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Bots, Bonds, and Belonging: Investigating Social Emotional Learning in Competitive Rural Robotics Programs (Fundamental, Diversity)

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Introduction

Educational robotics (ER) in K-12 science, technology, engineering, and mathematics (STEM) education is rapidly growing in popularity and use (Ouyang & Xu, 2024) and has evolved into a burgeoning strategy for developing STEM interest among K-12 students. In informal settings, the use of ER in classrooms aims to strengthen students' interest and engagement in STEM (Anwar et al., 2019) through interaction with robotics design components. As an integrated form of learning that encompasses many STEM content areas, such as engineering, computer science, and physics, ER programs have now evolved into competitions in which students must build, program, and operate robots in a team setting to meet various game design challenges. It is through these ER competitions that students can showcase and apply their STEM knowledge and skills in creative, novel, and exciting ways.

Given the inherent nature of competition to involve problem solving, cooperation, and communication amongst team members, engagement in these elements through ER competitions may then lead to the development of an individual's STEM identity, goals, feelings, decisions, and relationships. In that regard, ER competitions are authentic, informal STEM environments that advance the development of social and emotional learning (SEL) competencies, including self-awareness, self-management, social awareness, relationship skills, and responsible decision-making (Collaborative for Academic, Social, and Emotional Learning [CASEL], 2024). These competencies are critical for success in STEM educational pathways and are, therefore, essential to develop among K-12 student populations to ensure a competent and diverse flow of personnel into STEM fields.

However, providing multifaceted STEM experiences poses challenges, particularly in rural contexts. For example, research indicates that rural student populations across the United

States have fewer opportunities to engage in informal STEM learning opportunities (Saw & Agger, 2021). Moreover, rural schools are now a focus of national attention, evidenced by legislative mandates to explore the scope of research and federal funding for K-12 STEM education and workforce development in rural areas (National Academies of Sciences, Engineering, and Medicine, 2025). Encouragingly, competitive ER has gained traction among rural school districts as a method for increasing rural student exposure to STEM and building robotics teacher leaders who facilitate these programs (Meador et al., 2025).

Prior studies have demonstrated the positive student outcomes and impactful learning experiences associated with the use of both ER and SEL (Anwar et al., 2019; CASEL, 2024). However, what remains to be explored by research is the association between the two and how these outcomes and learning experiences may contribute to broadening participation in STEM fields, specifically for students who are historically underserved in STEM, such as those attending rural schools. Therefore, this project investigated informal STEM learning through the interactions of ER competition participation in four rural secondary high schools in Texas. Reasons for this include investigating which SEL elements from participation in competitive ER lead to increased interest and recruitment into STEM among students from underserved populations. The focus on the four institutions for this project is two-fold: 1. Each school has an established robotics program, with a track record of competition success, and 2. All schools serve populations that have been historically marginalized in STEM Education in terms of access and resources through their Title I designation. To satisfy the research aims and purpose, the following research question guided this investigation:

- Within the SEL framework competencies, what challenges or benefits do rural students experience regarding STEM content for participation in competitive ER?

The information from this investigation aims to contribute to the body of literature on STEM student outcomes, learning environments, social-emotional well-being, and experiences of students participating in informal STEM learning competitions in rural populations.

Literature Review

The Science, Technology, and Innovation (STI) output of a nation represents its competitiveness on the world stage. Three critical determinants of national STI are investment in STEM talent, discoveries generated through research and discovery, and the ability to transfer ideas from academia to industry through innovation (National Science Foundation, 2024). The fuel for each of these elements is a pool of competent students motivated to pursue STEM educational and career pathways. Unfortunately for the United States' competitiveness, this pool of American students has been uncomfortably shallow in recent decades. A recent survey by Specialist Staffing Group found that 79% of STEM professionals say a lack of technical skills in their workforce directly impacts their organization's ability to innovate (National Science Foundation, 2024).

Competition for roles in key STEM disciplines is expected to rise in the coming years amid turbulence in the international hiring market. Currently, 26% of foreign-born workers in the United States are employed in STEM positions (National Science Board, 2024), and maintaining a suitable flow of STEM-trained workers to maintain this portion of the US workforce will be increasingly more challenging in the current political climate. Evolving work visa policies are expected to limit the ability of U.S. innovators to recruit foreign talent for STEM roles (Clemens et al., 2025). However, there is an untapped wellspring of potential STEM talent residing on the outskirts of American cities. Rural students, who comprise 20% of the US student population, represent only 10% of STEM careers (National Center for Education Statistics, 2023). Increasing the proportion of these rural students who pursue STEM careers could help offset losses from declining numbers of international STEM workers while simultaneously increasing the diversity of backgrounds and perspectives within the current workforce.

Rural is defined in several ways, but is often associated with places with fewer than 2500 individuals and a predetermined distance from an urbanized area (Cain et al., 2022; National Academies, 2025). STEM development often lacks equitable distribution across rural and urban locales, and both settings face unique challenges. However, and specifically with STEM content in rural areas, teachers in rural districts often experience teaching multiple courses across several grade levels, geographical barriers to resources, a general lack of funding, and a potential increase in community resistance (Shume et al., 2022). Additionally, ever-increasing vacancies in rural education systems impede support overall for STEM programs (Shume et al., 2022). Hinderances such as these are complex systemic issues that can have long-lasting repercussions for rural STEM efforts and the communities involved. As such, traditional STEM models do not adequately develop a workforce from marginalized populations such as rural communities (Cain, et al., 2022). However, growing interest in STEM through extracurricular activities (e.g., robotics) can bring about change.

However, unlocking the potential of these rural students requires targeted effort. The geographic location of rural populations creates unique challenges that negatively impact K-12 education and career paths (Agger et al., 2018; Hillman & Boland, 2019). Rural students also experience fewer outreach efforts from industry professionals in STEM careers (Harris & Hodges, 2018; Lavalley, 2018), leading to lower interest in pursuing STEM pathways. Research and policy initiatives have made prodigious progress of late in providing increased awareness and access to STEM pathways among underrepresented student demographic groups such as racial and ethnic minorities, women, and individuals with disabilities (National Science Foundation, 2024). However, fewer resources have been allocated to rural student populations. Regarding the allocation of resources toward rural STEM education, Saw and Agger (2021) found that less attention has been given to geographically defined populations, especially rural and small-town students. Furthermore, there have been minimal efforts to support rural students who also belong to underrepresented demographic groups. However, an increasingly viable approach to reducing STEM engagement disparities experienced by rural students relative to their peers may be found in educational robotics.

Indeed, rural schools face distinct challenges in providing comprehensive STEM education. For example, in Texas, the second-most populous state in the United States and the state with the most students attending rural schools (Showalter et al., 2019), only 24% of rural high schools offer STEM or computer science courses compared to 46% statewide (WeTeachCS, 2020). These disparities reflect broader patterns of resource inequality, including limited access to specialized STEM teachers, laboratory equipment, and extracurricular enrichment opportunities. Thus, it can be argued that ER emerges as a particularly promising intervention for rural STEM education because it offers a portable, scalable model that can be implemented without extensive laboratory facilities. The competition structure provides external motivation and benchmarks that sustain engagement even in small programs, while creating opportunities for rural students to interact with peers from other schools and counter the isolation that can limit their STEM networks.

In states such as Texas, state-level initiatives demonstrate intentional efforts to expand robotics opportunities in rural areas. For example, the Texas UIL robotics championships explicitly include divisions for small schools (1A-4A classifications), ensuring rural schools can compete at the state level (University Interscholastic League Texas, 2023). At the same time, Texas 4-H leverages its substantial presence in rural communities to integrate robotics programming into youth development offerings. Programs like Project ROCS (Rural Opportunities in Computer Science) train rural teachers to integrate robotics with agricultural applications to make STEM content geographically applicable and build local transferable skills (WeTeachCS, 2020).

Universities also play critical roles in supporting K-12 robotics programs through diverse partnership models that leverage institutional assets, including facilities, expertise, student volunteers, and industry connections. However, institutions of higher education exemplify varied approaches. For example, and specific to Texas, the Get Excited About Robotics (GEAR, 2025) program pairs K-8 teams from rural schools with engineering student mentors for multi-week LEGO robotics contests offered at no cost to participating schools. Baylor University hosts FIRST Tech Challenge events in engineering research facilities, creating tangible connections between K-12 robotics and university research (FIRST in Texas, 2026). Austin's Code at the Texas Advanced Computing Center offers intensive summer camps featuring robotics and AI programming (Texas Advanced Computing Center, 2023), and Texas A&M's Spark! program brings mobile robotics labs directly to PK-12 classrooms, reporting reach of over 18,000 students and 7,000 educators annually (Texas A&M University College of Engineering, 2023). These partnerships expand students' social capital and access to resources beyond their immediate communities, provide role models from similar backgrounds pursuing STEM careers, and create continuity between K-12 and higher education, making transitions more navigable. For rural students with limited exposure to STEM professionals, university mentors provide particularly valuable connections that can influence career aspirations and pathways that bridge the cultural distance that can deter students from pursuing postsecondary STEM education.Despite growing evidence supporting robotics competitions as effective STEM interventions, essential research gaps remain. Most existing studies employ relatively weak research designs, relying primarily on self-report measures and non-equivalent comparison groups rather than rigorous experimental or quasi-experimental studies with longitudinal follow-up to establish causal relationships and assess long-term impacts. Research specifically examining rural robotics implementation remains limited, with few systematic studies of factors that facilitate or impede rural implementation, optimal support models for rural teachers, or the comparative effectiveness of different program designs in rural contexts. Understanding mechanisms through which robotics competitions influence outcomes, whether through technical challenge, team collaboration, mentorship, public performance, or connection to authentic contexts, requires deeper investigation to enable more efficient program design. Questions of sustainability and scalability merit attention, as many partnerships rely on soft funding sources or individual faculty commitment rather than institutionalized structures. Future research employing more rigorous methodologies, attending specifically to rural contexts, and underrepresented or underserved populations, and examining both implementation factors and long-term outcomes will strengthen the field's capacity to design and deliver effective robotics-based STEM interventions that serve all students equitably.

Theoretical Framework

As a theoretical base, SEL consists of five core competencies that broadly support learning and development (CASEL, 2024). Frequently referred to as the "CASEL wheel," the framework highlights not only the process by which skills such as empathy and emotional regulation may be developed but also establishes the importance of creating equitable environments in which these abilities will be cultivated (CASEL, 2024; Payton et al, 2000). Specifically, the interrelated knowledge, skill, and attitude competencies of self-awareness, self-management, social awareness, responsible decision-making, and relationship skills are connected through instruction and classroom climate; school-wide culture, practices, and policies; authentic partnerships; and aligned learning opportunities (CASEL, 2024). To fully describe and analyze the cases of the rural high schools in this study, SEL was chosen to investigate the individual, person-specific development of students in informal STEM learning that resulted from participation in ER competitions, while also giving attention to broader school factors (e.g., teachers and instruction) and the culture of the rural school and surrounding community. This approach fosters an awareness of the role of place (local culture, phenomena, and issues) and its intimate tie to student education, thereby enhancing the well-being of both the individual and the communities with which they interact (Smith, 2017). In terms of broadening participation in STEM among diverse populations, a holistic approach that integrates social-emotional learning with STEM content has the potential to increase interest and appreciation for STEM applications (Garner et al., 2018). Despite the suggestion that an integrated STEM curriculum, such as robotics, provides an optimal context for infusing SEL principles (Garner et al., 2018), research in this area is relatively new and limited. Thus, this project is poised to provide information in an emerging field of STEM education.

Methods

This study employed a comparative, qualitative case study methodology. A comparative case study is an innovative approach that draws on traditional case study procedures (Merriam, 1998; Stake, 1995; Yin, 2002) in a heuristic manner, engaging two levels of case investigation: the more common compare and contrast, and an inspection across sites (Bartlett & Vavrus, 2017). In this way, this form pushes the boundaries of the methodology by not only allowing for the investigation of similarities and differences among cases, but also analysis that "traces across" those cases in horizontal, vertical, and transversal comparisons (Bartlett & Vavrus, 2017, p. 5). The comparative case study methodology was selected for its iterative and contingent nature to "explore the historical and contemporary processes that have produced a sense of shared place, purpose, or identity concerning a central phenomenon" (Bartlett & Vavrus, 2017, p. 10). This method is appropriate given the focus on the rural context in which the study is situated and how this context, across different rural schools (the cases), contributes to the development of social-emotional competencies (purpose) through participation in competitive ER (central phenomenon).

Rural School Context and Participants

Four rural high schools located in Texas that participate in ER competitions served as the cases in this study. Pseudonyms are used for all schools. The successful robotics programs in this study come from Maroon, Purple, Blue, and Yellow (pseudonyms) High Schools. Table 1 contains demographic data for each school.

Table 1

Rural Robotics Schools Demographic Data

School Name	Number of ER Students	K-12 School Population	NCES Locale Designation	Title I	Percent K-12 Student Demographics		
					White	Hispanic	Other
Maroon	6	211	Rural Remote	Yes	4.7	94.8	0.5
Blue	22	250	Rural Remote	Yes	93.0	6.5	0.5
Yellow	6	591	Town Remote	Yes	41.3	56.5	2.2
Purple	34	1,182	Town Remote	Yes	8.0	90.5	1.4

Note: Data from the National Center for Education Statistics (NCES, 2023).

All schools are situated in rural, remote areas or remote towns (NCES, 2021), with education, healthcare, and agriculture serving as the primary industries. Households are often single-parent and of a low socio-economic status. In two of the four schools, the robotics program was initially started by a culinary arts or agriculture teacher who was approached by a student interested in starting a program. With no STEM training or skills, these teachers found the support and resources they needed to launch their respective programs. A study of these teachers as rural STEM teacher leaders was conducted as part of this project (Meador et al., 2025). The other two schools were started by the only high school science teacher, who migrated from one school to the next, recruiting students to the program within his science courses. At their inception, each competitive robotics program began as an after-school program but has since evolved into a school-day elective class. Each school has won a State Championship in its respective division and has qualified for the World competition, besting schools significantly larger in size, with more resources and access to industry, and originating from more urban areas across the nation.

Data Collection

For this study, data on the first round collection are reported with subsequent collections of additional data to occur at later dates. The data sources for this study included surveys, competition observation notes, and focus groups and interviews with the ER teachers and students. After receiving Institutional Review Board approval, data were collected over the course of one competitive ER season, spanning nine months. Additional data is being collected for a second ER season. Preliminary findings from this project will be presented for the first competitive ER season.

Data collection for the first season began with interviews with each of the teachers. Two interviews were conducted, one at the beginning and one during the competition season. All interviews lasted approximately one hour. A survey was administered to students in the respective programs at all participating schools during the competitive ER season. In the survey, students responded to all questions of the Science Identity Scale (Lockhart et al., 2022) and to the math, technology, and engineering portions of the STEM Career Interest Scale (Kier et al., 2014). Focus groups were conducted with groups of six to 10 students at each of the schools and lasted approximately one hour. Two focus groups were conducted with students at Blue and Purple High Schools, given that these schools had over twenty students participating in ER. Only one focus group was conducted with Yellow and Maroon High Schools, given that these schools had fewer than ten students participating in ER.

Observation notes were also collected by non-participant and independent members of the research team at three of the season's ER league meets. Each research member was assigned one of the participant schools to observe and made observation notes before, during, and after competing in a match at the league meet. Research members used an informal STEM observation protocol (Almendral et al., 2019) to guide notetaking. These researchers made time-stamped, handwritten notes about any relevant team experiences in the context of the study’s research question.

Data Analysis

The dataset for this project was analyzed using the theoretical framework for students’ SEL experiences. To examine the data, a codebook was created that utilized the theoretical framework of SEL and its five key competencies: self-awareness, self-management, social awareness, responsible decision-making, and relationship skills. For each competency, a definition was created from the CASEL (2024) framework to be included in the codebook for analysis of survey, observation, focus groups, and interview data using *a priori* methods (Lincoln & Guba, 1985; Shenton, 2004). An initial review of the data set was conducted to identify specific examples from the data sources to select an exemplar to be referenced when coding using the specified competencies of the SEL framework.

For this analysis, survey data were examined to identify specific questions for inclusion in the coded data set. Questions were included in the coded data set based on two criteria: 1. Whether the majority (greater than 70% of the respondents) of students responded with a strongly agree/agree or strongly disagree/disagree, and 2. Whether the question could be coded to the SEL competency. For example, 71% of the rural study survey respondents (n=17) strongly agreed/agreed with the statement "I would feel comfortable talking with people who are engineers," and this question was coded under social awareness.

For the focus group, interview, and observation data analysis, one of the student focus group transcripts was coded using the developed codebook, with excerpts highlighted in specific colors according to their coding assignment: green for self-awareness, yellow for self-management, blue for social awareness, purple for relationship skills, and red for responsible decision-making. An independent researcher not affiliated with the project was then consulted for coding validation. A discussion of coded excerpts was conducted to confirm the coding assignment. This entire process was then repeated with one interview in the data set to confirm the findings (Malterud, 2001) and to reduce the risk of bias in the independent coder's work (Saldana, 2025).

To address other measures of trustworthiness of this study, dependability was achieved through the use of *a priori* codes (Lincoln & Guba, 1985; Shenton, 2004) drawn from the SEL theoretical framework. Credibility was maintained through member checking with participants via clarifying questions during focus groups and by sending transcripts to teacher participants for accuracy (Saldana, 2025). Moreover, credibility was also maintained through the development of an audit trail (Lincoln & Guba, 1985; Malterud, 2001; Morse et al., 2002; Sandelowski & Barroso, 2007; Shenton, 2004). Each focus group and interview transcript collected during the first competitive ER season included line numbering to identify the specific excerpts within the data set, and each piece of the data set was assigned a label. For focus groups and interviews, this label began with the source (FG for focus group, and I for interview), the school (M for Maroon, B for Blue, Y for Yellow, or P for Purple), and a number to indicate whether this was the first or second piece of data collected of that form (e.g., 2 for second focus group with Blue's students), and a time stamp to indicate the specific place in the transcript. In addition, observation notes were transferred to an electronic form, labeled with the initial ON, line numbers inserted, and included a number to indicate which match of the season the observation occurred (e.g., ON2 for observation notes conducted at the second league meet).

For theme development, and although analysis is currently being undertaken, all excerpts coded to a specific SEL competency will be examined, and an initial theme description will be created. This description and the associated coded data set will then be presented to the independent researcher and the research team for review and discussion. During this process, a systematic, iterative approach will be maintained to ensure rigor, deep insight into theme development, and consensus (Miles et al., 2019). Once themes have been confirmed, two members of the research team will revisit the color-coded, competency-based data set to authenticate these themes. Then, the researchers will proceed to the entirety of the data set to further confirm the themes developed and to ensure the themes originated from multiple data sources and cases for triangulation of the findings (Denzin, 1978). To also satisfy the process of the comparative, qualitative case study approach (Bartlett & Vavrus, 2017), themes will not be included in the findings unless comparisons can be made and contrasts resolved across the cases, and the theme is present in the data sources across all school contexts.

Findings and Discussion

Qualitative data analyzed in this investigation of four competitive, rural ER programs led to the development of two primary macro-level themes: *External STEM Exposure for STEM Identity Development* and *Adaptive Persistence and Contextual Awareness Under Rural Constraint.* Both themes were present across data from all four teams and across data coded for the SEL competencies: self-awareness, social awareness, self-management, and relationship skills. Table 2 provides a description of each theme and their mapping to the SEL competency.

Table 2

Theme Descriptions and Map to SEL Competencies

Theme	Primary SEL Competencies	Description
External STEM Exposure for STEM Identity Development	Self-awareness, Social Awareness, & Relationship Skills	Teachers and students articulated their strengths, interests, and future aspirations defined through their ER experiences in team roles and hands-on engineering work
Adaptive Perseverance and Conceptual Awareness Under Rural Constraint	Self-management, Social Awareness, & Relationship Skills	Teachers and students manage their frustration and burnout while maintaining engagement through trial-and-error and long-term commitment Teachers and students recognize rural inequities and collaborate and communicate to sustain the ER program.

Although the data were coded to the SEL competency of responsible decision-making, they could not be directly linked to these macro-level themes and were insufficient in number. Additionally, and possibly due to the nature of this code, observation data collected during competitions played a more prominent role, making triangulation across multiple sources and participants challenging. For these reasons and others, the researchers decided to focus on themes that emerged across all participants' experiences and that included multiple facets of the theoretical framework's constructs.

The *External STEM Exposure for STEM Identity Development* theme extends to how rural students leveraged external collaborations to learn STEM knowledge and skills beyond their school context, which could be applied to competitive ER, such as engineering concepts or computer science. Additionally, this theme captures the additional skills gained from this exposure for STEM identity development through the growing self-awareness of their skills, interests, and aspirations from their ER participation and how they relate to the rural context. For example, a student provided the following excerpt regarding a benefit of participating in ER at a rural school for STEM knowledge.

> Kind of thinking about your future, because you want to be a computer scientist, or do you want to be a mechanical engineer? This helps. Oh yeah, I think in a small school like this, this is really the only exposure you can get to, like certain new technologies in STEM so it's a really big deal to be able to participate in it and get that experience. (FG-P-1, 11:03)

In a show of self-awareness, rural students and their teachers also acknowledged that their exposure to STEM content knowledge necessary for facilitating and engaging in ER was limited. For example, the ER students and teachers at Maroon and Purple High Schools, led by a culinary arts teacher and a woodworking teacher, mentioned issues with programming knowledge. The students revealed that they relied on alumni from the ER programs who went on to study computer science at institutions of higher education to return and assist in this area. Teachers reported building a community among themselves for support, leaning on each other’s expertise to help their students with their robotics projects, whether that was building or programming. For example, one teacher mentioned

> So, what I don't know about robotics, I know people that do, and I send my kids and I send other instructors to them. The lady from [other High School] was having some problems with programming. And programming is not my strong side. But it's Mrs. Sluder at that school. She's stronger in the programming side. So I gave her phone numbers to them. Call Mrs. Sluder she'll help you with it. And so sure enough, they hooked up and talked about it and figured out what was missing. So my deal is, you just got to reach out. You know, I've made a chain of higher ups, from programmers to builders, to referees. (I-M-1, 15:20)

Although challenging, rural students and their teachers were self-aware of these limitations and developed novel ways to overcome them in STEM by looking beyond their schools. The students responded to the challenge and saw the positive opportunities it offered not only for gaining STEM content knowledge but also for developing their STEM identity and other skills, such as communication and collaboration. Students at Purple shared the following:

> Yeah, a big one for me was definitely public speech. Because, like, I thought, whenever I joined this program, we’re going to build a robot, we're going to use it, and then that's it. But we have interview people and have other people interview us. Other people from other teams come talk to us, so that's definitely a big thing. And then also the computer design with CAD and 3d printing and stuff like that. I've had a lot of fun with that. I never, I never thought I would learn all the other stuff in here too. (FG-P-1, 35:58)

Having the exposure and collaboration with other ER students and teachers with a range of STEM knowledge was also evident in the survey data analysis, where, as mentioned, 71% of the rural study survey respondents offered that they strongly agreed/agreed with the statement "I would feel comfortable talking with people who are engineers."

The *Adaptive Persistence and Contextual Awareness Under Rural Constraint* theme emerged from participants' repeated descriptions of frustration, failure, and disappointment with their resource limitations, losses, and challenges at competitions and in their ER participation as a whole. However, within the context of the SEL competencies, these difficulties often served as a catalyst for self-management growth through trial-and-error as a normalized learning process, regulation of disappointment after losses or mechanical failures, and long-term perseverance despite short-term discouragement. For example, the all-female team from Purple had applied for and secured a competitive grant meant to encourage women in STEM through ER participation. As a result, they used funds to actively pursue several outreach and engagement awards at the season's final competition. However, despite their efforts, they were not considered for any award. Thinking about the experience, one female student on this team shared the following

> At the moment, it discouraged me. I was going to quit. I was like, so convinced, because I was fed up with it. At the end of the day, we were all exhausted and to get nothing out of the day. It was really disappointing. But after thinking about it, I know I will regret it in 10 years if I don't do robotics. So I'm going to do it, but it's even just up until this point of the season, I've been really discouraged, like burnt out and unmotivated because of that. But I'm not going to let it stop me from continuing next year. (FG-P-1, 24:13)

In terms of perseverance, another student shared that whether their team is at school or in competitions, they "just do what we can, as fast as we can… make sure we get it to work, trial and error coming the next day, and keep going" (FG-Y-1, 03:50)

Also, within this theme, study participants demonstrated advanced social awareness of their rural context, including ideas such as rural isolation, limited funding, smaller class sizes, and differing perceptions of robotics and STEM across rural communities. Participants recognized disparities between rural and urban teams, including facilities, mentors, and parts access. Although these limitations were mentioned, they were accompanied by the social awareness that their rurality also offered unique benefits. Participants regularly centered on their community values, such as skills learned through agricultural work, sports, or other extracurricular activities, and family, rather than on the prestige that comes with access to STEM. For example, one participant stated the following:

> What's important is the fact that kids here do everything. We're not like kids in other places who specialize in one thing. At those bigger schools, the robotics team just does robotics. The robotics team here? I mean, I'm in an AG class, he's in an AG class but, I mean, we're all doing stuff that's different. And that experience allows us to not rely on just what we've seen in here [robotics]. We're looking at things we've seen everywhere and putting it into our robot. And, I mean, it's something about rural kids. We all, most of us have a job. Most of us have spent time, you know, going out and working on stuff. And so we're taking what we, like life skills that we've already learned, and we're bringing it into this program. And a lot of kids are just using what they've learned in this program to continue working in this program. And I think that we have an advantage using all the things that we've grown up around (FG-B-2, 12:56)

Interestingly, within this theme and the constructs of social awareness and relationship skills, participants were cognizant of their invisibility "behind the scenes" as STEM labor to outsiders. This was particularly evident when parents, the school, or the community were mentioned, and whether these groups were aware of the ER program's goings-on, or of the ability of the rural teachers and students to articulate what they do to these groups as part of competitive ER. While the study's participants understood the need to involve the outside rural community to sustain their program through financial or other support, differing conceptions of STEM played a role in the disconnect. For example, one student offered the following

> Anytime my family sees like us in the newspaper, they'll send it to the group chat be like, look at our little nerd. Like, that's all they see. So I mean, for us, it's a really big deal, but to them, I think it's just another school activity. And then when in the reality, it's a really big opportunity to learn. They don't see it that way. And I feel like they don't like, they don't see it as careers. They see it as fun. That's what they see it as. Because there's some students in this other class over here, they will come, they'll stop by, and they'll see us driving the robots, and that's all they see. They don't see the programming behind it, the designing. They're like, "Oh, I'm gonna join robotics, I can drive a robot." Like, you have to build that robot, you have to wire that robot, you have to program that robot. (FG-P-1, 38:56)

This contextual awareness was also evident in the survey data. In the survey, rural ER students in this study saw themselves as someone who does well in activities involving technology, science, or math, with 70% agreeing or strongly agreeing on average with survey statements in this regard (e.g., I am able to do well in activities that involve technology). However, while very few students (less than 5% on average) strongly disagreed or disagreed with the statements, when asked if their parents or broader community saw them in the same way (e.g., My parents see me as a science person), the majority of student respondents, approximately 50% on average, indicated that they neither agreed nor disagreed with statements of this type.

With the themes in mind, and in responding to the research question “what challenges or benefits do rural students experience regarding STEM content for participation in competitive ER?”, the data shows promise that, in the frame of SEL, the challenges experienced by rural robotics students are not issues to overcome but opportunities for advantage. This type of exposure should be leveraged and used to support the adoption of ER use in schools that offer limited STEM learning opportunities, are underserved in STEM content, or have limited access to resources and funding. The challenges of providing high-quality STEM experiences can be overcome, leading to a host of STEM learning benefits.

Through the lens of the theoretical framework for this study, the theme of *External STEM Exposure* conveys a social awareness, as in the use of cultural norms to navigate interactions effectively and foster a positive environment. That students specifically called out the benefits of collaboration and skill development, such as public speaking, demonstrates a progression in rural students’ relationship skills and identity development that may not have occurred solely within STEM content or courses without ER participation.

Also within the purview of the theoretical frame, the theme of *Adaptive Perseverance and Conceptual Awareness Under Rural Constraint* notably frames rurality in the context of ER not as a deficit, but as a strength in the vein of rural cultural wealth (Crumb et al., 2022) that includes a tight-knit rural STEM community, STEM mentoring, and a sense of shared responsibility. The awareness communicated in the experiences of rural ER student and teacher participants reflects a high-level contextual awareness uncommon in secondary STEM narratives. In the true spirit of SEL, this awareness was used as an advantage to adapt and persevere, utilizing the skills of empathy and trust that extended within and beyond the ER community.

Conclusion

Despite challenges in facilitating and participating in ER in these rural schools, students were socially aware of their situational context, enabling them to acknowledge the challenges and lean into the benefits of ER. This aided in their awareness and an asset-based approach to ER, which contributed to their STEM identity development and adaptive persistence despite the constraints. The fact that the rural students in this study recognized the benefits of their access to a wide variety of experiences, such as those in agriculture, where work on farm equipment may be prominent, conveys a recognition of the value assigned to these experiences for learning and the ability to apply this knowledge to a unique STEM informal learning avenue, such as ER. This also conveys the notion that rural students perceive STEM content not as abstract concepts, but as practical knowledge and skills closely tied to their communities, environments, and everyday problem-solving.

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