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## Teacher Experiences in a Community-Based Rural Partnership: Recognizing Community Assets

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## Abstract

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## Keywords

teacher professional development, assets-based community partnership, self-efficacy, pedagogical content knowledge, teacher growth, middle school, grounded theory, industry partnership

## Document Type

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### Abstract

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### Introduction

With an increasing societal need for engineers, schools continue to receive pressure to integrate engineering concepts into their classrooms, yet many teachers are unprepared to teach engineering. Secondary teachers (middle and high school) are generally trained in one discipline, such as math or science, and are not familiar with engineering content or processes (Nadelson et al., 2013; Singer et al., 2016). Shifting science and mathematics standards recommend the incorporation of this content; one example is Next Generation Science Standards which has been adopted by 20 states and adapted by 24 states to

create similar standards. This has prompted a greater need for teacher professional development (TPD) focused on engineering, furthered by a lack of availability of engineering TPD and the widespread recognition of TPD as a cornerstone of educational reform (Al Salami et al., 2017; Cavlazoglu & Stuessy, 2017; Desimone, 2009; Fore et al., 2015; Guskey, 2002). This study mimics the common integrated approaches, with engineering being taught by science teachers within the science classroom, since engineering is not a core subject (Chai, 2019).

### *TPD in Rural Communities*

Most TPD experiences aim to have long-term positive impacts on teachers, such as changing their pedagogical views or shaping their teaching philosophies, but Chai (2019) found that the common workshop-only experiences (i.e., conducted within several hours and focused on sharing developed materials) fall short of having these lasting impacts on teachers. Longer-term professional learning communities are among the most effective teacher experiences, but the level of commitment and resources required makes them less common (Desimone, 2009; Faber et al., 2014). Furthermore, contextual elements within a school district and community shape the availability and effectiveness of TPD opportunities: such as subject matter knowledge of teachers, extent of continuous supports or resources, and amount of recognition for teachers (Chai, 2019; Granucci et al., 2017; Radloff & Guzey, 2017). Within rural areas, our population of focus, there are fewer opportunities for teachers to have exposure to engineers and engineering (Carrico et al., 2016; National Alliance for Partnerships in Equity, 2009). These limitations may be due to the challenges associated with rural communities, such as limited budgets and supplies for engineering TPD, or limited access to local resources and opportunities (Garner et al., 2015) due to the lower population density and related community organizational infrastructure one might find in other areas (e.g., nearby museums). Additionally, rural schools may have a difficult time recruiting and retaining highly qualified teachers, making professional development crucial to the experience of teachers and success of students (Ardoin, 2018; Garner et al., 2015).

### *Effectiveness of Asset-Based TPD*

With the need for more students pursuing engineering careers, TPD opportunities for rural teachers need to be designed in a way that integrates known contextual characteristics of rural areas. According to Moletsane (2012), problems in rural schools and the success of students are often attributed solely to the school and teachers. This deficit approach implies the simple solution is to have or hire better teachers. Deficit approaches to many educational issues have been identified as ineffective (Harper, 2010; Myende, 2015; Samuelson & Litzler, 2016). Instead, interventions, such as asset-based TPD, should address systemic challenges through the identification of existing community resources (Moletsane, 2012; Myende, 2015; Myende & Chikoko, 2014). This approach helps teachers prepare to integrate engineering into classrooms in a way that identifies and utilizes the assets already present in their schools and communities.

The need for asset-based TPD models is also imperative because rural students are underrepresented in higher education and engineering (Ardoin, 2018; Carrico et al., 2016). This underrepresentation has been attributed to many factors such as a lack of four-year colleges in rural areas, cost of education, and students' fear of potentially cutting off ties with their communities (Ardoin, 2018). Lottero-Perdue and Settlege (2021) argue that focusing on student assets, instead of deficits, is the only way to make the field of engineering more equitable. By identifying and highlighting schools' community assets and resources, teachers and students in rural communities can learn that there are many opportunities available close to home that can lead to fulfilling careers, and that regional institutions are invested in supporting teachers and the future pursuits of students. Asset-based TPD models can change the narrative that students need to leave rural communities to be successful, a phenomenon often referred to as brain drain, and can shift to the idea that there are opportunities for success in their local community (Carr & Kefalas, 2009). While our community partnership, called Virginia Tech Partnering with Educators and Engineers in Rural Schools (VT PEERS), focuses specifically on engineering and related careers, focusing on schools' community assets and resources is applicable to every discipline. For engineering partnerships, some of these regional institutions might include manufacturing, agriculture, energy production, higher education, or other related industries that would support the pursuit of a career in engineering or other science, technology, engineering, and mathematics (STEM) fields.

To better equip teachers for long-term implementation and success following a TPD experience, the learning should be authentic and connected with strong integration of community assets, making it easier for teachers to apply the knowledge attained (Reider et al., 2016). Given most TPD models are typically constructed on a needs-based approach and that rural teachers have limited opportunities to engage in engineering TPD (Zinger et al., 2020), our study provides a unique opportunity to understand rural teacher experiences in a TPD modeled from an asset-based lens. The purpose of this paper is to understand the role of the VT PEERS TPD experience in supporting middle school teachers' recognition of community assets related to the teaching of engineering for their students.

### *Research Context: VT PEERS Partnership*

The context of this study is a community-based partnership called VT PEERS. This partnership brings together local industry partners, middle school educators, and university affiliates to build a small community of practice that engages in a collaborative long-term professional development. The focus of this project is to implement recurrent, culturally relevant, hands-on engineering activities in middle school classrooms in counties in and near rural Appalachia. Examples of the culturally relevant activities and more details of the partnership can be found in Grohs et al. (2020). Goals related to the VT PEERS project include supporting middle school teachers' self-efficacy for teaching engineering, enhancing their knowledge of engineering-related topics and pedagogical practices, and supporting their relationships with other members of the partnership.

### *Rural Communities within VT PEERS*

This project's definitions for rural are based on those of the National Center for Education Statistics which classifies schools into four categories (rural, town, urban, city) based on their proximity to an urbanized location. The teachers in this project come from schools that fall under a rural or distant town classification (National Center for Education Statistics, 2020). All of the schools involved in this program share similar characteristics and challenges faced by many rural communities. Though we recognize that rural is generally hard to define based on numbers or distances alone (Coladarci, 2007), the contexts in which the schools exist could be described as rural and experience challenges related to being rural. As previously mentioned, these challenges include difficulty recruiting and retaining teachers and administrators, lack of access to educational opportunities outside of school, and limited access for teachers to engage in TPD and connect with other educators. According to a regional profile of the state region (Sen & Lombard, 2014), which includes two of the counties in this project, the median income is the lowest among all regions in the state and nearly 20% of the population falls below the poverty line. The unemployment rate in the region is at 6.6% and 67% of adults between ages 25 and 64 are employed, which is the lowest percentage in all the regions in the state, and the regions are majority White (University of Virginia Weldon Cooper Center, Demographics Research Group, 2020).

### *VT PEERS as Asset-Based Community Partnership*

Within VT PEERS, the implementation of engineering activities relied on a partnership between middle-school teachers, local manufacturing companies, and university affiliates. The activities were collaboratively developed and led by various community members to help students develop a deeper understanding of engineering and how it exists in their communities. This approach is aligned with asset-based community development principles as described by Kretzmann and McKnight (1996), who emphasize the importance of utilizing existing community resources and developing community relationships (Obermiller & Maloney, 2016). Partnership stakeholders also worked to show that engineering is not isolated from community contexts and that many paths into local engineering careers exist for both high-school graduates and those with higher education. In the context of VT PEERS, industry, university affiliates, and teachers were invested members of the immediate community and understood the relationship between the project and the greater community. Furthermore, the activities implemented in the classrooms (described in Grohs et al., 2020) drew from engineering that was locally present in their own community with industry partners demonstrating the applicability of engineering skills and the employability within the local community.

### *Asset-Based Approaches*

We define our asset-based approach as recognizing and building upon community resources and contexts in a collaborative partnership with local community members. Asset-based approaches redefine what kinds of capital and knowledge are considered valuable, including various community and family resources (Samuelson & Litzler, 2016; Yosso, 2005). This is different from common deficits-based approaches in which underrepresented students are compared to a "norm" group (i.e., often White and middle to upper class) (Yosso, 2005). Asset-based studies work to center the experiences of underrepresented students to identify commonly overlooked or unrecognized resources/capital within the community and lived experiences of participants. Given the underrepresentation of rural students in engineering and rural teachers in TPD, asset-based approaches will allow us to incorporate differential resources and experiences that they identify as helpful. Additionally, asset-based approaches recognize institutional and systemic barriers instead of centering individuals and communities as the source of problems (Samuelson & Litzler, 2016). By ensuring that VT PEERS partnership stakeholders were members of the local community, this work expands the community beyond the classroom and broadens the investment in youth by community members. Working with university affiliates, students, teachers,

industry partners, and school administrators to shape content and student interest, we move beyond students as individual actors (Yosso, 2005).

Though many asset-based frameworks focus on students as the individual actors, such as in the Community Cultural Wealth Model (Yosso, 2005), we recognize that teachers often serve as socializers for students (Lent et al., 1994) and are at the forefront of shaping student conceptions and interest. As was the case with elementary school teachers in Denham et al. (2012), teachers can support student development by developing knowledge themselves, modeling their knowledge or strategies for students, reacting in positive and supportive ways to students, and directly teaching students their knowledge. For example, teachers who are aware of assets can help identify various forms of capital that may support students, can serve as a crucial source of the transfer of capital to their students, and have a powerful role in utilizing community resources and knowledge in their classrooms. Ultimately, teachers' involvement in the partnership and their conceptions of engineering within their community support our ability to shape and understand the applicability of engineering to their rural students.

### **Purpose of Research Study**

The purpose of this paper is to understand the role of the VT PEERS TPD experience in supporting middle school teachers' recognition of community assets related to the teaching of engineering for their students. Our research focuses on teacher experiences throughout their second year in the partnership which is marked by greater ownership and individualization of the engineering activities for the middle school teachers. This research study utilizes the constant comparative methodology informed by grounded theory to address the following research question:

How do teachers recognize, integrate, and value community assets in support of engineering education?

### **Theoretical Framework: Sensitizing Concepts**

While we approached this research through a stance informed by recognizing assets, sensitizing concepts were used to further direct the analysis. Grounded theory is a qualitative methodology that uses an interplay of inductive analysis and continuous data collection to create a theory. This research uses constant comparative data analysis from the grounded theory literature. Supporting the inductive nature of the constant comparative methodology, sensitizing concepts are a departure point for the research, supporting a researcher's ability to focus on the purpose of the research while not bounding the analysis (Bowen, 2006; Charmaz, 2014; Groen, 2017; Groen & McNair, 2016). All of the below frameworks (pedagogical content knowledge (PCK), Interconnected Model of Teacher Growth (IMTG), and self-efficacy) were used as sensitizing concepts. They supported the initiation of the analysis phase and informed researchers' use of further questioning throughout the analysis process to enhance understanding and meaning of participant transcripts (Groen, 2017).

These frameworks were chosen due to their prevalence in the TPD literature and their relation to goals of the VT PEERS professional development experience. Self-efficacy and PCK constructs greatly capture the goals of VT PEERS, and the IMTG has been included to reflect the process that teachers have undergone to experience growth and change throughout the partnership. Collectively, these constructs allowed us to begin an initial analysis on teacher experiences in the VT PEERS program over the first two years.

#### *A. Domains of Teacher Knowledge*

The domains of teacher knowledge by Carlsen (1999), as shown in Figure 1, are aligned heavily with PCK and identify the domains of knowledge, or knowledge base, necessary for educators to engage in effective instruction and improve educational outcomes for their learners (Fernandez, 2014; Shulman, 1986). Aligning with other PCK frameworks, this theory includes domains of general pedagogical knowledge, subject matter knowledge, pedagogical content knowledge; but also incorporates the knowledge of both the general and specific context (Carlsen, 1999; Fernandez, 2014; Grossman, 1990). PCK is widely accepted in the field of teacher education in that there is little disagreement that the domains of knowledge presented increase the ability of an educator to enhance the learning experience for students and is heavily utilized in research studies (Carlsen, 1999; Fernandez, 2014; Shulman, 1986; Yildirim & Sahin Topalcengiz, 2019). PCK is commonly defined as the ability to translate subject matter knowledge so that it is comprehensible by others. The domain of PCK, which is defined by its relationship to the other knowledge domains, is the domain of knowledge that is used to distinguish teachers from other experts in the field (Shulman, 1986). Within this study, the domains of teacher knowledge helped to characterize individual knowledge of teachers, its development through VT PEERS and community assets, and the influence of this knowledge on teacher experiences.



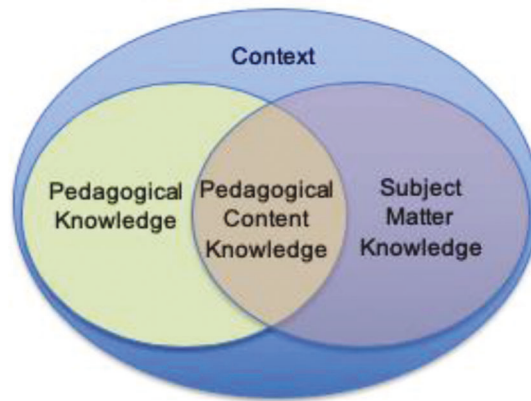


Figure 1. Domains of teacher knowledge. Adapted from Carlsen (1999).

### B. Interconnected Model of Teacher Growth

The IMTG, as shown in Figure 2, was developed by Clarke and Hollingsworth (2002) and represents a nonlinear process of teacher growth with four distinct domains (external, personal, consequence, practice) necessary for change and mediating elements of reflection and enactment that create change sequences between domains (Clarke & Hollingsworth, 2002). The flexibility and nonlinearity of this model incorporates individual differences in which teacher growth occurs, and acknowledges the impact of individual personality characteristics and the change environment (Clarke & Hollingsworth, 2002; Guskey, 1986). Justi and Van Driel (2006) used the IMTG as a theoretical framework to study the development of PCK within a professional development experience for science teachers. This helped us operationalize the domains of the IMTG within the context of VT PEERS as shown in Table 1.

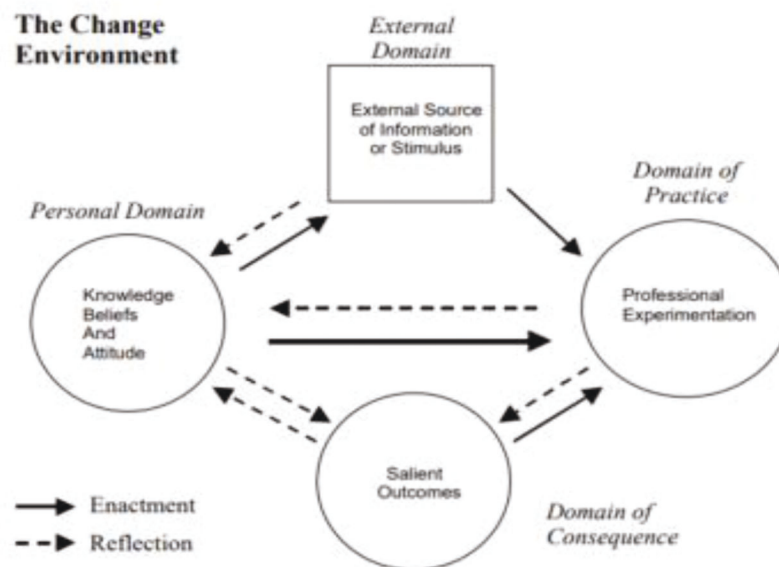


Figure 2. Interconnected Model of Teacher Growth (Clarke & Hollingsworth, 2002).

### C. Self-Efficacy

Self-efficacy is a construct of social cognitive theory as defined by Bandura (2010). Figure 3 shows the four domains representing the four sources of self-efficacy as defined by Bandura. Given that building confidence with engineering activities is a significant goal of VT PEERS, a self-efficacy lens is appropriate and helps create an understanding of teacher behavior and how professional development can increase elements of their self-efficacy (Klassen et al., 2011;

Utley et al., 2019). Using this lens provided a way for us to highlight specific elements of the program that were beneficial or detrimental to teachers, and these categories allowed us to pay particular attention to the role of emotions, vicarious or personal experiences, and external information—all of which our program initiates.

Table 1

Domains of the IMTG applied to VT PEERS community partnership.

Domain	VT PEERS application
External	The external domain represents information, resources, support or otherwise that the teachers received from an individual within the partnership, an individual or group outside the partnership, or a different resource, such as a website about engineering activities for middle school students.
Personal	The personal domain consists of teachers' knowledge of engineering and engineering activities, attitudes towards teaching engineering in the classroom, and beliefs about the potential integration of engineering and science. Other knowledge, attitudes, and beliefs related to these constructs also comprise the personal domain.
Practice	The domain of practice relates to teachers' engagement with implementing engineering activities, where they are able to practice their techniques as a teacher within an engineering activity.
Consequence	The domain of consequence comprises the outcomes that teachers notice as a result of teaching engineering and implementing the engineering activities. These outcomes can be related to teachers' abilities, student outcomes, community changes, school adjustments, or otherwise.

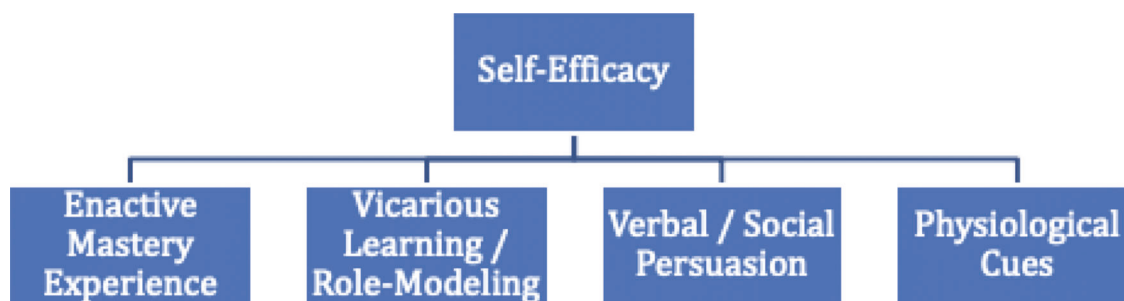


Figure 3. Components of self-efficacy. Adapted from Bandura (1994).

### Thinking Across Sensitizing Concepts

All the above frameworks are related to teacher change, including the knowledge, beliefs, or processes required to create and prompt long-term changes among teachers. The IMTG identifies various domains that are necessary for teachers to access and reflect on when shifting their beliefs, knowledge, or attitudes. The personal domain in the IMTG houses individual beliefs, knowledge, and attitudes of teachers which is related to the self-efficacy and PCK of teachers. Our goals are related to increasing both teacher knowledge and attitudes towards engineering and therefore both the PCK and self-efficacy models help to inform what constitutes the personal domain for a teacher. While our goals are focused on shifting the knowledge and beliefs of teachers, the aspects and processes that impact these shifts are increasingly important to understand for shaping future professional development experiences and can be captured through the IMTG framework. Together, these models create a foundation to understand how teachers are changing through their professional development experience by guiding and directing the open coding of interviews. While IMTG and PCK both recognize that teachers situate their understandings and knowledge within their context, community-based assets can shape and be shaped by these theories. Additionally, the development of teacher self-efficacy can support future integration of engineering and utilization of community assets.

### Methodology

Grounded research is a qualitative methodology that supports inductive analysis of a phenomenon through overlapping data analysis and continuous data collection (Bowen, 2006). Aspects of grounded theory were used, including the inductive, constant comparative method which prioritizes participants' words and allows themes to emerge from the data. The post-interviews of five teachers from three different counties were analyzed to understand their experiences in the program, including how it has contributed to their current perceptions of teaching engineering and their beliefs about assets in their students, school, and community. This research study is meant to glean general lessons of what worked for VT PEERS and



why it worked for the teachers within the study so that those in other contexts can identify whether these items would be a successful strategy for their teachers.

### Research Questions

The research is guided by the following research question which focuses on teacher perceptions of their community assets and their potential to support engineering education in their communities.

How do teachers recognize, integrate, and value community assets in support of engineering education?

### Data Collection

The qualitative data analyzed in this research were semi-structured interviews that took place at the end of the second year of engagement in the VT PEERS program. The interview protocol used with the participants is shown in Appendix A. This interview was collected to inform the future direction of the VT PEERS program as well as to evaluate its goals, so some questions extend beyond the specific context of the sensitizing concepts used in this research, but the nature of the grounded theory-inspired methodology allows us to focus on the prominent ideas shared by the teachers.

### Participants

The VT PEERS program engaged with nine 6th grade teachers throughout the first year of the program and expanded to 7th and 8th grade in the following years. The participants included in this research are those 6th grade teachers who have at this point been involved in the program for two years and who have completed their pre- and post-interviews for year two. These teachers are all from rural school districts (1 from New, 2 from South, 2 from Springfield), but range in their backgrounds and years of experience teaching as shown in Table 2.

Table 2  
Teacher demographics.

Teacher	Years teaching	Years teaching science	Education background
Teacher #1	31+	31+	Elementary education
Teacher #2	16–20	16–20	Science
Teacher #3	16–20	6–10	Special education
Teacher #4	6–10	6–10	Elementary education
Teacher #5	0–5	0–5	Science

### Data Analysis

This research study utilized the qualitative constant comparative methodology found in the grounded theory literature (Charmaz, 2014; Glaser, 1965). The focus of the analysis was on the year two post-interviews for all five teachers with open coding as the main analysis method. The analysis was composed of two main coding stages:

- Stage one: comparison within a single interview (analyzing the post-interviews for each teacher individually).
- Stage two: comparison between all post-interviews (analyzing and synthesizing across all five teacher interviews).

Using two stages allows for specific objectives in each stage, and improves the traceability and verification of the analysis performed in the study for greater transparency to readers (Boeije, 2002). A primary coder completed all of the research stages, but a secondary coder was included in an effort to minimize any researcher bias and to discuss overarching themes and ideas present in the interviews.

#### Stage One: Open Coding and Memos

Stage one included line-by-line coding of the five interviews as the first stage of open coding for each interview (Miles et al., 2014). This coding uses a combination of in-vivo codes and gerunds to assign codes that identify the action of the interviewee and keep the analysis active and emergent (Charmaz, 2014). Throughout the open coding of each interview, the overall asset-based lens of this research, as well as the sensitizing concepts of PCK, self-efficacy with teaching engineering, and the IMTG were used to lay the foundation of the analysis and guide the focus of the open codes that were assigned (Bowen, 2006; Walther et al., 2013). Following the suggestions of Charmaz (2008) and Walther et al. (2013), memos were written after the coding of each interview to capture ideas that guided the analysis toward a synthesis. Utilizing constant

comparative analysis ensured that coders were aware of previously applied codes and memos to identify patterns between interviews (Boeije, 2002).

#### Stage Two: Axial Coding

Once interviews were open coded, the codes in the codebook were combined to form categories by sorting the codes of similar content, which were subsequently used to perform axial coding of each of the individual interviews (Morse, 2008). The codebook was updated as necessary, incorporating patterns identified in the second reading of interviews and further developing category descriptions. After creating a memo that discussed potential initial themes and reflecting on the data, themes were corroborated and legitimized as described by Fereday and Muir-Cochrane (2006). The last stage was writing a thick description in response to the research question that legitimizes the data and fully represents the experiences of the individuals (O'Dwyer, 2004; Walther et al., 2013).

Figure 4 represents the specific process which was utilized in the constant comparative analysis, highlighting the repetition of stages that occurred for each interview (shown in the circular element of the process).

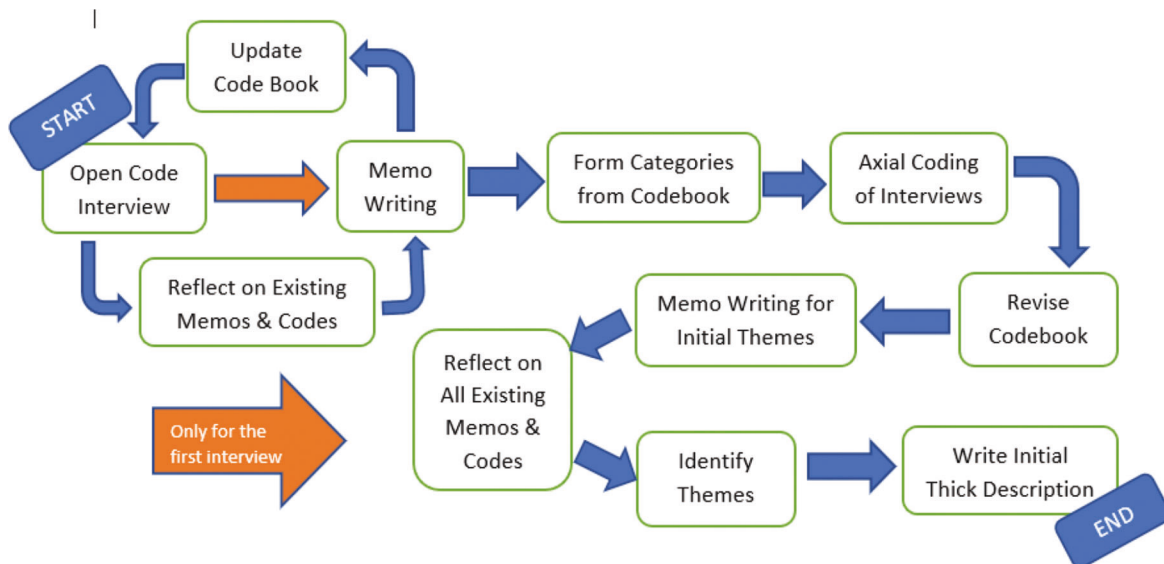


Figure 4. Visualization of the constant comparative analysis process.

#### Clustering Process

As a result of this analysis process, 633 raw codes formed 24 distinct categories, which were further clustered into 7 themes. These themes were further classified into the five overarching asset-based findings that were apparent in the five teacher interviews. The categories and themes are representative of teacher-identified information and codes in direct response to the interview questions, while the asset-based findings are a mapping of the identified themes onto community assets guided by our collective analysis of teacher transitions in their understanding of the utility of assets in their community.

#### Quality

Quality constant comparative analyses result in informed and extensive explanations of individuals, all of which are context dependent (Charmaz, 2014; Walther et al., 2013). To establish the quality in our research study, we include the quality criteria for grounded theory established in Charmaz (2014), which includes usefulness, resonance, originality, and credibility. Usefulness has many similarities to transferability (Borrego et al., 2009) and highlights that findings should be able to be applied to the everyday world and drive future research (Corbin & Strauss, 1990). Given the nature of the emergent research methods and the small number of rural study participants, the results in this study may include experiences unique to our participants; however, the themes, findings, and discussion are likely to highlight some experiences that are common across teachers participating in a TPD and conclusions abstract findings to high-level suggestions for future TPD.

To ensure resonance that findings portray the fullness of the studied experiences and represent the individuals within these experiences, a representation of all categories, themes, and abstracted findings is provided alongside their clustering in

Table 3 and a rich-thick description of the findings is included in the discussion (Creswell & Miller, 2000). With the intimate analysis involved and the reliance on the views and interpretations of the main coder, credibility of the findings was established through extensive memo writing, constant comparative analysis, utilizing negative cases, and having a peer reviewer engage in extensive memo writing from the interviews.

#### *Peer Reviewer*

A peer reviewer was used in this research to critically evaluate the researchers' interpretation and enhance the trustworthiness of the study through collective skepticism (Boeije, 2002; Creswell & Miller, 2000; Kolb, 2012; Walther et al., 2013). While reflecting on the existing memos and codes, two members of the research team engaged in discussions that led us to redefine, rearrange, and create new categories.

#### *Positionality Statement*

The following positionality statements have been written by each of the coders as an individual statement of their approach and biases related to the analysis and interpretation of results utilized in this paper.

#### *Coder 1*

As the main coder in this research, the biases that shape my views in this research include my prior experience as a high school teacher and my intimate engagement with the VT PEERS curriculum development. Alongside my previous teaching experience, I have had significant engagement with professional development, shaping my thoughts on the usefulness of these experiences for teachers. Extended engagement with the VT PEERS project throughout curriculum development and implementation built my understanding of project expectations and the outcomes we had identified thus far in our research studies. In an effort not to conflate teacher experiences with my own previous experiences or to identify outcomes that I expected, I began by identifying and acknowledging my potential biases in a memo completed prior to research. Throughout the research process I reflected on this memo and focused acutely on the words of the teacher using in-vivo codes when something was not explicit. This process is supported by my social constructivist beliefs and my understanding that humans have varying experiences and are truly individuals who experience and understand the world slightly differently. The perspective and experiences of the peer reviewer are different from mine and allow for an alternate perspective in an effort to identify the perspectives of the teachers with minimal bias or interpretation from us.

#### *Coder 2*

I joined the VT PEERS project in the third and final year of the study and have very limited first-hand experience with the activities and teachers. My previous work on this project involved analyzing teacher focus group data through a lens of self-efficacy, and I have developed an understanding of some of the teacher outcomes of this project. However, I do not have any formal teaching experience in the K-12 school system. I approached my role as the peer reviewer to capture and summarize in memos what each individual teacher was saying about their experiences related to the research questions and purpose of this paper. As a researcher, I believe that the use of asset-based approaches and frameworks allows people to identify the assets that are important to them and their communities, which will vary from community to community and individual to individual.

Collectively we focused on teacher perspectives and experiences in our analysis, reflecting on our biases and keeping teacher words at the forefront of our conversations and interpretations. Given the emergent nature of the research and the intimate connection between the findings and the interpretations of the researcher, we aim for transparency in writing our methods and discussion so that readers can discover and critically evaluate our conclusions. The results presented here are used to represent five teachers' experiences with potential and likely overlap of more teachers but are not meant to represent the only way that teachers can experience a TPD partnership or shift in their understanding of community assets as a result.

## **Findings and Discussion**

Analyzing five teacher interviews with an asset-based lens and specific attention to the sensitizing concepts has produced the findings shown in Table 3. These findings are representative of the collective experiences throughout the VT PEERS TPD for the five teacher participants and detail their impressions of community-based assets and the usefulness of these assets in their classroom.

To further discuss and understand the asset-based findings identified in this study, the remainder of this section discusses each asset-based theme holistically, including the role of the sensitizing concepts in shaping these findings.

Table 3

Overall asset-based findings, themes, and categories.

Asset-based findings	Themes	Categories
1. Teachers begin to view industry as an asset in the classroom and understand how they can contribute to future engineering interactions	Relationships with industry because of their support have been positive and contributed to the development of engineering knowledge, of both careers and the field  Teachers recognize and plan for long-term and extended engagement in engineering with their students	<ul style="list-style-type: none"> <li>• Positivity associated with industry involvement</li> <li>• Students have a relationship with industry folks</li> <li>• Teacher growth in knowledge of industry through industry involvement</li> <li>• Teachers and students learning about engineering through industry involvement</li> <li>• Developed relationship between teachers and industry</li> <li>• Need for long-term and extended engagement for lasting change with students</li> <li>• Extending the engineering engagement beyond the scope of the program</li> </ul>
2. Teachers begin to refine their understanding of best practices in teaching engineering based on their experiences throughout the partnership and their reconceptualization of engineering	Teachers are learning how to teach engineering through this experience by practicing and identifying the pedagogical strategies that are effective  Both students and teacher broaden their conceptions of engineering as a career and a field as a result of the partnership	<ul style="list-style-type: none"> <li>• Differentiating the behavior of students in response to pedagogies in the activities versus general classroom time</li> <li>• Learning to teach engineering through practice</li> <li>• Teachers identify themselves as learners</li> <li>• Growth in pedagogical knowledge through VT PEERS experience</li> <li>• Understanding the pedagogical strategies effective for teaching engineering through experiencing the lessons</li> <li>• Student growth in their knowledge of engineering through activities</li> <li>• Student growth in their knowledge of potential careers through activities</li> <li>• Broadening conception of engineering</li> </ul>
3. Teachers recount various emotions that them and their students had related to incorporating engineering into the classroom	Teachers and students experience various extreme emotions of happiness and nervousness throughout the partnership	<ul style="list-style-type: none"> <li>• Nervous about the transition from teaching with support to teaching the lessons alone</li> <li>• Enjoyment from students during activities</li> <li>• Enjoyment from being a part of the program</li> </ul>
4. Teachers identify existing barriers and assets that are dominant in their school and community	Teachers have contextual knowledge about their students, science curriculum, school, and broader community context	<ul style="list-style-type: none"> <li>• Awareness of the broad community context</li> <li>• Teachers have knowledge of their specific school context</li> <li>• Teachers are experts in their own science context and rely on this to adapt the program to fit their needs</li> </ul>
5. Teachers recognize assets in the partnership that were not presently available in their immediate school	Teachers identify specific elements of the partnership that were distinctly valuable in making the partnership a success, many of which factors were a clear distinction to current resources they utilized at their school	<ul style="list-style-type: none"> <li>• Importance of supplies</li> <li>• Value of the partnership allowing for access to others</li> <li>• Communication between partners</li> </ul>

### 1. Industry as Assets

Teachers began to view industry as an asset in the classroom and understand how they can contribute to future engineering interactions. While some teacher-identified assets and barriers were unchanged by their involvement in VT PEERS, some community factors, such as industry involvement, that went previously unidentified were recognized as assets in the post-interviews. Their interactions with industry throughout the program have allowed them to see and understand their value, such as providing real-life examples to the engineering and science lessons.

*“And the industry partners are great too, like I said, to get that real world connection type but things can be related back to a job, even if it’s a little different than what they regularly do. Usually, they have something they can add to relate it back to their job.”*

Teachers recognized that industry personnel were influential in shaping their pedagogical knowledge and PCK, and were their main avenue for gaining content knowledge, especially as it relates to engineering within their community. In particular, they identified industry as an asset that can support the integration of real-life engineering examples into the curriculum. One teacher described her experiences working with industry:

*“They’ve [industry partners] been great to work with, and they bring some knowledge to the table. I guess you could say some of our SOLs, it really just kind of adds to the content that we’re trying to teach. They’ve been very open for us.”*

It is not surprising that teachers grew in their content knowledge due to the involvement of an engineering expert, as this is commonly represented in the literature (Al Salami et al., 2017; Cavlazoglu & Stuessy, 2017; Faber et al., 2014; Granucci et al., 2017; Hardre et al., 2014; Kovarik et al., 2013; Singer et al., 2016). In TPD experiences, greater consideration should be given to the types of experts that are intentionally included in professional development experiences such that they are the most effective at supporting teacher growth in all the necessary knowledge domains. The incorporation of community-based industry partners in VT PEERS as engineering experts in the partnership not only supported the development of PCK for teachers, but also allowed teachers to shift their understanding of how industry can serve as an asset in their classroom and to their students.

Additionally, teachers identified the role of the vicarious experiences and the positive verbal persuasion of industry personnel and other VT PEERS stakeholders in shaping positive mastery experiences for them. Mastery experiences are important in ensuring the sustainment of the teaching of engineering within the classrooms. Without access to industry (part of the external domain) for resources and support about engineering knowledge, teaching the engineering lessons may have been insurmountable for many teachers. Aligned with the identification of industry as a classroom asset by VT PEERS, teachers also noted industry as an external resource and a community asset that supported their understanding of engineering and ability to provide real-life examples.

## 2. Teachers Refine Engineering Teaching Philosophies

We found that teachers began to refine their understanding of best practices in teaching engineering based on their experiences throughout the partnership and their reconceptualization of engineering, including shifts in their teaching philosophies and growth in their self-efficacy to teach engineering.

### *Pedagogies that Build on Student Assets*

Teachers expressed shifts in their teaching philosophies that were largely due to their experiences with facilitating the hands-on, team-based engineering activities in the classroom. All five teachers noted a significant difference in student behavior seen in traditional science lessons and the VT PEERS activities. These differences included students taking on greater leadership roles, students relying more on their previous experiences, lower achieving students engaging more heavily and experiencing more success, and students being more excited about the activities. Identifying assets that students can bring to the curriculum that were not being utilized in the traditional classroom activities led to shifting teaching philosophies for many of the teachers, including but not limited to a shift in their beliefs about the effectiveness of various pedagogies and their thoughts on the pedagogies that are most effective for teaching engineering specifically. Teachers seemed to value pedagogical strategies that build on student assets.

*“I do notice that the traditional students that are not engaged in normal classrooms become more, like activities. They do take a more leadership role in the VT PEERS. It seems to be the high achieving students will always do well and they can do anything, that’s why they’re so high achieving. But the low students that struggle on a typical day, they seem to. It surprised me a lot when they step up and they’ll take more of leadership roles during VT PEERS and a lot of that comes with their experiences. They’re more experienced in the engineering kind of thing with their home lives a little bit. Like as far as, I had a student the other day who when VT PEERS left and I said, hey man, that was really good how you knew how to do that. I would never thought about that. Something I can’t even remember really the [inaudible]. And he said he knew that because he had to fix the tractor. It led him to do something in class that was outside the box, but he had that experience at home. So I think it gives those learners that don’t come in every day and want to do traditional school work, it gives them an opportunity to really shine.”*

### *New Pedagogical Strategies*

Throughout the activities that were implemented in science classrooms, teachers recognized various pedagogical strategies that they did not often use in their classrooms, but that they found to be effective for their students since they more strategically build on student assets.



*“So I think the collaboration’s been good just as an eye-opening experience, as well as just sharpening the tools and the thought process that we have every single day and to make it more, I guess, hands-on and real world-like for our students.”*

Some of these pedagogical strategies include design-based learning, problem-based activities, and culturally relevant discussions. One teacher recounted how students in her class were more receptive to the constraints within these activities since they were related to a culturally relevant and hands-on project.

*“And I like the fact that there were also constraints, that there are rules to follow. These kids today have no... They just do anything they want to whenever they want to. But when you put down the limits, you put the limits to what they could do, and they actually accepted those limits better than they would other rules in other things.”*

### *Engineering Pedagogical Strategies*

While teachers learned new general pedagogical strategies, teachers also expressed growth in their understanding of what pedagogical strategies work well for teaching engineering, specifically, PCK. One teacher explained how the activities were developed in a way that made them accessible to a wide range of her students.

*“These labs [VT PEERS activities] are engineered so that there’s something for the more advanced, and then there’s something for the kids, a lot of the kids that you would label, or that are labeled, I should say, slow learners, enjoy the labs because they’re hands-on. A lot of the kids that struggle with reading or writing can do the hands-on part and really enjoy it, and maybe even think outside the box more than the kids that do read and write very well.”*

While this growth in PCK is positive, it should also be noted that teachers highlighted various pedagogical strategies that were effective for engineering but were challenging for a traditional classroom teacher to implement, such as having several adults available in the classroom to support student projects.

### *Importance of Positive Teacher and Student Experience for Pedagogical Growth*

Teachers’ shifts in their philosophies around teaching engineering were in large part attributed to their mastery experiences of teaching engineering to their students, where teachers had the opportunity to apply their knowledge gained in VT PEERS and from industry. Below is a quote from a teacher describing her experiences with practicing the implementation of the engineering activities.

*“This year, it was more of us actually getting in and teaching the lessons that we had kind of worked through, but also putting our own twist and turn on them as we felt needed to and applied them to our classrooms that were a best fit method. So it’s hard to process.”*

While many teachers initially found the idea of teaching engineering in their classroom to induce anxiety, facilitating lessons with their students and recognizing the salient outcomes that students experienced transitioned these feelings of anxiety and nervousness into those of excitement. Teachers highlighted student outcomes and their mastery experience as extremely important for contributing to their sustained teaching of engineering within the classrooms, with a big motivator being the potential implications that long-term engineering engagement can have on their students. Teachers described their students’ reactions to the VT PEERS activities.

*“I think what’s motivating about this is the students have actually become excited when we get these lessons, and they want the days that we say, ‘VT PEERS is here.’ They’re excited to have that take place, and so that’s been more encouraging to try to make other lessons be more like that.”*

*“I think [the students] know more about engineering, engineers, at this point.”*

The recognition of students experiencing positive outcomes from these engineering activities has been a theme apparent in most of our previous data collection with teachers. The domain of salient outcomes within the IMTG has also been utilized as the main measure to determine the effectiveness of a TPD experience by Al Salami et al. (2017), but in a 2019 review of STEM professional development experiences Chai (2019) indicates that student outcomes are not generally used as a measure of success for TPDs, despite their significance in shaping the views of teachers. Our results support the importance of salient outcomes for the students in shaping teacher views.



Both the domain of practice and the recognition of salient outcomes for the students were noted by the teachers as influential in shaping their personal domains, mostly through shifts in their teaching philosophies. Noting the significance of student outcomes on shaping the personal domain of teachers, and the lack of its current use in determining the effectiveness of TPD, future TPD experiences may want to reevaluate the measured outcomes used to determine its effectiveness.

#### *Individual Characteristics Shape Extent of Pedagogical Shifts*

Beyond shifts in teaching philosophies related to teaching engineering, changes in other elements of the personal domain (knowledge, attitudes, beliefs) were not stated as explicitly in the interviews. It appears that one's personal domain plays a role in how quickly a teacher was willing to adapt their practices, but eventually all teachers were adapting their practices to incorporate more engineering. While all teachers reported growth in their self-efficacy to teach engineering, teachers entered the VT PEERS program at varying levels of teaching engineering self-efficacy. Throughout the first phase of the partnership, teachers are learning almost solely through vicarious experience as they engage in the classroom in a supportive role. One teacher described the value in watching the lessons take place.

*"I noticed where I can actually put [engineering] into lessons a little bit easier based on some of the lessons that I've seen take place throughout the year through...VT PEERS. So that, I think, has broadened and opened up eyes to how we can put it into other lessons."*

Within the second phase of the partnership, teachers attribute their growth more to their mastery experiences, noted above for their influence in shaping teachers' PCK. Aligned with prior research, all teachers reported their intention to continue teaching engineering in their class as a result of strengthening their teaching self-efficacy (Coppola, 2019). Teachers shifted their teaching philosophies and self-efficacy related to teaching engineering, and attributed much of this to their mastery experiences and recognition of positive student outcomes.

### *3. Emotions Play a Role in the Partnership*

We found that teachers recounted various emotions that they and their students had related to incorporating engineering into the classroom. Throughout the initial phase of the partnership where teachers engaged in lots of vicarious experience and very rarely were the sole teacher in the engineering activities, teachers noted their excitement with the lessons due to student excitement and engagement. One teacher described her excitement in the following quote:

*"It just makes class more fun and I enjoy it just as much as [the students] do, watching them and interacting with them. I think to me is a lot of fun. I see more smiles when we're doing these activities than you just do in a regular class."*

During the transition to the second phase where teachers will maintain a leadership role within the classroom and other partners will hold a supportive role, teachers expressed being nervous about the transition because they lacked previous experience and they were limited in their engineering knowledge. Despite this apprehension, teachers highlighted their mastery experience, engaging as the main facilitator of VT PEERS lessons, as extremely important for contributing to the sustained teaching of engineering within the classrooms.

### *4. Unique Barriers and Assets at Teachers' Schools*

Teachers identified existing barriers and assets that are dominant in their school and community. Teachers generally had a positive experience in the VT PEERS program, noting beneficial outcomes with the partnership, expressing enjoyment at engaging with industry, and highlighting the excitement of students in the program. These experiences were shaped by their understanding of their community assets and the potential role they identified for them in the classroom.

#### *Preconceived Notions of Assets*

Teachers entered the partnership with preconceived notions about existing community assets, and these existing assets differed by school, county, and teacher. During the first year of the partnership teachers expressed that there were limited jobs in their community, especially those related to STEM, and that industries changed often.

*"There are no jobs in South County."*

*"I can't keep up with the industries, because they do come and go."*

They also expressed that their schools did some activities to engage students in engineering, but that these activities fell short of supporting students in their thinking about a future career or in developing their interest in engineering.

*“When we do the STEM trip, the girls do the STEM trip in the fall, the science and the math teacher goes. There’s usually some type of engineering activity there.”*

*“but as far as engineering my sixth graders don’t...they don’t even think about it or talk about it, which is so exciting that it’s coming into the classroom.”*

#### *Asset Identification After VT PEERS*

After the second year of involvement, teachers further recognized differential assets they are aware of within their community that support students in their pursuit of STEM degrees, such as STEM scholarships or specific middle school staff dedicated to pursuing STEM activities for students, such as a STEM coordinator. A teacher identifies assets of her community:

*“However, our community does a really good job of making sure that if students want to go on and pursue a degree, that they can get that free by the (scholarship) program in our schools... It’s just a free two-year program that they can choose to work so many hours in order to be able to go to... Our county does a lot of fundraising to make sure if a student wants to go on, they can.”*

#### *Identified Community Barriers*

While these assets varied based on county and school, all of our teachers identified barriers and challenges that exist with their rural students’ familial ties and their limited expectancies in pursuing college and engineering. Throughout our program, these beliefs seem to remain consistent for teachers, as they do not identify assets related to familial ties by the end of their second year of involvement, which is often identified as a form of capital in asset-based literature (e.g., Yosso, 2005).

*“Honestly, parent attitude. We have a high rate of low income, and sometimes I think the kids don’t get the motivation at home, and it’s really hard to change the family mindset to say, ‘Yeah, you can do this. I know you can.’ So I think that’s a barrier, as well.”*

In the interviews, teachers also identified the expectation that students will follow closely in the career paths of their family members, as is often suggested by rural literature (e.g., Ardoin, 2018). This was consistent over the two years and is identified by teachers as a barrier to students pursuing STEM or any college degrees, given the current lack of degrees held among rural families (Ardoin, 2018).

*“Many of them can it in their heads already what they’re going to do. it’s like what their parents have done, this is what they’re going to do and kind of.”*

Our program did not intentionally focus on the identification of parents as assets in the teaching of students, but given the prevalence of the conversation around parent influence on students in the teacher interviews, it is important to discuss here and merits greater attention in future studies. There is great benefit in acknowledging the role and potential asset of familial ties within rural communities, and it is suggested that future community partnerships consider their inclusion. Overall, some of the teachers’ preconceived notions around community assets were shifted, such as the availability of STEM positions within the community, but other community elements were not identified by teachers as assets in the community, such as familial ties.

#### *5. VT PEERS Partnership as an Asset*

Teachers recognized assets in the partnership that were not presently available in their immediate school, and identified their significance in supporting teacher growth throughout their two years of engagements. These elements included the opportunity to engage with industry partners, the value in engaging in the lessons as observers of their classrooms, and the availability of supplies that were directly applicable to hands-on engineering activities that aligned with science standards.

### *Value of Vicarious Experiences*

Some teachers noted the value in observing someone else teach their students, one element of the partnership, allowing them to observe pedagogical practices and student outcomes from the lesson. Previous literature focusing on the importance of vicarious experience is limited, but our study suggests that having vicarious experiences and positive verbal persuasion from partners seem vital to the success of any mastery experiences for teachers. Vicarious experiences also provide teachers an opportunity to observe student engagement, supporting their ability to identify pedagogies that effectively build on student assets. Remembering her time spent discussing curriculum with other teachers, one teacher shared the following:

*“So, I definitely will never complain about having time to sit down with another person and share thoughts and ideas.”*

Without access to the vicarious experiences and the industry and university personnel in the classroom, teaching engineering lessons may have been insurmountable for many teachers. This is also true for the availability of supplies relevant to engineering activities.

### *Importance of Material Supplies*

Supplies were provided by VT PEERS throughout the engineering activities and most supplies and all developed curriculum will remain in the classrooms for teachers to use beyond the program. Below is a teacher quote about the importance of the readily available supplies provided throughout VT PEERS.

*“I think we had talked about like a supply box, a stockpile of supplies...things that I can access when I get ready to teach it. I see that that would be a big, me check it out, me have it in my classroom so that I could use it and so on.”*

There were many assets of the community partnership that were noted as significant by teachers, but the opportunities for vicarious experiences where they were able to observe their classroom and students, and the availability of personnel resources and supplies for the lesson were mentioned the most.

### *Summary of Asset-Based Findings*

This research suggests that teachers shift in their recognition, integration, and value of community assets as a result of the partnership. Overall, we found that throughout the first two years of experience in the VT PEERS program, teachers maintained their understanding of some community-based assets (i.e., scholarships) and barriers (i.e., family ties), but also shifted their recognition of other community elements that were intentionally integrated into the TPD to assets (i.e., industry, student experience). Teachers move through the domains of the IMTG to develop their self-efficacy and PCK, partly through their conceptualization of assets.

While teachers came into the partnership with some preconceptions about the community assets that they recognized in their community, verbal persuasion and influence from involved partners and the vicarious and mastery experiences of the teachers shifted their perspectives and ideologies around the assets in their community. For example, after the partnership, they placed greater value on collaborating with other teachers and involving local industry in the classroom. Over time, teachers shifted their recognition of industry as assets by identifying that they provided real-life context to classroom lessons, during both the vicarious and mastery experiences. VT PEERS, and the individual partners involved in the partnership, influenced the ways in which community assets were integrated into the classroom and how teachers intend to continuously integrate these assets. With the shift in teacher recognition of student assets, teachers discuss their intentions to continue to implement effective engineering pedagogical strategies that allow students to capitalize on their individual strengths. Since teachers are largely responsible for enacting engineering lessons and activities that draw from community assets and student strengths, this shift in teachers' recognition, integration, and value of community assets is crucial (Chiu et al., 2021). However, it is also worth noting that this program did not seem to impact teachers' recognition of parents as community assets, and rather the value placed on family impact was minimal.

### **Implications**

Based on our research findings detailed in the summary section, we find two significant implications that we should focus on in future practice. First, there is a benefit to including industry partners or disciplinary experts that are local to the community in educational partnerships. Second, many components of the VT PEERS partnership proved to be effective for supporting teacher recognition and integration of community-based assets and should be implemented in future partnerships.

### *Recognizing and Valuing Industry as Community-Based Partners*

In terms of asset-based community partnerships, the involvement of industry in similar partnerships can help provide real context to engineering problems but also demonstrate the investment from community partners in providing exciting and educational opportunities to students. For teachers, this kind of support can be important when teaching engineering concepts or content with which they may not be comfortable. Additionally, involvement from partners can demonstrate the various entry points into careers in a student's community that they may not have realized existed. Allowing opportunities for students to realize they do not have to leave home to find careers can help with a phenomenon called "brain drain" which occurs when young, talented people feel that they have to leave their communities to pursue careers and other opportunities (Ardoin, 2018; Carr & Kefalas, 2009).

### *TPD Recommendations*

Generalizing from these research findings, we would recommend that when engaging teachers in a professional development partnership, an emphasis is put on the elements of the partnership that teachers do not currently have access to within their traditional school systems or have not yet identified as assets. Specifically, we would recommend that partnerships build in more time for teachers to spend with other teachers external to their immediate school to discuss and brainstorm ideas for lessons related to engineering (Desimone, 2009). This study indicates that effective aspects of a professional development experience for rural teachers would include:

- access to supplies,
- effective and consistent communication,
- recognition of teachers as a partner with expertise of their own context,
- access to other people outside their school (teachers, engineers, etc.),
- opportunities for teachers to practice and reflect, and
- material that facilitates a broader understanding of the content and its application to careers and real-life contexts.

Many studies have already identified the importance of including experts in professional development experiences (Al Salami et al., 2017; Faber et al., 2014; Granucci et al., 2017; Hardre et al., 2014; Kovarik et al., 2013; Singer et al., 2016), but this moves beyond the inclusion of an expert to identify that these experts should be positive, receptive to teacher requests, and viewed as knowledgeable of the given topic by the teachers. While we also recognize and understand that assessment of program elements by community partners and student outcomes are both important indicators of the success of a TPD experience, this is beyond the scope of this paper. All of these elements should be given careful consideration in the development of a professional development experience for teachers, especially with regard to the specific educational context and their current available resources.

### **Limitations and Future Studies**

We note some limitations of this work. One is that the categories and themes developed through analysis were from the perspective of the researchers involved. Though our perspectives were addressed through the inclusion of positionality, it is possible that others would develop different categories and themes based on their own perspectives. Due to the in-depth nature of a grounded theory-inspired analysis, a small number of participants were included, but we feel that the teachers represented the diversity of the teachers in the region. With an in-depth grounded theory-inspired study, the intention is not to generalize findings, but rather to provide a thick description of analysis for others to understand the transferability of results into their context. Additionally, because the interview data were collected by members of the VT PEERS team, it may be likely that teachers were more likely to respond positively about their experiences in the partnership. Lastly, the construct of self-efficacy is commonly measured using survey instruments, but our interviews asked questions similar to those that are reflected in some surveys and allowed participants to bring their experiences to the forefront with open-ended questions in the interview.

Future studies should continue to explore how teachers identify assets in their communities and then use these assets in their classrooms to change not only their students' conceptions of engineering, but also their own conceptions of engineering. It is also important to continue the use of asset-based approaches in engineering education research. Future studies could focus more closely on the role of industry in shaping teachers' self-efficacy and PCK throughout a community-based partnership. Aligned with previous studies, this research has indicated that industry was crucial in the VT PEERS partnership to support teacher content knowledge and self-efficacy and provide real-world examples to improve student engagement and learning.

## Conclusion

Teachers have their own core set of beliefs about teaching, learning, students, and their community context (Carlsen, 1999). Through our analysis, it became clear teachers entered the VT PEERS program with certain beliefs about engineering, teaching engineering, their students' capabilities, effective pedagogical strategies, and their community and school context. While teachers initially recognized some assets within their community, teachers also noted a shifting understanding of how their broader community, especially manufacturing industry, can be an asset to engineering integration in classroom activities. Similar to the shifts in teachers' beliefs about industry involvement, teachers also express shifts in their teaching philosophies and perspective of student behavior in the classroom. Therefore, we conclude that TPD experiences can enhance teacher recognition and utilization of assets they have not previously identified in their community. However, this transition is facilitated through the external domain within the TPD and the role of verbal persuasion, suggesting that TPD experiences should intentionally incorporate the identification and facilitation of community-based assets to support teacher acknowledgement of assets. Without intentionally identifying and integrating these assets, teachers may not shift their beliefs within their personal domain, as was the case with VT PEERS and teachers' beliefs about the role of familial ties with their rural students.

Overall, engaging in this partnership has allowed teachers to redefine their philosophies around teaching engineering and develop their engineering PCK through the incorporation of various community-based assets, such as industry and university involvement. They rely heavily on their experiences in the engineering activities (domain of practice) and the examples provided by industry (external domain) to broaden their understanding of engineering, and they share their beliefs that students have also broadened their understanding of engineering. We suggest that future rural TPD opportunities facilitate the relationship and discussion around community-based assets to support teacher identification of these assets, by means of including local industry partners or families within the TPD partnership. One way to accomplish this can be through assets mapping, which is a way to identify efforts and resources that can be utilized in communities (Highlander Center, 2020). This is also aligned with suggestions from Darling-Hammond et al. (2017) to "provide coaching and expert support" in TPD opportunities to support knowledge growth and expands that these experts should be community-based experts.

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## Appendix A

### Interview

*The interview will be semi-structured with questions similar to the below asked. The interviewer will provide transitional statements to promote the interview's flow. The interviewer will verify the informed blanket consent is on file*

Thank you for participating in VT-VT PEERS this year. Now that we have completed Year 1 of VT-VT PEERS, we are interested in your thoughts on your experiences, views, and insights. As possible, if you can provide an example, please do. We are interested in all thoughts, positive, negative, and neutral.

1. In your opinion, what outcomes might result from this collaboration?
  - a. <Prompt for positives and negatives>
  - b. <Prompt for students, school, you personally>
  - c. <Prompt for change since start of partnership>
2. Who do you think is benefiting from this collaboration? Why/How?
  - a. <Prompt for which students are benefiting>
  - b. <Prompt for change since start of partnership>
3. What role will/have you played in the collaboration?
  - a. <Prompt for change since start of partnership>
4. What role will/has the university/industry partner played in the collaboration?
  - a. <Prompt for was help for 6th grade classes appropriate for student learning needs? Was the amount of VT engagement as expected?>
  - b. <Prompt for change since start of partnership>
5. What do you see as your/other partners "ideal" role? Why is this different from reality?
6. If the project ended this year, would you be comfortable contacting (insert industry partner) in the future?
7. Have you gotten the information you need to be successful in implementing the curriculum?
8. Why do you think Virginia Tech and your industry partner are part of this program?
9. Any other thoughts about how the collaboration has changed over the first year? How has it changed for you specifically?
10. What, if any, specific challenges that you encountered (or you think the project encountered) during the first year?
11. Have your conceptions of engineering or engineers changed since the start of this partnership? If so, how? What factors contributed?
12. Have your feelings about your ability to teach engineering changed since the start of this partnership? Why or why not? What factors contributed?
  - a. <Prompt for both positive and negative changes to self-efficacy>
13. Has your motivation to teach engineering changed since the start of the partnership? Why or why not? What factors (people or things) contributed?
14. What barriers, if any, do you anticipate in teaching your students about engineering in middle school? Are these unique to you or your setting, how?
15. Have any barriers changed since the start of the partnership (either less or more)?
16. What, if anything, do you think makes teaching middle school students, in rural communities, about engineering different than other communities?
17. What, if anything, makes teaching middle school students in your community about engineering different than other communities?
18. We've heard from other teachers that they are surprised at the variety of learners that are engaged during these activities. Have you noticed anything along these lines in your class?
19. [DAET triangulation] In analyzing the DAET, we noticed students from your class [specific data, e.g., saw that students wrote about helping people but does not match drawings here], we were wondering if you could provide any insights into why this may be?
20. What do you think are the barriers or supports to pursuing engineering as a career for your students?

21. Did having VT PEERS in your classroom change any routine dynamics for the day or surrounding days? How? Was/ were they helpful/not helpful?
  - a. <prompt for the teacher's norm and for the students' norms> (in some situations we noticed the principal entering the classroom and even participating in some cases; how might this change the classroom norms)
22. So, you must be thinking ahead to next steps, what would you want next year to look like?
  - a. <prompt for any steps that have taken towards actualizing their vision>

## Appendix B

### *Clustering Process: Open Coding to Categories*

Throughout the methodology section of the paper, the coding strategies were discussed and this Appendix provides further details of the clustering process. After the open coding of the five interviews, there were 633 raw codes, consisting of gerunds and in-vivo codes. To revise this codebook and identify categories, each code was associated with as many of the sensitizing concept constructs that were applicable. These constructs included:

- content knowledge, pedagogical knowledge, pedagogical content knowledge and context-specific knowledge (domains of teacher knowledge),
- mastery experience, vicarious experience, physiological support, and verbal persuasion (self-efficacy), and
- practice domain, external domain, personal domain, and salient outcomes (Interconnected Model of Teacher Growth).

Other constructs developing through a focus on assets included industry partners, supplies, partnerships, and future ideas which were all born out of the memos which identified these categories as being present in all of the teacher interviews. This organization supported the development of categories, of which 24 distinct categories were developed.

The clustering process was initiated by grouping codes that were linked to the same elements, such as listing all the codes linked to "industry partners." As an example, the category titled "Understanding the pedagogical strategies effective for teaching engineering through experiencing the lessons" is made up of 53 raw codes across all five participants and highlights that teachers identify specific pedagogies that were particularly useful in teaching engineering during the activities and make decisive claims about what pedagogies are necessary to teach engineering lessons. To better depict the process of analysis for each line of the interviews, the below figure indicates the coding and categorization process for one quote.

*Coding process: moving from teacher quote to category.*

