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# Portraits of a Rural Georgia High School STEM Program

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## Portraits of a Rural Georgia High School STEM Program


### Abstract

This research examined school personnel's strategies and practices responsible for increasing student science proficiency at a certified rural high school STEM program. In the United States, difficulties have developed in adequately preparing students for careers in STEM sectors, especially in secondary education. This trend has led to increased difficulties for high school graduates competing globally for high-paying jobs. Rural schools have been especially susceptible to inadequately preparing their students academically. I used qualitative research portraiture to generate a mental image of the STEM program at the selected high school. I interviewed three teachers and two administrators in a certified rural high school STEM program regarding their day-to-day interactions within the STEM program. Data collection occurred through observations, interviews, and document analysis. Data were analyzed using coding procedures to generate themes. The findings can offer support to schools, including administrators, seeking to increase future STEM program development speed and accuracy. Boards of education and programs in our universities and colleges may also benefit from this study through support for students pursuing STEM degrees. Increased students' exposure to science, technology, engineering, and mathematics concepts may help provide STEM education for more students thereby increasing the number of students attaining proficiency in STEM fields and fostering development into the innovative thinkers needed for success 21st-century workplace. Findings may help the United States Department of Education, state educational agencies, university systems, school districts, and counselors at all levels to promote schools' participation in technology-enhanced pedagogy.



### Keywords

STEM, STEM Program, Rural Education, Qualitative, Portraiture, Secondary Education

Within the United States, adequately preparing students for careers in science, technology, engineering, and mathematics (STEM), especially in secondary education, has become increasingly difficult (McMullin & Reeve, 2014). Businesses and educators have indicated a need for an enhanced focus to meet the future economy and job market (Boe et al., 2011). According to a study by the Center for Advanced Communications Policy (CACP) for the University System of Georgia (USG), there has been a significant discrepancy in the number of students graduating at the collegiate level with STEM degrees and the number of STEM jobs available in the state; STEM jobs vastly outnumber the degrees earned (CACP, 2017). Despite this finding, the implementation of STEM in secondary schools has not shown uniformity within Georgia.

The state of Georgia could remedy this misalignment through careful use of STEM curriculum and the addition of more quality STEM programs in the local school districts, particularly in the underserved rural school districts. Compared to their rural counterparts, schools in urban and suburban areas show more success at meeting the state's criteria for STEM certification (STEM/ STEAM Georgia, 2020). Margot and Kettler (2019) determined that there has been insufficient information in the literature to adequately understand effective implementation in a rural school. Thus, there is an urgent need for additional research in rural, suburban, and urban settings involving diverse student populations to learn more about appropriate implementation strategies with STEM (Margot & Kettler, 2019).

Studies in recent years on STEM education and rural schools have justified continued research on this topic (Goodpaster et al., 2018; Gulen, 2018; Margot & Kettler, 2019). Workforce trends have shown a gap developing in the national workforce's ability to adequately meet the needs of an evolving job market due to a lack of STEM knowledge and technical understanding (McMullin & Reeve, 2014). Havice et al. (2018) noted an integrated STEM approach gave students academically challenging opportunities by requiring critical thinking skills to solve real-world problems through developing potential solutions. Students seeking a STEM-related career need to participate in these types of experiences to diversify their skillsets and better prepare themselves for the rigors of the collegiate environment and the workplace.

STEM education is a uniquely specific pedagogical approach in the classroom. Gilson and Matthews (2019) surveyed teachers in STEM education and determined five vital instructional strategies that succinctly describe the sum of STEM pedagogy. These instructional characteristics of STEM include: (a) emphasizing hands-on learning, (b) using inquiry-based teaching methods, (c) requiring student collaboration with peers, (d) promoting the value of learning from mistakes, and (e) promoting creative thinking by asking students questions with no single answer or solution path (Gilson & Matthews, 2019, p. 248). The researchers also determined specific characteristics of STEM through classroom observations. They concluded that the students' learning environments promoted flexibility in teacher/student interactions, leading to student growth through appropriate classroom rigor.

According to Akran and Asiroglu (2018), teachers have reported the positive impact of a STEM educational approach in the classroom. They found teachers believe STEM education enhances student interest in course material and boosts students' intrinsic motivation; additionally, the use of technology fosters growth for students both in the classroom and in their lives. Lesseig et al. (2016) found teachers believed in implementing specific design challenges in their classrooms. Teachers indicated these challenges led to an increased level of student perseverance when working on these projects. Teachers reported the unique design of these challenges prompted students to value completing the tasks. These tasks encouraged students to develop problem-solving and critical thinking skills using modern engineering design practices and enhancing their 21st century skills (Lesseig et al., 2016).

Various STEM education researchers have established the impact of STEM on marginalized student populations (Alvarado & Muniz, 2018; Glennie et al., 2019). Alvarado and Muniz (2018) determined that STEM-focused education significantly impacts minority students' educational trajectory. They found that if minority students participated in these programs, they were much more likely to choose an Advanced Placement (AP) STEM course while in high school and ultimately choose a STEM major once in college (Alvarado & Muniz, 2018). Glennie et al. (2019) emphasized the importance of exposing marginalized students to STEM courses earlier in high school if possible. They noted that when students did not take college preparatory classes in STEM content areas during the ninth and tenth grades, their options were severely limited for advanced STEM courses before high school graduation.

Alvarado and Muniz (2018) established the importance of exposure to advanced content through increased pass rates of STEM classes and other advanced coursework, including AP courses. They concluded that STEM students have been less likely to struggle with chronic attendance issues, behavioral problems, and graduating on time. These results also align with those from Glennie et al. (2019). In their research, marginalized STEM students found a benefit to a modified school structure that emphasized STEM content. They indicated "…the supports provided by these schools not only facilitate their college and career readiness but also keep them engaged with high school" (p. 250).

Multiple scholars have reported rural schools' difficulties stem from significant challenges with funding, resources, and teacher retention (Payne et al., 2018; Goodpaster et al., 2018). McConnell (2017) explained that rural schools would face increasing difficulties with these types of changes. He further indicated that teacher retention at the secondary level becomes even more critical when STEM areas focus on the school. He found that many students develop an ardent desire to learn about STEM- related material in their secondary years (McConnell, 2017). With the continually changing landscape of education and the difficulties facing rural schools, an enhanced focus on STEM successes in these environments may provide the necessary blueprint for rural schools to move forward in their STEM-related curricular goals.

## STEM in Georgia

The Georgia Department of Education (GaDOE) has implemented a specific initiative designed to increase STEM pedagogy saturation throughout the state. This initiative, known as STEM/ STEAM Georgia "…is dedicated to preparing students for 21st century workplace careers by providing high-quality educational opportunities in science, technology, engineering, arts, and mathematics fields" (STEM/ STEAM Georgia, 2020, para. 1). According to the GaDOE, STEM education in Georgia currently utilizes two implementation models (STEM/ STEAM Georgia, 2020). One model requires the entire school to develop and implement a STEM-focused mindset in the classroom. The second model is a school-within-a-school format in which at least 10% of the student population is instructed in a specialized STEM-focus curriculum. According to the STEM/ STEAM Georgia (2020), the program format incorporating the school-within-a-school model is the overwhelming choice for high schools. This may be due to the perception that a STEM-focus curriculum is a better fit in the high school environment. The STEM/ STEAM Georgia (2019) STEM Certification Continuum includes 19 criteria explicitly considered when determining a school's successful implementation of a STEM curriculum. These criteria include the comparative diversity of the STEM cohort compared to the rest of the school, performance with Career, Technical, and Agricultural Education CTAE disciplines, appropriate teacher certifications, and evidence of collaborative planning between teachers of various fields (STEM/ STEAM Georgia, 2020). Infusing a STEM-focused fundamental change in curriculum and pedagogy is a complex process and presumes a great deal of planning with local stakeholders. However, if Georgia is going to bridge the gap between school preparation and workforce readiness, it is important to find solutions for implementation of a quality STEM-focused curriculum in local school districts.

## Purpose

In Georgia, the Department of Education (GaDOE) developed certification protocols for schools desiring to implement STEM pedagogy in their classrooms. At the time of this study, there was one certified STEM high school in a rural community in the state of Georgia and 18 certified STEM high schools in urban and suburban communities. This study examined the life and educational experiences of teachers and administrators working in a rural Georgia high school with a STEM program certified by the GaDOE. The purpose of the study was to determine the strategies and practices used by school personnel responsible for increasing student science proficiency in a certified rural high school STEM program.

## Theoretical Framework

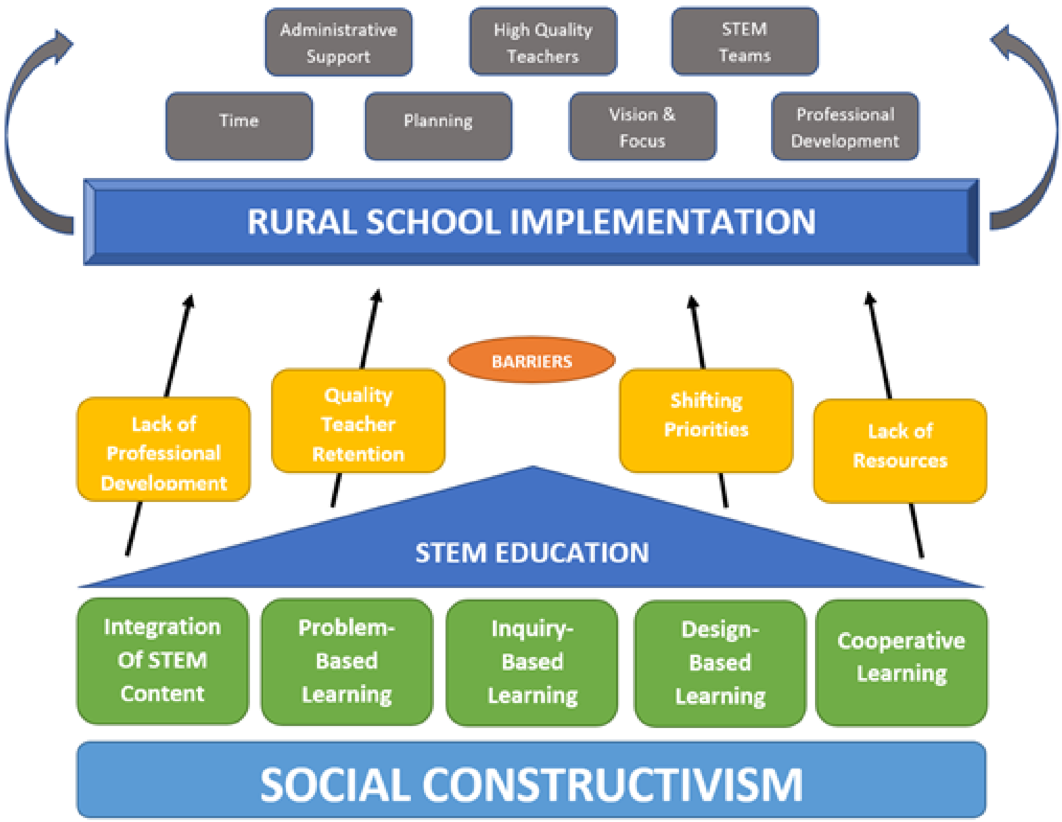
We used social constructivism to gain a fundamental understanding of STEM education. Under the larger learning theory umbrella of constructivism, social constructivism, more emphasis rests on the social environment, particularly how culture and context influence the learning (Schunk, 2012, p. 240; Vygotsky, 1978). Social Constructivists contend that learners integrate their prior knowledge into the learning process as they actively construct meaning from classroom experiences (Prawat & Floden, 1994). Constructivists emphasize collaboration and communication among learners through “social negotiation” to form the foundation for current STEM pedagogy in schools (Ertmer & Newby, 2013, p. 57). Students participating may use the social constructivist approach to understand the classroom’s unique experiences as they participate with others in an interactive or engaging manner (Ertmer & Newby, 2013). Students use this process to take their prior meaning and understanding of knowledge and actively build a better understanding of content through their classroom experiences placed in the proper context with the outside world (Eastwell, 2002). This type of learning’s social component indicates a shared learning process alongside other students instead of being experienced in isolation (Prawat & Floden, 1994). STEM educational practices place a premium on students using time in the classroom to work. Students work together and construct the meaning of the world through collaboration to develop their knowledge. Social constructivism is pervasive by nature in the STEM-focused classroom, and this theoretical learning construct influences the practical nature of how learning occurs.

Social constructivism was used to gain a fundamental understanding of STEM education at one rural Georgia STEM program. Students use this process by incorporating their prior understanding of an idea and actively building a better understanding of content through their classroom experiences placed in the proper context with the outside world (Eastwell, 2002). This social component of this type of learning indicates a shared and mediated learning process alongside other students, as opposed to learning in isolation (Prawat & Floden, 1994). Constructivism is pervasive by nature in a STEM-focused classroom, and this theoretical learning construct influences the practical nature of how learning occurs.

Constructivism supports critical characteristics of integrated STEM education, including (a) integration of STEM content (Havice et al., 2018; Lin et al., 2019), (b) problem-based learning (Ertmer et al., 2014), (c) inquiry-based learning (Yildirim & Turk, 2018), (d) design-based learning (Gulen, 2018; Lesseig et al., 2016), and (e) cooperative learning (Ertmer et al., 2014; Wang et al., 2020). STEM implementation involves critical attributes, including (a) a proper vision and focus (Alsbury et al., 2018), (b) adequate planning (Wang et al., 2020), (c) high-quality teachers (Yildirim & Turk, 2018), (d) STEM teacher teams (Wang et al., 2020), (e) administrative support (McConnell, 2017), (f) time (Gonzales et al., 2014), and (g) professional development (Baker et al., 2015; Havice et al., 2018). Barriers that restrict the implementation of integrated STEM education in rural schools include: (a) lack of professional development (Stevenson et al., 2015), (b) quality teacher retention (McConnell, 2017; Stevenson et al., 2015), (c) shifting priorities (Alsbury et al., 2018), and (d) lack of resources (Goodpaster et al., 2018; Payne et al., 2018). The relationships among these concepts are crucial in establishing a context for a successful STEM program in Georgia.

Figure 1

*Conceptual Framework*




*Note*. This figure illustrates how schools might build STEM education upon social constructivism. It represents the barriers to STEM implementation in rural school settings based on the critical characteristics of the concept adapted from (Thibaut et al., 2018, *Figure* 1).

Despite the current understanding of the constructivist underpinnings within STEM education, barriers that affect rural schools in implementing effective programs remain. As shown above, these barriers are often the primary obstacles for rural schools attempting to maintain positive academic momentum and implement new programs. Regardless of these perceived barriers, strategies exist for marginalizing the effect of these problematic characteristics of rural schools. As indicated at the top of the above concept map, these strategies provide areas of focus for personnel in rural schools while working toward success.

## Method

The lead author conducted a qualitative study using portraiture to create a mental image, or portrait, (Lawrence-Lightfoot & Davis, 1997) of the STEM program at the selected high school by detailing the experiences of teachers and administrators working in the STEM program. Lawrence-Lightfoot (1983) proposed that the portrait "would be defined by aesthetic, as well as empirical and analytic, dimensions" (p. 13). This approach inquired into teachers' and administrators' experiences as they described the process of developing and maintaining a STEM program in a rural high school.

## Research Questions

This study was conducted to answer the following research questions:

RQ 1. What were the lived and career experiences of school personnel who were responsible for increasing student science proficiency in a certified rural high school STEM program?

RQ 2. What strategies were used by school personnel who were responsible for increasing student science proficiency at a certified rural high school STEM program?

RQ 3. What practices were used by school personnel who were responsible for increasing student science proficiency at a certified rural high school STEM program?

## Setting

This study occurred at a rural Georgia high school that has successfully implemented a STEM program and has also received STEM certification through the Georgia Department of Education (GaDOE). With the vast majority of STEM programs in Georgia high schools being in or near large urban areas, the participants at the research site provided data that illustrated a clear picture of the successful implementation of a STEM program without the benefits of being near larger, more developed urban areas.

## Participants

Purposeful sampling, precisely a criterion-based sample, was used to select teacher and administrator participants based on their experience with the STEM program through its many stages of development (Patton, 2002). Participants provided the detail and meaning regarding the development, implementation, and maintenance of the STEM program within the selected school. The participants included the principal, an English Language Arts (ELA) instructor, a Career Technical and Agricultural Education (CTAE) director, a media specialist, a chemistry instructor, a physics instructor, and a STEM director. The participants included three women and two men, ranging in age from 42 to 49. Their years of teaching experience at the school site ranged from four to 16 with a total number of years of teaching experience ranging from five to 26 years.

## Data Collection

The first author generated the corpus of data through three methods – observations, interviews, and program documents. The first author conducted observations during five visits to the school over a four-month period. During the observations, the first author attended to the surroundings of the school and classrooms, looking for context and the ability to piece together each portrait by considering the layout of the school and the facilities available in an effort to build thick, rich description (Lawrence-Lightfoot & Davis, 1997).

The first author also interviewed the five participants, seeking to make meaning of their experiences and to determine the practices within the program that most impacted students. Using Seidman's (2006) protocol, the first author conducted three rounds of interviews. In the first round of interviews, participants were asked to describe their path into the education profession and establish a baseline for their educational philosophy based on their life experiences leading into the educational field. In the second round of interviews, participants were asked to delve into their individual perspectives and experiences within the STEM program. In the third round of interviews, participants were asked to reflect on the meaning of their experiences within the STEM program's confines. In total, participants were interviewed on average 3.5 to 4 hours over a four-month period with interviews spaced about three weeks apart.

The first author also analyzed program documentation to more fully understand the processes undertaken when teachers in the program worked and collaborated together. The reviewed documents included planning itineraries, meeting notes, lesson plans, and project descriptions; the STEM director at the school provided these documents.

## Data Analysis

Data analysis was a continuous, iterative process throughout and after the collection of all data. The interview data were transcribed using the software, Otter, which is capable of audio recording conversations and transcribing the audio into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text. Those transcripts were then cleaned by comparing them to the original recordings to ensure the accuracy of the transcriptions. Data analysis began with a review of the interview transcripts to identify the meaningful data that most directly reflected the STEM program.

Following the completion of each transcript, the documents were converted into Word files and printed. The first author then engaged in in-vivo coding, which used the participants' own words in order to stay close to the participants' language (Saldaña, 2016). Next, the first author conducted two further rounds of coding for emotion and for process. After these rounds of coding, the first author began creating categories from the codes that were similar in composition and emotion (Saldaña, 2016). Finally, the first author grouped the categories by participant, which ultimately became the headings for each portrait. These headings or categories were then used across all five participants in order to create significant themes.

As outlined by Patton (2002), the first author employed several strategies to ensure the data collected and results were valid. The first author engaged in member checking throughout the interview and data analysis process. The first author gave participants adequate opportunities during the interview process to reflect on the meaning of their involvement in the STEM program and to verify the data collected. The first author asked questions that allowed the participants to reflect on their previous responses during and after interviews and allowed the participants to validate the initial conclusions generated during the iterative process of data analysis.

Additionally, the first author engaged in "triangulated reflexive inquiry" (Patton (2002, p. 495). This process allowed the first author to reflect on various aspects of self-reflection throughout the entire research process. One part of this was school visits where the first author was able to attend meetings and meet with school personnel. Unfortunately, due to the COVDI-19 restrictions, no classroom instruction was able to be observed. The first author was also able to review artifacts such as meeting notes, agendas, lesson plans, and projects provided which allowed them to confirm what was said during the interview process. When considering applying this approach to ensuring validity within a study involving portraiture, several strengths become apparent. Through these question-based strategies, portraiture as a methodology is strengthened through the researcher's actions, greater depth in the narrative developed, and a more meaningful understanding of how the reader will ultimately view the picture of the elements within the research site's confines.

## Results

Three major themes were identified: *the importance of peer collaboration*, *goal setting and success for all*, and the *progressive program pedagogy* found in the STEM program at the school. The themes generally encapsulated the answers to all three research questions. The narratives on the importance of peer collaboration, goal setting and success for all, and the progressive program pedagogy found in the STEM program provide context to the participants' experiences within the school and the STEM program. Each of these themes must be considered through the lens of rural program implementation and the successes the research site experienced while navigating the development and eventual certification of their STEM program.

The three tables below outline how the in-vivo codes were coded, categorized, and grouped into themes.

**Theme 1: Progressive Program Pedagogy**

| Quotation | Code | Category |
|---|---|---|
| DW (Interview 1)<br><br>I just think again, it comes to that early adopter thing. When you come down to [it], I've been in a position since the beginning of this with other people that are not tying our hands. It's a team approach that I feel like we've made it together, and I think we were able to have the freedom to be able to do these things and just make something as a blank slate and write it however we want to. And I do think that we've made something that's neat, and we're about to go spread it through a whole school with the College and Career Academy grant that we just got when we're starting building construction in August this year, and we're pretty excited. | Freedom to create something great (process) | Characteristics of the Program |
| DW (Interview 3)<br><br>So, those are the tough conversations. How do we fix this? We work together with the math department head, the STEM [Director]. Another crucial conversation would be the dual enrollment person with the STEM person [and] the counselor. … So, then you got to get them all in there and explain the consequences for everybody, and then you've got to draw a line in the sand of like, "I'm sitting here. I don't care what you do, but don't [complicate] third period. Not saying they can't ever talk [about scheduling] something third period, but don't force [a change]. I always think of those cohorts like new | Constant adjustments for improvement (process) | |

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| cranberry sauce. Just dump it out of a can. Don't make the whole can do it. You're just literally taking all these options out for all these kids. | | |
| MS (Interview 2)<br><br>We still have those times [of traditional instruction] because you know that kids need to learn how to take notes. So, we still have some traditional aspects, more so in the fall semester, and [in the] spring, you hardly ever see us at the board. We usually introduce things, introduce topics, and then boom, they're off to work, they're off to the races. So, it comes, you know, it starts out a little more teacher-centered, and you teach them how to work together, you teach them those group skills and how to collaborate with each other, how to be team leaders, how to be team followers, how to be team players. And you know, as you get on towards the end of the year, you reach a point where (and now we always love this time of year) we can sit down, and we can relax. Now we can let them run with it. So, we're trying to make them [become] the owner of their knowledge and learning. | Students become owner of their knowledge/ learning (in-vivo)<br><br>Fun, challenging, collaborative, student-centered (in-vivo) | STEM Program Culture |
| AM (Interview 2)<br><br>Kids hate busy work. I hate busy work. It all needed to matter. And so I think I impacted it that way in keeping us focused and keeping us organized and making sure that we had what we needed to do at the end, in a way that makes sense to everybody. | Kids hate busy work (emotion) | STEM as the ELA Teacher |
| DW (interview 3)<br><br>You've got to let them be experts and you don't want to micromanage them. You want to have good trust [with] them and [I] trust her totally to make the right decision for kids. Well, more than I would trust some of the other entities if that makes sense because she's proven time and time again to make the right decision. | People trust our STEM teachers (in-vivo) | Developing the STEM program |
| AM (Interview 2)<br><br>And it would be just enough to get their brains working, you know, so just such a high level of engagement, and they enjoyed coming to school. We have so many field trips. It's hands-on. Fantastic, love it, and the kids got really excited about that and they felt special, because we celebrate them, and we do so much for them and with them. They become family. They call her momma [the STEM director]. They sure do. She's like, another mom, and I know they can go to her | They call her momma (in-vivo) | Building Student Relationships |

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| because she's our STEM director. They see her a lot more than anybody else. | | |

## Theme 2: Goalsetting and Success for All Students

| Quotation | Code | Category |
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| AM (Interview 3)<br><br>They're very grade conscious because they're high achieving kids anyway so you have to teach them that. You got 65 on that first paper, but you're going to get better because you see all these comments I wrote, and you're gonna fix that … It may be December when you're happy with that paper. So learning to fail and achieve [is so important] … how are you gonna fix that, what are you gonna do, there's so much questioning, and I love that. | Learning to fail and achieve (in-vivo) | Defining Success in the STEM Program |
| AM (Interview 2)<br><br>We wanted to integrate all those subject areas so that every unit was interdisciplinary and connected with all four subjects, every time. And we wanted kids to see how that tied to real-life skills … But that's a really big piece of it that they had to do real-world things so at the end of every unit there was a public performance piece like we would invite judges outside of school, to come and evaluate the things they created or the presentations they were doing, and we gave those judges rubrics that the kids had too, and we said they're going to be looking at all these things and they're going to grade you and what they tell you got is your grade. We're going to give you a grade too for what you've done, but what really matters is what those outside people think because they're the experts in their field. | Outsiders judging final products/projects (process) | |
| DW (Interview 1)<br><br>I just think again, it comes to that early adopter thing. When you come down to [it], I've been in a position since the beginning of this with other people that are not tying our | Expanding success throughout the school | |

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| hands. It's a team approach that I feel like we've made it together, and I think we were able to have the freedom to be able to do these things and just make something as a blank slate and write it however we want to. And I do think that we've made something that's neat, and we're about to go spread it through a whole school with the College and Career Academy grant that we just got when we're starting building construction in August this year, and we're pretty excited. | (process) | |
| MS (Interview 3)<br><br>So, success in my classroom would be students being able to overcome obstacles, overcoming failures, overcoming difficulties learning the content, yet still coming out with positive applications for future courses content, career, etc. That's what I would label success. It's not whether they get an A, B, C, or D [as a grade]. It's whether or not they were able to overcome obstacles in their way and continue to learn and keep moving forward. They didn't get stopped, you know, didn't stop and just got completely railroaded. They were able to keep moving forward no matter what. And that way, we were able to continue to raise the bar higher and higher for them. | Finding joy in the struggle (emotion) | Program Goals |
| MS (Interview 3)<br><br>Success in the STEM program, I think it's kind of the same thing, but just to the next level. Overcoming everything that was put in [their] way, but yet now they have a plan. They have a good background. They have good content [knowledge], [and] they have fulfilled their obligations of completing a math and science honors track. They've done an internship, they have an idea of what they want to do, and we've kind of sort of help them guide them into what their future could be and put them in contact with people who can help them further on. That to me, I feel like when students are confident when they graduate. That makes me happy. | Program flow encourages individual growth (process) | |
| JH (Interview 2)<br><br>I feel that one of the things that we're trying to accomplish is to turn our students into adaptive thinkers, and students who can solve problems. | I want to produce critical thinkers, adaptive thinkers (in-vivo) | Success For All Students |
| JH (interview 3)<br><br>When my kids are able to leave, and you know they're a little | More grounded in their thinking, | |

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| more grounded in their thinking they're able to defend their arguments a little more. They're able to analyze information and take important pieces of information away and feel like I've been successful. | able to defend their arguments (in-vivo) | |

## Theme 3: Peer Collaboration

<table>
<tr><th>Quotation</th><th>Code</th><th>Category</th></tr>
<tr><td>JH (Interview 2)<br><br>You have to be willing to set aside your own personal interests for the interests of the kids. And I think you have to have the right personalities together. I don't think … that every teacher that we have, and every teacher in this building, would work well collaboratively. I think you have to have the mindset of, I'm willing to try something new, and I'm willing to fail at it. You know, I'm willing to just struggle.</td><td>Being vulnerable leads to success (emotion)</td><td rowspan="4">Collaborating With Peers</td></tr>
<tr><td rowspan="2">AM (Interview 2)<br><br>We work really well together. To do that, we both get excited about kids getting excited about learning and we want to bring [the energy] as much as we can because you know there are some people we don't work as well with. And if they don't see our way of thinking, it's harder to work with them, and if they're not with the whole grading thing [we use to allow multiple opportunities to learn through mastery], we want to make sure that they're doing what we're doing with the grading. You can't have one group that's going to be like, ‘Nope, you failed. Sorry, moving on.’ I can't do that. They have to fit our STEM philosophy of, ‘They're failing, what can we do to fix that? How are you going to help them learn that concept?’ You can't just let them go on. It's got to be learned before they go on to the next thing.</td><td>We have no ego problems (in-vivo)</td></tr>
<tr><td>Agreeing philosophically with other teachers is important (process)</td></tr>
<tr><td>MS (interview 3)<br><br>They know we're not perfect. We're gonna make mistakes. You can get past the mistakes. It's okay. And sometimes, some things that we try might not work the best the first time. Sometimes it'll be a disaster and sometimes it'll be great. And just having enough confidence in yourself to accept the failures, and to learn from them and move forward is, I think, a necessity of a quality of a person in a STEM instructor. You want the same quality to be in your students. You want them</td><td>Learn to step back, be patient, and let it happen (in-vivo)</td></tr>
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| to be able to fail and learn from those failures and then take the next step. So, I would say that the ease of not getting too prideful is very important. And if you have a person on your team that thinks they are everything, they need to get off [the] team because that's the first indicator. You are not everything. So, you can't help me because I don't want people to tell me what to do. I want to learn and work with them and figure it out together. It needs to be collaborative, just like we want the students to be collaborative. | | |
| MS (Interview 3)<br><br>Another company that is a great partner with us is Panel Built. They invited us to come in and spend a day with them so they could show us all the different jobs they have and what different people do. Their engineers spent a few hours showing our kids what a typical day looks like for them, what they do, how they do it, and the software they use. I mean just little things like that, which meant the world to the kids. I mean, because they had no idea that the company was even there. … They build prefab buildings, like the guard shack at our school, they build things like that. Yeah, or like in warehouses, if you have offices and stuff, they build those offices, and they prewire them and everything. They're just set up like little houses. It's prefab, [it's] made together. You just take it. Boom. Set it up, and it's done. So, it's pretty cool the stuff that they do there. | Bringing relevance into the classroom (process) | Focus on the Journey, Not the Destination |
| MS (Interview 1)<br><br>I think learning how to apply knowledge is a huge thing because if you went through school as I did, you didn't learn how to apply the knowledge. You just got the knowledge. We didn't know what we were learning it for. "We just told you to learn it." And so now you have to go back, and you know it's hard to go and talk to these people in these businesses and be like, "I don't know why this is useful. Can you help me? Tell me why this is useful." You feel dumb because you don't know, but they're like, "Oh well, this is how you can use it." You're like, "Okay, that makes sense because I've not been in their world." Being willing to admit that you don't know everything [is crucial] because I think teachers have this fake persona that we're supposed to know everything, always be right, and we don't. And we are not always right, especially nowadays. | Application of knowledge is key (process) | |
| MS (interview 1)<br><br>A lot of teachers are really afraid of failure, and they're afraid of their kids not learning the standards by doing it the same | We do what the team says, what's best for the kids (in- | Moving Past the Fear of Failure |

| | | |
|---|---|---|
| old way, and they're afraid of opening their doors and using time more freely as opposed to [a] very structured [approach]. It's hard. It does take special people to teach STEM because you have to let go of a lot of control. As a STEM teacher, I have to be willing to listen to what [various STEM teachers] have to say. And we have to put our ideas together. It's not just one of us. We're always a team, and sometimes you're like, "I don't know if that's right." But if the team agrees, we do what the team says, and we always try to do what's best for the kids. | vivo) | |

These themes answer Research Question 1: *What were the lived and career experiences of school personnel who were responsible for increasing student science proficiency in a certified rural high school STEM program?* The data suggest that the participants frequently implement each theme in their daily practice. The themes act as an outline of how the participants approach their jobs concerning the STEM program. They consistently work together, set and maintain success goals, and use progressive instructional strategies.

Research Question 2 asked: *What strategies were used by school personnel who were responsible for increasing student science proficiency at a certified rural high school STEM program?* The three themes developed from the data explicitly describe the strategies enacted in the program. The teachers believed that constant and effective collaboration was vital, they established goals for students to reach, and they believed that all students could achieve success in the program. They worked to accomplish these ideals through a progressive pedagogical approach.

The practical application of each of the three themes answered Research Question 3: *What practices were used by school personnel who were responsible for increasing student science proficiency at a certified rural high school STEM program?* A unique relationship between research questions two and three exists in that the practices that the participants implemented in the program specifically address how the strategies were applied. All three themes provide insight into the STEM program's practices that the teachers and administrators.

The results of the study through the themes, lived experiences, and strategies and practices articulated indicate the methods of success conducted by the teachers and administrators in the STEM program at the school. The data in the study confirmed much of the current literature (Alsbury et al., 2018; Baker et al., 2015; Gonzales et al., 2014; Havice et al., 2018; McConnell, 2017; Wang et al., 2020; Yildirim & Turk, 2018). The critical difference between this study and any prior studies is the deliberate focus on successfully implementing a high school STEM program within a rural community.

## Discussion

Findings from the participants suggest critical characteristics of their experiences working within the STEM program. First, to highly impact the students within the program, the teachers and administrators work to identify key strategies that will yield the most significant impact on their students, including constantly collaborating, working to maintain a common goal and focus across the program, and teaching the students through progressive means. Following the identification of these strategies, the specific practices the participants utilize daily were highlighted. Second, communication is maintained by setting aside regular times to meet for both short-term and long-term planning. Informal meetings also happen regularly in an impromptu fashion, indicating the desire and focus the participants have in maintaining success within the STEM program. Third, due to their constant collaboration, the teachers and administrators can better create a singular and unified vision and set of goals for the students and work toward helping them become successful based on these goals. Finally, the progressive nature of their pedagogical approach in the classroom is attained through strategies such as inquiry and project-based instructional formats that heavily emphasize applying knowledge in realistic contexts.

The participants in the study all showed a strong sense of pride regarding their work in and around the STEM program. They found value in their work to better prepare students for the next step in education or the workplace. In addition, they valued the real-life context that the coursework embodied from the physics projects that aligned with engineering principles and geometry to the biology courses filled with out-of-school experiences such as visits to the hospital to see the practical application of the content being taught.

It is vital to consider the accomplishments of the STEM program at the research site considering the challenges that rural schools face in education today. In rural schools, there are perceived barriers to higher education due to an insufficient number of advanced and STEM-focused courses offered at the high school level (Henley and Roberts, 2016). The authors also noted rural areas tend to lag more developed regions regarding industries embedded within the community. Stipanovic and Woo (2017) also recognized that rural schools have fewer course options for students to choose from, and students in their study confirmed this fact. Despite these potential limitations presented in the literature, the teachers and administrators at the Georgia high school used for this research were successful in overcoming these potential obstacles. The rural Georgia STEM program found a partnership with a local college for adding dual enrollment courses at the school to accelerate students within the STEM program. They showed a continual sense of flexibility in using the resources that were available instead of dwelling on the resources that were missing.

Another key point of emphasis when looking through the lens of rural school implementation is that no two rural communities look alike. The resources available in one community will not mirror another. Alsbury et al. (2018) posited that since rural schools do not fit many traditional models and can be unique in organization, there cannot be a single one-size-fits-all model for STEM curriculum implementation. Instead, a customized model for each school must be considered. These data are in direct alignment with the GaDOE model of STEM program implementation. The GaDOE believes that STEM program implementation will be unique at each school location and the resources and community partners available at the site to supplement interdisciplinary instruction will determine the program's design (STEM/ STEAM Georgia, 2019). The methods of recruitment to a program such as this must match the interests of the student body. Ertmer et al. (2014) posited that students within a rural school striving to implement STEM successfully appear to react in a more positive manner when they can identify the relevance between the classroom activities and the local economic landscape. This same economic landscape will vary from one community to another. The teachers and administrators at the rural Georgia high school that participated in this research knew their community and how to present an educational option for the students that would directly impact the community in a positive manner and generate buy-in from local stakeholders.

The challenges of small, rural school systems can be narrowed down to specific issues, such as a lack of meaningful educational funding and resources, falling populations, and continual problems in hiring and retaining qualified teachers (Goodpaster et al., 2018; Payne et al., 2018). With population densities ever increasing in urban and suburban areas, these issues will not be reduced in the near future. Rural schools must do their part to make themselves attractive for potential teaching candidates, especially at the secondary level in math and science disciplines when many students develop a genuine appreciation for STEM related content (McConnell, 2017).

Administrators within rural school systems must remain vigilant against these factors that can weaken a school's or program's ability to effectively instruct students. Also, these apparent challenges serve as a call to maintain a sense of proactivity in keeping quality educators in the building to ensure the education students are receiving will continue to remain at expected levels of excellence. My time with the teachers and administrators at the research site demonstrated that they are ever aware of the changing landscape around them within their community and are constantly working to maintain a level of excellence in their school. The development of the CCA proves they are listening to their community partners and


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attempting to mold the educational experience into one that will potentially have the greatest impact on the community for years to come.

The results of this study could hold relevance for administrators who seek to implement a STEM-focused pedagogy for a portion or all their student body. As leaders in their respective schools, these individuals may glean understanding from the participants' experiences in the study and find commonalities with teachers in their schools. Administrators could benefit from building upon the developed themes from the study and finding ways to implement these approaches within their schools specifically. In that case, they may see increased teacher collaboration working toward building advanced levels of science content knowledge in their students. Despite the identified themes specifically addressing success in a rural school environment, it is possible that the lived experiences of the participants, the strategies they developed, and the practices they demonstrated may not provide support for other practitioners seeking to implement a STEM-focused approach in their schools.

## Limitations

Limitations within a study must be identified in qualitative research to provide authenticity and trustworthiness to the data collected and conclusions drawn (Patton, 2002). Although purposeful sampling and Siedman's interview process yielded quality participants and rich data, there is still a lack of voices of those who did not participate but whose insights could have further added to this work (Patton, 2002; Siedman, 2006). Participants included three teachers and two administrators with roles directly linked to the STEM program. Other participants who were active teachers within the STEM program and could speak to the developmental process of the program were initially identified for the study but could not be included for various reasons. Each participant held varying roles within the school, including principal, English Language Arts (ELA) instructor, Career, Technical, and Agricultural Education (CTAE) director, media specialist, chemistry instructor, physics instructor, and STEM director. Other roles involved in the program, including geometry instructor, algebra instructor, and biology instructor could not be used in the study due to difficulties in scheduling interviews and preferences to not participate in the study. As a result, some data comparisons across participants could not be conducted.

## Recommendations

Opportunities for future research exist following the completion of this study. A more comprehensive sample of participants that covers every aspect of a school's STEM program may provide a more detailed look at the strategies and practices that successful STEM programs utilize in their day-to-day operations. STEM programs from rural, suburban, and urban regions could also be studied to search for commonalities in their successes. Additionally, time spent observing teacher-student interactions during the school day within a rural STEM program would powerfully work to illuminate critical strategies and practices that successful STEM programs utilize in their day-to-day operations. Student feedback, including the differences between male and female students or across multiple ethnicities, may help ensure that schools provide equitable opportunities for all demographics represented in a school's population. As a different approach, a study on up-and-coming STEM programs seeking GaDOE certification may shed light on how schools attempt to shift their instructional practices to focus on an interdisciplinary approach and the possible pitfalls that may arise. Through these varied approaches, future practitioners may glean other qualities of a thriving rural STEM program and implement such instructional strategies more efficiently.

## Conclusions

Studies in recent years on STEM education and rural schools have justified continued research on this topic and validated the completion of this study (Goodpaster et al., 2018; Gulen, 2018; Margot & Kettler, 2019). It is encouraging that schools such as the one in the study are pushing the implementation of inquiry-based and project-based instruction to help eliminate the workforce trends that have shown a gap developing in the national workforce's ability to adequately meet the needs of an evolving job market due to a lack of STEM knowledge and technical understanding (McMullin & Reeve, 2014). For students seeking a STEM-related career in life, experiences like these are needed to diversify their abilities and prepare them for the rigors of the collegiate environment and the workplace.

The GaDOE consistently supports schools desiring STEM-focused educational strategies through the clearly outlined expectations of the STEM Continuum Requirements for a whole school or program implementation. The apparent discrepancy of high school STEM programs in the state vastly favors those schools in and around prominent urban locations. Through the completion of this study, we hope that the successful characteristics of a certified STEM program in a rural high school can become more discernable to practitioners seeking a similar educational format for their students. With a better understanding of what makes STEM pedagogy successful in a rural environment, smaller schools can plan for their STEM-focused implementations by focusing on strategies and practices that may expedite the process while simultaneously avoiding pitfalls that either slow or nullify progress made in this arena.

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