Challenges & Opportunities for STEM Teachers in Rural Schools: A Case Study

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Abstract

This project is a single ongoing case study that focuses on the teaching experiences of two early-career math teachers working in rural schools and the factors that influenced their decision to work in these environments (Yin, 2014). Both teachers are graduates of Clarkson University's STEM Up NY program, a National Science Foundation (NSF)-funded Robert Noyce Teacher Scholarship Program designed to strengthen STEM teaching and to learn in high-need schools. This project is part of a larger, 14-partner Noyce research collaboration focusing on STEM teacher persistence, retention, and recruitment (TPR2) in rural schools. TPR2 addresses the national shortage of STEM teachers in rural communities, which is critical for future student success. This larger project seeks to identify programmatic features of STEM teacher preparation programs that aid in rural STEM teachers' recruitment, retention, and persistence.

Keywords: STEM, rural, teacher, Noyce

Introduction

The demand to fill STEM careers with homegrown talent persists. While STEM may be integrated into curricula at a young age, attracting and retaining qualified STEM teachers at all K-12 levels is difficult. According to the American Association for Employment in Education, teaching positions in mathematics, physics, and chemistry were in the top five highest shortage areas in the US in 2018 (AAEE, 2018). STEM teacher shortages are widespread but are even more prevalent in rural areas. Although young professionals may seek out rural areas to be closer to family or to take advantage of the lower population density and opportunities to enjoy outdoor recreational activities, rurality has its own unique challenges that can lead to a limited pool of potential applicants to fill available teaching positions. Administrators have shared that finding STEM teachers willing to work in rural areas is sometimes the most difficult challenge (Brenner et al., 2022). Higher poverty rates and geographic isolation can make recruitment difficult. Small rural communities often lack political capital and suffer from a loss of economic base and inadequate funding (Showalter et al., 2017; 2019), which translates to lower teaching salaries and fewer resources. In addition to a general lack of access to quality programming, and materials, teachers in rural schools may often teach multiple subjects because there are fewer faculty and staff. Rural students also have barriers such as fewer resources and skewed values between school and home. For these reasons, rural areas are often seen in an unfavorable light (Aragon, 2016). Rural students face inequitable access to quality STEM education as a result. Moreover, the lack of resources and,

often, limited parental involvement also contribute to leaving rural schools on the fringe of quality STEM education.

Nevertheless, there are positive benefits to teaching in rural schools. Rural teachers tend to know their students and their families well because they may have taught a sibling or parent of their student; additionally, because the school district is often one of the larger employers in the area, teachers may even know parents who work in the school. Azano et al. (2019) claim that more rural students can get a good STEM education if preservice teachers are trained to deal with the unique challenges of rural schools. Understanding how STEM teachers overcome unique barriers in rural schools and preparing preservice STEM teachers can improve the recruitment and retention of quality STEM teachers, ultimately increasing equitable access to effective STEM education for rural students (Azano et al., 2019). With the proper resources, support, and persistence, rural spaces can remodel themselves to be sustainable and innovative. In this project, we explore the narrative that supports rural school teaching success and how teachers can leverage rural spaces to create success in schools.

Literature Review

There is a shortage of STEM teachers in K–12 schools across the country. However, this deficit manifests differently depending on geography, demographics, and subject area. Rural schools have trouble hiring and maintaining talented instructors. STEM teacher shortages are a consistent challenge across the US, and rural school shortages are most pronounced, especially in high-poverty, rural, and low-achieving schools (Cowan & Goldhaber, 2015; Anthony et al., 2017). In addition to limited resources, the challenges are often intensified by the fact that many rural areas lack access to broadband connectivity (Croft & Moore, 2019; Saw & Agger, 2021).

While this is true, we also know that high-quality STEM teachers can play a significant role in student learning (Maynes & Hatt, 2015). Tackling STEM teacher work shortages can help create more equitable opportunities for students. Both urban and rural schools tend to be considered high-need schools, yet fewer resources have been established to improve STEM teaching in rural schools (Azano et al., 2019). While it's easy to focus on the drawbacks of working in rural schools, the benefits of working in these rural spaces often get overlooked. In our fascination with large metropolitan areas, rural areas often get seen as secondary to their primary urban center (Brenner & Franz, 2015). Some of these benefits include small class sizes, more teacher autonomy, and leadership opportunities (Sutcher et al., 2016). Rural areas can also offer refuge for those seeking time outdoors and wanting to participate in natural recreation spaces. This may warrant recruiting teachers interested in living in and spending time in rural areas, not just mass recruitment. This strategy may help to draw teachers who are more likely to persist and be retained in rural schools (Goodpaster et al., 2015). Still, there are national, state, and local plans to find and keep employees. Some of these strategies include "grow-your-own" programs, incentives for teachers who are willing to teach in schools or subject areas with the most need, better recruitment and hiring practices, more support for teachers at the school level, and the use of interactive technologies to meet informational and professional development needs. At the national level, there is discussion about a "national manpower policy" for education, alternative certification programs, different incentives for teaching in schools that are hard to staff, mentoring programs, and ways to improve school culture and working conditions (Garcia, A. 2022).

There will always be compelling reasons for educators, especially young educators, to leave the district where they work. Some reasons include young educators getting married or because they don't have a strong support system. The prevalently highlighted solution is to find and train local talent since they already have roots and are less likely to move away if given good benefits. A review of research and practice shows that there are good ways to find and keep good teachers in rural classrooms; some strategies include 1) collecting state and local data on teacher supply and demand, 2) base recruitment efforts on data analysis, 3) expand or refine recruitment efforts to increase the pool of candidates, 4) include all vital partners in collaborative efforts, 5) offer targeted incentives, 6) regularly evaluate efforts, 7) invest in "grow-your-own" initiatives to develop teachers, 8) encourage universities to customize teacher education programs, and 9) include building levy funding. (C. McClure & C. Reeves, 2004). These strategies help substantiate some success; however, there is still "a dearth of knowledge about rural teacher preparation" (Moffa & McHenry Sorber, 2018, p. 27), and less is known specifically about rural STEM teacher preparation.

Methodology

Our current project focuses on two early-career math teachers' experiences in rural schools and the factors that impacted their decision to work in these spaces. Seven scholars' data was collected and analyzed; however, these two teachers were selected to be shared in this study. The two cases shared here were the most "telling" examples, meaning the researchers selected these two teachers because they represent "telling" examples in the sense that "the particular circumstances surrounding [each] case serve to make previously obscure theoretical relationships suddenly apparent" (Mitchell, 1984, p. 239). Both teachers are alumni of our STEM Up NY program, a Noyce program at Clarkson University funded by the National Science Foundation (NSF) to help strengthen STEM teaching and learning in high-need schools. This project is also part of a larger collaborative research project, a Noyce research program, focusing on STEM teacher retention, recruitment, and persistence in rural schools.

A single-embedded case study design was employed for this study (Yin, 2014). Both teachers were interviewed, and interviews were then analyzed using classical grounded theory techniques (Corbin & Strauss, 2008). The interviews were openly coded to identify the initial codes using the software Dedoose (sample interview questions are shared in Table 1). The teachers also wrote weekly journal reflections on their teaching that consisted of open-ended prompts such as, "What went well this week?", "What can be improved upon" and "What students stand out to you this week and why?". The data sources included interviews, post-interview notes, and weekly journal reflections, all of which were analyzed to allow cross-validity checks (Patton, 2002) and to enable triangulation of findings (Howe & Stubbs, 2003). The journal reflections added to the richness of the data and enabled the researchers to better understand the early career teachers. A grounded theory approach was used to make a coding schema to capture the major categories appearing in the data. The codes were focused on characterizing the words that the participants used as they expressed their thoughts.

Table 1: *Semistructured Interview Questions: Sample Questions*

1. How would you describe your school, and what do you believe makes it a rural school?
2. What do you think is important to know about teaching, specifically in a rural school?
3. How can the local rural community support students to become interested in STEM?

4. How can STEM teachers support students to become interested in STEM?

Each researcher inductively developed codes, which were kept in a "living codebook" (Reyes et al., 2021). The codebook is a table that was simultaneously updated as new data was analyzed. The analysis was an iterative process, where the researchers met three times to discuss their codes, each noting similarities and resolving interpretive discrepancies. Codes that had to be negotiated were shared with faculty members of the Noyce team; this strategy is consistent with other teams conducting qualitative research (Cornish et al., 2014; Richards & Hemphill, 2018). In the next step, researchers determined which codes could be grouped into broader categories to move toward theme generation (Strauss & Corbin, 1998). Researchers carefully examined the codes to ensure their placement was appropriately identified (Sample codes are in Table 2).

Table 2: *Codebook Sample Showing Relevant Themes Including One Example Code for each Theme*

	Theme	**Example Code**	**Code Definition**
Research Question	**Theme 1** *Community Connection*	Family of student	Instances of any connection to a family member of a student (coached sibling, colleague, etc.).
	Theme 2 *Habits of Mind*	Lifelong learner	Instances refer to continuous learning or professional development.
	Theme 3 *Potential Opportunities*	Elective course	Any reference to a course based on local people or place.

Three salient themes were found through reading and re-reading the preliminary analysis of the data. The themes discovered include 1) Community Connection, 2) Habits of Mind, and 3) Potential opportunities. To strengthen or triangulate the analysis, member checks were completed by sharing the data with participants to confirm the participants' experiences were accurately captured. The follow-up communications helped to triangulate the data and confirm findings (Patton, 2002).

Findings

There are many challenges in rural education; however, we look at how two teachers have made positive contributions and success in their role as STEM teachers in rural schools. We also learn what factors matter to them when deciding where to teach and what they want from their teaching career. We ask, how do STEM teachers create positive experiences working in rural schools, and what factors impact their decision to continue working in these spaces? This section describes three themes developed by analyzing the data from two math teachers: community connection, Habits of Mind (HoM), and potential opportunities.

Community Connection

The connection to the community was a significant part of the data collected. This theme supports the idea that individuals need to become a part of the community for rural communities to thrive. It also highlighted the connection made when teachers grew up in a similar setting as their students. Kyle is from a rural area in the northeast; while he did not specifically seek a rural school to work in, he felt more drawn to rural areas because it was what he was used to. Kyle states

> I mean it's you could find a close community anywhere really but it definitely feels different, like for a small town type of thing. You know everyone knows you, you know everyone and generally people do care. The people in the community are definitely involved in your life. I just feel more comfortable, you know, in the middle of nowhere. I know that sounds weird to most people…
>
> I believe this roots back to where I grew up. I grew up in a small town community that has its fair share of poverty. Looking back on my town, I will always remember how community members would come together to escape their problems for a big high school sports game. During those games, it didn't matter what wage you earned, where you lived, or what car you drove, all that mattered was the moment.
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> Back at [undergraduate institution], I met a lot of kids that grew up on farms, that were farmers. But they were interested in engineering, because it combines some of the stuff they've already learned by being a farmer and, especially, you know they get excel and engineering, a lot of them. People that went to [undergraduate institutions] came from those backgrounds, not all of them, but a lot of them did. Someone in their family kinda showed them how farming is connected to engineering. So it made sense.

Kyle talks about his identity as growing up in a rural area and attending college with other rural students. Kyle identifies himself as a 'rural person,' so it should not be surprising that he prefers life in a rural area, even with its challenges. One example quote from Kyle was coded as both community connection and potential opportunities. Kyle discussed being white in a predominantly Black school and becoming the JV basketball coach:

> So the school I was at, you know I would consider the deep south and also very rural, I mean, there's no one out there and…there was…I wouldn't say racial tension, but, you know the white kids stayed with the white kids and the black kids stayed with the black kids. Everyone gets along [fine] and most people [are] from here. The gym teacher [who is black] was born and raised there. So that helped him, you know. And he affirmed me. So that helped me as well…and I grew with them [the kids]. And we gained respect for each other, and just you know for the love of basketball. I mean that [connection with basketball] helps. I see, I think, like it helped my relationships in school…that definitely helped.
>
> Even if I was only coaching for an hour or two, I knew I was helping these kids in basketball and momentarily escaping reality. There is no greater feeling than seeing the joy on a player's face that is happy to be back at practice. I've had many of my players tell me that

> basketball practice was the only thing they had to look forward to. Unfortunately, it is also true that far too many students believe sports talent alone is their only way out of their current living situation…I've learned that teachers in high needs school districts are so much more than teachers. As this was the case with my high school, teachers in high needs schools might be the only authority figures and role models that the students have. For this reason alone, we need quality teachers in these schools.

Expanding on his role and identity in the school, Kyle describes how many of his students viewed him. He states

> I was like the first math teacher that stuck around, at least these kids say that…that alone I kid you not, that alone kinda was like Oh, my goodness, they told me before that they never have had a stable math teacher in like five years…you know they love me, of course, I did a good job, but I am motivated also because they haven't had and they told me, you know we don't a lot of math teachers, they don't stay here, they don't stay for whatever reason… I was like I love it here. But it's just, it was just different very, very different…I'm gonna be real honest. So.The school. You know I would consider the deep South and also very rural, I mean…there's no one out there and…there was, I wouldn't say racial tension, but…you know the white kids stayed with the white kids, the black kids with the black kids…okay…but you know if you group them together everyone gets along fine, like they just naturally go that way it's very it was very, very weird. I think, like like my relationships in school and even in basketball, they both definitely helped…

The second teacher, Rich, is teaching in a town similar to where he grew up. He describes his perception of the community and what teaching in a rural school district feels like, his connection with the community in several different aspects, and describes the school he is teaching in now.

> I grew up not far from rural areas. I think more of my friends were from rural areas and [undergraduate institution] was in a very rural area. I was a TA there too and lots of the kids I worked with were probably from rural areas. Or it just seemed like it. The school I'm currently teaching in is…probably…rural and suburban? And I live in the more rural part of town. There are lots of family members who work in the district too, like, I have a kid in class who's mom works at the elementary school and they have siblings in the district. It's pretty common to see like a whole or part of a family in the district. So I guess because of that…they're like really into what's going on at school, like it's not just a kid in my class, but it's like they have this network at school. I think you have to really see that, like acknowledge that, it's just like a part of what the school and families are like here. If you're not a local, like I didn't grow up here, you have to still like respect how it is here. I think if you want to stay teaching here you have to get that…you can't be like oh I'm here now just do things my way…there's definitely a buy-in with the people…

Rich acknowledges that the culture of the school and people are integral to becoming "accepted" and included in the district. There are local values and a way of life in the school district and the people who attend there, so teachers need to find a way to connect to that culture.

Habits of Mind (HoM)

As the data was analyzed, similar codes appeared in both Kyle and Rich related to who they are as individuals or having to do with their disposition. Dispositions in teaching can be thought of as what decisions are being made in a classroom and how that is based on an individual teacher. Using this idea, we use Costa & Kallick's (2008) definition of Habits of Mind (HoM). HoM can be thought of as "dispositions" that help individuals to work through life situations to gain a positive outcome. HoM are essentially the tools used in attentive decision-making. The second theme we identified from the data is HoM. Costa & Kallick provide a list of 16 life-related skills or HoM; here, we focus on four HoM that presented themselves in the data: Persistence, listening with understanding and empathy, applying knowledge to new situations, and remaining open to continuous learning.

Persistence

Productive teachers don't give up easily; they strategize how to solve problems and stick with their goals to help students. These teachers ask their colleagues for alternative strategies to help their students; if something does not work, they're willing to try another method. Kyle described his mindset when he started working in the school and what his mentor shared with him.

> …basically this guy [mentor] said, you know it's gonna be a lot of negative teachers, once you get a feel for the school find the true teachers that like really, really care about the kids…and once you find those teachers. Those are the one you should go to. For advice and support…I had I was just lucky enough to have a room next to like the teacher of the year for that county… So I was like that's the guy I want to be like you know, like…he's got it he knows what's going on, like he was just such a fantastic teacher everything he did…even when things were tough he just pushed through and didn't quit…you know like give up on the kids or anything. I think…yeah…he showed me how to stick through it even when teaching gets hard. And it does get tough…a lot sometimes…

Listening with Understanding and Empathy

Teachers who listen to students with understanding learn not only about what students are saying explicitly, what may be hidden underneath the surface. Listening to others speak is generally not taught and rare in teacher education. However, it is essential to connect with students. Rich describes what he realized after listening intently to students:

> Once you get to know the students and really, kind of understand them, some of them, I mean a bunch in my classes, were really not thinking about going to college or just didn't think it was for them. So I realized talking about grades in class and the importance of college wasn't going to work, I needed a different carrot.

Applying Knowledge to New Situations

People learn from experience and reflect on experiences. When teachers face a challenge in the classroom, they may draw on previous experiences. Teachers recall prior knowledge and experience to help them with the problem at hand; Rich states,

> I was having issues with getting the class settled when they first came into the room, then I thought back to my mentor teacher during residency…she had a system in place, so the kids knew what to do soon as they walked in. They had an entrance ticket every day, even if it was something silly or just not even related to math directly, but there was something for them to get done when they walked in. I created some math questions as entrance tickets, nothing too challenging, but something I know they can do when they walk in…it took some time to become a regular thing, but it's help…it's like they know what they should be doing now.

Recollection can be a powerful tool for teachers; to take what they learned and carry it forth to help solve a new challenge gives them more experience to draw from.

Remaining Open to Continuous Learning

Good teachers are in a perpetual state of learning; they are always looking to grow, improve, and adapt. Teachers with this HoM realize that no student is the same and no classroom is the same, and so they find each classroom, each challenge, and each student as an opportunity to learn.

> I learned a lot when I did my residency, but nothing really prepares you for like that first year of teaching. I mean, even though I knew a lot…I was like still trying to figure out how things would work here, what adjustments I had to make…and, I don't know…I just have this sense that even though I know some stuff, I don't know everything…especially in a new building, a new school…I think it's helpful to be somewhat humble and take in what you can from your new colleagues. They have a lot they can teach me…even if I don't always agree, I am willing to walk away with something, something new I learned, from them…

Good teachers are not static; they are always learning and growing. These four HoM shared here help highlight what characteristics are important to success as a teacher, particularly in a rural setting. Dispositions make up just a part of the teacher, but HoM help to show how dispositions are connected to making a decision in the classroom. While other HoMs may have been present in the data, these four HoMs were most prevalent in the data.

Potential Opportunities

A third theme that was salient in the data was the different opportunities available to teachers in these rural schools. Typical, rural schools are talked about for lacking opportunities or not having enough resources. The teachers were given opportunities to enhance their teaching positions in these two cases. Kyle, for example, stated

> My principal saw my resume and was like, hey, you know we're trying to get going with project lead the way…we're trying to get the ground rolling with this because they're so far behind they didn't like have a program established. [My principal] was like you're gonna do math and you're definitely doing that engineering class that you're certified to teach…I mean that's what I went to school originally, you know the funny part is… I kind of joke about like…I got out of engineering for a reason. But I do know a lot about it and all my friends that I graduated with…you know they're all engineers and I actually had a few of them come [into class] over zoom.

Kyle also spoke about coaching basketball at the school, an opportunity that arose when he first started working there, he said

> I never expected to coach basketball…I just assumed that I wouldn't have the skills to coach, I mean I play but that's not the same thing. They needed a coach if they were going to have a team so when there's less people to pick from it was easier for me to get to coach I guess…but it ended up being this awesome thing. Like lots of my students were on the team and that helped with the school part too.

Rich also shared an opportunity that he was not expecting to have as a newer teacher

> Because the small size of my class, I was able to try out some different things in my class that I wouldn't have been able to in a school like I did my residency in…that was just too big, too many students and probably would have been kind of a disaster. One nice thing about my classes now are they're small, like less than fifteen kids, so I have more time to try different things in class. I had a lot of experience doing math modeling as an undergrad so I could do it in this class too because it was just easier with a smaller group.

These are just a few examples of opportunities in these secondary rural schools for STEM teachers. These three themes were established, helping to understand what considerations exist when a STEM teacher thinks about working in a rural school. Kyle and Rich described how their opportunities and choices helped them succeed as STEM teachers in rural settings.

Discussion

Recruiting strategies help bring STEM teachers to rural areas; however, school districts still have the challenge of retaining these teachers. According to Ingersoll et al., 2018, more than a third of teachers leave the field within the first three to five years of teaching. Instead of considering what rural spaces lack, it can be more beneficial to highlight the supports and opportunities that rural spaces offer STEM teachers. By emphasizing a positive narrative about teaching in rural spaces, new STEM teachers can envision what their teaching career may look like in the future. There is a better chance of these new teachers seeing themselves in these locations.

In this project, Kyle talked about being connected to the community in different ways that helped ground him in the community and school. Kyle grew up in a similar community and sought out a similar environment; school community members can seek out new teachers and genuinely connect them with the community. This can be easily overlooked, so it's important to remind other leaders in the district to help new teachers feel like a part of the community (Roberts et al.,

2021). Teachers who feel like a part of the community have the potential to connect with students' families and thereby greatly impact their influence on students. Additionally, students who grew up in similar communities may serve as role models to these students. In this project, Kyle and Rich grew up in similar communities as their students and graduated with a STEM degree not long ago. Students can look up to these two STEM teachers as mentors who can help them navigate their path in secondary school and beyond. Having these mentors who bring social capital with them can be a wealth of knowledge for some students. For example, Kyle talks about how farming is connected to engineering; he can also speak to his own experience as an engineering major and the kinds of questions he was asking himself along the way. Simultaneously it is productive for administrators to think about sharing the different local opportunities to help teachers be involved in the community. Rural areas may have fewer opportunities for events and activities; administrators may need to think beyond the typical strategies for recruitment (Brenner, Azano, & Downey, 2021).

The four HoM shared here may impact all teachers all over; however, these habits are particularly impactful in a rural setting due to the context of rural schools. For example, we want all of our teachers to be able to listen with understanding and empathy. In a rural setting, this is especially important because students who live in the rural community, day-to-day, can provide insight, perspectives, and values. In this case, because Rich listened to his students, he understood how students felt about college; he realized it could not be the 'carrot' to incentivize students but also learned he could have conversations about this topic to understand why they felt this way and potentially share different perspectives about going to college. Listening to students here brings Rich closer to the community and helps to understand what they value. In rural areas, many students feel pressured to stay in the area to help their families. This may influence the effort students put into school and their long-term career plans. Using this knowledge, Rich can help students see how STEM is connected to their local community, potentially incentivizing their pursuit to further their education and return home. Or maybe to find out how they can further their education, pursue STEM, and stay near home. Instead of trying to pull rural students out of where they live, it may be more fruitful to find out how rural students can still live near their families and have fulfilling STEM careers. Another HoM found in this project, open to continuous learning, can help teachers become more effective, specifically in rural areas. For example, place-based curricula have been routinely used in rural communities. For teachers, using place-based pedagogy can leverage students' knowledge about their locale, aiming to make learning more relevant. By doing so, students are free to bring their own funds of knowledge or their own body of knowledge based on their experiences to the classroom. Teachers can then help facilitate connections between students' funds of knowledge and curricula, and teachers can also learn from their students (González, Moll, & Amanti, 2005; Vélez-Ibáñez, & Greenberg, 1992).

Rural schools are often discussed with deficit language, such as a lack of opportunities. However, with some intentional and creative thinking, there are spaces for opportunities for students in this setting. For example, in this project, Kyle had a background in engineering even though he was a math teacher. The principal at that school realized this was an opportunity to leverage the skills Kyle brought with him and develop the Project Lead the Way program (a nonprofit organization that empowers students in STEM) the school has been trying to initiate and also considered creating an engineering class so students in the community could learn about how engineering is connected to their lives, potentially learning about engineering jobs and living in rural communities. This project can help inform teacher educators as they work to prepare future rural teachers and support in-service teachers. Geographically rural areas have one of the

most promising yet underutilized opportunities for STEM education. This data can help better support STEM teaching and learning in rural schools.

Conclusion

One of our roles as teacher educators is to fight for marginalized students to receive an equitable education. As a STEM education community, we must leverage our positions to create authentic change and examine our assumptions about what we believe is best for our students in rural communities. Holding onto deficit language and negative stereotypes can be harmful to students (Steele, 2010; Steele & Aronson, 1995) and may ultimately prevent high-quality STEM teachers from working in rural schools; this would be a disservice to rural communities. Doing self-reflective and critical work can help other educators see the richness of rural communities.

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