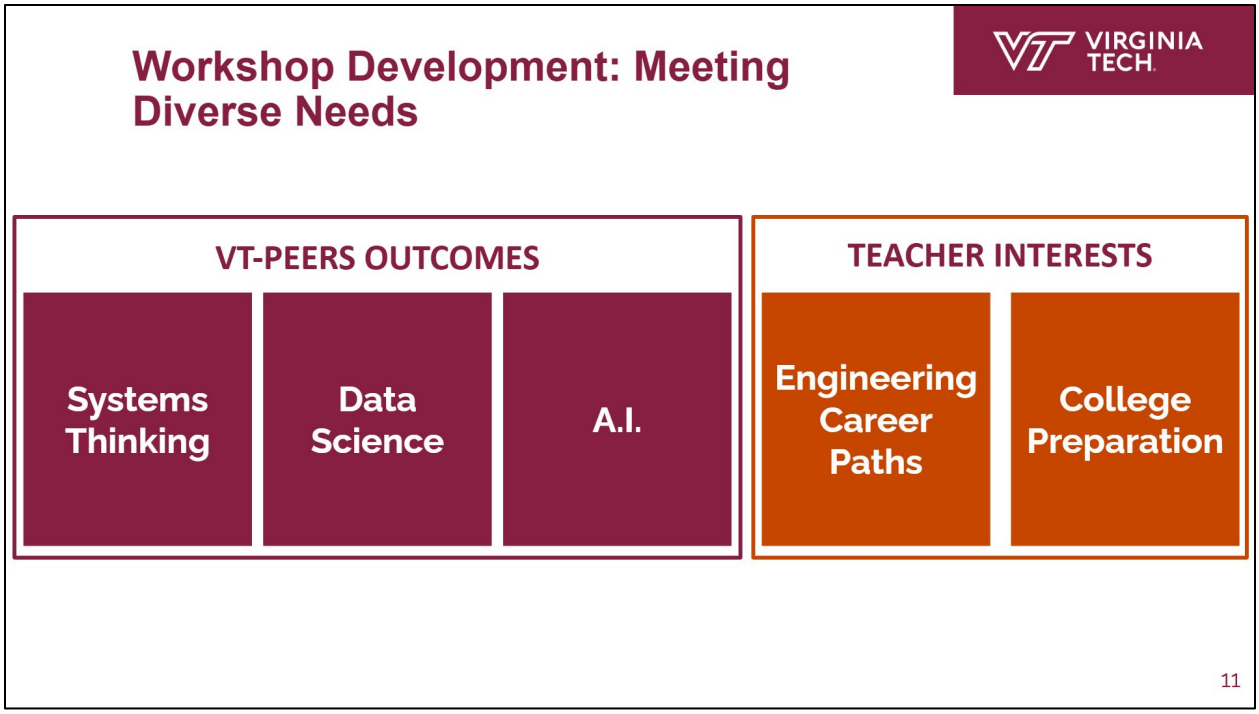
One of the major themes that emerged from our needs assessment was the challenge of access in rural populations. Many teachers told us that they often have to travel long distances to attend professional development, which is not always feasible given their already demanding schedules. Additionally, the professional development opportunities that are available locally are often too broad or not directly relevant to their needs. Some specialized trainings are only held at certain times of year, which makes it difficult to work into teachers' already busy schedules. These findings informed every aspect of our workshop design, from the topics we covered to the way we structured the sessions. By bringing the workshop to the region and designing it to be as practical and relevant as possible, we aimed to overcome these access challenges. The following approaches were used to address these challenges. All participants received a $500 stipend for their engagement and a VT PEERS quarter zip. Additionally, all costs associated with participation were paid by VT. This included hotel accommodations for those who requested them, as well as meals and mileage reimbursement. We sent campus parking passes via mail ahead of time. By holding the workshop on Virginia Tech's campus, we were able to bring quality PD to the teachers instead of having them travel far distances. The longest someone traveled was two hours. We planned the timing of the workshop strategically to align with the end of school for local K-12 school systems. We did our best to avoid the conflicts that come with vacations and travel later in the summer by providing the workshop in early June.



Our goal was to help teachers from different subject areas integrate engineering into their classrooms. Engineering integration involves two approaches. The first approach focuses on engineering as curriculum, which would be like a traditional engineering course (e.g., drafting, introduction to engineering design). The other approach focuses on engineering enhanced curriculum. This involves teaching a specific subject and using an engineering activity to frame a problem that is specific to that subject. In this context, the engineering activity acts as a hook, but then the lesson becomes about the subject that the class is focused on. Integration requires a deeper understanding of both subject areas and both should be equally represented.



The selection of participants was another critical aspect of the workshop's success. We aimed to include a diverse group of teachers from different counties in the region and subject areas to ensure a broad range of perspectives. Getting the word out was not easy; we used connections made during school system visits and leveraged our liaison network through Virginia Tech's Center for Educational Networks and Impacts. This network consisted of local CTE directors who helped us connect with teachers, facilitate communication, and provide support throughout the project. The liaison network played a crucial role in ensuring that the workshop was well-attended and that the content was relevant to the participants' needs. By leveraging these local connections, we were able to build trust and create a more effective professional development experience. Participants were selected based on their interest in integrating engineering into their teaching and their ability to contribute to a collaborative learning environment. This diversity helped create a rich and diverse workshop experience, where participants could learn from each other as well as from the presenters.



One of the biggest challenges we faced in developing the workshop was meeting the diverse needs of the participants. Teachers from a wide range of subjects, including English, math, welding, and family and consumer sciences, were all involved. To address this, we used systems thinking as a unifying theme. This allowed teachers to explore engineering concepts in a way that was relevant to their specific subject areas. For example, an English teacher might focus on communication systems, while a math teacher could explore mathematical modeling as part of systems thinking. In addition to systems thinking, the workshop also featured sessions on data science and using artificial intelligence for curriculum design. These themes were chosen because they align with the grant's goals and address the evolving needs of modern engineering education, and they are applicable across a wide range of subjects, making it suitable for our context since the participating teachers taught a variety of different subjects. Some of these concepts were also selected based on previous experience with the original VT PEERS project (systems thinking) and responses to the needs assessment and conversations with teachers (data science and AI). We worked hard to align the workshop content with the specific needs identified in our assessment, trying to ensure that the sessions were relevant and engaging for all participants. We'll discuss the activities in more depth later on in the presentation.

Workshop Itinerary

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First Day	
Time	**Activity**
8:00 am - 9:00 am	Check In & Coffee
9:00 am - 10:00 am	Introductions
10:00 am - 12:00 pm	Systems Thinking Intro
12:00 pm - 12:30 pm	Industry Panel
12:30 pm - 1:30 pm	Lunch
1:30 pm - 3:15 pm	Lab Tours
3:00 pm - 4:00 pm	Advising
4:00 pm - 5:00 pm	Breakout Sessions

Second Day	
Time	**Activity**
8:00 am - 9:00 am	Pastries & Coffee
9:00 am - 10:30 am	Engineering Activity
10:30 am - 11:30 am	AI for Curriculum
11:30 am - 12:30 pm	Facilitated Planning
12:30 pm - 1:30 pm	Lunch
1:30 pm - 2:30 pm	Facilitated Planning
2:30 pm - 3:30 pm	Idea Sharing
3:30 pm - 4:00 pm	Reflections & Closing

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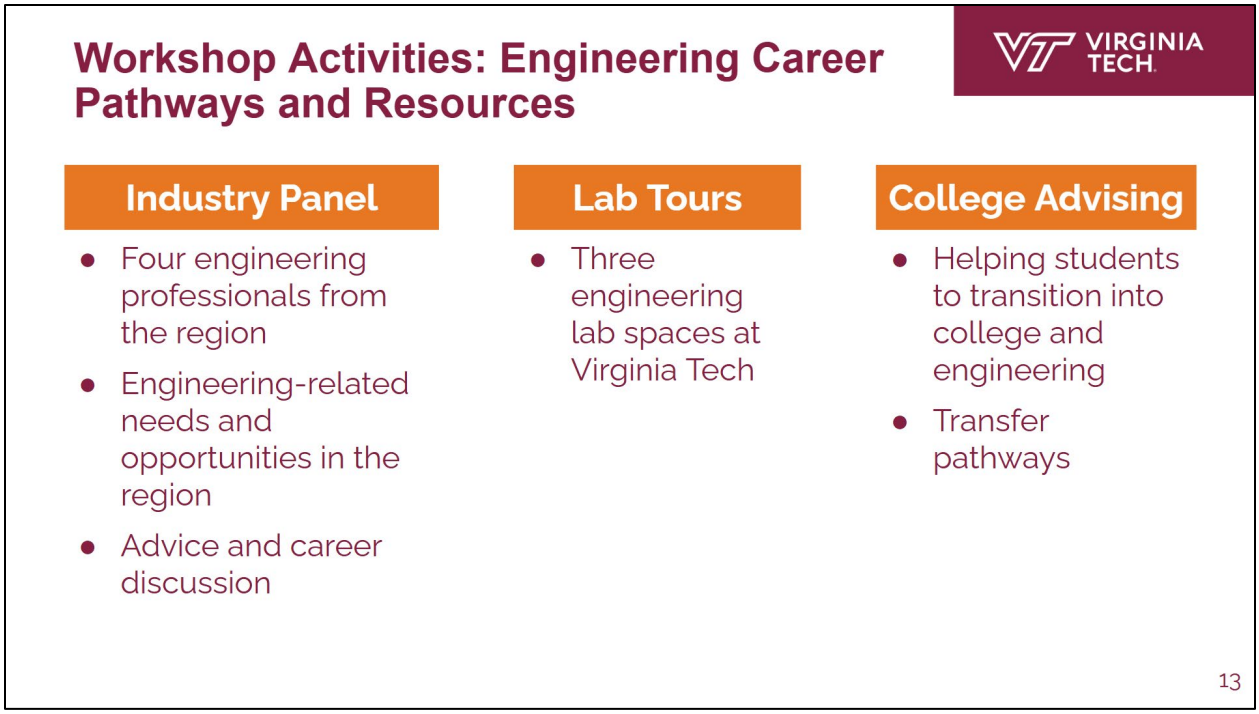
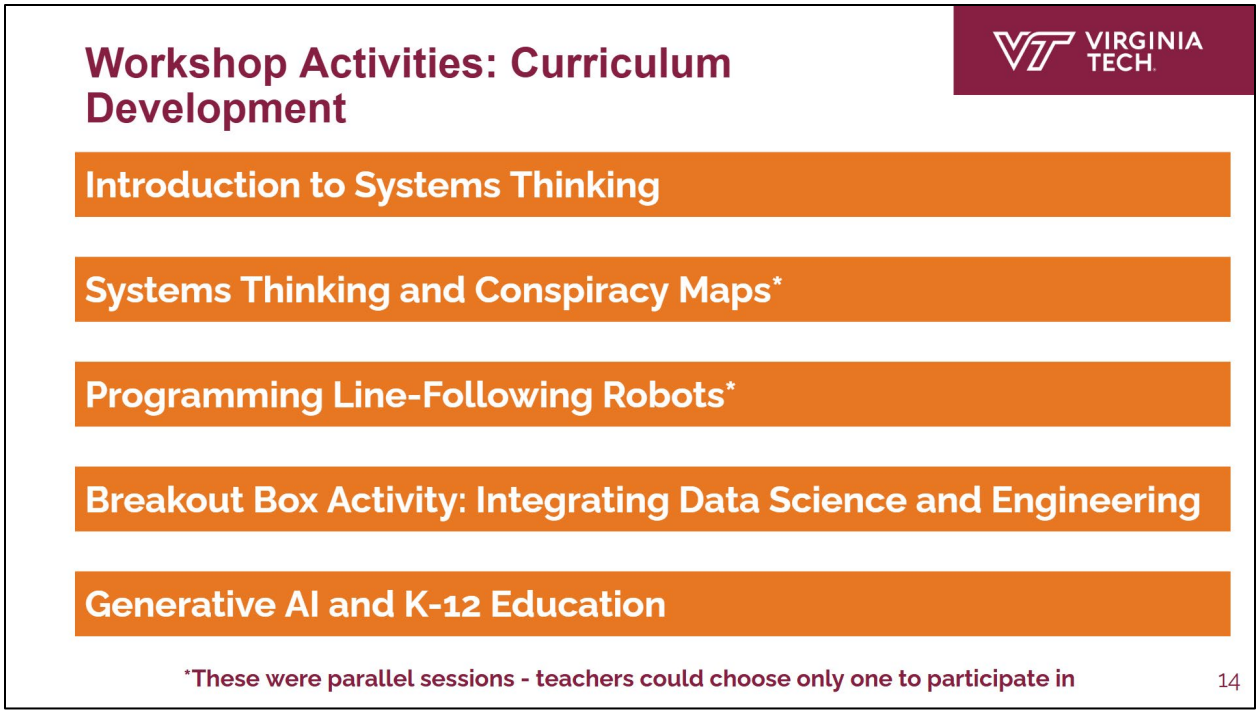
This is an overview of the activities and sessions that took place during the 2-day workshop. We held sessions that focused on the specific interests and needs of the teachers as well as the intended outcomes of the project and grant. We also gave teachers time for planning and reflection at the end of the workshop; this aligned with a need the teachers identified about effective professional development opportunities by having tangible takeaways. We'll go into more detail about some of the specific sessions next.



To meet the teachers' needs of engineering career pathways and gaining an understanding of the resources available to students at Virginia Tech, we provided three specific sessions that addressed these needs. An industry panel of 4 engineering professionals who work in the Southwest Virginia region came to speak to the teachers about their careers, offered advice on how to prepare students for the engineering workforce, and answered any possible questions the teachers had about the engineering industry generally and in the region specifically. Teachers also participated in tours of three engineering lab spaces at Virginia Tech - one in the Department of Industrial and Systems Engineering; the Helmet Lab in the Department of Biomedical Engineering and Mechanics; and the first-year engineering makerspace. Virginia Tech has a first-year engineering program where students come in as general engineering majors and then select a specific engineering discipline at the end of their first year. A first-year engineering advisor spoke to the teachers about what students could expect in college when majoring in engineering, how teachers could help prepare students for college, and answered any questions the teachers had.



To address the teachers' need for learning about engineering content, as well as to align the workshop with the project's outcomes, we provided five sessions that would enable teachers to see how they could incorporate engineering, systems thinking, data science, and generative AI into their curriculum. The first session introduced teachers to the concept of systems thinking, how systems thinking can be used in different educational settings and contexts, and provided teachers with an opportunity to think through how they could apply systems thinking to their own contexts. The next two sessions that will be discussed were parallel sessions, so teachers could select the session that suited their needs the most and participate in that activity. The first parallel session introduced teachers to Virginia Tech's first-year engineering learning outcomes and curriculum, as well as how engineering education is shifting to prepare students to solve complex problems that will require systems thinking. In addition, teachers worked on an activity that has been used in a first-year engineering course at Virginia Tech to prompt students to apply systems thinking to an open-ended problem. The other parallel session involved giving teachers an example of how they could incorporate and introduce programming concepts into their curriculum by using line-following robots. Another session provided teachers with an example of how they could bring data science and engineering into their classrooms through breakout boxes, a game-based activity, that requires students to solve clues using data science techniques and practices to unlock locks on a box containing materials for an engineering activity. Finally, a session was dedicated to introducing teachers to the basics of generative AI - what it is, where to find some of the tools, how these tools might be used or misused in teaching and learning, and broader considerations for schools and teachers. Teachers were also given time to work with some of the AI tools and identify ways that they could use AI for curriculum development purposes.

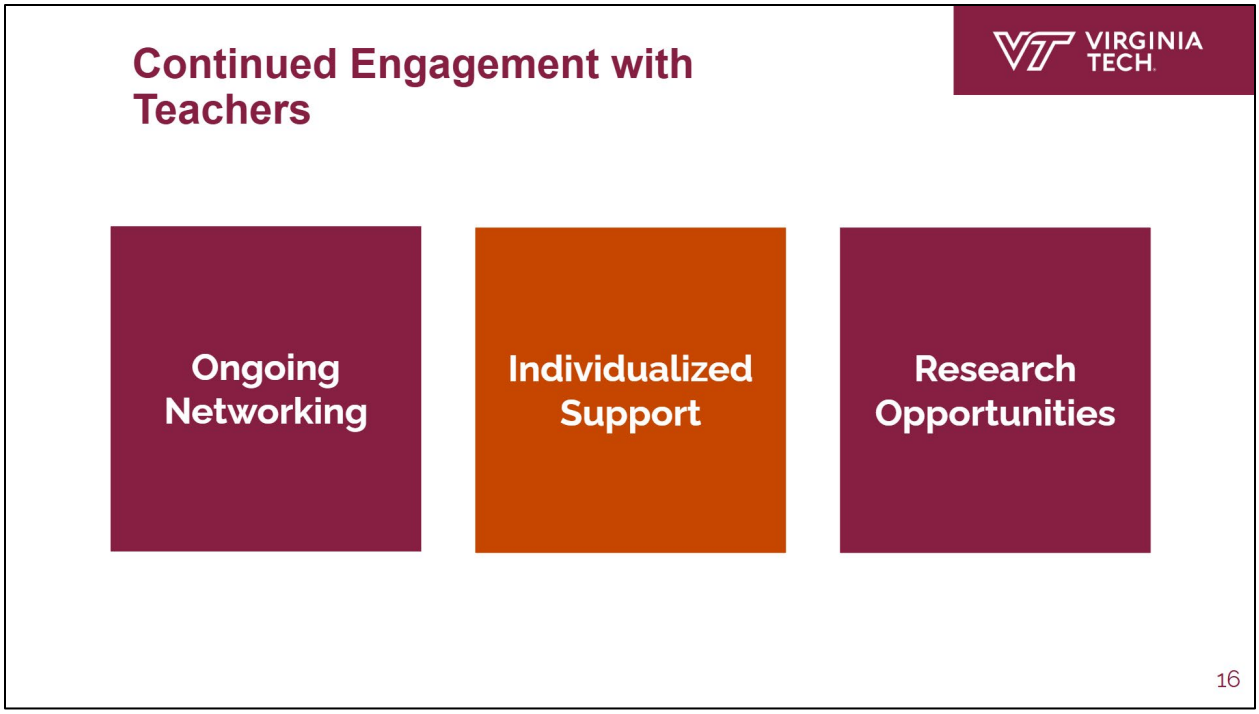
Post-Workshop Evaluation

VIRGINIA TECH

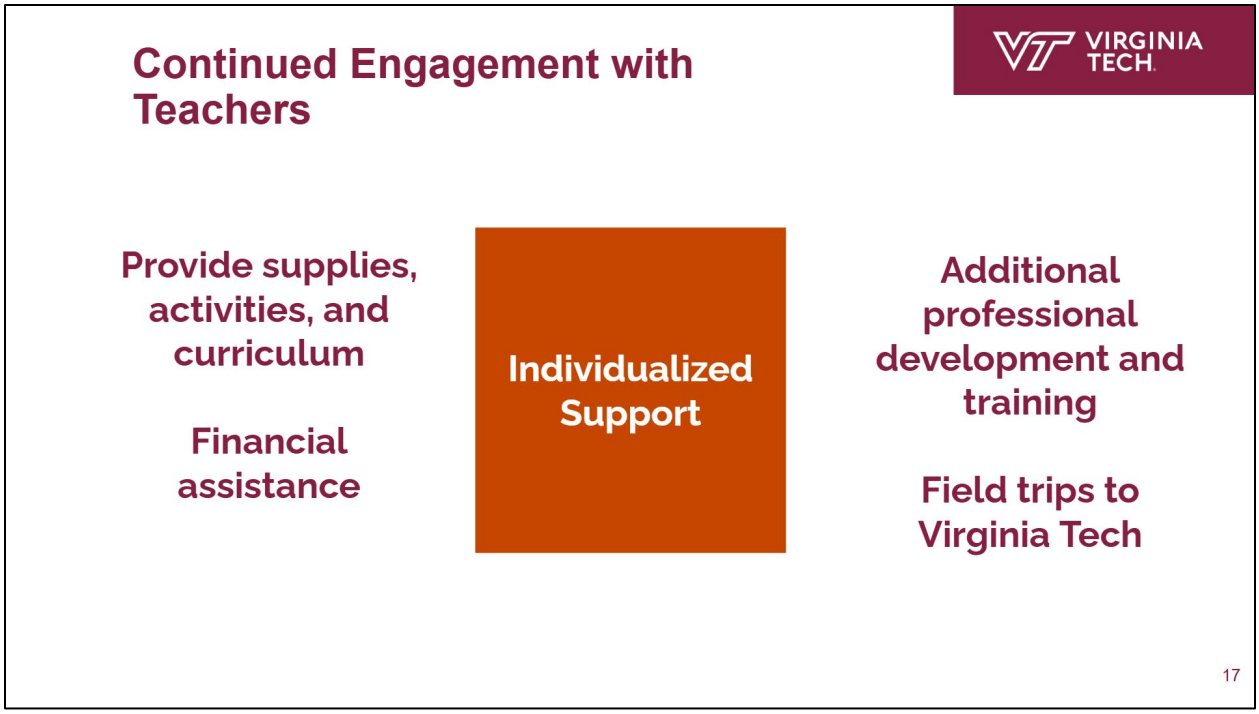
"I am better equipped to help my students navigate the admissions process here at the college. I have picked up a couple of activities to implement in my class"

"I will implement the activities to suit my students and their levels. I will also use the connections and contacts that I have gathered here to guide the students to an engineering career."

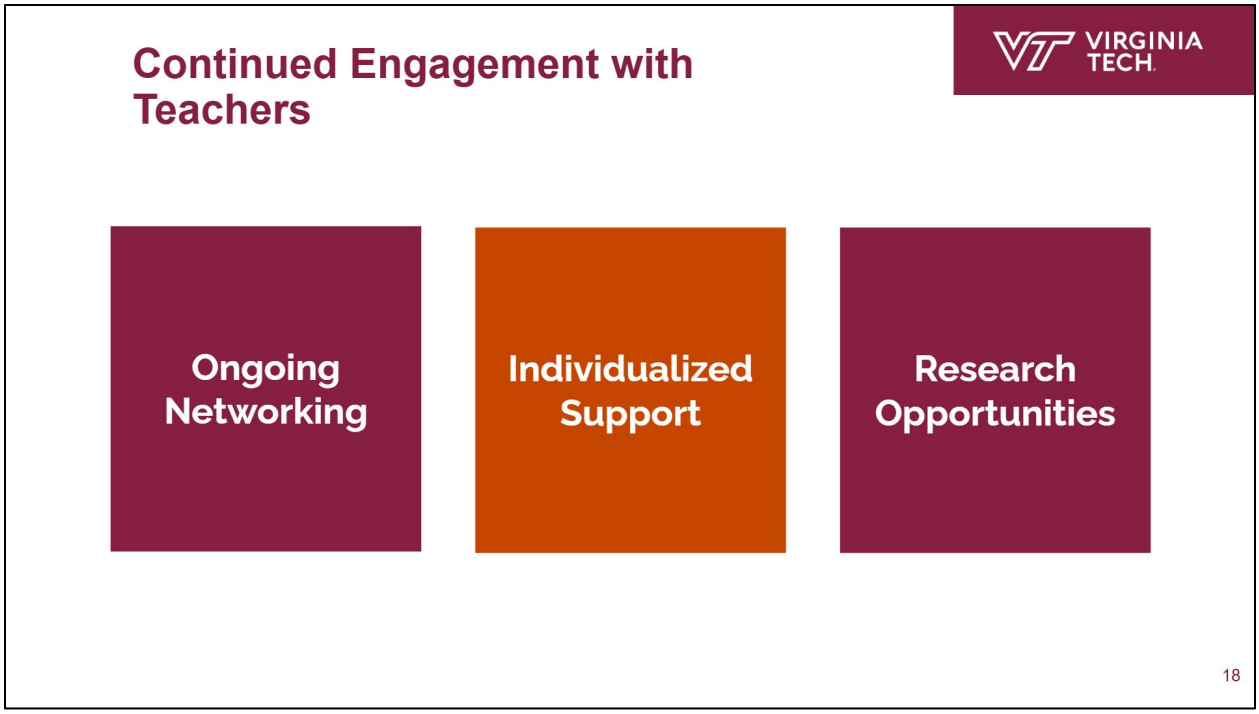
After the workshop, we conducted a brief survey to gather feedback from participants. The responses were overwhelmingly positive, with teachers reporting that the workshop was both relevant and practical for their needs. It is important to note that the positive response could be in part due to lack of available quality PD opportunities. Participants particularly appreciated the hands-on activities and the opportunity to connect with peers and presenters. Some of the constructive feedback we received focused on the need for the following: breakout groups by subject area; more time to explore VT's campus; more time spent on lab tours; less planning time and more instructional content/workshops.



We have continued to engage with eight teachers who were interested in maintaining an ongoing relationship with us following the summer workshop. We conducted brief phone calls with interested participants in the weeks and months after the workshop to gauge level of interest in continuing to receive support from VT and to begin defining the scope of what that continued support may look like. We then developed a formal application process that included the scope of work for teachers as well as what they can expect from our team. We've continued to support participants through follow-up sessions, resource sharing, and ongoing communication. This includes providing teachers with networking opportunities in the form of facilitating monthly large group Zoom calls with the research team and participating teachers.



We've also provided teachers with individualized support based on their specific needs and how they want to integrate engineering into their curriculum. Teachers reach out to us with the materials and supplies they need to do an engineering activity with their students and we order and pay for those materials for them. Some teachers have reached out to us to ask for guidance in designing an engineering lesson for their students and we've provided ideas, suggestions, and recommendations for how they could create a lesson based on the subject topics and concepts they are teaching. We've also provided additional professional development and training throughout the academic year for interested teachers. We've also planned several field trips to Virginia Tech for their students to see the university campus and visit some engineering labs.



In addition, research will be conducted on the impacts of engineering integration initiatives. By maintaining these relationships and providing sustained support, we hope to have a lasting impact on engineering education in Southwest Virginia.

What are teachers doing with their students?

Field trips to Virginia Tech

Speaker engagements with Virginia Tech engineering faculty and students

Various engineering activities:

- Examples:
  - Breakout boxes
  - Using systems thinking to design a lesson plan

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So, how are teachers integrating engineering into their curriculum? Several teachers have used this as an opportunity to take their students on field trips to Virginia Tech to meet engineering faculty and students and see some of the engineering labs at the university. In addition, several teachers have had Virginia Tech engineering faculty and students come into their classrooms to talk to their students about engineering career pathways and disciplines, systems thinking, AI, or to facilitate an engineering activity. For instance, one teacher had a faculty member from the engineering education department at Virginia Tech who also presented the line-following robots lesson during the workshop visit her classroom to do that activity with students in one of her engineering classes. Many teachers have decided to teach their own engineering activities in their classrooms. For instance, several teachers have used some version of the breakout box activity presented during the workshop to integrate engineering into their curriculum. One teacher who teaches a career and technical education course focused on introducing students to teaching careers developed a lesson that required students to apply systems thinking, a skill required for engineers, when designing a lesson plan.

Lessons Learned

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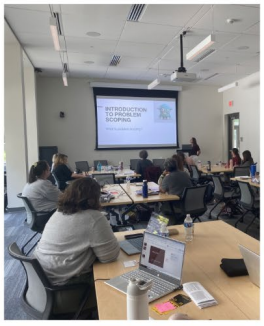
1. Important to **understand the local context and specific needs** of your population
2. **Building relationships** is critical for creating a supportive learning environment
3. **Flexibility** and **adaptability** are vital when designing professional development opportunities



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As we reflect on this project, there are several key lessons that stand out. First, it's essential to understand the local context and the specific needs of the population you're working with—this was the foundation of our success. Second, building strong relationships, both through a liaison network and with participants, is critical for creating a supportive and effective learning environment. Finally, flexibility and adaptability are key when designing professional development, especially when working with a diverse group of educators. We hope these lessons will be useful to others who are looking to implement similar programs in their own contexts.

Final Reflections

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Building **lasting relationships and support** for teachers in Southwest Virginia will hopefully…

- help **teachers' ability to integrate engineering** into their curriculum
- increase **students' awareness of and interest in engineering** as a potential career path

To pull this altogether, we aim to build lasting relationships with teachers in Southwest Virginia who are interested in integrating engineering into their curriculum through this effort. In turn, we hope this effort will help these teachers' ability to integrate engineering into their curriculum in whatever ways they see fit. This includes providing them with access to resources and opportunities that are not typically available to K-12 teachers, especially rural teachers. In addition, we hope that this effort can help increase rural students' awareness of and interest in engineering as a potential career path for themselves, which may help broaden the participation of rural students in engineering, and in turn help in diversifying the engineering workforce with different experiences and perspectives.

Current/Future Work

VIRGINIA TECH

Continue working with the current cohort of teachers

- Providing support, materials, resources, and opportunities for teachers and their students

Research about teachers' engineering integration into their classrooms

- Teachers' pedagogical choices

Prepare to engage a new cohort of teachers for Summer 2025

At this time, we are still working with teachers through the end of this academic year and supporting them in their engineering integration endeavors. These are the same activities that we described earlier in the presentation and includes providing support, materials, resources, and opportunities for teachers and their students. We are also conducting research with the teachers, with a specific focus on examining their pedagogical choices when integrating engineering into their curriculum. Future work includes preparation for another iteration of this program with a new cohort of teachers in the region, where we will provide a professional development workshop for interested teachers during the summer of 2025 and work with any interested teachers throughout the 2025-2026 academic year by supporting their efforts in integrating engineering into their classrooms.

Acknowledgement

This material is based upon work supported by the National Science Foundation (DRL-1657263, DRL-1943098). Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the NSF.

We'd like to acknowledge that this work is supported by the NSF and that any opinions, findings, and conclusions or recommendations do not necessarily reflect the views of the NSF.

Thank you! Questions?

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If you have any questions or want to learn more about this work, we're happy to discuss them now or feel free to contact us at the emails listed on the slide. Thank you very much!

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