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Engineering as a Career Choice in Rural Appalachia: Sparking and Sustaining Interest*

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Research shows that interest is often reported as a primary reason for career choice selection among majority students but not necessarily for underrepresented students. At the same time, research focused on rural Appalachian youth in Virginia and Tennessee (students underrepresented in higher education broadly and specifically within engineering) has shown interest as preferentially important in engineering fields though not in other fields. To better understand how interest in engineering is sparked and sustained among Appalachian students, we used a qualitative multi-case study approach to first compare interest in engineering and healthcare fields among high school students and then to compare high school and college student interest in engineering careers. For high school students, our findings reveal interest sparks in engineering were more likely to be associated with organized experiences, while health care interests were primarily associated with personal experiences. We also found an association between engineering interests and a preference for math and science classes, but the same association did not exist for interests in health care fields, despite the potentially equivalent math/science intensity of these career fields. With regard to interest development phases among high school students, individual rather than situational interests tend to be associated with intention toward engineering majors, whereas the opposite was true for healthcare fields. For college engineering students, we identified a greater balance between individual and situational interest than in the high school sample of students interested in an engineering career. College students were also more likely than high school students to indicate a personal experience as sparking his or her interest in engineering than an organized activity. Finally, though we compared two case sites in rural Appalachia, our findings revealed commonality in interest levels and sparks across sites. In combination, these findings have implications for designing interventions intended to spark interests in engineering such that the interests can also be sustained.

Keywords: interest; Appalachia; career choice

1. Background

K-12 education has become an increasingly important site for recruiting students into engineering careers, but despite a broad range of interventions, enrollment trends have seen little change in recent decades, particularly for underrepresented populations. These flat enrollment levels suggest the need to better understand students' intended career choices if we seek meaningful change. Much of the existing research points to interest as central to K-12 students' pathways to career choices. For example, the highly influential Social Cognitive Career Theory (SCCT) model [1, 2] prominently features interest as an important construct influencing career choice pathways. Moreover, research has confirmed the importance of interest specifically within Science, Technology, Engineering, and Mathematics (STEM) careers [e.g., 3, 4].

However, research on the role of interest in career choice is complex and sometime conflicting. Studies of underrepresented groups across higher education in the U.S. often find interest less important than constructs such as cultural milieu and outcome expectations [5–9], internalized stereotypes [10], or socio-economic status (SES) and social class perceptions [3, 11]. In the work by Bystydzienski, Eisenhart, and Bruning [3], for example, interventions for high-achieving high school girls in the U.S. did increase interest in engineering as a career choice, but that interest was not sufficient to overcome financial constraints or gaps in social support and self-efficacy for low-income women. Moreover, Kim and Seo suggest that the role of interest in major choice may only reflect national, and specifically European or U.S., cultural values. Their work with upper-level South Korean university students showed a lack of connection between interest and major choice goals [12]. At the same time, even when factors other than interest dominate students' choices, strong levels of interest may be linked to persistence within a major. For example, in a study of Taiwanese college students, Liao and Ji [13] found that students were more likely to persist when major choice stemmed from personal preference rather than family influence.

The prominence of interest as an influence on students' major choices, coupled with conflicting

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evidence regarding the strength and scope of that influence, suggest a need for a richer and more nuanced understanding of this central concept. Studies such as those described above often treat interest as simply a pattern of likes and dislikes for specific activities or a process by which learners are energized [14, 15]. But rather than seeing interest as a single construct, educators and researchers alike would benefit from understanding and exploring the roles that different types of interest play with respect to students' career choices. Toward that end, we turn to the work of Hidi and Renninger [16], which posits four phases of interest development, with situationally generated interest on one end of a spectrum, and individually maintained interest at the other. Their model is particularly useful for studies of engineering interest in K-12 because much of the work in this area, both in the U.S. and internationally, focuses on interventions with the aim of increasing interest, but that are often evaluated based on immediate results and not on interest sustainment. Interventions cover a broad range of activities, from single exposure workshops (e.g., day-long field trips or Saturday workshops) and short-term programs (e.g., First Robotics programs), which are often isolated or disconnected from other interventions, to interventions integrated into the classroom curriculum (such as Project Lead The Way) that offer exposure over a five to six week period and often require student involvement beyond the class period via homework assignments [17]. Such interventions may act as external mechanisms to generate and initially sustain interest. However, moving from such externally generated interest into career choice is not always a direct translation, as the work of Bystydzienski et al. [3] and others suggests. We cannot assume that interventions that generate interest, though potentially necessary, are in themselves sufficient to support students' choice of and persistence in engineering or other STEM careers.

To situate our study on the ways different phases of interest intersect with career choice, we focus on one specific group: students from rural Central Appalachia. Though students from this region are not classified governmentally as underrepresented, the region itself has high rates of poverty and low rates of educational attainment, and few students from the region pursue engineering careers. Poverty rates in the region are typically 150% of the national average, while college completion rates for counties in this region are typically less than half the U.S. national average [18]. Moreover, our prior work in this region suggests that factors other than interest *generally* influence career choices (including, for example, in healthcare fields), but interest is a key influencer for *engineering* as a career choice [19–21], reflecting some of the contradictions noted above as well as in previous studies of career choice in Appalachia broadly [8, 9, 22–25].

In seeking to broaden the conversation around the role of interest in supporting engineering career choice, we present a multi-case study of two distinct sites (geographic regions) in Central Appalachia: one in southwestern Virginia and the other in the Cumberland Plateau region of Tennessee. Each case included multiple counties (with varying (though all low) socio-economic conditions and school sizes), county-by-county economic and education data to contextualize the cases, and interviews with both high school and college students who are pursuing engineering careers. Participants included students who had and had not experienced engineering-related interventions during middle and high school. Including high school students allowed us to capture engineering major choice as it was happening. At the same time, given that high school intentions do not always translate into college actions [26], college students provided a quasi-longitudinal perspective and allowed us to ensure that we included students who, in fact, had chosen engineering as a major. In addition, to consider relationships between interest phases and major choice in a wider context, we included high school students who declared career interests in healthcare. Healthcare offers three compelling benefits as a comparison point: (1) engineering and healthcare are both high paying career fields, and a desire for stable jobs is particularly important for students from our case site regions [20, 26]; (2) many healthcare and engineering fields require post-secondary degrees and have similar math and/or science pre-college prerequisites and college course requirements; and (3) healthcare was sufficiently prominent as a career choice among participants to provide a sample pool for comparison.

This multi-case approach enabled us to expand our findings across U.S. state boundaries and highlight the ways findings from this study may be transferable to other contexts. However, consistent with the goals of qualitative research broadly, our goal is not to generalize our findings across all, or even all underrepresented, populations. Instead, our study explores the ways in which different phases of interest development intersect with participants' career choice goals as a means to broaden and nuance the conversation about interest and highlight areas for future work. Toward this goal, our study addresses three research questions: (1) What sparked interests in engineering vs. healthcare careers for current high school students from rural Appalachia? (2) How well developed are the career-related interests of current high school students from rural Appalachia who intend to pursue engineering or healthcare careers? (3) How do the interest sparks and interest development phases compare between high school students considering, and college students actually enrolled in, engineering degree programs?

2. Theoretical framework

We used Hidi and Renninger's Four-Phased Model of Interest Development [16] as our theoretical framework for this analysis. The phases in this model are sequential and represent a deepening interest (Fig. 1). Hidi and Renninger [16] state, "The potential for interest is in the person, but the content and the environment define the direction of interest and contribute to its development." (p. 112) Consistent with this idea, they proposed a model where interest develops over time with phases marked by degree of personal ownership.

In a Phase 1 interest, a person may be exposed to an activity and be excited about that activity in the short term. The activity is the environment that sparks the interest, but the interest is also externally supported by that activity, i.e., without the activity the interest may fade. In Phase 2, the interest is still externally supported (e.g., continued engagement in an activity), but the interest is becoming more personally meaningful to the individual. The interest may still fade without continued exposure to the context that supports the interest. In Phase 3, the interest becomes self-generated such that the person begins seeking out additional knowledge and builds personal value for the activity. In Phase 4, the interest is completely self-generated and the person intentionally seeks out ways to continue engaging in the activity. Phases 1 and 2 are classified as situational interest because of the reliance on context. In contrast, Phases 3 and 4 are classified as individual interest because there is less reliance on external supports or context. Situational interest and individual interest are theoretically distinct constructs [27, 28]. Although situational interest can predict development of individual interest [28], not all situational interest becomes individual interest. It is anticipated that individual interest would be more likely to lead to interest being a primary factor in career choices. However, degree of interest has not been studied in this way.

3. Method

To answer our research questions, we used qualitative multi-case methods [29, 30]. Our primary data source was semi-structured interviews with high school and college students from two case sites: one in the rural Central Appalachian region of Virginia (Virginia case site) and the other in the rural Cumberland Plateau Appalachian region of Tennessee (Tennessee case site). We interviewed a total of 75 participants, including 51 high school students (20 male, 31 female) and 29 college students (20 male, 9 female). For this analysis, we focused on the 24 high school students intending to pursue engineering or healthcare fields and the 25 college students pursuing engineering majors. We analyzed the data using a combination of coding, summary sheets, and organizational tables consistent with case study analysis approaches [31].

3.1 Case sites

As noted, we intentionally selected two case site regions because they shared some common demographic features with each other and with other groups underrepresented in STEM majors, but there are also differences across the case sites and with other underrepresented groups. The Virginia case site was situated in the nine southwestern-most counties of Virginia [26], while the Tennessee study region included four counties situated along the Cumberland Plateau; all counties in both regions were classified as "rural" and "distressed" by the Appalachian Regional Commission (ARC) [20]. Both areas had populations that were primarily Caucasian and where few post-secondary degrees are earned. Both regions had, on average, small high schools (ranging between 20 and 120 students in a graduating class) and between 1 and 3 high schools per county. In addition, both had counties with declining populations, though two Virginia counties had shown a population increase in recent years. Both regions had a low percentage of working engineers. Differences between the regions were primarily economic and geographical. The Virginia

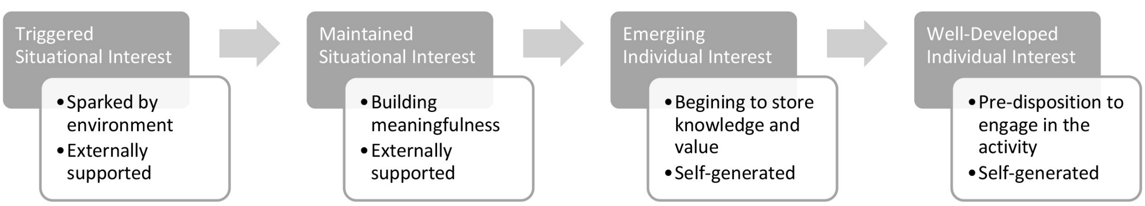

Fig. 1. Four-Phased Model of Interest Development Based on Hidi and Renninger [16].

case site was in a mountainous area associated with mining (especially coal), with some manufacturing, and has one major interstate highway (higher speed roadway) through the area. The Tennessee case site was in a less mountainous area commonly referred to as the Cumberland Plateau; it was not a coal-producing region of Appalachia and instead depended on farming and manufacturing. While no interstate highways ran through these counties, the geography favored better roads and transportation access to large cities such as Nashville, Knoxville, and Chattanooga as compared to the Virginia case site. Similar to other groups underrepresented in engineering, participants from our case study regions tended to be (or were likely to be) first generation college (FGC) students and from low SES backgrounds. In contrast to other underrepresented groups, students from our case site region were primarily white and living in rural not urban areas.

3.2 Participants

Table 1 shows the demographic information (school level, case site, and gender) for the participants included in this analysis. Note that we did not specifically ask about sex or gender, but rather we observed gender-expression [32] based on names and manner of dress. We assigned pseudonyms to all participants.

We used differing recruiting plans for high school and college students within and across the two case sites. In both regions, high school participants were recruited through an extended process of seeking permission from appropriate stakeholders that included county superintendents, high school principals, parents, and students. We requested that the study be advertised to all juniors and seniors in the selected high schools. In most cases, a local contact at the high school helped advertise the study. All students with permission from a guardian who provided consent were interviewed. Although we did not intentionally oversample for females, both the larger NSF pool of participants and the pool for this study included more females than males at the high school level.

College student participants were sought via a combination of a snowball approach and classroom visits. Two of the authors knew students local to the case study regions who were pursuing engineering degrees, and the authors had contacts at the colleges within the case study regions. College students were recruited via approved IRB methods of emailing both known individuals and general entry-level engineering courses. In addition, college participants were asked if they knew of additional students from the selected region who might be interested in the study. Interviews of college students continued until we reached saturation (i.e., new information was not being generated from the interviews) [33]. The college student participants were an approximately equal distribution of first year (freshmen) through fourth year (seniors). Unlike the high school recruitment, at the college level we intentionally tried to recruit women enrolled in engineering majors, but our actual sample reflects the typical proportion of women to men in engineering majors (20–30%). We also intentionally sought participants in the Tennessee study region to better understand how access to a formal engineering program in school influenced students' desired future careers and factors that enhanced their association between engineering careers and these desires [20]. As a result, most of the Tennessee students had participated in a formal engineering-related program during high school.

Table 1. Participant Demographics

			Gender	
School Level	**Case Sites**	**Total**	**M**	**F**
High School	VA	10	3	7
	TN	14	5	9
College	VA	11	8	3
	TN	14	11	3

3.3 Data collection and analysis

We designed the interview protocol to include contextually and culturally relevant probes for the research setting, as described elsewhere [34]. The open-ended questions allowed rich, deep descriptions of participants' experiences and beliefs [33, 34]. Interview questions specifically asked about interests while in high school (inside and outside of class) and about career plans. The protocols for high school and college participants were similar, with the notable exception that we also asked college students to reflect back to high school to explain why, at that time, they chose their current career pathway. This reflective portion of the interview often called for additional prompts to focus on the past rather than the present. Two researchers conducted the high school student interviews, one male and one female. Interviews took place at the student's school, and lasted approximately 45–60 minutes to accommodate class times. The college interviews were conducted in a mutually agreed upon location and lasted 45–60 minutes and were conducted by a single interviewer. The interviews were audio recorded.

The interviews were transcribed verbatim and we used MAXQDA software to identify relevant segments of text with interest codes related to the participants' likes and dislikes toward career choices, courses, hobbies, and other items identified as related to influencing a career choice. We then created a summary sheet for each participant [31] showing gender, high school or college, year in school (junior or senior in high school, year in college), case site region, specific career, career field, a short description of if/how interest was sparked and sustained, and a compilation of actual interview segments coded as interest statements. Using these summary sheets, we categorized participants into one of the four phases of interest development described by Hidi and Renninger [16] and defined in Fig. 1. Our interest development phase categorizations were consistent with findings by Crowley et al. [35] that students scoring higher on an interest scale tended to engage in more exploration such as the use of the internet, viewing documentaries, or reading books. In making our categorizations, we examined the interview segments for evidence of sustained interest and the degree to which the interest was personally vs. externally supported. For example, multiple references to an interest in engineering or referring to the interest over time provided context for a sustained interest. In addition, the use of phrases such as "I investigated" vs. "the class included activities" aided in differentiating personally vs. externally supported interests. We also grouped the interest sparks as stemming from an organized experience, personal experience, or "none" if no spark was noted. An organized experience referred to an activity in an organized setting such as a class in school, before or after school program, summer camp, Future Farmers of America (FFA), etc. A personal experience was something they did on their own or with someone else but outside of an organized context. Examples of personal experiences included working on farm equipment at home, working with a parent or peer on bikes or cars, or watching videos on the computer or on TV. Participants with no spark were those who made statements about a long-standing interest (e.g., "always interested," "interested since I was little") or those who could not remember what got them interested.

Throughout our study, we used researcher triangulation to support the quality of our study [33, 36]. Two members of the research team completed approximately half of the categorizing together. The pair was an appropriate match for researcher triangulation [33, 36] as they could challenge each other's biases. The first researcher might have been biased by each participant's entire story as she had participated in all the interviews and had spent considerable time analyzing the interviews. The second researcher might have been biased by only what was on the summary sheet taken out of the context of the interview, as she had not been a significant participant in the interview data collection or previous analysis. In the one case where there was disagreement, the researchers discussed the participant until agreement could be reached. The second researcher then categorized the remaining interviews.

Once the interviews were categorized, we created a summary table showing gender, case site, career interest category (e.g., healthcare or engineering), interest phase, the high school course participants expressed most liking in high school, and the type of spark participants reported as initiating the interest. We then examined the entire summary table looking for patterns.

4. Results

When we compared high school students considering healthcare and engineering fields, and when we compared high school and college students considering engineering careers, our data yielded important patterns with regard to sources of interest (sparks) and interest development phases. Surprising to us, we found no differences by case site region, or gender, and thus we integrate results from the two sites and genders in the following sections.

4.1 Interest sparks and development phases among high school students

Table 2 shows a summary of results for high school participants with regard to our first two research questions on interest sparks and development phases. In answer to our first research question, we found that interest in engineering careers tended to be sparked by an organized activity such as a formal class or afterschool activity, and was marked by a preference for mathematics (math), science, or engineering classes in high school. In comparison, we found that interest in healthcare tended to be sparked by personal experiences, and was marked by a preference for a variety of courses including English or history. In answer to our second question, engineering careers tended to be associated with individual interest phases (specifically Phase 4), whereas healthcare fields tended to be associated with situational interest (Phases 1 and 2). To illustrate the identified sparks and different phases, we provide examples from participants intending to major in engineering and healthcare.

4.1.1 Phase 1

Recall from Fig. 1 that Phase 1 interest is sparked by the environment and is typically externally supported. Hillary provides an example of a Phase 1 interest in engineering. When asked about her interests in school she mentioned an engineering class she was currently taking along with a series of

Table 2. Interest Sparks and Development Phases for High School Students

Career Category	Case Site	Gender	Participant	Interest Phase	In-school Course	Interest Spark
Engineer	VA	F	Debbie	4	Math	Organized
	VA	F	Ashley	4	Math	Organized
	TN	F	Destiny	4	Science	Organized
	TN	F	Haley	4	Engineering	Organized
	TN	M	Joseph	4	Math	Personal
	TN	M	Noah	4	Agriculture	Personal
	TN	M	Jackson	2	Agriculture	Organized
	VA	F	Hillary	1	Science	None
	VA	M	Kyle	1	Math	Organized
	TN	M	Alex	1	Unknown	Organized
Healthcare	TN	F	Hannah-Mae	4	English	Personal
	TN	F	Abigail	4	Science	Organized
	VA	F	Karen	2	Math	None
	TN	F	Mary	2	History	None
	TN	F	Madison	2	History	None
	VA	F	Kelly	2	History	Personal
	TN	F	Ashleigh	2	Science	Personal
	TN	F	Ella	2	Unknown	Personal
	VA	M	Fred	1	Science	None
	VA	M	Brian	1	Unknown	None
	VA	F	Michelle	1	English	None
	TN	F	Emma	1	History	None
	TN	M	Christian	1	Science	Organized
	VA	F	Laura	1	Unknown	Personal

biology courses she had taken. When asked why she took the engineering course, she said:

> I actually wanted to take another dual-enrollment class just so I would have five . . . I did like computer classes and stuff like that in the past, and I was just tired of it. It was just like, engineering, like, you get to work hands on, because I had, I had a friend that was in an engineering class and he would talk about it all the time, like they did all kinds of fun stuff, and they would build things.

Hillary did not set out to explore engineering, she picked the course because a friend enjoyed it and she needed a fifth dual enrollment course to meet a certificate requirement. She talked about how much fun the course was and how she had no idea there were so many different branches of engineering. She specifically mentioned how the instructor talked about biomedical engineering and that truly caught her attention. She also very much liked the Real World Design Challenge they were doing. She said, "I never would have imagined that you could do anything like that, I guess because I just never really heard about it or thought about it." The interviewer asked how it might be changing her possible career path, she said, "I've always wanted to go into the medical field, and I really want to integrate some type of engineering into that, like I think, I think that would be pretty awesome [chuckles]." Through the course, she learned about the kinds of projects engineers do and she specifically learned about biomedical engineering as a career. Since she was considering careers in medicine, she began to think about how she could integrate engineering. Hillary also mentioned that she had not applied to any colleges or scholarships yet because she had not had time between school and all of the extracurricular and community activities in which she was engaged; she also stated at that point that she had not "really had time to think about what I'm really interested in." Her interest in engineering was based on the situation (i.e., the organized activity of an engineering class) and it is not long-standing.

Note that Hillary also represents a Phase 1 interest in a healthcare field. She stated that she "always" wanted to go into the medical field. However, within her interview, this interest was only loosely tied to liking her biology classes and the medical field did not seem to represent concrete, long-standing interests. In fact, she stated that she has not even begun to look into college requirements, and medicine, like engineering, has extensive post-high school educational requirements. She did not cite a particular personal experience or organized activity as sparking her interest in healthcare.

Hillary exemplifies a typical Phase 1 interest for both engineering and healthcare. Participants rated as Phase 1 interest for engineering typically cited an organized activity as having sparked an interest though the interest was not further developed. In healthcare, Phase 1 interest was typically not associated with a particular spark.

4.1.2 Phase 2

Like Phase 1, Phase 2 interest is also typically externally supported, but in this phase people begin to develop personal meaningfulness. Jackson provided the only example of Phase 2 interest in engineering. Jackson was a male high school junior from Tennessee. When asked what type of job he was considering Jackson said,

> 'Cause I really like helping people. So I either wanted to kind of go into a doctor or nurse area, but after getting in Ag, I kind of like the building stuff and everything so I wanted to kind of to be an engineer and build stuff and design it and all that.

Jackson described a transition from an interest in healthcare, where he could help people, to engineering, where he could build and design. One of the factors that contributed to categorizing this as Phase 2 rather than Phase 1 was the reference to "getting into Ag." Jackson had a strong interest in, and hobbies related to, farming that were grounded in his experiences with an organized agriculture-related club. He was beginning to connect agricultural engineering to his farming interest. When asked how he learned about engineering, he mentioned two teachers who introduced him to engineering. Thus, his interest in engineering, sparked by an organized activity, was building meaningfulness because he was connecting it to a longer standing interest in farming. His interest in engineering as a career had extended for some time, but it was still externally supported through the courses he was taking; he had not engaged in exploring engineering careers on his own.

Madison provides an example from healthcare. Madison did not report any specific spark for her interest in healthcare. Her favorite high school class was history. When asked about her career plans, she indicated a desire to enter the healthcare field. She had taken a related class in high school that she enjoyed and she had shadowed a family member that works in healthcare. She had moved beyond Phase 1 interest because her interest was longer-term and was becoming meaningful for her. It was not yet a Phase 3 interest because her interest was still supported by the environment, in particular family members promoting the medical field and the teacher of the class she enjoyed. Of the six participants rated as Phase 2 with regard to interests in healthcare, three, like Madison, did not cite a specific spark for their interest. The other three participants in this category cited a personal experience as sparking interest. For example, Kelly had interacted frequently with a specific type of healthcare provider and was therefore interested in a career in that healthcare field. Even if sparked by a personal interest, Phase 2 interests showed limited continued development and internalization.

4.1.3 Phase 3

In Phase 3, interests become self-generated and more associated with personal (individual) values. No participants considering healthcare or engineering fields were categorized as Phase 3 in this analysis. From the larger NSF project dataset, only three participants were categorized as Phase 3. These three participants, tended to have a long-standing interest that connected with other aspects of their lives; they were engaged in activities related to the career independently (e.g., outside the scope of a class), but they stopped just short of having a forward-looking component (e.g., participants investigating what it will take to have a career in their area of interest). We do not mean to suggest that Phase 3 is not an important development phase for students considering engineering and healthcare fields, rather our data set did not contain any participants in this phase planning to pursue either of these careers. Future work in this area could include a sampling protocol to improve the likelihood of yielding data from all of the phases.

4.1.4 Phase 4

Phase 4 is the most developed interest characterized by a predisposition to engage in an activity in self-developed ways. As an example, consider Joseph, a junior from Tennessee. He worked on his family farm where he helped fix equipment. When asked why he was interested in engineering, he said,

> Well, I've been looking into the engineering because I've read up on some of it and there's, they got, basically the mechanical engineering 'cause they, they do a lot of building and designing and stuff like that, and that's kind of what interests me in it. And I've asked teachers, and they've said yeah I've described what I wanted to do and they said engineering field is what they do and that's how I kind of got to looking into it. You know something like, like I said I always like to take things apart and see how they work and see what's wrong with them and understand how they function and how to make stuff better and things like that.

Designing, building, and improving were activities he had enjoyed doing for an extended time. He expressed this interest as developing through personal experiences rather than through an organized activity, as in Jackson's story. Importantly for categorization as Phase 4, Joseph had taken significant steps to understand engineering as a career field and what it would take to get an engineering degree. Notably, a guidance counselor pointed Joseph towards engineering. Although this was an external support, similar to the teachers in Jackson's story (Phase 2), Joseph continued to do a significant amount of research on his own. Of the six high school participants having Phase 4 interests in engineering, one other had a personal experience like Joseph and four reported organized activities as sparking his or her interest.

In healthcare, Hannah-Mae had a long-standing interest in a medical career. In describing her interests outside of school, she said she was interested in the medical field and "likes helping others." She had a significant personal experience that made the medical field important to her; hence, her interest was self-generated. Not only had she investigated what it takes to be successful in her chosen field, she had already begun earning healthcare certifications and planned to continue earning higher levels of certifications. She indicated her favorite part of high school was English. The other participant with a Phase 4 interest in healthcare reported engagement in an organized activity as sparking her interest.

4.2 Comparing college and high school students

In answer to our third research question, we compared high school students considering engineering careers with college students enrolled in engineering majors. To support this comparison, we need to describe interest sparks and development phases for college students as we did for high school students. Table 3 shows this information, listed by participant, for college students. Note that college students rarely described a specific high school course (unless it was an engineering-related course) as the spark for interest. Therefore, Table 3 does not include high school course preferences as Table 2 did. Following Table 3, we offer examples of sparks at each interest development phase and then compare high school and college students.

4.2.1 Phase 1

Among the college students, the three participants rated as Phase 1 gave little or no detail regarding interests or relationships between interests and engineering. For example, Mark said he knew nothing about engineering as a career when he chose it (no interest spark). Nicholas was interested because of a business his father owned (personal experience) and Daniel liked math but found a college math major was not what he wanted to do and switched to engineering (no interest spark).

4.2.2 Phase 2

Participants rated as Phase 2 expressed an interest spark, though it was often lacking detail and was more a statement of a condition or fact that had always existed. Of the 11 participants rated as Phase 2, seven reported a personal experience as sparking the interest. For example, Hunter talked about an interest in construction that stemmed from a family member working in this area. Four of the participants mentioned an organized activity as sparking interest in engineering. For example, Alyssa described an introduction to engineering class she took as a senior in high school that sparked her interest. However, having had a relatively late interest spark, she had little time for self-sustained interest development before college.

Table 3. Interest Sparks and Development Phases for College Students

Case Site	Gender	Participant	Interest Phase	Interest Spark
VA	M	David Lee	4	Organized
VA	F	Sharon	4	Personal
TN	M	Dylan	4	Personal
TN	M	Eli	4	Personal
TN	M	David	3	Organized
TN	M	Jonathan	3	Organized
TN	M	Benjamin	3	Organized
VA	M	Tyler	3	Personal
VA	M	Nicholas	3	Personal
VA	M	Richard	3	Personal
TN	F	Lauren	3	Personal
VA	F	Marie	2	Organized
TN	F	Alyssa	2	Organized
TN	F	Sydney	2	Organized
TM	M	Logan	2	Organized
VA	M	Bob	2	Personal
VA	M	Shane	2	Personal
VA	M	Dave	2	Personal
TN	M	Hunter	2	Personal
VA	F	Hannah	2	Personal
TN	M	Steven	2	Personal
TN	M	Micah	2	Personal
VA	M	Mark	1	None
TN	M	Daniel	1	None
TN	M	Nicholas	1	Personal

4.2.3 Phase 3

Similar to participants rated as Phase 2, participants rated as Phase 3 tended to have a professed long-standing interest in engineering with four stemming from personal experiences and three from organized experiences. Unlike participants rated as Phase 2, participants rated as Phase 3 tended to state or imply further self-directed learning stemming from the interest spark. For example, Benjamin was very enthusiastic about his participation in a high school engineering class (organized activity). He described in detail what interested him about the class. He also connected this class to other experiences and talked about what he knew from his father being an engineer and his own work in construction in high school. Dave talked about growing up working on cars and being passionate about working on cars and motorcycles as a foundation for his interest in engineering.

4.2.4 Phase 4

Participants rated as Phase 4 took ownership for self-directed learning about engineering. Three participants' interests stemmed from personal experiences and one from an organized experience. For example, Dylan developed his personal interest in computers by engaging in internet research about taking things apart to understand how they work. He describes his interest as "the summation of . . . of these small events and just having this . . . this, this curiosity about how [things] worked." Dylan describes a long-standing interest but talks about how he engaged in learning about engineering. For other participants such as David Lee, interest emerged from, and was sustained by, continued engagement in classes in school and summer camps and organized activities related to engineering. David Lee specifically mentioned eighth grade and high school classes along with Governor's school and other activities. He also tied these organized experiences into work he did on the farm growing up.

4.2.5 Comparison of college and high school students

In answer to our final research question, we directly compare high school students considering, and college students enrolled in, engineering programs. Whereas high school students reported organized experiences as sparking interest development, college participants more commonly reported personal experiences as sparking interests. Whereas high school students expressed a general interest in math and science courses, college students reflecting on high school were less likely to mention a specific class as being interesting to them in high school (unless it was an engineering or engineering-related course). Although Phase 4 interest was common among high school students considering engineering careers, ratings of Phase 4 interest were less common among college students. Interest ratings for college students tended to be Phase 2 or 3, as participants indicated what sparked the interest with fewer details of how the interest developed and became self-generated.

5. Discussion

Our data yielded important patterns with regard to sources of interest and phases of interest development for high school and college students from our two case sites in rural Appalachia. These patterns have implications for how researchers and educators prompt and promote interest in engineering among students from rural Appalachia and, by extension, perhaps other underrepresented groups. Importantly, our data did not reveal different patterns by case site or by gender.

Comparing high school students considering engineering vs. healthcare careers, we found that organized activities were associated with sparking interest in engineering while personal interests tended to spark interest in healthcare fields. Also, although both engineering and healthcare fields rely heavily on math and science knowledge, a preference for these courses in high school tended to be associated with engineering rather than healthcare career plans. We also found evidence of students in interest development phases at each end of the spectrum, situationally supported and individually maintained. However, engineering tended to be associated with Phase 4 interests and healthcare fields with Phases 1 or 2.

Comparing high school students considering engineering careers to college students enrolled in engineering majors, we found college students tended not to directly state the specific steps that contributed to advanced interest development phases, i.e., the self-directed learning about and engaging in engineering-related activities, as high school students had. We similarly found different sparks for interest among the populations; for college students, personal experiences were reported as sparking interest more often than organized activities, whereas the opposite was true for high school students.

5.1 Interest sparks

Consistent with current literature, we found that interest is important in STEM-related careers [6, 7] and that engineering tends to be associated with a preference for math and science classes [37]. However, our findings also expand current literature by showing distinct differences between students intending to pursue healthcare careers vs. engineering careers. Although course interests are often used as predictors of career interests [e.g., 38], our findings suggest researchers and educators should proceed with caution in doing so for the population we studied. For our Appalachian regions, engineering career intentions tended to align with interests in math and science classes, but healthcare career intentions did not. However, interests in engineering careers tended to stem from organized activities (sometimes associated with schools), whereas interests in healthcare careers tended to stem from personal experiences. In combination, these findings could suggest that students may think they know what healthcare careers entail and do not have to prove an academic-related interest or ability in a related academic subject to support their career-related intentions. This possibility is consistent with our findings from the Cumberland Plateau region highlighting the ways in which personal relationships (e.g., knowing an engineer or a pharmacist) were critical in helping students move from engineering-related activities to engineering-related career plans [20]. Because engineering, unlike healthcare, is messaged as a career that requires both a knowledge of and love of math and science [39], students may feel compelled to express math and/or science ability and interest to pursue these careers. Conversely, students who do not have confidence in their math or science ability may not pursue a spark in engineering, minimizing any opportunities to develop a personal interest in engineering. Students might also lack understanding of what academic requirements are needed for specific careers [26].

Notably, college students, who have already chosen a career path, tend to view this choice, and associated interests, as less malleable and more fixed. They thus expressed interests as factual and long-standing—e.g., "I've always wanted to do this"—rather than as developmental over time and with intentional engagement. These findings are also consistent with current research. Crowley et al. [35] interviewed 69 professionals, including a combination of academics, scientists outside academia, and other people with careers involving science. Similar to the interviews we conducted with college students, researchers asked participants to reflect on elementary, middle high school, and college years separately, asking about influences on their "science learning trajectory." Results showed that 86% of their participants reported a strong childhood science-related interest with 54% mentioning a particular topic, though only 16% were "specific and deeply held throughout childhood and into adulthood, even driving the choice of a career." (p. 52) Our findings echo these in that interest is important, but the credit college students attributed to specific, detailed interests was limited. The prominence of personal experiences in reflective interviews over organized activities in prompting interest among college students is also consistent with Crowley et al.'s finding that 38% of their participants reported that interest developed in school (28%) and through organized out of school activities (10%), while 45% attributed interest to out-of-school activities such as trips to museums and zoos.

5.2 Interest development phases

Our results show that organized activities, one lever that researchers and educators can pull to promote STEM career awareness, can provide the spark for interest (Phase 1), but may not be sufficient to sustain interest (Phase 4). Organized activities that sparked interest in engineering included courses taken through school, as cited by Hillary, but also other formal clubs and activities, as cited by Jackson. Organized activities are an important environmental support for interest; without them, a student like Hillary may not learn that engineering exists and perhaps would not have a chance to develop a sustained interest. At the same time, our data suggest that a spark is not enough to sustain a Phase 3 or Phase 4 interest. This is particularly important when considering engineering career intentions for high school students tended to be associated with Phase 4 interest.

One reason a spark may be insufficient for promoting interest development may be the complex interplay of interest with other motivation-related variables. As noted earlier, Boynton's work with the Cumberland Plateau case site suggests that personal relationships were key in helping students link organized activities to outcomes they considered important in their career choices, and thus translate enjoyment of those activities into intended careers [20]. Similarly, Durik et al. [40] reviewed a series of studies and described relationships relative to interest development. For example, in one set of experiments, activities designed to promote situational interest do in fact promote situational interest for students with low interest but can have the opposite effect on students already having a high interest. In a different set of experiments, researchers found that enhancing self-generated utility value for a task promoted situational interest among students with low self-concept of ability but had no effect on those with high self-concept of ability. When externally generated value is present, activities designed to promote interest have a greater impact on people that already have an interest. Finally, in the previously cited work by Bystydzienski et al. [3], although interventions increased interest, the increased interest was not sufficient to overcome financial constraints or gaps in social support and self-efficacy for low-income women. Considering such research findings and the context of our Appalachian case sites, specifically high poverty and low higher educational attainment, it is not surprising that the value of pursuing an engineering career is entangled with interest. Specifically, within our case site regions, there is a strong pull for students to remain local and find steady, well-paying work [20, 26]; students in our population do not have the luxury of pursuing careers for the sake of interest alone.

5.3 Findings by case site

Another important finding from our study is that we found no differences between the two case sites regarding interest sparks or interest development phases. Recall that our case sites share strong family ties, a desire for stable work, and a desire to remain local, which are all linked to outcome expectations relative to careers, but differ with regard to geography and primary employment sectors (coal mining in VA and farming in TN). Although we anticipated that these features might make a difference with regard to situational vs. individual interest, we found no such difference through our analysis. This absence could mean that the higher-level values shared by a population might matter more than local physical or environmental features. Such a finding is consistent with the claims of theories used to examine career choice such as SCCT [2], which posits outcome expectations as one of the factors in career choice, or Expectancy-Value Theory, which posits the important role of socializers' (e.g., parents and teachers) beliefs in shaping student outcomes [41].

6. Limitations and future work

At the outset of the research, we planned to interview a broad sample of high school students from each location with regard to career choices, academic experiences, and background characteristics. We did achieve diversity in our sample with regard to career choices, academic experiences, parent/guardian education level, and high school resources. However, we believe our recruiting process, and use of the word "engineering" in our consent and assent forms, may have created oversampling with regard to students who, at the time, believed they were in the top 10% of their graduating class and were college bound. It is difficult to know for sure because class status and college intentions were self-reported and data shows not all students with intention to pursue college actually attend college [42]. We do not believe this possible overrepresentation diminishes the value of our findings because we are not making absolute comparisons about who does or who does not pursue college and/or engineering careers. Rather, we are describing how interest develops over time. Our sample is also limited in that it is quasi-longitudinal, meaning we interviewed separate groups of high school and college students rather than following individual students over time. To minimize impacts of this study feature, we intentionally asked college students to reflect back on high school experiences for comparison to our high school sample. We were careful to use as many prompts as needed to help participants focus on the past rather than the present in this portion of the interview. Future research that includes a stratified sampling plan and a longitudinal component could help address both of these limitations. The stratified sampling plan could more intentionally focus on students who are considering and those who are not considering college pathways. A longitudinal study would enable us to confirm intention to enroll vs. actual enrollment for all students, but particularly for those considering engineering or other STEM careers.

6.1 Conclusion and implications

Within our rural Central Appalachian case site regions, high school students generally needed to move beyond initial situational interest (Phase 1) into well-developed individual interest (Phase 4) to consider engineering careers. And even among college students majoring in engineering, most had moved beyond Phase 1 and almost half had reached individual interest levels. While sparking interest is important (i.e., building exposure to engineering), the self-generated nature of individual interest suggests that a student must be prepared to take the next steps to pursue a career-related interest. Specifically, our data suggest we should consider the level of student-perceived familiarity with a career field (e. g., engineering) and the interest level necessary for students to pursue the field, and thus design (or adapt existing interventions) to include explicitly teaching students about what engineering is in addition to having them "do" engineering projects. At the same time, our findings suggest that such explicitness should link to local values. Thus, within Appalachia and possibly for other groups underrepresented in STEM majors and careers, interventions need to expose students to engineering in ways that support the values of strength of family ties, a desire for stable work, and a desire to remain local. Importantly, interventions designed for our regions of Appalachia may not work in regions where these values are not the same or are not manifested in the same way. Thus, when we discuss the importance of context when designing course projects, workshops, or other interventions, place-based features should be considered, but higher level cultural and contextual characteristics of place may be as or more important and transferrable than geographic and environmental features.

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