COLLABORATIVE LEADERSHIP FOR RESEARCH INVESTIGATING STEM TEACHER PREPARATION ACROSS MANY INSTITUTIONS

Dana Franz
Mississippi State University
dfranz@oire.msstate.edu

Keith Hubbard
Stephen F. Austin State University
hubbardke@sfasu.edu

Devon Brenner
Mississippi State University
dgb19@msstate.edu

ABSTRACT
This paper describes the creation of a collaborative research team investigating the impacts of education preparation on the recruitment and retention of science and mathematics teacher candidates in rural settings. Our collaborative research includes a core leadership team across 3 institutions and with collaboration across 14 total universities. We discuss the process from the inception through year two of this program, including the structure of leadership, communication techniques with the large group, and efforts to translate this research into scalable action. Using a framework for transdisciplinary research (Hall et al., 2012), we describe the processes and challenges that we encountered while engaging 14 institutions in a collaborative research project.

KEYWORDS
collaborative research, STEM teacher education, rural education

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Over the past few decades, large-scale collaboration has emerged as a useful and informative model for research projects, particularly within the field of education. At the same time, as research requires input from and collaboration between a widely dispersed group of stakeholders, collaborative technologies have advanced in ways that enable groups across the United States and even globally to engage together in real-time. Examples of national efforts to foster this type of collaboration include National Science Foundation (NSF) Robert Noyce Teacher Scholarship (Noyce) Track 4 Collaborative Research grants (NSF, 2023a), the Association of Middle Level Education Research Initiatives (Mertens et al., 2015), and the recent call by the NSF S-STEM scholarship program to create research hubs that link multiple institutions across multiple sectors to “investigate evolving barriers to the success [of low-income students]” (NSF, 2023b). This paper examines the conception, grant proposal development, and initial enactment of a project supported by an NSF Noyce Track 4 Collaborative Research Grant entitled Teacher Preparation for Rural STEM Teacher Persistence and Retention or (TPR)². This 14-institution collaboration is focused on understanding the recruitment, preparation, and support of rural STEM teacher candidates as they complete educator preparation and become novice teachers in STEM classrooms; an endeavor that lent itself to a widely dispersed research collaboration involving multiple rural-serving educator preparation programs.

(TPR)² brings together multiple institutions, including large R1 universities and smaller teaching-focused schools, public and private institutions, as well as regional and main campus institutions, to jointly investigate a shared research question. Our multifaceted research design attempts to examine the impact of educator preparation programs by (a) understanding the ways that science and mathematics teacher preparation programs are addressing place and rurality, (b) exploring the connections between science and mathematics teacher education practices and beginning teachers’ willingness to seek out and accept rural teaching placements, and (c) studying how networking across institutions may provide insights into the recruitment and retention of science and mathematics teacher candidates in rural settings. A multi-institution collaboration was necessary for this project, not simply because the funding agency called for proposals for collaborative projects, but because of the interconnected nature of the work and the partnering institutions. Many of the institutions that serve rural STEM teachers are small in size or have a teaching-focused mission. These types of schools benefit from collaborating with institutions that have administrative capabilities that are adequate to undertake a research project of this magnitude. Also, smaller institutions have lower enrollment in their educator preparation programs and most likely would not, on their own, have enough data to lead to generalizable findings about educator preparation. It should be noted that even the largest programs in our project have only a handful of students enrolled in the various STEM education degree programs. Collaboration was also necessary because rurality by its nature means the programs being investigated were widely scattered geographically.

The obvious question, given the realities of rural research, is how might a team of researchers, STEM faculty, and teacher educators build the structure to make this collaboration work? This paper describes the creation of a research team that includes a core leadership team representing three institutions and collaborative partners across a total of 14 universities. We discuss the process from inception through year two of the program, including the leadership structure, the communication techniques we used for working with a large group, and our efforts to translate this research into scalable action. Using a framework designed by Hall et al. (2012),
we describe the processes and challenges we encountered while engaging 14 institutions in a collaborative project.

**Background**

Close to one-half of all U.S. school districts are rural or have schools that are classified as rural (Showalter et al., 2019). Research into rural education challenges is not new. Attracting and retaining STEM teachers to rural schools has been a pervasive problem for the past century (Biddle & Azano, 2016). As early as 1944, researchers were noting the marked differences between rural and non-rural schools (Dawson & Hubbard, 1944). Although there has been increasing attention to the crisis of teacher shortages in rural schools in recent years (e.g., Ingersoll & May, 2011; McHenry-Sorber & Campbell, 2019; Tran et al., 2018) staffing STEM classrooms continues to be a challenge for many rural schools across the U.S. Compared to urban and suburban schools, rural schools may offer lower salaries and have fewer resources for teachers. Other challenges to rural teacher recruitment include small communities facing their own economic challenges and higher poverty rates (Aragon, 2016). Perceptions of rural places may also contribute to recruitment challenges, including the persistent stereotype that rural students are somehow less capable and the widespread message that rural teaching is less desirable. While there are advantages to rural teaching that can include smaller class sizes, professional autonomy, community connection, and opportunities for leadership (Barley & Brigham, 2008), these advantages are not well-communicated, perpetuating the lack of teachers in rural settings (Goodpaster et al., 2012; Sutcher et al., 2016).

Similarly, there is a wealth of research on the increasing difficulties of recruiting, training, and supporting STEM teachers to any classroom, urban or rural. Colleges and universities continue to face decreasing enrollment in schools of education despite the increasingly sophisticated recruitment practices of many institutions. This is even though researchers with Get the Facts Out (2023) note that surveys of students in STEM programs indicate nearly half of all STEM majors have an interest in teaching. Institutions are forced to find non-traditional ways to support the dwindling numbers entering the field of education (King & Yin, 2022). For the past 20 years, NSF Noyce has provided funding to institutions of higher education to offer scholarships for STEM and STEM education majors who commit to teaching in high needs schools. The scholarship is an enhancement for students, but there are still barriers to recruiting a sufficient number of STEM teachers for the large number of high needs schools across the U.S.

Teacher shortages are also exacerbated by high rates of teacher turnover. In 2015, the National Center for Educational Statistics report (Gray & Taie, 2015) stated that nearly one-quarter of novice teachers leave their schools after three years. Teacher education accreditation standards have called for increases in content knowledge and higher entrance requirements with the hope of sending better prepared teachers into the field (Association of Mathematics Teacher Educators, 2017) and with the belief that increased entrance requirements might lead to more stability in the STEM teacher workforce. Teacher attrition rates are highest in rural areas, particularly in southern states and in schools that serve low-income and minority students (Anthony et al., 2017). Because teachers who persist in teaching become more effective over time (Papay & Kraft, 2015), attrition has a profound impact on student achievement (Darling-Hammond et al., 2017). Addressing persistence and retention in rural schools is a crucial step in providing equitable access to STEM teaching and learning for rural students (Behrstock-Sherratt, 2016; Eppley, 2016).
It may be that educator preparation programs can better prepare teachers for placements in rural schools so that they are more likely to consider a rural placement and, once hired, to remain in a rural school. We aimed to investigate how educator preparation programs address place and also the potential impact of specific features of educator preparation such as field placements, required readings, rural-focused scholarships, and other features, on new teachers’ initial placement and persistence in rural schools. Consistent with the NSF Noyce Track 4 call for collaborative research projects, (TPR)² aimed to create a research hub to collaboratively investigate these questions. This unique collaboration brought together both education and STEM faculty from 14 institutions to pool resources and share information about their programs in a truly multi-sector, trans-institution collaboration.

Collaboration across multiple institutions is complicated. Organizational and managerial research indicates the complexity of research when all partners do not hold the same titles, responsibilities, or credentials (Kieser & Leiner, 2011). The Carnegie Classification (Indiana University Center for Postsecondary Research, n.d.) provides a framework for designating types of institutions based on levels of degrees awarded, research activity in doctoral degree granting universities, size and type of enrollment, as well as specialized rankings such as tribal colleges. Large doctoral granting universities, often classified as R1 institutions, prioritize research while smaller regional colleges, or those that offer only undergraduate or masters degrees, prioritize teaching. Furthermore, multi-institutional research introduces the complications of each institution’s design, procedures for conducting research with human subjects, expectations for large-scale, grant-incentivized research, and faculty workload allocated to research endeavors. Thus, navigating the landscape of multiple institutions adds layers of complexity beyond the identified research agenda. Corley et al. (2006) discuss the need for either a highly organized research agenda or a well-developed organized collaboration structure for multi-institutional research to be successful.

Clearly, collaborative research is never easy. With this paper, we want to share the significant details, structures and supports that have helped us build a successful research team and contribute to a greater understanding of the features of multi-institution collaborative research that may support other projects.

Framework

Our research project is a collaboration between a wide variety of institutions from R1 universities to small regional colleges. Additionally, we have faculty that reside in either Colleges of Education or STEM departments in Colleges of Arts and Sciences. To understand the complexity of our work, we needed to draw upon the literature of teams. Hall and colleagues (2012) outline a model, drawn from team science, for conceptualizing a transdisciplinary framework in four phases: Development, Conceptualization, Implementation, and Translation. The Development phase of a transdisciplinary project entails convening a group of collaborators to examine a specific problem or area of interest. A Conceptualization phase is when the team collaborates to formulate hypotheses, conceptual models, research designs, or research questions to address the area of interest. During the Implementation phase the conceptualized plan is executed. Finally, a Translation phase consists of moving findings “from one level of analysis to another or across the discovery–development–delivery continuum in order to create innovative strategies for resolving or ameliorating societal problems” (Hall et al., 2012, p. 416).
This framework is explicitly articulated for transdisciplinary research, which the University of Harvard’s School of Public Health, adapted by Young (2023), define as “research efforts conducted by investigators from different disciplines working jointly to create new conceptual, theoretical, methodological, and translational innovations that integrate and move beyond discipline-specific approaches to address a common problem.” They draw a distinction between transdisciplinary and interdisciplinary research, which they define as “any study or group of studies undertaken by scholars from two or more distinct scientific disciplines. The research is based upon a conceptual model that links or integrates theoretical frameworks from those disciplines” (Global Arts and Humanities, Ohio State University, 2023) (see Figure 2).

Choi and Pak (2006) state that “[i]nterdisciplinarity analyzes, synthesizes, and harmonizes links between disciplines into a coordinated and coherent whole. Transdisciplinarity integrates the natural, social and health sciences in a humanities context, and transcends their traditional boundaries” (p. 359). Time will tell, but our research aspiration is indeed to transcend the traditional boundaries between rural education, STEM preparation, and classical educator preparation programming in a manner that addresses the preparation of rural STEM educators as a cohesive endeavor rather than several fractured parts. Additionally, Hall and colleagues (2012) argue that transdisciplinary research is distinctive in that it seeks to address societal problems and hence contains more traditional researchers as well as team members specifically included for their “relevant expertise to translate research findings into practice and policy applications” (p. 416). This is entirely consistent with our team design, which values research expertise in a variety of areas, but simultaneously includes team members particularly for their potential to translate findings and products into practical implementation, including faculty who work at teaching-focused and smaller rural-serving institutions. Hall et al. (2012) are explicit that these phases are typically not linear but cyclical, as our collaborative endeavors illustrate. Our research process will be interpreted through this framework.

The Development and Conceptualization Cycle

NSF Noyce aims to “address the critical need for recruiting, preparing, and retaining highly effective elementary and secondary mathematics and science teachers...” (NSF, 2023a). Tracks 1 and 2 of the program provides scholarships to individuals who seek to become STEM teachers—either through traditional undergraduate programs or through post-baccalaureate teacher preparation programs. Institutions design programs intended to recruit and support new STEM teachers and apply for funding. Track 3 grants provide funding to build leadership capacity and provide mentoring for current STEM teachers. Track 4 is intended to increase knowledge generation and translation by supporting collaborative research projects that investigate the programs and innovations being implemented in Noyce teacher preparation projects. Track 4 grants specifically call for teams to come together around a theme to investigate a shared research topic. It should be noted that Track 4 grants provide extra funding if a program has or previously had Track 1, 2, or 3 funding. This section describes how our team initially coalesced around the idea of submitting a Track 4 grant proposal.

Gauging Interest in Rural-Focused Collaborative Research

An early developmental step was realizing that rural teacher education might be a topic worth studying and gauging the interest of others in doing collaborative research. In the fall of
2019, two faculty at Stephen F. Austin State University (SFA)—a math professor and an education professor—who led Noyce programs for preparing teachers for rural Texas classrooms discussed how rural-serving Noyce teacher preparation programs were common, but how each individual program seemed to lack the scale to generate evidence about STEM teacher preparation that could move substantially beyond case study research. In order to gauge wider interest in rural STEM teacher preparation research, they developed a brief questionnaire about research interests and institutional connections to rural STEM teaching. Then, using the NSF Noyce project locator, they identified and contacted over 90 institutions that had programs that served rural students. From the perspective of transdisciplinary research, this was the initial development and conceptualization cycle in our work – two researchers believed that it might be important to collaborate to understand more about preparing rural STEM teachers, then used that work to identify a broader research team.

Of the institutions that were contacted, about 34 individuals responded with interest in collaborating on data gathering and research. Dozens of emails, phone conversations, and conference chats over the next two months led the SFA researchers to two conclusions: (1) that there was broad interest and willingness to examine the rural STEM teacher pipeline; and (2) as a regional, teaching-focused institution with limited research support for large collaborative projects, SFA was not an ideal institution to lead a group consisting of dozens of researchers, dispersed across the country, at least not at the level that this project deserved.

Identifying a Core Leadership Team

In their work to establish a broad team, the SFA duo also reached out to the National Rural Education Association (NREA) and began discussing the project with Devon Brenner, the editor of the organization’s journal and a rural education researcher at Mississippi State University (MSU). After several discussions with MSU, our team agreed that MSU would be well positioned to lead such a study but that it also would be wise to include Texas A&M University (TAMU) because of their researchers’ experience with Noyce programs and their methodological expertise in survey design and analysis—a key component of the project. The addition of research team members with expertise in distinct domains relevant to the key area of interest is one of the recommendations made by Hall and colleagues (2012) as part of the Development phase of transdisciplinary research projects. An important theme in cultivating these research connections is the significance of research associations. SFA researchers were able to connect with MSU researchers because of NREA, and MSU researchers had existing connections with TAMU researchers because of the Mathematics Teacher Educator Partnership—a network of mathematics teacher preparation programs begun in 2012 by the Association of Public Land Grant Universities.

This three-institution core leadership team began meeting regularly, formulating more precise goals and strategies, identifying previous research and a framework and logic model for a cross-institution research project, and building a shared understanding of the project’s research goals and the NSF Noyce Track 4 funding mechanism. In Table 1, we outline the collaborative strengths and weaknesses of our lead institutions and their research teams.
Table 1
Collaborative Strengths and Weaknesses of Lead Institutions and Research Teams

<table>
<thead>
<tr>
<th>Institution</th>
<th>Collaborative Strengths</th>
<th>Collaborative Weaknesses</th>
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| MS State    | • Expertise and connections in rural education, including rural teacher shortages  
• PI connected to NREA and editor of *The Rural Educator* and author of multiple seminal pieces about rural teacher preparation  
• Co-PI had experience with Noyce Track 1 and Capacity Building projects and other NSF teacher education grants  
• MSU Classified as an R1 institution with institutional resources to support collaborative research  
• Office of Research Compliance manages multiple multi-institutional projects needing IRB approval | • PI is less experienced in STEM research  
• Leadership has many other administrative duties |
| SFA         | • Experience with Noyce Track 1, 3, and 4 projects  
• Experience with studying rural STEM teachers  
• Network of dozens of rural STEM teachers | • Lacks large-scale research support structure  
• Lacks experience coordinating multiple institutions |
| TAMU        | • Experience with Noyce Track 1 and 4 projects  
• Expertise in longitudinal STEM teacher education research and publishing  
• Classified as an R1 institution with institutional resources to support collaborative research  
• Evaluator with expertise in STEM research | • Leadership has many other administrative duties  
• IRB approval system is complex |

Developing a Focus for Research Collaboration

The research coalesced around two central data collection components: (1) examining the Educator Preparation Programs (EPPs) at universities involved in the study, then (2) surveying prospective teachers who had participated in these EPPs over a sustained period to understand whether they had taken jobs as teachers, whether their teaching jobs were in rural schools, and whether they persisted in remaining in the teaching field and persisted in teaching in rural classrooms. After discussions with potential partners, over time we settled on proposing the following goals:
Goal 1: To investigate the impact of EPP programmatic features on program completers’ intention to teach as well as their persistence (continuing to teach at the same school) and retention (continuing to teach but at a new school) in rural STEM classrooms.

Goal 2: To engage in deep reflection leading to programmatic adjustments within collaborating partners’ EPPs intended to increase equitable access to effective instruction for rural schools.

Goal 3: To share emerging knowledge about programmatic features of EPPs that support program completers’ intention to teach, their employment decisions after completing the EPP, and their persistence and retention in rural placements.

Identifying Collaborative Partners

Another theme within transdisciplinary research is identifying not just the research challenges but the logistic and human challenges to long-term collaboration, then forming a team and a strategy to address those challenges. Accordingly, as the core research team developed a clear understanding of the types of engagement that would be needed from partner universities, the vision was communicated to the 34 institutions who had expressed initial interest in collaborating on a rural teacher education research project. A key task was to build the full research team, including determining which institutions not only had an interest in the research (and in securing the funding) but also would have the ability and the staying power to work through their local institutional review board (IRB) and other research requirements, participate fully in the proposed project, acquire the data necessary for analysis, and continue the research for the multiple years required to conduct a longitudinal study such as this one.

For the core leadership team, it was important for the whole team to keep the long view in mind – having “partners” who would not be able to follow through on all of the commitments would detract from the entire project and make success far less likely. Frankly, we aimed to identify collaborating faculty and institutions that would readily reply to communication (email) and provide data to support the collaboration. One strategy we used to identify partners was to request information that would be helpful for proposal development. We asked potential partners to report the numbers and demographics of students who had graduated from each of their programs over the past year—this information was necessary for the development of the proposal, but asking for data about their programs was also an opportunity for institutions to demonstrate their institutional capacity to identify and share program data in a timely fashion. As the project's details were developed, a few institutions determined they were unable to complete the project and chose not to participate. Eventually our team consisted of 11 partner universities in addition to the three core universities—the maximum number of collaborating partners allowed by the Noyce Track 4 funding mechanism and the number of institutions expressing interest in developing the joint proposal and participating in the 4-year project. See Table 2 for a complete list of partners and their roles.

Seeking Funding

The culmination of the conceptualization phase of the project was formulating a Noyce Track 4 collaborative grant proposal. We began the work of writing research questions based on
Table 2
Partner Institutions and Collaborators, Along with Their Roles

<table>
<thead>
<tr>
<th>Institution</th>
<th>Affiliations of Collaborators</th>
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<tbody>
<tr>
<td>Alabama A&amp;M University</td>
<td>Department of Physics, Chemistry &amp; Mathematics</td>
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<td>Office of Teacher Education and Certification</td>
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<td>Clarkson University</td>
<td>Department of Mathematics</td>
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<td>Department of Education</td>
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<td></td>
<td>Department of Physics</td>
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<td>Institute for STEM Education</td>
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<td>School of Engineering</td>
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<td>Fort Hays State University</td>
<td>College of Education</td>
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<td>Department of Physics</td>
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<td>Science &amp; Education Institute</td>
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<td>Mississippi State University</td>
<td>Department of Biological Sciences</td>
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<td>Department of Education</td>
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<td>Office of Academic Quality</td>
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<td>Social Science Research Center</td>
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<td>Morehead State University</td>
<td>Department of Middle Grades and Secondary Education</td>
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<td>MSUTeach</td>
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<td>North Dakota State University</td>
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<td></td>
<td>Office of Teaching and Learning</td>
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<td></td>
<td>School of Education</td>
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<tr>
<td>Stephen F. Austin State University</td>
<td>Department of Mathematics &amp; Statistics</td>
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<td>Department of Education Studies</td>
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<td>Texas A&amp;M University, Commerce</td>
<td>Department of Physics and Astronomy</td>
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<td>Department of Curriculum and Instruction</td>
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<td>Texas A&amp;M University, College Station</td>
<td>AggieTeach – Arts &amp; Sciences</td>
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<td>College of Arts &amp; Sciences</td>
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<td>Department of Mathematics</td>
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<td>Department of Teaching, Learning, and Culture</td>
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<td>Education Research Center</td>
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<td>Texas Tech University</td>
<td>Center for Integration of STEM Education &amp; Research</td>
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<td>Center for Transformative Undergraduate Experiences</td>
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<td></td>
<td>College of Education</td>
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<td>University of Alabama at Birmingham</td>
<td>Center for Community Outreach Development</td>
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<td>UABTeach</td>
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<td>University of Kentucky</td>
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<td>University of Wisconsin River Falls</td>
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<td>Winthrop University</td>
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<td>Department of Biology</td>
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<td>Department of Mathematics</td>
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the funding agency’s Request for Proposals and the defined scope of work. Each of the co-PIs brought a piece of the puzzle to the collaborative work—experience with the rural teacher preparation and the Noyce scholarship program, quantitative or qualitative research expertise, teacher preparation experience, and project management experience. It was important that we have explicit discussions about who would take responsibility for each task. We also identified an evaluator and included her in our discussions early in the process.

**Facilitating Communication**

The media tool used for collaboration, Zoom, and the way it was utilized, was also fundamental to the project. A platform for connecting remotely was absolutely necessary given the disperse geography of the 14 institutions. Zoom allowed for a certain degree of community building and added visual, voice, and document sharing facets to our collaborative efforts. The team was very intentional about the structure of Zoom meetings, particularly with the full group of 14 institutions, discussing both content and relational aspects of the agendas, engaging participants in smaller break-out groups, etc. It is likely that the circumstances that necessitated the decrease in in-person meetings during the COVID-19 pandemic strengthened our collaborative efforts since the intense time of formulating the collaboration was in the spring and summer of 2020, when most states were locked down.

Online tools like Zoom and the implementation of COVID-19 protocols put collaboration with colleagues across the country on an equal footing with collaborating with colleagues who work down the hall. For our project, all core leadership meetings take place through Zoom and have a clear agenda that is set prior to meeting. We designate a specific hour each week during each semester for our meetings and cancel meetings only for holidays or if most of the core leadership members are attending a conference. Each Monday, the program manager (described in more detail below) provides a recap of the previous week’s project-based work as well as information for consideration or items to complete before the next meeting. Whole group meetings (i.e., meetings that include all 14 institutions) are held once a month. Similar to the leadership meetings, an agenda and updates are sent to the whole team every few weeks.

Equally important is the document and information sharing within collaboration. Since communication is central to all four phases of transdisciplinary research, choosing a method and a medium for synchronous communication was vital. The core leadership team utilizes Microsoft Teams as the primary document storage platform. We found additional platforms just added confusion. Our program manager assists all members with storing and locating documents and data.

We close this section on the conceptualization and development process that we followed with a brief vignette highlighting how a transdisciplinary team with diverse stakeholder connections enriched our research.

**Vignette – Expertise and Learning from Each Other**

Our original conceptualization of the engagement of prospective STEM teachers in an investigation of place centered on Azano and colleague’s (2019) 3 Cs model for preparing rural teachers – focusing on Curriculum, Context, and Conveyance. The 3 Cs framework was co-authored by the PI. This model makes explicit both the importance of bringing to the forefront issues of preparing teachers for potentially teaching in rural places, and it seeks to intentionally
identify the different domains that contribute to this work. Designed by rural teacher education researchers, the framework does not yet appear to have permeated thinking in other disciplines – specifically for our purposes, the field of STEM educator preparation.

The 3 Cs framework emphasizes the need for placed-based teacher education experiences to develop a preservice teacher’s understanding of the importance of the interplay of context, curriculum, and conveyances in a rural education classroom. An example of context in small rural schools is when teachers are assigned non-traditional tasks or asked to fulfill multiple roles including teaching multiple grades, teaching a variety of courses within or across content areas (e.g., teaching calculus and physics), or sponsoring extra-curricular activities potentially even during their first year of teaching. Programmatic features related to curriculum include instructional practices that focus on place and leverage of local resources for mathematics teaching (Avery, 2013). Programmatic features related to conveyance focus on access to teacher education programs. Conveyance includes recruitment strategies (e.g., focus on rural residents, partnerships with rural high schools, or grow-your-own programs) and flexible offerings for completing the educational requirements for licensure.

After funding, first our core leadership team, then our full 14-institution transdisciplinary team began to grapple with the 3 Cs framework in greater detail. When the mathematicians and scientists began to engage with the definitions of Curriculum, Context, and Conveyance as they are presented in Azano et al. (2019), they were much more concerned with precisely delineating the categories than the original authors had been. This led to a fruitful discussion, which persisted over several months about what really constituted each area of the framework, how they differed, and even whether the category definitions should be refined slightly to fully communicate the meaning to stakeholders across disciplines. Engaging in this type of collaboration took tremendous humility on the part of the rural education researcher on our team. In particular, a willingness to allow researchers from outside of her discipline to challenge established frameworks within her discipline. But the result has been a thoroughly engaging exercise that has pushed forward both the understanding of place-focused teacher education and our efforts to code the data (e.g., lesson plans, syllabi, interview transcripts, etc.) collected for this study as belonging to one or more of the 3 Cs categories. Transdisciplinary teamwork has informed our conceptual framework so that a broader group can engage deeply with it, and we can use it to pursue our research goals more effectively.

**Implementation in Team-Based Research**

The implementation process interacts cyclically with conceptualization and development informing how the project is conceptualized and guiding development. Early in our work, the team engaged only in the three areas depicted in Figure 1 (see Hall et al., 2012, p. 417). The development and conceptualization phases were iterative and implementation was our initial goal. Implementation is the phase of a project where a shared understanding transitions into fully developed functional roles – who knows what, who does what, how things get done, and how interactions occur (Mesmer-Magnus & DeChurch, 2009).

**Team Communication**

The core leadership team determined that regular communication was absolutely essential in keeping our cross-disciplinary team collaborating. As soon as NSF funded our project, the
leadership team resumed the weekly Zoom meetings that had been the hallmark of the development and conceptualization phases of the project. It should be noted that the core leadership team has been very consistent with the continuation of weekly meetings which we believe has helped us to maintain our research-focused momentum.

Whole team meetings and regular email updates provided both the onboarding that was necessary at the beginning of the project and essential ongoing support for collaboration over the first two years of the project. Whole team meetings involving at least one PI or co-PI from each of the 14 partner institutions have been held 2-3 times per semester (about every other month). While monthly whole team meetings were originally planned, due to the ebbs and flows of developing surveys and collecting data it became evident that monthly meetings were not necessary and potentially could be seen by attendees as just one more obligation. We worried that unless there was a real need to meet—to get feedback on survey development, or to share plans for data collection, for example—meeting for the sake of meeting might have the unintended consequence of diminishing participation.

In addition to virtual meetings, we meet as a whole team in person once each year. We “all but require” attendance at a half-day meeting prior to the annual PI meeting for all Noyce projects which is held in DC each summer. Travel is already built into the project budget, so collaborators should have minimal hindrances to attending. Our in-person gathering is used for community building and developing a shared understanding of the project framework, timeline, and goals for data collection, analysis, and dissemination.

We also needed effective avenues for asynchronous communication. We designed a webpage to share information both externally and within the team (with password protection). We needed team members to have ready access to information and collaborative components of the project and to be able to upload documents and data in a secure format. Most importantly, the platform needed to have an organizational structure that people could understand and easily access. Unfortunately, the website approach, though conceptually valid, did not end up implementing well as some team members were unable to access secure files, and others had trouble understanding where different files were located. We attempted other collaborative file-
sharing solutions before settling on OneDrive and Microsoft Teams since these platforms are supported by many of the universities involved and are more secure than other formats we investigated. This is another small example of the iterative nature of collaborative research. Ultimately, data management and the handling of diverse research artifacts was best facilitated by having an experienced researcher assume the role of Program Manager (PM) along with seasoned qualitative and quantitative researchers on the team serving as co-program managers.

**Team Facilitation**

The PM is a vital member of our research team. Finding someone to serve in this role to complement the research strengths of other team members was essential. A researcher with a PhD in biology, an interest in STEM education, and experience coordinating large teams serves as PM and strengthened the team in two specific ways. Although the core leadership team members had expertise in rural education, educator preparation, mathematics and mathematics education, program evaluation, and both qualitative and quantitative research methods, the team lacked an individual with experience in the natural sciences. The PM added this important research perspective, and, perhaps more importantly, brought translational benefits to the project collaborative experience in this area and the ability to translate our research findings in ways that are significant to natural science faculty across the 14 institutions as well as to a broader audience.

To date, the PM has collected data about educator preparation programs, including interviews with faculty and administrators and documents such as course syllabi. She has cataloged and organized the data in such a way that the leadership team can access information at any time. She has also distributed surveys to teacher candidates and program completers and compiled survey responses. She is currently leading the beginning steps of data analysis. The PM’s job, however, is not just to do the research collection and analysis, but rather to facilitate the team as a whole in the process. This is an essential step in implementation – allowing the research work to truly be distributed across the team. The PM collaborates with the core leadership team as well as with team members and stakeholders at all 14 institutions. For example, once hired, the PM immediately began systematizing the communication process and data storage procedures. Summary emails are sent by the PM to members of the core leadership team every Monday, recapping the previous week’s work, setting the week’s agenda as well as providing materials that should be considered by the team prior to the Thursday Zoom meetings. The PM keeps an eye on our overall timeline and scope of work to ensure that project deadlines are being met. She schedules, plans, and sends out summaries of whole team meetings, and sends regular email updates about the current status of data collection and analysis to keep the entire team informed about the project.

**Overcoming Obstacles**

Distributed research involves challenges that are distinct from more traditional research. One example is the process of obtaining IRB approval for all 14 institutions to participate in data collection for the (TPR)² project. Our research plan emphasized having the PM and the research team at MSU conduct the majority of the data collection including interviews and survey distribution. Therefore, we planned to use a single IRB submission for collaborative research through the MSU Office of Research Compliance. Although we were conducting research
methods that are standard educational practice and ultimately the project was determined to fall in the “exempt” classification for human subjects research (see Health and Human Services, n.d.), the process of obtaining IRB approval took months longer than we anticipated. Further, of the 14 institutions awarded NSF funds through the project, only 12 institutions were able to move forward with approval under the central MSU IRB application. Another two institutions spent months attaining IRB approval at their own institutions. One of those institutions concluded that only university employees may distribute the surveys and communicate with participants, while the other ruled that the IRB process that was in place was sufficient. We needed an understanding of institutional policies and procedures as well as persistence to overcome this obstacle. We were not anticipating the length of time nor the complexity of the task that was necessary to get approval for all institutional partners.

**Putting it All Together**

Once the team was in place and the collaboration and facilitation obstacles had been addressed, we were ready to move forward with the work of the project. The next section highlights how the logistical and organizational planning for implementation and conceptualization has resulted in meaningful collaboration across multiple institutions. In fact, we believe the work of our project is stronger because we are collaborating.

**Collaboration in Action**

We have selected one story to highlight how the diversity of our research team in a variety of ways including research specialties, academic roles, and geographical locations has influenced the project. Although the activities are squarely a part of the implementation phase, they also overlap significantly with conceptualization and development phases, and even the translation phase (discussed below) as described in Hall et al. (2012).

The development and implementation of surveys was central to the research goals for our project. We identified three distinct surveys that we planned to create and distribute to gain longitudinal insights into prospective rural STEM teachers plans and decisions at the end of their teacher preparation program. For this purpose, we developed the Teaching Intention Survey as well as the Initial Employment Survey, completed at the beginning of the first year and after program completion, and the Teacher Follow-Up Survey, completed a year after program completion.

The content and validation techniques of these instruments are described in more detail elsewhere (e.g., Whitfield et al., under review). Here we will focus on the role of these surveys in our project’s collaborative efforts. A first draft of each survey was designed by the lead research team and shared with all partners before we submitted the initial grant proposal to NSF. At the time our project was developed no validated survey existed in the literature for exploring teachers’ views about teaching in rural, and, since they were in draft form, our survey items had not been evaluated for face or content validity. Once the grant was funded it became clear that the draft surveys needed a great deal of revising in order to align with our research questions and provide valid data about teachers’ intentions and views of rural teaching and teacher preparation.

The first noteworthy obstacle was that we aimed to determine whether graduates of our programs sought out or accepted rural teaching positions and to understand their views about teaching in rural schools. However, we found that we had many questions about what counts as
rural. Across our team, we met several times to discuss “rural”. Whether, for example, a small college town was “as rural” as a farming community or whether students from forested areas of upstate New York or the plains of Kansas would consider themselves “rural.” Much of our initial work to revise and finalize our surveys focused on discussions about defining this word.

The federal government has at least 15 different definitions of rural in various agencies and funding programs (see Washington Post, 2013) and rural researchers themselves do not always use a concrete definition of the word rural (Longhurst, 2022). We also debated whether to classify places using terms like urban, suburban, rural, or remote, to distinguish between distance from urban areas or population density. This was familiar, and comfortable, territory for the educational researchers on our team, but not for the biologists and mathematicians who expected a single, concrete definition of rurality. After repeated discussions, listening to team members and their thoughts about rurality and the students and communities they serve, and reading some rural education scholarship on defining rural (e.g., Brenner, 2022; Longhurst, 2022) we settled on two terms—rural and not-rural—and a definition of rural for our surveys of “a community smaller than 50,000 people” with the hope that this definition would allow survey respondents to consistently answer survey questions about where they are from and where they are teaching. It should be noted that the definition we settled on is derived from the multiple definitions put forth by federal agency literature.

Similar in-depth conversations about terminology, survey item wording, and survey focus influenced the development of the final versions of other survey items as well, including questions related to course assignments and experiences in teacher preparation. Having dozens of researchers in different contexts provide multiple rounds of feedback allowed us to understand which questions might be interpreted differently by survey respondents. This iterative and collaborative review process also allowed us to evaluate the connections between different survey prompts and our project research questions from different vantage points. Since the target audience for completing the surveys was science and mathematics majors, it was important to cover significant educational ground but to do so in a way that would make sense to those with STEM training and research interests.

Most significantly, all 14 institutions had to be sufficiently aware of and committed to implementing the final versions of the surveys. With their understanding and support, we felt they would encourage students to take our surveys ensuring good response rates. Again, this was a collaborative effort. The surveys were customized by the PM. For most sites, IRB allowed student contact information to be provided to the PM so that the surveys (and reminders) could be distributed centrally. However, for two sites, the IRB panels determined that the surveys had to be distributed internally. Response rates on the second round of the Teacher Intention Survey were distinctly lower than the first. Luckily, one of the PM’s roles was to keep abreast of these response rates. The core leadership team reflected on the response rate issues and chose to develop a solution as a collaborative effort. Rather than treating certain sites as ‘problems’ that needed to get in line with a proposed solution, all sites gathered, discussed response rate issues, and explored solutions collaboratively. Different institutional contexts required different solutions. At one institution all of the potential respondents gathered for a particular class so the survey link and reminders could be shared during that class. At another institution, it was best to have a person other than the professor of the course distribute the survey. We believe collaboratively approaching the response rate concern not only helped generate a broader range of potential solutions for a variety of contexts, but also increased the engagement of institutions in the overall project.
Translation

The translation phase of collaborative research also interacts cyclically with the other phases, as depicted in Figure 2; although translation, as our team is designed, was the last phase to be included in the cycle. The figure depicts the entire interactive model. However, given the nature of our work and the time necessary to collect data across 14 institutions, after three years, our project is entering into the translation phase.

Figure 2
Four Phase Model of Transdisciplinary Research (Hall et al., 2012, p. 417)

Currently, the (TPR)² project is about half-way through its funding cycle, so we see ourselves as beginning to move to a more translational focus. Year One surveys have been collected and are in the process of being analyzed. Interviews of key stakeholders have been completed and transcribed and we are in the process of coding and interpreting the documents. The core leadership team as well as other partners have presented at several conferences on the need for rural STEM teacher education research, the structure of the collaboration as a promising practice, and preliminary findings based on our analysis student survey data to date. Through these efforts, we are working to communicate what we have initially learned about the significance of considering place, while also extending an invitation for rural-serving educators to join our collaborative efforts. Additionally, our research team has written two blog posts and is in the process of writing three collaborative papers on topics such as the early results of place-based STEM education methods, large-scale survey development, and the implications of influencers on the selection of schools or districts where graduates who are seeking teaching jobs are accepted. Partners are teaming with core leadership team members to investigate other topics of interest that have arisen during our whole team meetings. We are working to raise awareness of the significance of place in educator preparation, to increase the exchange of ideas about curricula and contexts that foster this type of place-based educator preparation, and to establish connections with university stakeholders who are interested in moving forward with this work.

While interest is evident, translation implies that the research results impact practice. It is too early in our project to measure this effect. However, the framework does seem to have implications for collaboration in educational settings.
Conclusion

At the midpoint of the funding of our project, we appear to have a successful collaboration that is leading to meaningful transdisciplinary research. The intentionality of building and enacting collaboration is key to continuing our project and eventually to our research findings having a transformative effect on the fields involved. The transdisciplinary framework developed by Hall and colleagues (2012) provides a structure for understanding why our work can be used as a model for building and understanding collaborative research. As we move further into the translation phase, there will be an emphasis on shared research, shared conference presentations, and other collaborative opportunities. The initial translation stages indicate that our group will be able to continue to work collaboratively in meaningful ways.

It was important for the establishment of our team to spend a significant amount of time in the development and conceptualization phases. As suggested by Corley et al. (2006), we needed to have a crystalized picture of what we hoped to accomplish. We were able to develop and implement a research project because we took the time to make sure each member of the core leadership team had a shared vision of the work. As described in this paper, we had to navigate the differences of our team members’ research interests, the positions we held at different universities, and the administrative and procedural complexities of our universities even though two of the three lead institutions are classified as R1 institutions. Only after the significant work of development and conceptualization could we begin the process of implementation. And, in our case, writing a grant that was selected for funding with a defined scope of work that indicated to reviewers at NSF that we would accomplish this work.

The cyclical and iterative processes of the Hall et al. (2012) framework helped us realize our collaboration is successful. Each time we experience challenges, we rely on the structure of our team to help us navigate to a solution. The key components for our team development appear to be:

• the intentionality of selecting members of the core leadership team,
• the significant amount of time spent on shaping the goals of the research work,
• the careful assembling of the larger research team with clear messaging about the work and participation expectations,
• well-defined self-reflection and self-correction plans as demonstrated by communication procedures and survey development,
• the selection of the program manager with specific organizational skills, and
• organized, regular meetings of both the core leadership team and the larger whole group.

We openly acknowledge that our core leadership team has developed into a friendship over time. This friendship has enhanced our work time as we share the successes and challenges of the project. While team building as well as opportunities to get to know each other were deliberately part of the development and conceptualization phases, the true friendships that have evolved were an unforeseen but welcome bonus that emerged from the process.

By sharing our process, our successes, and our challenges in this article, our intent is to allow other teams working at the intersection of STEM, education, and rurality to better approach the large collaborations necessary to affect the broad change called for by Biddle and Azano (2016) in addition to many others. Sustained, multi-institution dialog and the exchange of best practices seems to be the only reasonable path for improving rural STEM educator preparation and support. This transformative work is clearly necessary if our rural communities are to have equitable access to high quality STEM education.
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References


Global Arts and Humanities, Ohio State University (2023, April 9). *Why cross-disciplinary research matters*. [https://globalartsandhumanities.osu.edu/research/cross-disciplinary-research](https://globalartsandhumanities.osu.edu/research/cross-disciplinary-research)


