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RESEARCH ARTICLE

"I've Always Loved Science": a Qualitative Exploration of Rural College Students' STEM Interest Development and Maintenance

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Abstract
Despite its increasing importance in today's society, STEM learning opportunities in rural areas are limited. Factors such as limited learning resources and experiences may negatively impact students in rural areas in developing interest for STEM subjects, and eventually STEM careers. In this qualitative study, our purpose was to understand how STEM interest develops and how this interest is maintained for rural college students in STEM majors. Supporting the core of the interest development framework by Hidi and Renninger (*Educational Psychologist, 41*(2), 111–127, 2006), we found out that there were internal and external factors that impacted both the spark and development of STEM interest. Students mentioned the importance of family and school-related factors, as well as environmental factors as triggers of interest. Development of the initial interest was established through sustained cognitive and emotional activities which were also supported by external and internal factors. STEM interest was then maintained during college through elements within the college context and personal factors. Since rural students' STEM interest is developed and maintained through both internal and external factors, we argue that schools and colleges should provide STEM learning opportunities to assist with these processes.

Keywords STEM education · Interest development · Rural students · Qualitative research

The ever-increasing need for a renewed and improved science, technology, engineering, and math (STEM) workforce necessitates that students pursue learning

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opportunities in science, technology, engineering, and mathematics-related school subjects and coursework, and eventually pick STEM-related careers (Thoman et al., 2019). However, concerns relating to "access, achievement, and opportunity" (Showalter et al., 2017, p. 37) of STEM education persists for rural students. For instance, in 2015 fewer rural schools offered at least one AP STEM course (62%) compared to suburban (93%) and urban schools (88%, Mann et al., 2017), decreasing the likelihood of rural students going in a similar coursework in college (Gagnon & Mattingly, 2016). Additionally, people from rural areas may also have less access to informal STEM educational opportunities like STEM extracurricular activities, museums, and role models (Fisher et al., 2021; Showalter et al., 2017). Furthermore, students from rural areas are graduating high school at a rate on par with their more urban peers (National Center for Education Statistics, 2011); however, rural peoples' enrollment (National Center for Education Statistics, 2015) and bachelor's degree attainment (United States Department of Agriculture, 2017) fall short of their peers from urbanized areas.

Fixing the "leaky STEM pipeline" has been of national interest in the USA for the last decade (e.g., U.S. Department of Education, 2018). Despite these initiatives, however, more research is needed to clearly identify problems through theory-based descriptive lenses to find effective solutions. Using the interest development framework (i.e., Hidi & Renninger, 2006), our purpose in this study was to qualitatively investigate the STEM interest development and maintenance of undergraduate students who graduated from rural high schools by examining how their interest was developed and how it was maintained during their college years. Given the lack of research that combines rural contexts and STEM and the importance of participation of rural populations in the STEM workforce (Harris & Hodges, 2018), we were also specifically interested in identifying advantages and disadvantages stemming from "ruralness" and their impacts to STEM interest development and maintenance in college.

Background

STEM Education

The science, technology, engineering, and math (STEM) workforce is a vast field that is made up of multiple sub-workforces and critical for global competitiveness and innovation capacity (National Science Board, 2014). This includes a wide range of occupations, from mathematicians to biomedical researchers, and at degree levels from bachelors to PhD (Xue & Larson, 2015). While the demand for STEM professionals is on the rise, the production of degreed STEM students is not increasing at the same level (Doerschuk et al., 2016).

The *STEM pipeline* is considered a career pathway that starts in school and extends through the STEM workforce. Problems within the "leaky STEM pipeline" have been identified at multiple points. Students in the K-12 setting that do not have access to mathematics courses like Algebra I in late middle school are unlikely to reach more advanced math and science courses in high school, which is an indicator for their future success in STEM (U.S. Department of Education, 2018). For students who continue to enroll in a STEM-related program, there are challenges of diversity and retention, such as underrepresentation of racial minority students, varying tuition rates by the program of study, advisement, and challenging introductory classes (Hinton et al., 2020; Libassi, 2018). As noted by Cannady et al. (2014), pathways to STEM careers “do not occur in a vacuum” (p. 447) and are impacted by many factors, including sociocultural differences and career choices. It should also be highlighted here that the pipeline metaphor is problematic because it approaches the issue from a deterministic perspective. Importantly, such a view assumes that output of the “pipeline” is directly related to the input (its quality and quantity) and leaks are self-determined (Sparks, 2017). In fact, in addition to the input-related issues, there are problems that lead to attrition that are beyond the control of the individuals in the pipeline, disproportionately affecting people of color and women entering in the STEM pipeline (Sparks, 2017).

In terms of the completion rate, the US President’s Council of Advisors on Science and Technology report (Olson & Riordan, 2012) indicates that fewer than 40% of students who enter with a major in a STEM field complete a degree in STEM. Degreed STEM students follow various pathways that lead to careers in both STEM and non-STEM fields (Graf et al., 2018; National Science Board, 2014). There is a growing field of research on ways to support students’ within STEM despite the “leaks.”

Defining Rural

Often in education research in the USA, rurality is not clearly defined (Thier et al., 2021). Given the broad definitions and characteristics of rural areas, it is difficult to characterize the term *rural* (United States Department of Agriculture, 2019). For instance, Cromartie and Bucholtz (2008) noted that “rural definitions can be based on administrative, land-use, or economic concepts, exhibiting considerable variation in socio-economic characteristics and well-being of the measured population” (p. 1). However, definitions are crucial in research because even small changes to the way the word rural is defined may have large impacts on what and who are characterized as rural (United States Department of Agriculture, 2019).

One definition sometimes employed is the US Census Bureau’s, which defines rural places as places with less than 2500 people (United States Department of Agriculture, 2019). The National Center for Educational Statistics (National Center for Education Statistics, 2006), another possible delineation commonly used in educational research, adds minimum distances from urbanized areas to the Census definition to create their rural categories. Within the National Center for Education Statistics (2006) definition, rural areas are divided into fringe, distant, and remote areas. Rural fringe areas are census-defined rural locations that are less than or equal to 5 miles from an urbanized area and less than or equal to 2.5 miles from an urban cluster. Rural distance areas are more than 5 miles but less than or equal to 25 miles from an urbanized area and more than 2.5 miles but less than or equal to 10 miles from an urban cluster. Lastly, rural remote areas are more than 25 miles from an urbanized area and more than 10 miles from an urban cluster (National Center for

Education Statistics, 2006). No matter the definition used (or not used), there are differences in rural education compared to other locales and there are differences within various rural areas across the country, resulting in unique challenges and opportunities for rural students (Malkus, 2018).

Rural Students

Students from rural areas often benefit from higher parental engagement in their schooling, higher test scores, and higher high school graduation rates compared to their urban peers (Malkus, 2018). Regardless of this high school success, however, students from rural areas are less likely to enroll in postsecondary education compared to their more urban counterparts (National Center for Education Statistics, 2015; National Student Clearinghouse, 2021). When rural students do attend college, they are more likely to attend public institutions and they are more likely to attend less selective colleges than their suburban and urban peers (Byun et al., 2012). Additionally, 65% of rural students who participate in postsecondary education attend 2-year institutions at some point in their educational journeys, and 24% of rural students who attend college enroll in 2-year institutions before transferring to 4-year institutions (Byun et al., 2017). Furthermore, it has been found that associate degree completion of rural students is not significantly associated with geographic regions; however, rural people from the Northeast are more likely to complete bachelor's degrees than rural people from the Midwest, West, and Southern regions (Schmitt-Wilson et al., 2018).

Beyond these generalized trends, it is crucial to consider the educational attainment of rural students based upon their multiple identities (Cain et al., 2020). For example, rural women are completing higher levels of education compared to rural men (United States Department of Agriculture, 2017). Race and ethnicity also influence educational attainment with the percentage of people who identify as Black, American Indian or Alaska Native, and Hispanic or Latino from rural areas less likely to graduate high school, to have at least some college education, and to earn a bachelor's degree or higher compared to rural people who identify as White (United States Department of Agriculture, 2017). Additionally, the educational experiences of rural students influence their educational attainment. Taking advanced coursework (e.g., AP and dual enrollment courses) and participating in college preparation programs in high school, for instance, have shown to influence rural students' pathways (Byun et al., 2012, 2015; Cain, 2021; Mann et al., 2017). Thus, although there are benefits of being a student in or from a rural area, there are also challenges these students face too.

STEM Education in Rural Areas

Rural students often attend schools in rural areas. Burdick-Will and Logan (2017) found that many rural public schools face economic disadvantage and low achievement. In part this may be because rural communities receive limited funding and resources compared to their urban counterparts (Harris & Hodges, 2018; Miller & Votruba-Drzal, 2012). For instance, large cities received the most amount of Title I funding in 2015 compared to all other NCES locales (National Center for Education Statistics, 2019).

Rural communities, therefore, may also have little ability to entice in-demand STEM teachers to schools which is leading to a deficit of STEM courses in rural schools. It is hard for these communities to entice teachers due to the geographic isolation of the area, small student populations, and lack of funding (Avery, 2013; Lavalley, 2018). There is also a lack of incentivization for rural teachers in the way of federal funding compared to their urban counterparts. Urban areas offer federal incentives that provide teachers with loan forgiveness for those who agree to work in impoverished areas (Harris & Hodges, 2018). These urban areas are more likely to receive funding for these incentives than a rural area at the same poverty level (Harmon & Smith, 2012). These examples of lack of funding make it difficult to create viable STEM programs.

In a recent study, using national data to identify the differences between rural and urban STEM career pathways of high school students, Saw and Agger (2021) found that there were STEM career aspiration differences between rural and urban students. This seems to have stemmed from a lack of opportunities to learn (OTL), whereby rural students felt more underprepared for STEM subjects. This perpetual cycle in rural settings that starts with lack of (quality) STEM learning opportunities, to low STEM achievement, and low STEM career aspirations and participation most likely ends in a rural system that does not attract creation of quality STEM learning opportunities. Since the Bureau of Labor Statistics projects that there will be a need of 2,292,600 workers by 2026 in STEM-related fields from the creation of new jobs and from those exiting the workforce (Saw & Agger, 2021; U.S. Department of Labor Statistics, n.d.), the lack of STEM programs despite an increasing need for STEM careers is having a widespread effect on rural communities.

Theoretical Background

Interest Development

In order to raise interest levels in STEM, it is important to recognize what is drawing people to STEM, as well as what might serve as hindrances. One domain of motivation that strongly influences future behavior is interest development (Renninger & Hidi, 2022). Interest is a psychological state and motivation construct that is strongly related to one's persistence in tasks (Hidi & Renninger, 2019). Interest is a key component for sustained learning efforts (Renninger & Hidi, 2022), and historically it has been considered as a key motivational construct associated with effort and learning (Dewey, 1913).

According to Renninger and Hidi (2022), interest is always triggered and this triggering can be purely serendipitous, socially driven, or self-generated. Acting on the triggered interest (finding self-relation, developing knowledge) leads to interest development. Interest is believed to develop in four stages: triggered situational interest, maintained situational interest, emerging individual interest, and well-developed individual interest (see Fig. 1; Hidi & Renninger, 2006). To develop from initial stages of interest to the later ones, certain conditions need to be met: cognitive (i.e., learning), value (i.e., connecting to self), and affective (e.g., excitement; Dewey, 1913; Long & Hoy, 2006). It should also be noted that it is possible for individuals to lose interest through the progression, or regain it at a later time (Alexander et al., 2019).

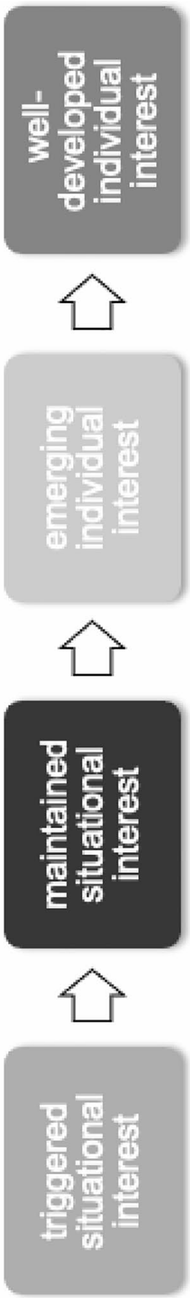

Fig. 1 Interest development (Based on Hidi & Renninger, 2006)

In their recent work, Renninger and Hidi (2022) highlighted the importance of self-relatedness, content knowledge, and social support for the development of interest. In other words, for an individual to become genuinely interested in a topic, their interest needs to be sustained through finding a relation between the topic and their lives first. Through this connection, it is believed that by gaining more knowledge and with the presence of social support, the individuals' interest develops. Notably, interest development is closely linked with social support and cultivation, regardless of how developed it may or may not be (Renninger, 2009). In fact, "feedback" is seen as a key component of interest development according to Renninger (2009). Therefore, whether in a classroom or within the family or friendship contexts, individuals need to feel supported to further their interest in a topic.

Especially in STEM contexts, intent or interest is a key component for future STEM career aspirations (Saw & Agger, 2021). One struggle with interest development in STEM fields in rural areas is the lack of social and content support due to the lack of STEM learning opportunities in schools (Saw & Agger, 2021). Interest in STEM fields, however, can be triggered in a variety of ways, whether it be from topics covered in school, media (e.g., TV shows), or even picking up a science magazine while waiting to be seen at the doctor's office (Hidi & Renninger, 2006). Nevertheless, as a big part of the future generations' lives, schools play utmost importance in triggering and developing interest for STEM careers. Therefore, to increase professionals in STEM fields, it is important to see what factors gauge student interest.

The Present Study

This study investigated the STEM interest development and maintenance of undergraduate students by examining how their interest was developed and how it was maintained during their college years. Due to the importance of participation of rural populations in the STEM workforce and their unique contexts, we were also specifically interested in identifying assets and challenges stemming from the students' rural places of origin and their influence on the students' STEM interest development and maintenance in college. Given that all of our participants were undergraduates seeking STEM degrees, and graduates of high schools in town or rural locales according to the National Center for Education Statistics (2006), our research questions in this study were:

1. How does STEM-related interest develop for college students from rural high schools?
2. How is STEM interest maintained during college?

Methods

Participants and Setting

This study was part of a larger qualitative research project exploring interest development and maintenance of STEM, college-choice processes, perceptions of majors and programs of study, and future goals of STEM students from rural areas. A public Carnegie Doctoral/R2 higher education institution located in southeastern USA was the site of the study.

The participants in this study were purposefully sampled to best meet the aims of the research project (Creswell, 2014), including their age, major, and high school location. To participate, students had to be at least 18 years old, be full-time undergraduate students at the institution enrolled in STEM majors, and have graduated from public high schools located in rural or town locales as defined by the National Center for Education Statistics (National Center for Education Statistics, 2006). Both rural and town locales were used in this study because both of these locales are outside of Census-defined urbanized areas (National Center for Education Statistics, 2006), and because using both locales increased the number of eligible student participants at the institution. We recruited the undergraduate student participants through multiple means, including paper flyers, tabling at a STEM career fair, and advertisements within the campus' career services electronic newsletters. Students who were interested in participating in this study completed a brief Qualtrics survey. The survey allowed us to see who was interested in participating in interviews and to confirm that they met the inclusion criteria. We then emailed eligible students to schedule their first interview sessions. Sixty-one students completed the survey, 27 students met the inclusion criteria (most of the eliminated students graduated from public high schools not in town or rural locales), and 11 students followed through to the interview stage of the project. Each student selected their own pseudonym for the study. See Table 1 for select demographics about the participants.

Instruments, Data Collection, and Analysis

A constructivist epistemological approach guided us in this study (Denzin & Lincoln, 2011). Data was collected using in-depth phenomenological interviewing (Seidman, 2013). The students each participated in two interview sessions of about 1 h

Table 1 Select demographic data about the student participants

Participant	NCES locale of high school	Major	Year	Gender	Race and/or ethnicity
AJ	Town distant	Chemistry	Senior	Female	African-American
Amber	Rural distant	Computer Science	Senior	Female	White
Cucuya	Rural distant	Biology	Senior	Female	Hispanic
Annabelle	Rural fringe	Physics	Sophomore	Female	White
John	Rural fringe	El. Engineering	Junior	Male	White
Josh	Rural fringe	Biology	Junior	Male	Hispanic
Kasey	Rural distant	Biology	First-Year	Female	White
Lyrik	Rural fringe	Biology	Sophomore	Female	African American
MacKenna	Rural fringe	Exercise Science	Sophomore	Female	Hispanic
Olivia	Rural distant	Physics	Senior	Female	Hispanic
Sierra	Rural distant	Chemistry	First-Year	Female	Biracial (White and Asian)

in length with one of the first two authors of this article. The first interview session focused on the students' experiences related to their STEM interest and educational pathways, and the second interview focused on the students' reflection of meaning of these experiences (Seidman, 2013). For participating in this study, participants received $25 Amazon gift cards.

All interviews were audio recorded and transcribed verbatim. The written transcripts were then analyzed through a phronetic iterative process (Tracy, 2020). In the phronetic iterative approach, analysis alternates between considering established research questions and theories as well as emerging qualitative data (Tracy, 2020). Coding was first completed by three trained graduate assistants through two rounds of open coding. Throughout this data immersion phase, the whole research team had regular meetings to aid with sense-making and consideration of various interpretations of the data. Each of us initially created our own codes. We then discussed these codes at length and compared them to the research questions and theoretical framework. After the final codebook was created, the graduate students next completed one final round of coding. With this phase of the analysis complete, we identified and constructed final themes through individual analysis followed by another group dialogue with all investigators.

Findings

Following our coding process, we identified themes from our interviews that centered on the theoretical lens that guided this research: interest development (Hidi & Renninger, 2006). In this section, we will first describe the sources of STEM interest (or STEM spark) for these students. Next, we will discuss the factors important to maintaining the students' interest in college.

Sources of STEM Interest/STEM Spark

Our first theme focuses on sources of STEM interest that were highlighted by the students. Our analyses revealed that the sources of STEM interest (i.e., triggered situational interest) were internal and external. Internal sources included personal traits and personal attraction, while external sources included the influence of family members as well as their high school contexts and experiences, and what they were able to provide.

For this study, most of the students showed interest in school or academics. For instance, several of the students talked about being in Advanced Placement (AP), honors, dual enrollment, or gifted classes in high school. Additionally, when asked how they would describe their high school selves, many of the students discussed being studious, strong students, or academically focused. Cucuya, for example, said, "I liked school. I wanted to get the highest grades possible, so I was very dedicated." For some students, their interest in not only school but STEM began at an early age and seemed to be internally motivated. For instance, Annabelle said, "I've always loved science" and John described, "I know even early in life, even elementary school, they would have books on space and the solar system. I'd go renting those from the library and read them."

Alternatively, some of the students discussed external sources of STEM interest development. About half of the students described a teacher or class as being their trigger. Josh noted, for example, "My favorite classes, in general, were the science ones, so biology, physical science. Those were pretty fun. I also thought the material was very interesting." Additionally, AJ noted how her high school chemistry teacher influenced her interests saying, "He was my first real exposure to chemistry. I always thought chemistry, you just, periodic table and electrons, but I never had my actual full, comprehensive taste of it per se, until I got into his class." Two of the students also talked about how their STEM interest was influenced by their parents. These students had a parent who worked in either the engineering or medical fields, exposing the students to their STEM careers. Conversely, three of the students recalled their STEM interest being sparked by media outlets, such as cartoons, television, and YouTube videos. Kasey shared:

> It goes all the way back from when I was little. One of the first shows—one of my first favorite shows out there came on the public broadcasting station 'cause we didn't have cable or fancy Disney, none of that. We had eight channels, and one of them was called Zoboomafoo...and it'd teach us about, like, "This is an amphibian. This is what amphibian means." It would just go with different reptiles and stuff. I started realizing, oh, they're cute. … Then, as I got older, I got interested in the crocodile hunter, Steve Irwin. It just grew. I started to really enjoy animals, really loving animals, and I just went myself.

Sometimes in qualitative research noticing what is not said by participants is also critical to analyze (Tracy, 2020). We noticed, for example, that the students in this study did not talk about STEM experiences, (e.g., STEM summer camps, museums, visiting labs or industry) outside of their immediate family, school, and media access as avenues to develop their STEM interest.

Of the 11 college student participants in the study, 10 students described their STEM interest being developed or sparked prior to their college experiences. One student, Olivia, however, communicated that her interest in STEM did not begin until she was a second-year student at the university due to a lack of exposure to STEM earlier in life.

> It was my second semester or second year here. It was the spring. I remember ... I took an astronomy class as part of my core, and I was just listening to the professor talk, … and I was like, "I really like this. I'm really interested in this. This is so cool. Oh, my God, there's nothing that I've been taught before that makes me as passionate, and that I care about as much. Even if I'm absolutely struggling more with it, I am interested in this.".... I think the biggest thing was introduction. Like my high school, I never had a physics class. I had a chemistry class, … but it didn't catch me in the same way physics did and so like being exposed to it was in my case, the biggest thing that—it was like, "Oh, wow."

The students were able to name specific sources of their STEM interest. Some students shared that their spark was self-ignited; yet, others were influenced by teachers or classes, parents, or media. Oftentimes, however, it was a combination of these internal and external sources that triggered their interest in STEM.

Maintenance of STEM Interest in College

Our second theme centers on the sources that maintained these students' STEM interest (i.e., individual interest) in college. Our analysis of the transcripts indicated that elements inherent to the college context (i.e., advisors, professors, clubs and other campus resources, and friends) and personal factors (i.e., personal traits, personal passion) were important for maintaining the students' STEM interests.

About half of the student participants mentioned the support they received from their advisors and some STEM professors as key elements that helped them stay in STEM. For instance, Annabelle mentioned her positive relationship with her academic advisor several times during her interviews. She said, "my academic advisor, she's just amazing. If I have an academic question, I go to her." The students who noted their professors as key supporters in their college STEM experiences noted characteristics of these faculty members that attributed to these rapports. Makenna stated, "most of my teachers have been really understanding. They've gone out of their way to help if you don't understand a topic, or if you need more help, they have office hours." Sierra also described a particular professor by saying, "he's rather fun-loving, and he'll make sure you understand him too, really. He's very caring….He's caring about his students as well."

Other participants were also actively involved in college events and clubs or volunteered, which both maintained and increased these students' STEM interest. Amber noted, "I am in the club, Society of Women Engineers, and they help me feel at home. I know some of my friends are in a similar group called, I believe it's called National Society of Black Engineers. They felt at home in that group too." Cucuya, on the other hand, commented on the importance of being a volunteer in the local community through university initiatives. She said, "I think volunteering is something people—like we always focus on the learning we do in class, but I've done so much learning outside of class. Not grade-wise, but learning about people." Campus resources beyond academic advisors, professors, and organizations are additionally attributed to the maintenance of a few of these students' STEM interest in college. Sierra explained how several of these sources contributed to her experiences.

> I take advantage of resources to help better myself, like counseling resources. I attend events whenever I can to try to make connections and meet new people. I've joined clubs as well that are based on my major in order to try to get a foot up on there too.

A couple of the students also specifically discussed how their friends and peers assisted them in maintaining their STEM interest in college. Amber's friends who were STEM majors assisted with her STEM interest and overall success in college so much so that when asked what advice she would give the university for improving persistence she stated, "I think maybe encouraging more making friends, the other STEM majors. We get a culture among ourselves. It's easy to become a part of it. I think making friends is the biggest thing to encourage."

Alternative to external sources, it was also noted that there were some personality-related aspects to the maintenance of STEM interest. For example, the students frequently mentioned that they were hard workers, similar to their initial interest development. Some students additionally mentioned the importance of finding passion while maintaining their STEM-related college work. For example, MacKenna articulated, "I always found 'em [STEM classes] very interesting. I know science isn't everyone's cup of tea. I always enjoyed the lectures and topics that I didn't know much about." Additionally, Annabelle exclaimed, "there are some [classes] that I'm really, really excited about, but I know they're gonna be really hard … Quantum mechanics. I am really excited to take that class, but I know it's gonna be very difficult."

Some students moreover mentioned career-related aspects related to personal interests and goals for their persistence in STEM domains. AJ, for example, discussed her passion for green chemistry and renewable energy.

> The attraction is just because I always had a drive to live more green in terms of always asking my family, can we start recycling? … I always had this drive just going to Arizona and just seeing what they have in terms of nuclear studies, or even the ExxonMobil they're doing more. … I wanted to see how that would be in terms of how it can help the world 'cause medical is one thing, but it's scarier to think that we're using up our resources so quickly and we need to start changing. We need more innovation to help people realize that.

These data suggest that these students' interests in STEM were maintained by various sources. Additionally, each student's interest was maintained by more than one source, and included a combination of internal and external factors. These findings, therefore, show how complicated the maintenance of STEM interest for college students can be.

Discussion

As developed by Hidi and Renninger (2006), the four-phase model of interest development posits that our initial situational interest is first triggered and then is maintained. This situational interest, eventually, becomes individual interest when supported and sustained. Situational interest can be triggered by social factors (e.g., family, school, etc.), luck (e.g., watching a documentary), or self-generated connections between the topic and one's life (Renninger & Hidi, 2022). In our findings, we identified that the participants were attracted to STEM disciplines through such factors that were usually in their immediate environment (e.g., family, friends, media). Through re-engagement with tasks and gaining more knowledge, this initial triggered interest becomes maintained situational interest. Our findings indicated that in the case of development of STEM interest, maintenance of this triggered situational interest was mainly through family and school support, as well as the individuals' personal affinity with the tasks and the subject. These findings both align with and provide examples of Renninger and Hidi (2022) conclusions on the importance of self-relatedness, content knowledge, and social support for the development of interest. We provide a summary of our findings in Table 2, listing the key factors for interest development and relevant quotes from our interviews.

Interest becomes more enduring when individuals develop value for the activity, usually self-generated, and still benefits from external support mechanisms (Hidi & Renninger, 2006; Renninger & Hidi, 2022). Our participants' interviews revealed that for STEM interest to become maintained, individual interest in college requires support from the college learning environment (e.g., professors, clubs, student services). Our results also confirmed the fact that value (finding the relevance of the task for the future) is an important aspect of interest development into individual interest. Our participants indicated that campus resources helped them find relevance and utility value for their STEM coursework. In thinking about college learning experiences, STEM courses and campus career services can specifically create learning opportunities where there is relevance of in-class topics for the outside world (Prinski et al., 2019). Finally, well-developed individual interest refers to the interest that is based on increased levels of knowledge and value (Hidi & Renninger, 2006). Even in this stage, external support still contributes to the maintenance of interest. But what is key here is that interest can self-sustain. In our data, we have seen cases of this when our participants mentioned that they had internal ability and knowledge to sustain their interest. It should also be noted that positive domain-general factors such as personality traits (e.g., hard-worker) were generally mentioned in our participants, but the triggering stemmed from domain-specific events (e.g., science-related TV show). Therefore, it is potentially possible that both are needed for the development of interest, especially in rural settings where (exciting) STEM triggering events are less likely to be found.

Interest supports learning and improves performance (Hidi & Renninger, 2019). Thus, it is important to create opportunities for students to trigger and sustain their interest in STEM disciplines. As indicated by our findings, the students who were able to develop interest for STEM in rural schools were supported by their family and, as much as possible, by their school environment. Although the students' advanced learning opportunities and informal exposures to STEM concepts (e.g., camps, museums) were limited in their rural areas similar to other rural students (Fisher et al., 2021; Showalter et al., 2017), these students were able to develop and sustain their academic interests. Since Saw and Agger (2021) found a lack of social and content support due to the lack of STEM learning opportunities in rural schools, it is essential for schools to ensure they offer students access to high-quality STEM learning experiences to attract and sustain more STEM-focused students in the future. This means rural educators should integrate STEM learning activities into their curriculum. These activities should connect STEM concepts to the everyday lives of the rural students and these activities should be accompanied by support for STEM interest development (Renninger & Hidi, 2022). Additionally, since rural schools are often left out of educational policy decisions (Lavalley, 2018; McNamee, 2019; Showalter et al., 2019) and are often underfunded (Harris & Hodges, 2018; Miller & Votruba-Drzal, 2012), priority should be given to providing financial

Table 2 Summary of findings

Triggering events	Maintaining events
Personal • "I liked school. I wanted to get the highest grades possible, so I was very dedicated." • "I know even early in life even elementary school, they would have books on space and the solar system. I'd go rentin' those from the library and read'em. I don't know. Just numbers, you get second grade. It's like, 'Oh, I can add and subtract three-digit numbers.' It's crazy." • "I was a good student. I usually had As and Bs… I was part of the gifted program." • "Very ambitious, very grade driven in terms of academics per my family."	**Excitement** •"there are some [classes] that I'm really, really excited about, but I know they're gonna be really hard … Quantum mechanics. I am really excited to take that class, but I know it's gonna be very difficult." • "I've always wanted to learn as much as possible. I just enjoy learning." • "Make sure you're doing something you enjoy because, if you're not doing something you enjoy, then it's probably not worth your time."
School-related • "My favorite classes, in general, were the science ones, so biology, physical science. Those were pretty fun. I also thought the material was very interesting." • "My chemistry teacher. He was definitely one of my role models." • "My mom didn't want me to ditch the course. It was like, 'Okay, fine. I'll just stick with it,' and I ended up really liking it.… I got really interested in it. Then I went on to take the math and the science AP courses." **Media** • "We had eight channels, and one of them was called Zoboomafoo…and it'd teach us about, like, 'This is an amphibian. This is what amphibian means.' … Then, as I got older, I got interested in the crocodile hunter, Steve Irwin. It just grew. I started to really enjoy animals, really loving animals, and I just went myself." • "I've, honestly, just always liked animals, and I thought they were cool. When I first went to the Tennessee Aquarium, that was when I wanted to be a marine biologist." **Family** •"my sister… she was also one of my biggest support and role model. … I wanted to be just like her in terms of that regard" • "I feel like initially my dad. He was actually an electrical engineer for AT&T. Growing up I always had computers around…That's what got me interested. I don't know what specific force drove me to computer science. I don't think it was at my school or anything."	**Social support (Professor/Advisor)** •"most of my teachers have been really understanding. They've gone out of their way to help if you don't understand a topic, or if you need more help, they have office hours." • "He's [professor] rather fun-loving, and he'll make sure you understand him too, really. He's very caring." **Social Support (Friend/Club)** • "I am in the club, Society of Women Engineers, and they help feel at home. I know some of my friends are in a similar group called, I believe it's called National Society of Black Engineers. They felt at home in that group too" • "I would say definitely for women 'cause I've seen events on campus where panelists of women in STEM I believe, professors would speak up about what they're dealing with or what they've experienced." • "Again, I think maybe encouraging more making friends, the other STEM majors. I think making friends is the biggest thing to encourage. I do see some people in my classes they are lone wolves. … Some people we need a sense of communication and culture."

support for STEM education in rural schools to encourage more rural students' interest in STEM fields in the future.

Limitations

There are a few limitations of this study. First, all 11 of the undergraduate participants graduated from high schools in rural areas in the South. Since the geographic location of rural areas influences many educational outcomes (Malkus, 2018), this study may not be representative of the experiences of college students from other rural areas in America. Also, all of the students attended the same undergraduate institution. Because different institutions employ different recruitment and retention strategies as well as have various STEM major contexts, it is key to keep these characteristics in mind when applying the findings to other postsecondary institutions environments. Lastly, although the study is valuable due to its in-depth exploration of 11 students' pathways, more research should be conducted on additional college students from rural areas and their STEM interest development and maintenance in the future to gather more information about this unique student population.

Conclusion and Implications

Addressing access to STEM education is of great importance (e.g., U.S. Department of Education, 2018). Given the significance of rural populations within the STEM workforce and the lack of literature combining STEM and rural education (Harris & Hodges, 2018), this study employed a theory-based descriptive lens using Hidi and Renninger's (2006) interest development framework to explore how STEM-related interest was developed for students from rural high schools and how this STEM interest was maintained during college. Our findings indicated that STEM interest was sparked by both internal and external sources for the students within the study. This STEM interest was then maintained during college by elements inherent to the college context and personal factors.

Given these results, there are several implications for educators. First, since STEM interest for these students generally began in childhood and adolescence, introductions to STEM concepts are critical within elementary and secondary school settings. For instance, Fong et al. (2021) found that the students who had higher motivation within math and science in high school were more likely to persist in college and maintain their STEM college majors. To attract more rural students to STEM disciplines, Harris and Hodges (2018) recommended gaining parental and community member support for STEM education; place-based STEM education that connects STEM concepts to local, rural life; and STEM education created for all students and not just those labeled "in need" or "gifted." Additionally, Crain and Webber (2021) discovered that rural and small-town students had equal or greater interest in STEM careers as their more urban peers. Nevertheless, rural geography and K-12 school characteristics sometimes created barriers for rural students along their educational pathways (Crain & Webber, 2021). Therefore, early interest can be sparked through engaging coursework that evokes STEM curiosity and problem solving (e.g., project-based learning) that is both place-based and context-based (e.g., local culture, area industries, available resources).

We should also note, however, that STEM interest can be triggered later in life as well. For example, one of our participants, like many other rural students, did not have adequate exposure to STEM experiences until college. Thus, faculty members and higher education professionals can additionally do their part in igniting a love for STEM within postsecondary students. STEM summer bridge programs (Kitchen et al., 2018), STEM living learning communities (Dean and Dailey, 2020), and STEM student organizations (Aruguete & Mwaikinda, 2016) can all be beneficial for the academic success or career preparation of STEM majors. Also, since these college personnel played a crucial part in the maintenance of STEM interest for these students from rural areas, there is an opportunity for these offices to extend their support of rural students. Many STEM topics are considered to be quite challenging; thus, instructional interventions such as pair programming (placing students in pairs and assigning them different, but collaborative roles) can make learning more entertaining, build social relationships, and prove to be beneficial in enhancing education and developing higher interest in students (Campe et al., 2019).

In summary, for too long rural people and communities have been ignored within STEM research and initiatives, but there is a growing need for a rural STEM workforce. Additionally, recent research indicates that the traditional STEM pipeline model of workforce development inadequately represents the reality of a modern STEM career and excludes marginalized populations (Batchelor et al., 2021). Since students' STEM interests are sparked and maintained by a variety of internal and external sources, education professionals across the P-20 educational spectrum should prioritize initiatives to assist with interest triggering and development within current and future rural students.

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Code Availability Not applicable.

Declarations

Ethics Approval This project was IRB approved at Georgia Southern University (#: H20241).

Consent to Participate All participants signed a consent form to participate in interviews.

Consent for Publication This article has not been previously published. All text and images can be published and are not copyrighted.

Conflict of Interest The authors declare no competing interests.

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