Stories of Appalachian Engineers: A Phenomenographical Study of Appalachian Students' Quest for Success in Undergraduate Engineering Programs

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Work In Progress: An Exploratory Study of Appalachian Students' Quest for Success in Undergraduate Engineering Programs

Abstract

This work in progress paper reflects on a qualitative study that explores the unique undergraduate engineering experiences of engineers who identify as Central Appalachian. This study employed interviews to collect data on how engineering students of Central Appalachia develop interests, make choices, and achieve success in their academic and career experiences. In terms of engineering education access and job opportunities, the inhabitants of Central Appalachia have historically faced a unique set of challenges. However, this study took an asset-based approach to understand the unique cultural capital these students hold.

The primary goal of this study was to understand the experiences of engineers who grew up in the Central Appalachia region, navigated undergraduate engineering at a major university that likely did not have many Appalachian attendees, earned their engineering degree and are now working in the field as engineers.

On the campuses of major universities, Central Appalachian students are often marginalized because these educational spaces were not created with their needs and experiences in mind. The primary research question is, ***"What types of cultural capital did Central Appalachian engineers use to become career-ready engineers during their undergraduate engineering experience at a major university?"*** This study seeks to provide pilot data for a future phenomenographic study, with the outcome space being stories of success to provide paths forward for tomorrow's engineering students from the Central Appalachia region.

Introduction and Background Literature

The Region

Central Appalachia encompasses 68 counties in greatest economic distress within the rural regions of Kentucky, Virginia, Tennessee, and West Virginia [13]. Job creation and access to higher education within Central Appalachia has proven difficult because of the isolation and rugged terrain of mountainous geography. This isolation has limited infrastructure that supports industry and provides the resources desired by people who could be enticed to live and work in the area [1]. Within the region, companies that employ engineers have a difficult time hiring and retaining engineers [1]. Companies have also reported a need for an increase in the number of engineers local to the region. [2] However, low job prospects and low wages within the region have caused many Appalachian students who leave the region to attend college to continue to live and work outside of the region after college.

Per the Appalachian Regional Commission's most recent report, from 2016 to 2020, Central Appalachia lagged the rest of Appalachia in employment, economic wealth, and educational attainment [7]. Much of the existing research on undergraduate STEM students in Appalachia focuses primarily on the Central Appalachia region.

Frameworks

This study employs the framework of Social Cognitive Career Theory (SCCT) to understand the processes through which engineering students of Central Appalachia "form interests, make choices, and achieve varying levels of success in educational and occupational pursuits" [8]. This framework explores barriers encountered during these pursuits, but also

acknowledges the importance of identifying contextual conditions that support and enable members of marginalized groups to pursue their goals in the face of deterring conditions [9].

Many Central Appalachian engineering students share characteristics with minoritized groups such as low socioeconomic status [2], first generation college status [10], and entering a local college rather than leaving home to pursue a desired degree [2]. For several centuries, Appalachian people have been marginalized because of discrimination, geographic isolation, and distinctiveness of the culture [3]. As such, I propose that the experiences and needs of Central Appalachian people can be modeled using tenets of a framework that was created for marginalized groups.

Although SCCT provides a space to understand the experiences of students who grew up in Central Appalachia and left the region to pursue an undergraduate degree, the component of SCCT that is focused on enabling these students to employ their cultural capital to succeed can be organized within the six tenets of Community Cultural Wealth (CCW). This theoretical framework focuses on positioning oneself for success in a domain not created with one in mind [4]. The six tenets of the framework are aspirational, navigational, social, linguistic, familial and resistant capital. This study uses these tenets to identify ways undergraduate engineering students from Central Appalachia can come to recognize and leverage their strengths as they approach degree attainment and come to see themselves as workforce-ready engineers. Stating that these undergraduate students are living and studying in a system that was not predominantly made for them places the root of their difficulties on lack of access to resources and experiences commonplace to many of their peers.

Methods

Data Collection

Drawing from previous works [1], [5] an interview protocol was created that explored participants' transition to college, childhood experiences, college experiences, transition to career and advice in retrospect. Three participants: two practicing engineers and one recently retired engineer, were recruited to participate in this study through personal connections and word-of-mouth. Their demographics are shown in Table 1 in Appendix A. Interviews were recorded and lasted approximately one hour each. Recordings were manually transcribed to ensure accuracy and identify feeling, vocal patterns, and emotion. The interview protocol is shown in Appendix B.

Data Analysis

Participants were assigned the pseudonyms of Gage, Steve and Wayne. The first step in data analysis was to read all three transcripts question by question to understand the variations in responses across interviewees. This method aligns with analysis for phenomenography because it allows the researcher to begin to recognize differences in experiences across interviewees. After reading transcripts twice for familiarity, coding began. A first round of coding was conducted to create categories of qualitatively different conceptions of the phenomenon and phrases were assigned to them

At the time of interview protocol creation, a primary goal and three supporting goals for the study (shown in Appendix A Table 2) were defined and used to develop the interview protocol. As such, referencing them during the analysis phase allowed for creation of three a priori codes (Shown in Appendix A Table 3) used to bolster procedural validation [12] by

providing a feedback loop to determine if the goals defined at the outset of the study are being supported by the interview protocol as it is currently written.

After conducting the first coding pass, codes that contained all the same phrases as other codes were consolidated.

Because the list of codes grew throughout the duration of the first coding pass, a second coding pass was necessary to ensure that all transcripts were coded with an equivalent code book. Also, by conducting an additional pass of coding after the codebook had been completed, respondents' experiences were captured, even when they moved from topic to topic in a non-linear manner. A complete list of codes can be found in Appendix A Table 4.

Finally, the phrases assigned to each code were organized and their essences were written in paragraph form. Five dominant themes that explained participants' ways of understanding their experiences as undergraduate engineering students emerged from the data analyses. These terms were coined as "global meanings." [6] This created an outcome space in which each paragraph served as a summary of thoughts, feelings, and experiences surrounding one global meaning.

Results

The five global meanings resulting from data analysis are shown below. In some cases, they were interconnected.

Seeking Connections & Finding Support

All three participants knew they wanted to become engineers prior to beginning college. At the outset of their engineering journey, they had support from their friends and/or family. However, once they were at college, they did not turn to family or friends from home for guidance—with the exception of friends from home who had become engineering peers at college. All three participants noted that they did not have many or any peers who were from the Central Appalachia region, and no participants could recall professors from the region either. All three knew someone from their upbringing who went to college with them or nearby, but not necessarily in their major or field. Gage immediately mentioned that having a professor from the region would have been extremely helpful. Role models were few and far between for participants as well. Only Wayne identified an engineering role model. Gage mentioned that once he began working, his dad was supportive and helpful to him because though his dad was not an engineer, they both had careers in related fields.

When asked about study partners, all three indicated that they did not study with their best friends. Wayne said that he wanted to keep his "study friends" and "social friends" separate because he didn't want to talk about engineering when he wasn't working. Steve said that although he had a couple of best friends who were engineers, he preferred working alone because he could stay focused more easily. Gage did not have best friends that he studied with, but said that when he wanted to study with others, he did not seek friends, but rather people who seemed to be "like him" and had similar academic struggles.

Overcoming Program Rigor & Building Engineering Identity

Although Steve and Wayne indicated that they were confident in becoming an engineer from the outset, all three expressed fears and doubt early in their engineering journey. All three repeatedly mentioned the difficulty of the content, the heavy workload, and a constant fear of falling behind. Steve mentioned feeling unable to go home to see family for fear of being unable to catch up on work. Wayne said he would "never miss a day of class" because he would have to

catch himself up. Gage said that the rigor caused him to lack confidence in his ability to become an engineer.

All three participants also mentioned being singled out for various reasons in college. Steve and Gage mentioned feeling self-conscious about their Central Appalachian accent. Gage and Wayne both mentioned negative reactions from college peers and peers' families when they told where they were from. Gage was the study participant from the most rural region of origin. He noted several times that he was always conscious to avoid portraying stereotypes of Appalachian people and worked to eliminate his accent.

For all three participants, their confidence in their ability to succeed academically increased as they progressed toward graduation. Unprompted, both Wayne and Steve mentioned that they had been extremely independent since childhood. They indicated that their independence played a role in their ability to successfully navigate their journey to becoming an engineer. It made them persistent people. Engineering Identity developed differently for each of the three participants. Gage said he didn't have the confidence that he could be an engineer until a couple of years into his degree process. He mentioned feeling less cultured than his peers--jokingly calling himself a "dumb hillbilly," and noted that he tried hard to separate himself from the stereotypes of Appalachian people. He desired to "fit" with those around him. He did come to see himself as capable of becoming an engineer, but that came closer to graduation. Another participant, Wayne, noted that although his friends in college and from his hometown were not engineers, he developed an engineering identity quickly because he worked as an engineering co-op during most of his time in college. When he graduated, he said, "I was ready." Another participant, Steve, shared some similar sentiments. He co-oped for six quarters. He had a "management mindset" for the duration of his time in college. Although he noted that his curriculum was "hard work" and had "high expectations," he knew he could succeed after the first quarter.

Working While Learning

Steve and Gage noted that the cost of college was a barrier to entry that they had to navigate around. All three participants worked through college. Gage interned during summers, and Steve and Wayne co-oped with the company that ultimately hired them and retained them for the duration of their careers. All three linked strengthened relationships within engineering and a bolstered feeling of ability to become successful engineers to the hands-on experiences they gained through their work during college, and the hands-on experiences they had growing up. Wayne said that working construction with his dad had fostered a desire for understanding how to build things. Gage noted that through hands-on experiences, "You see the creative ways that things are built and brought together." He also made mention of social understanding from hands-on experiences. For example, through working summer jobs with non-engineers and having a father with a technical but non-engineering background, he understood how to get work done collaboratively as a young engineer. Steve commented that hands-on experiences can also help you understand what you don't want to do. Although his time working as a mechanic helped him understand engineering applications, it also served as motivation to stick with the degree because he did not want to be a mechanic for his career.

Discussion

Lack of engineering role models indicated by participants is aligned with marginalized engineering students' experiences. This finding supports the notion that these students are operating in an environment not created with them in mind. Support from family and friends

"back home" may help students navigate emotionally but not academically if those people of influence are not engineers. Central Appalachian students need peers who are learning partners inside and outside the classroom. This study also demonstrates the need for instructors who are seen by Central Appalachian students as "like them." Existing literature shows that students need to feel they have an advocate and someone who relates to their lived experiences. [11] When students see an engineer who reminds them of themselves, it boosts their own engineering identity. This is supported by Gage's desire to study with people who he felt were "like him" and his quick expression of desire to have had professors from Central Appalachia. Wayne, when speaking about the positive outcomes of his own career, mentioned peers from Central Appalachia in college who became engineering professors. He indicated that he felt they had great careers and he had desired to keep up with them all his life.

All three participants referenced difficulty of content and heavy workload in their engineering programs. These characteristics caused them to be reluctant to leave campus during the semester, and delayed their development of engineering identity because of fear of failure. However, the catalyst for development of engineering identity and a positive "can-do" perspective for all three participants was the engineering-related work they did during college. Phrases that were coded to the largest quantity of codes were related to participants' experiences doing work that was related to their career. Often, work that provided "Hands-On Experience" (a code in this study,) also bolstered participants' "Engineering Identity" and increased their "Wanting To Become An Engineer." As shown by this quote, hands-on experiences also had links to the codes: "Employment of Navigational Capital," "Formative Education," "Hobbies and Interests," and "Childhood Experiences." These strong ties across codes demonstrate the importance of hands-on practice during students' engineering undergraduate experience."

"But you learn a lot just from being outside and your dad working for the power company. We used to--we would help him. He would wire new houses, you know, with some of the contractors around. They were building houses, and Dad would wire them, and we would go and help him, you know, drilling the holes in the two by fours and things to run the wiring, and actually then pulling the wiring and stuff like that."

Although all three participants felt "singled out" at various points in their undergraduate engineering journey, retrospectively, they no longer seemed to care if they are "different" than their peers because of their region of origin. Wayne mentioned that in college, he felt people sometimes singled him out for being from Southwest Virginia, but he later talked about the other engineers he worked with who were from the region, and how they had been lifelong friends to him, and they had "all had great careers." Steve mentioned being self-conscious about his accent when he was young, but he realized that he could not change it, and did not try to. Looking back, Gage feels his career "lined up to help him achieve his goals." He also mentioned that he is now "a lot freer and open in talking about where I grew up and how I grew up than I was then."

Steve and Wayne noted childhood friendships that had carried into their engineering education and careers. These friendships served as cultural capital for these participants. Steve had four or five friends he grew up with that he continued to spend time with in college. Wayne had lots of connections with other engineers in various capacities around Central Appalachia. Those connections helped him be successful in his career. Some of them dated back to his upbringing. While Gage didn't mention specific friendships, he noted it was "extremely

important to find friends who were from the same background" during the transition into college. Creating that cultural capital made the transition much easier.

Lastly, all three participants had advice for young engineering students. Gage said that we as Appalachian people know we are smart, we are capable, we are good people. He said "If you believe what the people are telling you, it will crush you." Keep fighting. Everyone has had a punch in the face. Don't give up. Steve noted that in an ever changing world, it is important to be a lifelong learner and to always be ethical. Wayne noted that several of the people he grew up with got engineering degrees, got their doctorate, and returned to Appalachia. These people serve as examples of what Appalachian people can achieve. Wayne echoed Gage's sentiment that Appalachian engineering students can't go in half-heartedly. They must give 100%.

Limitations and Future Work

This study was conducted as a pilot for a larger study. Several opportunities for refinement of protocol content were identified. The section of the interview protocol that focused on what participants did during their career did not yield relevant codes. Although participants' stories about their careers were interesting, the content was, in many cases, not aligned with research questions or goals of the study. Additionally, three codes: "Faith or Religion," "Familial Education," and "Hobbies and Interests" did not yield findings that related to the research question or study goals.

During the analysis phase, new topics of interest were uncovered. Some topics that were aligned with the research questions and goals of the study came up organically during interviews. These topics proved interesting and provided groundwork for additions to the interview protocol. For example, it would be valuable to understand how participants built connections with peers during their time as students. It would also be interesting to know more about people who were influential to them and why. One participant, Wayne, organically mentioned both of these topics, but the other two participants did not. Additionally, Steve discussed learning strategies that had been successful for him. To build on the value of understanding participants' learning strategies, one must also understand how they make decisions and solve problems. Some participants loosely referenced that, but the topic was not probed directly.

While participants all indicated feelings of uncertainty and insecurity related to their region of origin at the outset of their undergraduate engineering path, and later indicated that they have now become comfortable speaking about their region of origin and made many positive comments about the progression of their careers, the transition away from insecurity and toward positive reflection on their upbringing was not studied.

Conclusion

Participants in this study did not have many instructors or peers who were "like them." They also did not have many engineering role models. In retrospect, they lamented that. Committed effort to bring Appalachian faculty into engineering classrooms could greatly support development of engineering identity for Central Appalachian students.

Development of engineering identity and a mindset of being "capable" of earning the engineering degree were both directly linked to work experience during childhood and college for all three participants. This supports the value of co-ops and internships for Central Appalachian students. Needs of hands-on experience and financial support are both supported by co-ops and internships for these students also.

All three participants noted Appalachian characteristics that they were self-conscious about during college. For all three, the insecurities faded over time. Participants' advice for the next generation of Central Appalachian engineers all centered around positivity and belief in self.

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Appendix A

Table 1: Participant Demographics

	Participants		
	Gage	**Steve**	**Wayne**
Region of Origin:	*Outside Virgie, Kentucky*	*Scott County, Virginia*	*Bluefield, Virginia*
Degree:	*Mining Engineer*	*Industrial Engineer*	*Mining Engineer*
School:	*University of Kentucky*	*Virginia Tech*	*Virginia Tech*
Career Stage:	*Mid-Career*	*Late-Career*	*Recently retired*
Currently Living:	*Outside Central Appalachia*	*On the border of Central Appalachia*	*In Central Appalachia*

Table 2: Supporting Goals Used for A Priori Code Creation

Supporting Goals
Understand how Appalachian engineers experienced the phenomenon of becoming an engineer, and how they leveraged their cultural capital to navigate barriers and challenges on their journey to becoming engineers.
Explore how Central Appalachian engineers' personal and professional identity changed over time as they progressed from their engineering degree programs into their engineering careers.
Identify how the stories of practicing Appalachian engineers can empower current Appalachian engineering students to recognize and utilize their own cultural capital to develop their identity as engineers.

Table 3: A Priori Codes Used in Analysis

A Priori Codes
Engagement of cultural capital
Identification of cultural capital
Empowering future Appalachian engineers

Table 4: Code Names and Examples

Code Name	References	Example Quote
Developing Engineering Identity	35	*"I really saw myself then, you know, as kind of even with like a management mindset and everything. It hasn't really turned out that way. But that's definitely how I saw myself when I when I was in college."*
Childhood Experiences	32	*"...being mostly an independent kind of person, even growing up. I liked to be as independent as I could, and self sufficient emotionally, and stuff like that."*
External Influence from Other People	27	*"I think my dad and my grandfather, even though they're not in the career with me, you know, they were an influence to the career."*
Employment of Navigational Capital	24	*"(my dad) he'd say, 'Well, let me tell you what you need to do so they don't make fun of you.'"*
Social Capital	20	*"I'm a normally, naturally a sort of backward person and not real outgoing or anything. And it helped me to get confidence that I could go away from home..."*
Time-Oriented Perspective	20	*"Several of the guys I went to school with ended up being professors at Virginia Tech--continued to stay and went to graduate school, and, you know, got their doctorates and then they came back..."*
Educational Performance	19	*"A lot of them had gone to private schools or a lot different educational background than I had, but I realized I could compete with them in the classroom."*
Wanting to Be an Engineer	19	*"...you start off to be an engineer, but nobody you know, ever has ever been an engineer."*
Hobbies and Interests	18	*"I think those interests help me be more mile wide."*
Regional Nuances	16	*"...as a Appalachian student going to Uk was--I didn't talk like everybody else. And people made fun of you for that."*
Formative Education	14	*"Learn the value of work. Learn the value of money. Just learn the value of finishing the job."*
Hands-on Experience	13	*"...because I was going back to the same company where I co-OP'ed to start work, you know, I felt like I at least had what I needed to get started."*
Recognition of Financial Circumstances	11	*"I ended up in mining engineering in particular because of finances. It was a financial decision."*
Empowering Future Appalachian Engineers	9	*"You are much better than what some people are going to think you are. And inherently, we know this growing up in Appalachia, because we know we're good people. We know we're smart people."*
Outlook on the Field of Engineering	9	*"Lot more people could be engineers if they just stuck with it a little longer."*
Identification of Cultural Capital	8	*"I did not (have Appalachian instructors). Not at Virginia Tech. Very few of them were from Appalachia."*
Meeting Career Goals	7	*"...we would go to Grundy Law School and so it was a whole bunch of professors from Virginia Tech, with a bunch of engineers from the coal fields, and they would put on courses..."*
Region of Origin	7	*"Had I grown up in a really urban area, I probably would have felt like, you know, Blacksburg and Virginia Tech, for example, was really backward."*
Engineering Role Models	6	*"I wanted to be an engineer, you know. and I want to do what My Uncle Lawrence did."*
Engagement of Cultural Capital	4	*"...it was extremely important to find friends who were from the same background."*
Faith or Religion	4	*"...faith was also a big part of my life growing up."*
Familial Education	4	*"...both of my papaws loved to read, even though they didn't even--my two papaws didn't even have too many years of education."*

Appendix B

Interview Protocol:

Notes for the interviewer:

Bring to the interview:

- At least one voice recorder; two is ideal in case one doesn't work. The Voice Memo function on an iPhone works well.
- Copy of the information letter
- Copy of the interview protocol
- Pen or pencil

Wear business casual clothes. After talking over the interview with the interviewee (see notes below), start recording and open the interview with some casual questions such as, "How is your day going?" If they are talking for a bit on these points let them keep going and do not cut them off. You want them to talk throughout the interview, and it can help to get them going early on a topic that they are comfortable talking about.

Avoid bringing in large pieces of technology if possible as they can be distracting/intimidating. Find a space that does not have a formal interview set up (you behind a desk and them on the other side). If the room has more than one seating option let the interviewee pick where they

want to sit as that will make them more comfortable (some people don't like having their backs to the door).
Having a second person in the room can be helpful so that you can have time to pause and think or someone else can make sure that you have asked all the questions/all answers given by interviewees are actually clear. A second person can also note non-verbal cues the interviewee gives.
Try to avoid asking the interviewee to speak in a different tone or volume than their natural speaking voice as this may make them feel uncomfortable or inadequate. Instead move the recording device around if needed.
Throughout the interview, avoid affirming or disagreeing with the interviewee. Do not "lead" the interviewee toward a response. Agreeing or disagreeing with the interviewee can skew the interview data because it can change the direction of the conversation, and also can cause the interviewee to overshare or undershare on certain topics.
This is a semi-structured protocol. Interview questions will be asked as listed, but additional follow up questions may be included based on individual responses to probe interviewee answers. You don't need to ask all follow up questions.
Reminder: Primary research question for the study is, "What types of cultural capital did Central Appalachian Engineers use during their undergraduate engineering experience to become workforce-ready engineers?"

Transition to College

How did you get into engineering? Sit back, wait, and listen
What factors do you think influenced this decision?
Did you consider other majors outside of engineering?
Why did you choose to go to college?
How did people react to your decision to go to college? To become an engineer?
What did you learn or experience during your upbringing that made you feel more prepared to become an engineer?

Childhood Experiences

Where did you grow up?

- Tell me what it was like growing up there.
  Probes: (don't ask individually—but as a cluster) Family? Church? Neighborhood? Friends/Peers? (This is a long question)

What did you do outside of school, growing up?
What were some of the advantages and disadvantages of the area where you grew up?
Tell me about your activities and interests growing up.

- Have any of your childhood interests or hobbies continued into your adult life? Have they shaped your personal or professional development?

College Experiences

When you were in college, did you see yourself as an engineer? Why or why not?

- [If yes] Can you give me some examples of ways in which you saw yourself as an engineer?
- [If no] What would have helped you see yourself as an engineer?

During college, how confident were you in becoming an engineer? Why?

- In what ways did you feel more like an engineer than your peers? (in college)
- In what ways did you feel less like an engineer than your peers?

What innate characteristics of yourself do you feel helped you become an engineer?
What were some of the things that made it difficult for you to achieve your goals?
What learned behaviors helped you become an engineer?
Did you recognize behaviors or "social norms" that you attempted to emulate to "fit" in engineering?

- How did you identify these "social norms"?
- Where did you learn them?
- Who defines them?

Were there characteristics common of Appalachian people (that you saw in yourself) that helped you succeed in engineering?

- How did you come to see these characteristics as being common among Appalachian people?
- When did you notice these characteristics?
- How did these characteristics help you succeed?
- Were there characteristics common of Appalachian people that you tried to hide or separate yourself from? Why?

When you were in college, did engineering feel like a good fit for you?

- What made you feel that way?
- Did it feel like more or less of a good fit as you progressed toward graduation?

Had you grown up in an urban area, how do you think that would have changed your engineering undergraduate experience:

- Elaborate on positively and negatively
- Elaborate on Inside the classroom and Outside the classroom

When you went to college, how did you identify people to befriend? How did you identify study partners?
To what degree was it important to you to find friends from your home region? From Appalachia as a whole?
Did you have any instructors from Appalachia?

- Did that matter to you? If so, in what way?
- How did you know they were Appalachian?

Did being Appalachian ever make you feel like an outlier? If so, in what ways?
When you graduated, did you feel you had the skills you needed to start an engineering job? Why or why not?

Path to Job

Tell me a little bit about your career path – how did you get to this position?

- Key steps along the way
- Key decisions

Who were some of the key people who influenced you during your career and why?

Advice in Retrospect

If you could give advice to the next class of graduating Appalachian engineering seniors about what to expect when they enter their jobs, what would that be? Why would that advice be useful? Would you have listened to that advice?