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Balancing Strengths and Challenges in Rural STEM Preservice Teacher Education: A Conceptual Framework

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ABSTRACT

This article explores best practices foundational to JacksTeach, a STEM teacher preparation program at Stephen F. Austin State University serves the rural East Texas region. In response to high rates of uncertified STEM teachers, JacksTeach is supported by six Noyce grants through the T4 project. Its framework combines constructivist theory with early field experience, mentoring, and community building. The program addresses rural challenges such as teacher turnover and limited resources while leveraging strengths such as strong community ties. Key features include a job shadow program, peer and faculty mentoring, and cross-campus collaboration. The outcomes are strong: all 26 graduates earned certification, 82% entered and remained in teaching, and graduation rates exceeded those of peers by 10%. The study recommends strategies for rural teacher preparation.

Keywords: project-based learning, teacher preparation, virtual exchange, STEM

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INTRODUCTION

Across the educational landscape, numerous voices are sounding alarms concerning the dramatic rise of uncertified teachers entering the classroom, the challenges of retaining teachers, and the detrimental effects that school staffing issues have on student learning (Marder, 2024; Kirksey, 2024). Recent research has revealed that “the majority of first-time teachers in Texas are now entering the profession either through alternative certification routes that often include little to no student teaching or without any certification at all, resulting in a workforce that has experienced increasingly little preservice clinical practice before taking on responsibilities for teaching children” (Bland, et al., p. 2, 2023). The unavailability of trained teachers is prevalent in Texas, “especially in rural and small-town schools, where almost 75% of new teachers hired in 2023-2024 were unlicensed” (Van Overschelde & Lopez, 2024). While significant in all areas, the impact of a quality, stable teaching force is obvious in science and mathematics (Ekmekci & Serrano, 2022). Stephen F. Austin State University (SFASU), where these programs are held, is situated in rural East Texas and was initially established as a teacher college, boasting a long history of certifying teachers who teach in rural areas.

Beginning in the early 2000s, a dedicated group of STEM and Education faculty came together to pursue federal funding to support high-quality curricula and financial support for STEM preservice teachers. The work of these faculty has resulted in six Robert Noyce Scholarship grants. It has provided millions of dollars in scholarship money as tuition assistance for STEM preservice teachers through a project titled Talented Teachers in Training for Texas (T4). This program also created a community of stakeholders that began laying the foundation for shifting STEM preservice teachers from a general education preparation program to a STEM-specific teacher education program.

In 2019, SFASU initiated curriculum and program changes based on the success of the Robert Noyce grant, creating a program called JacksTeach—a specialized STEM teacher preparation program designed to emulate the structure and curriculum of UTeach. The UTeach program, developed by the University of Texas in the early 2000s, is a specialized STEM teacher education curriculum designed for STEM majors, preparing and certifying them to become STEM teachers. The decision to pursue specialized STEM teacher education at SFASU was based on the experiences of faculty through the Robert Noyce grant working with public school STEM teachers and responding to their feedback about their teacher education programs, the importance of research-based best practices for STEM teachers, the STEM teacher shortage in the rural and

remote areas surrounding SFASU, the recognition of the direct economic impact of increasing numbers of STEM teachers in the Deep East Texas area, and the potential for pursuing state and federal funding to support high-quality STEM teacher education. Throughout this process, the faculty and administrators involved in the Robert Noyce program collected data, published, presented, and shared their experiences about the success in recruiting, improving persistence, and increasing retention of STEM teachers within the program. Identifying the critical components of the Noyce program at SFASU, supported by data on recruitment, persistence, and retention, was key to the development of the JacksTeach program. This effort is captured in the evaluative research question guiding the development and implementation of the theoretical framework presented in this article: “What program characteristics within the SFASU Noyce program (T4) are most effective on the basis of research and current data that can be incorporated as program characteristics into the Jacksteach program?”

THEORETICAL FRAMEWORK

Within the UTeach model, there are key research-based characteristics that provide theoretical frameworks for coursework and field experiences, guided first and foremost by the theory of constructivism, where students are given experiences to construct their own knowledge (Dewey, 1997; Dewey, 2007; Piaget, 1950). The UTeach model and constructivism theory work as an umbrella concept over the three theoretical frameworks that guide the design of the JacksTeach program at SFASU, which adds additional conceptual models to support the success of STEM preservice teachers specifically on the basis of the context, location and strengths specific to SFASU: early field experiences, a mentoring network, and attention to building communities in rural areas.

Constructivism

UTeach coursework is based on the concept of constructivism (Dewey, 1997). Constructivism creates a learning environment where students are allowed to experiment and experience, and as they do, they are able to construct meaning from those experiences to form new knowledge (Dewey, 1997). Dewey goes on to state about effective and constructivist pedagogy: “Experiences as the perception of connection between something tried and something undergone in consequences is a process” (p. 123, Dewey, 2007). Piaget (1950) also advocated for constructivism as a critical piece of the development of human intelligence: “The complete act of intelligence thus involves three essential stages: the questions which directs the quest, the hypothesis which anticipates solutions, and the process of testing which selects from them” (p. 95). Within the UTeach

coursework, students do not passively learn from a lecture-based class; instead, the classwork is project-based, allowing students to experience science and math curricula firsthand and form hypotheses and conclusions about what works within the classroom. At the same time, they are given access to STEM curriculum research to provide context and theory for the hands of coursework. Another layer of this constructivist-based coursework is that, concurrently with coursework, students also teach and co-teach real science and math lessons in a variety of public school classrooms, providing real-life applications to the coursework they experience within their teacher education classes. This network of experiences, practical applications, research and experimentation allows students time and space to truly understand how best practice research-based STEM curricula should be taught and learned in the STEM classroom. This approach is critical within rural and remote areas such as Deep East Texas, where SFASU is located. Some of the assets of rural schools include smaller class sizes, close connections to local community resources, and the science and math of place-based curriculum connections. Rural schools can also be challenged by certain aspects of their location and environment, including a shortage of STEM classroom resources, limited access to high-quality STEM curriculum and instruction, a lack of expertise and experience among STEM teachers, and inadequate accessibility to high-quality STEM experiences within the classroom. The combination of these assets and challenges is best addressed within the framework of constructivism, where experiences are prioritized as a curriculum, where students are given time and space to reflect, build and rebuild hypotheses about experiences, and where students are allowed to experiment within their experiences to construct knowledge. Rural teachers must continually construct and reconstruct classroom pedagogies based on the needs of their students, the assets and challenges of their rural communities, and available resources. This type of constructivism is called “teacher inquiry” and is a key strength that rural educators must employ daily. According to Azano, Brenner, Downy, Eppley, and Schulte (p. 252, 2020), “When you engage in teaching as inquiry, you generate practice-based evidence. You are generating knowledge about what works, with which students, under which context, is it based on actual classroom practice and outcomes for students. You will be learning about practices that work for your students in your rural context.” The JacksTeach program at SFASU, by utilizing the UTeach curriculum, has created real-time experience for future rural STEM teachers to be able to practice teacher inquiry as a key component of the program.

Characteristics of the successful rural STEM teacher certification program

Field Experience. Research findings have indicated that early field experiences are best practices for all EPPs (Darling-Hammond, 2006; 2010). The UTeach model emphasizes early field experience in the first two courses required for students before they enter the EPP. The JacksTeach program at SFASU not only utilizes the UTeach early field experiences in the Step 1 and Step 2 courses with financial incentives provided by T4 and other sources but also has an option for a weeklong early intensive field experience through T4. This early intensive field experience, called the job shadow, allows participants to shadow a STEM teacher in a local school district for an entire week. The participants are provided with a stipend and housing to support their participation, and they are required to attend an orientation and debriefing, as well as complete daily reflective prompts. This program has shown great success in allowing potential recruits to construct their own knowledge about STEM teaching in public schools, allowing them to make more informed decisions about their desire to teach (Hubbard et al., 2019; Cross et al., 2021). The combination of the Job Shadow and Step 1 and 2 coursework has allowed SFASU to implement a structural design that best fits the needs of the rural and remote areas in which the program is located as well as the low socioeconomic status of the students. Providing coursework with early field experience (Marder, 2020) and paid opportunities to shadow STEM teachers (Hubbard et al., 2019; Cross et al., 2021) allows students with low socioeconomic status access to different ways to experience STEM teaching before they choose to enter the EPP. This increased access allows potential STEM teachers to be more confident in their decision to choose STEM teaching as a career and increases their chances of persisting in certification and graduation (Cross et al., 2021).

Mentoring. Mentoring within educator preparation programs has been indicated by research findings to be best practice; however, there is a great variety and design of mentoring programs (Orland-Barak & Wang, 2023). For STEM preparation programs in rural areas, the mentoring network lays the foundation for preservice STEM teachers to understand how to engage in and establish a professional network (Azano et al., 2020). The JacksTeach program at SFASU has established a mentoring network based on a Noyce mentoring program developed in 2011. The Noyce mentoring network allows program faculty to identify individuals with specific strengths within the organizational components of the program, such as field supervisors who are also experienced STEM teachers, faculty with experience in Texas teacher certification, faculty with expertise in science and math content, peers within the program, and mentor teachers

in the STEM teaching field (Cross et al., 2020). This network of mentors allows each participant in the JacksTeach program access to a diverse group of people with different skill sets who can support them in the way that they need. In fact, in a qualitative case study of Noyce participants at SFASU, Cross et al. (2020) reported that in-service teachers who experienced the Noyce program, when observed in the classroom and compared with a similar group of STEM teachers who did not participate in the Noyce program, Noyce scholars used a greater variety of research-based instructional methods and used them for an increased amount of time during their classroom instruction. In rural and remote locations, where school support systems can be limited, the JacksTeach program has an awareness of the skills of faculty and staff within the program and has developed a responsive and comprehensive mentoring network to support the STEM preservice teachers in the program, thus creating stronger and more confident STEM teachers for schools in rural areas.

Community Building. Finally, a key piece of the success of the JacksTeach program is the development of a community built on the context and assets of its rural location. Understanding the nuances of the rural area is vital to the academic success of the program's students. While the community is prioritized in the UTeach model by the UTeach network, a smaller and more focused JacksTeach network is supported by all of the faculty and staff within the program. This rural community building is based on the idea that “a connection to rural places and a responsibility to help their students develop a positive sense of place that will contribute to their sense of themselves as learners and as members of a community” (Azano et al., p. 267, 2020). Successful facilitation of a rural STEM teacher education program requires the faculty and staff with the program to be knowledgeable about the challenges and strengths of STEM teacher training in a rural area. The faculty and staff must be committed and understand that creating a positive and supportive community within rural areas is crucial to the academic success and persistence of STEM preservice teachers in certification. The size of the JacksTeach program is small enough that each JacksTeach student is advised by the program director, and each faculty member and staff member in the JacksTeach program know each student by name. The faculty in the Noyce program are also involved in the mentoring network and early field-based experiences, so the students in JacksTeach know well who they can reach out to for help and support. There are specific events that support the building of the community, which include celebration events for the JacksTeach students, a student STEM teacher organization holding biweekly meetings with experienced STEM teachers, community spaces such as workrooms, study areas, and shared classrooms, and high-quality communication from the program director. Additionally, T4 funding

provides financial support for beginning- and end-of-semester student community events, such as a cookout at the local lake, and facilitates student travel to regional and national STEM teacher conferences. The success of the JacksTeach students is built on the commitment of the JacksTeach personnel to build a community with the unique needs and experiences of the students. Research findings by Cross (2020) have indicated that Noyce participants directly reference the Noyce community, other participants, mentors, and the community as a whole as contributing factors for their classroom instructional choices, classroom management decisions, and success in the classroom (Cross, Hubbard, Beverly, Gravatt, Aul, 2020; Cross, Wagnon, & Hubbard, 2023; Hubbard, Cross, Gravatt, Beverly, Wagnon, 2021; Wagnon, Hubbard, Cross, 2020). A chart summarizing the conceptual framework and its alignment with rural STEM EPP characteristics is presented in *Table 1*.

Table 1-Characteristics of rural STEM *teacher certification programs*

Conceptual Characteristics	Specific Program Characteristics	Rural STEM EPP supports and resources
Early Experience	Field Job Shadow Recruitment	Experience, Step 1 and 2 courses
Mentoring Network	Network of faculty/staff within JacksTeach and outside program; SFASU faculty and staff have close relationships with administrators and teachers in local schools	
Emphasis on Community Events	to build community provided by JacksTeach and T4;	
Building	faculty and staff attend local school events to deepen connections with school personnel	

Context of the Program

In 2022, the USDOE began the “Raise the Bar: You Belong in STEM” initiative to encourage public schools and educator preparation programs (EPPs) across the United States to direct their energy into creating high-quality STEM programs in public schools, facilitating high-quality preparation for future STEM teachers, and investing in STEM education by utilizing federal, state and local funding (USDOE, 2022). This initiative addressed a nationwide decline in STEM majors at institutions of higher education (IHEs) and the critical STEM teacher shortage exacerbated by the COVID-19 pandemic (Fuentes & Bloom, 2023). According to Fuller (2023), the United States has experienced a consistent decline in individuals who enroll in educator preparation programs of approximately 25% since 2008; this is also indicated in Title II report data, which note that STEM teacher certification has sharply

declined since 2011 (USDOE, 2022). This decrease was caused in part by stagnant teacher salaries in most states and an increase in anti-public education media coverage (Fuentes & Bloom, 2023; Fuller, 2023).

In rural areas, while student enrollments have been increasing (Ingersoll & Tran, 2023), schools report that filling teacher vacancies in math and science is the most difficult task.

Furthermore, rural schools that are considered “high poverty” have the highest attrition rates within the nation (Ingersoll & Tran, 2023). In Texas, almost all public school districts can be classified as Title 1, a federal designation for a high number of low-income and at-risk students, and 658 of the 1200 public school districts can be classified as rural or small-town districts (Harris, 2024). Additionally, within the state of Texas, teacher shortages have led to a historically high increase in the hiring of noncertified teachers, who are not required to enroll in any certification program. According to the Texas Education Agency (TEA), the percentage of newly hired teachers who are noncertified rose to 34% in 2024 ($n > 17,000$), and traditional certification has continued to decline (TEA, 2024). This trend contributes to increased retention challenges, as more than 30% of noncertified teachers leave the profession after only one year of employment, and the 5-year retention rate for this group is less than 40% (TEA, 2024).

According to Van Overschelde and Lopez (2024), 75% of newly hired teachers in rural and small-town Texas were not certified from 2023-2024, which is an increase of 17% over a ten-year period. Van Overschelde and Lopez noted that the attrition rate for these uncertified teachers is 45%, costing rural and small-town districts \$9--\$12K per individual to retrain a new teacher to take their position. According to Kirskey (2024), students who are put into the classroom with an untrained, uncertified teacher will be 4 months behind their peers in reading and 3 months in mathematics.

Nuances, Assets, and Challenges of Local and Institutional Characteristics

Institutionally, SFASU enrolls a high number of first-generation students, who sometimes experience perceptions of social class differences from their peers (Phillips et al., 2020) and are more likely to be considered low income (Ives & Castillo-Montoya, 2020). First-generation students have strong innate pride in their identity, a strong sense of altruism, a deep sense of persistence, and appreciation for education, making them well suited to becoming educators themselves after successfully completing college (Havlik et al., 2020; Song et al., 2020). However, these first-generation students often need mentoring and structured community building to be successful (Ives & Castillo-Montoya, 2020).

Facilitating high-quality STEM field experiences in rural and remote schools can be a challenge. Many rural teachers teach six to seven different science or math courses at high school and middle school levels. This massive amount of preparation, curriculum work, teaching, and grading often decreases the quality of the STEM academic experience. As previously mentioned, there is a critical shortage of STEM teachers in rural areas, so many are not certified and may have no previous coursework in any math or science content area. Local STEM teachers must be carefully vetted before they are matched for mentoring or observation. There is also a high rate of turnover in rural districts, so each semester, JacksTeach faculty and staff spend significant time working to recruit host teachers, who utilize active learning strategies such as 5E lesson plans and other research-based best practices, and support STEM preservice teachers in implementing them.

Since SFASU is in a rural and remote area, for dozens of area schools, it is the only accessible pool for STEM and education faculty, professionals and other staff. The amount of work in the field of STEM education in the Deep East Texas area often overwhelms the pool of qualified STEM professionals. Faculty and master teachers within the JacksTeach program often serve in other departments as well. This creates an environment where many of the STEM faculty and Education faculty are overworked and simply cannot take on new projects that would be of direct benefit to the STEM EPPs or local schools.

While there are challenges facing JacksTeach in the rural setting, the program has many assets, including a history of support from administrations at the Perkins College of Education and the College of Sciences and Mathematics, including instructors from both colleges. JacksTeach relies on the Perkins College of Education infrastructure and close relationships with support staff and education faculty for support in grant and research writing, state certification requirements, federal data collection, and clinical teaching placements.

The small size of the program (40–60 students) allows for individual student connections. The entire JacksTeach team knows all the students in the program and strives to create a sense of belonging for them. This is evident from the high number of students who use the physical JacksTeach space for studying and socializing. In addition, many scholarship opportunities have been presented to JacksTeach students through implementation grants as well as the T4 grant, which provides 2 years of 100% tuition assistance for STEM preservice teachers.

The close-knit community surrounding JacksTeach creates a sense of camaraderie between the STEM and education faculty and the local STEM teachers and administrators. While developing a network of host teachers has been challenging, we have been able to utilize a wide variety of local schools to emphasize the ideas presented in class.

The characteristics of the JacksTeach program and its symbiotic relationship with the Noyce grant at SFASU have created an environment where these conceptual and research-based ideas create a rural STEM EPP that addresses the complexities and assets of preparing STEM teachers in Deep East Texas.

Program Outcomes

All 26 JacksTeach graduates have earned a teaching certification. As of January 2024, 18 of the 22 JacksTeach graduates (82%) had entered the K-12 profession, and all 18 were still teaching, all in Texas, and 13 (72%) were teaching in Title I schools. The remaining 4 graduates pursued graduate degrees.

The preservice teachers who are enrolled in the JacksTeach program have consistently shown a higher graduation rate than their peers who are STEM majors across the College of Sciences and Mathematics. In the 2021 and 2022 academic years, the preservice teachers' graduation rate for students in JacksTeach was 10 percent higher than the graduation rate for other STEM majors at SFASU. This information is summarized in *Figure 1*.

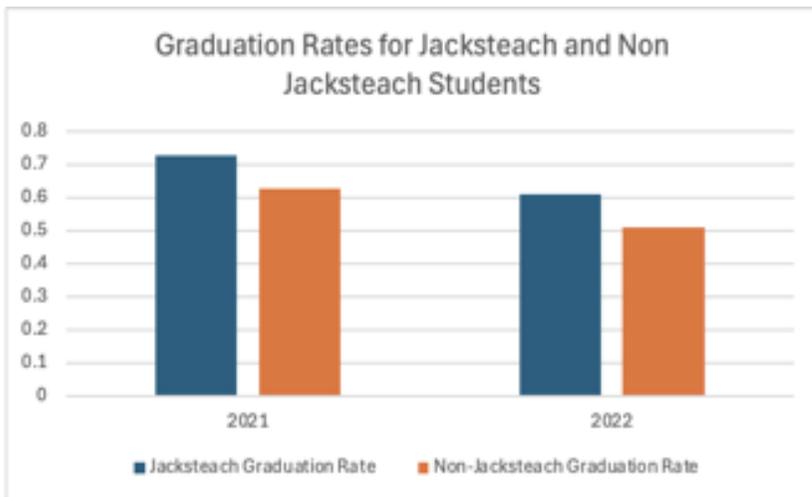


Figure 1- Graduation rates for JacksTeach and non-JacksTeach students

For the JacksTeach preservice teachers who were also participants at T4, 100% of the 44 teachers who had received scholarship money had successfully graduated and completed teacher certification.

IMPLICATIONS

The rise of unlicensed, and often underqualified, teachers across the nation, particularly in rural communities, is alarming. Unlicensed

teachers in classrooms create unique challenges, including increased teacher turnover and negative impacts on student learning. “Studies show that these fully prepared graduates are considerably more likely to stay in teaching than those who enter without full preparation” (Bland, et al., p. vii). The high attrition rate is costly—as much as \$21,000 to hire and train a replacement for each teacher who leaves (Van Overscheldele & Lopez, 2023). On the basis of our experiences within a rural STEM EPP, we urge researchers to continue this type of research but to include specifically the economic impact for rural districts and rural communities, as well as the direct impact on the academic achievement of STEM subjects for students in rural areas.

Academically, unlicensed teachers present a twin challenge. First, there is evidence that underprepared teachers are correlated with lower student learning gains, particularly in mathematics (Kirksey, 2024; Kirksey & Gottlieb, 2024; Ekmekci & Serrano, 2022). Second, because teachers are much more likely to leave the classroom, students do not benefit from the learning gains associated with experienced teachers, particularly their specific grade level and content (Huang & Moon, 2009; Kini & Podolsky, 2016). Furthermore, “more experienced teachers support greater student learning for their colleagues and the school as a whole, as well as for their own students” (Kini & Podolsky, 2016, p1). Therefore, uncertified, likely short-term teachers adversely affect their students, colleagues, and schools. On the basis of the Noyce team at SFASU’s 15 years of data collection and research focused on STEM teacher recruitment, persistence, and retention and our published research, we highly recommend that some of our characteristics that have brought us success within our remote and rural areas be implemented within other rural educator preparation programs. While each community is unique, commitment to early and authentic field experiences (Cross, Hubbard, Gravatt, Beverly, 2021; Cross, Wagnon, Hubbard, 2023), building a strong and continuous mentoring network both for preservice and in-service STEM teachers (Cross, Hubbard, Beverly, Gravatt, and Aul, 2020; Wagnon, Hubbard, Cross, and Aul, 2020), and creating a supportive community to surround preservice and in-service STEM teachers (Hubbard, Cross, Gravatt, Beverly, Wagnon, 2021; Cross, Wagnon, Hubbard, 2023) can be implemented to build a successful rural STEM EPP.

CONCLUSION

JacksTeach and other UTeach replication programs, geared toward serving the needs of rural preservice teachers, are vital in combating the ongoing teacher shortages faced in Texas and rural communities across the country. Program strategies such as creating early intensive field

experiences, intentionally focusing on community building and fostering close relationships within the program, and creating a mentoring network have been successful for the SFASU STEM EPP. These could be effective program strategies for similar programs in similar rural areas. The use of a strong research-based theoretical framework to match the complex needs of the community, institution, state, and national trends has led SFASU to achieve strong program outcomes and a healthy record of producing high-quality STEM teachers in a rural and remote part of Deep East Texas.

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