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Traversing educational deserts: a community case study of technical STEMM pathways in Wyoming's rural remote transfer ecosystem

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Across Wyoming's remote educational landscapes, rural technical STEMM educators (RTSEs) engage in complex relational work supporting student navigation through challenging institutional, cultural, and physical barriers. Through analysis of lived experiences shared by 42 RTSEs across eight counties, this community case study reveals how successful rural STEMM education emerges through integrated supports addressing mental health needs, family dynamics, and cultural contexts while building vital technical skills. Evidence demonstrates RTSEs operate simultaneously across geographic, economic, and demographic dimensions—bridging between local knowledges and broader academic systems. Key findings highlight the importance of relationship-centered approaches that honor rural contexts while addressing universal challenges. Recommendations include developing coordinated support networks and expanding industry-education partnerships grounded in local community needs.

KEYWORDS

technical–vocational, rural STEM education, faculty, community college, student support

Introduction

At daybreak on Wyoming's high plains, a student's headlights pierce the darkness as they travel miles between home and their chemistry class. These educational landscapes may appear barren to outside observers, but beneath the surface exists a complex network of relationships reflecting what Wenger (1999) identifies as knowledge-sharing networks. Like desert flora that develop extraordinary root systems to survive in challenging environments, rural learners and educators create intricate networks of support to navigate distances and institutional boundaries. Desert plants survive not through isolation but through sophisticated interconnection—sharing resources, communicating through mycorrhizal networks, and adapting collectively to harsh conditions. Similarly, successful rural technical science, technology, engineering, mathematics, and medicine (STEMM) education thrives through relationship networks that connect students, educators, institutions, and communities. Within this ecosystem, rural technical STEMM educators (RTSEs) function as vital connective tissue—building relationships that bridge geographic barriers, connect diverse knowledge systems, and create pathways for student navigation.

Wyoming's rural technical STEMM education landscape illustrates this relationship-centered ecosystem in action. On tribal lands, Eastern Shoshone and Northern Arapaho students attend classes alongside students from ranching families and energy industry workers, connected through educators who build relationships honoring diverse ways of knowing while preparing students for evolving technical careers. These communities remain committed to the land and rural-regional sustainability as an intergenerational concept (Reid et al., 2010). In farming communities, first-generation college students conduct NASA space-grant funded research in rural-serving community colleges, guided by RTSEs who forge relationships between local knowledge and broader academic frameworks, challenging the myth that rural area places of illiteracy (Green and Corbett, 2013). These examples reveal how rural technical STEMM education operates through networks of relationships that simultaneously honor distinct cultural contexts while addressing common challenges of resource constraints.

Technical STEMM education encompasses specialized learning to employment pathways combining scientific, technological, engineering, mathematical, and medical disciplines which include hands-on training designed for middle-skill professional roles—those requiring more than a high school diploma but less than a four-year degree (Holzer and Lerman, 2009). Rural-serving institutions like community colleges and tribal colleges play vital roles as anchor institutions in technical STEMM training, providing educational access while contributing to community sustainability (Koricich et al., 2022). These institutions help build career pathways that allow students to remain in and contribute to their communities rather than feeling forced to leave for opportunities elsewhere (Byun et al., 2017). Research suggests successful approaches integrate local knowledge and values are successful when they connect students to real career opportunities familiar and valued by students and their families located in their community (Ardoin, 2017; Gibbons et al., 2020).

Through focus groups and interviews with 42 RTSEs across eight Wyoming community colleges and several non-profit and for-profit workforce training programs, this community case study investigates how relationship work operates across geographic, economic, and demographic dimensions of rural social space (Reid et al., 2010; Reid, 2017). Drawing on rural social space theory and rural intersectionality theory, we develop a relationship-centered transfer navigation framework that recognizes RTSEs as cultural brokers who build vital connections between local knowledge systems and broader academic frameworks. Cultural brokering is the act of bridging, linking, or mediating between groups or persons of different cultural backgrounds for the purpose of reducing conflict or producing change, a role that RTSEs fulfill as they help students navigate between local contexts and academic requirements (Jezewski and Sotnik, 2001). This approach extends Taylor and Jain (2017) conceptualization of transfer as the movement of students from one higher education institution to another and the process by which academic credits or credentials students earn are recognized at a receiving institution to include the broader flow of knowledge through educational ecosystems. The study advances understanding of how rural STEMM education operates through relationship networks.

Rural technical STEMM education: context and challenges

Defining technical STEMM education

Technical STEMM education encompasses specialized pathways that combine scientific, technological, engineering, mathematical, and medical disciplines with hands-on, practical training designed to prepare students for specific, high-demand professional roles. Drawing from the Association for Career and Technical Education's (ACTE) framework for high-quality Career and Technical Education (CTE), we examine how rural technical STEMM education operates at the intersection of academic knowledge, occupational skills, and technical competencies (Imperatore and Hyslop, 2018). Stone argues that meaningful career preparation must integrate rigorous academics with workplace learning while building both technical and non-cognitive skills—a particular challenge in rural contexts (2014, 2017). In Wyoming, these include roles such as wind energy technicians, medical laboratory assistants, industrial maintenance workers, and data center technicians. For example, a rural wind energy technician program in Wyoming might combine physics and mathematics coursework with practical training in industrial maintenance, apprenticeships at local wind farms in Carbon or Sweetwater County, and professional development in equipment maintenance, safety protocols, and technical communication. The effectiveness of these programs—measured by student completion, credential attainment, and successful employment—depends on relationship networks that connect academic preparation with workplace learning opportunities across vast distances (Rojewski and Hill, 2017).

Wyoming's rural education landscape

Wyoming's vast landscape illustrates key challenges in rural STEMM education access, where physical remoteness shapes both opportunity and barriers. Using the USDA rural-urban commuting area (RUCA) codes, 17 of Wyoming's 23 counties are classified as rural or frontier with population densities under six people per square mile (USDA ERS, 2020). Across 97,813 square miles, the state's educational landscape consists of a distributed network of seven community colleges, one land-grant university, one tribal college, and several private and not-for-profit workforce development programs.

These institutions serve diverse populations across dispersed communities. While predominantly White, the region includes significant Native populations, particularly from the Wind River Reservation where Eastern Shoshone and Northern Arapaho tribes maintain strong cultural connections to the land while facing historical and contemporary barriers to educational access. Growing Latino populations have become integral to ranching and extraction communities, while increasing numbers of working adults and single parents seek educational opportunities to advance their careers. The state's population of 576,851 is dispersed across communities ranging from 60,000 to under 100 residents, with 69% of residents living more than 60 miles from the nearest metropolitan area (US Census Bureau, 2020).

This geographic and demographic context creates what Hillman (2016) terms "education deserts"—vast spaces between educational opportunities where physical remoteness and sparse population density create unique challenges. However, we reframe these spaces not as areas of deficit but as unique ecosystems where distance and dispersion foster innovative relationship networks. Across Wyoming's rural communities, recurring challenges around childcare, mental health services, and transportation manifest distinctly based on local contexts, requiring relationship-centered approaches that address these intersecting barriers.

Rural technical STEMM educators (RSTEs)

For this study, rural technical STEMM educators (RTSEs) are characterized as community college faculty, workplace trainers and directors, and other educators who teach math, science, and technical skills for middle-skill STEMM careers in rural contexts. These educators play vital roles through anchor institutions, industry employers, and community-based workforce development non-profits, providing educational access. Their work encompasses both formal classroom instruction, informal career counseling, work-based learning supervision, and social services support. What distinguishes RTSEs in rural contexts is their central relationship-building function and ability to serve in multiple roles at once. They build bridges between student strengths and abilities, academic preparation, local industry workforce needs, and community support services (Eppley, 2015). Building on Mannion et al.'s (2013) work on place-responsive pedagogy and Gruenewald (2003) multidisciplinary framework for place-conscious education, RTSEs help integrate local learning while building knowledge about educational pathways through relationships that honor local contexts.

The challenges RTSEs face in facilitating technical STEMM education are deeply intertwined with the geographic, economic, and demographic dimensions of rural social space (Reid et al., 2010). Physical distance limits access to specialized equipment, industry partnerships, and peer collaboration. Economic transitions in traditional industries like mining and agriculture create evolving workforce needs requiring continuous adaptation of educational programs. Demographic diversity demands culturally responsive approaches that honor different ways of knowing while building technical competencies valued across contexts.

Theoretical framework: relationship-centered transfer navigation

This study introduces a relationship-centered transfer navigation framework that builds upon and integrates two established theoretical perspectives: rural social space theory and rural intersectionality theory. Rural social space theory conceptualizes rurality through the dynamic interaction of economy, geography, and demography (Reid et al., 2010). Rather than viewing rural spaces as merely non-urban, this theory foregrounds how these dimensions collectively shape opportunities, constraints, and social relations in rural communities. The economic dimension encompasses both traditional and emerging rural industries and workforce needs. The geographic dimension considers both physical space and place-based meanings, while the demographic dimension examines population characteristics and social relations that define rural communities (Reid, 2017; Reid et al., 2010).

Rural intersectionality theory examines how rural identity intersects with other social identities to shape educational experiences and outcomes (Crenshaw, 1991; Sansone, 2023). This lens reveals how rural students face overlapping barriers that can compound disadvantage while also illuminating how different groups within rural communities often share common experiences despite varying backgrounds. This framework recognizes colonization and geographic marginalization as endemic to rural spaces, particularly for communities of color (Azano and Means, 2022; Brayboy, 2005). Understanding these shared experiences helps explain how rural identity functions as a meaningful social category that interacts with other aspects of identity. This theoretical perspective suggests effective rural education requires both universal supports addressing common rural challenges and targeted approaches accounting for specific intersectional identities.

Building on these foundations, we propose a relationship-centered transfer navigation framework that positions relationship work as the primary mechanism through which rural technical STEMM transfer occurs. This framework draws from Kisker and Carducci's (2003) concepts of community college partnership development. Central to this framework is the concept of "navigational capital" from Yosso's (2005) community cultural wealth theory, which addresses the skills needed to maneuver through social institutions that weren't created with marginalized communities in mind. In rural contexts, navigational capital includes the ability to traverse both physical distances and institutional boundaries while maintaining vital community connections (Means et al., 2016). RTSEs help students develop this capital through relationship work that connects local knowledge systems with academic frameworks, reflecting successful partnerships that bridge classroom learning with practical applications in work environments and community welfare supports (Kisker and Carducci, 2003). This framework conceptualizes effective rural education as creating multiple pathways for student success through relationships that honor rural contexts while building transferable skills. Effectiveness is measured through multiple indicators: student completion, credential attainment, successful employment in technical fields, and critically, the development of navigational capital that enables continued learning across contexts.

Figure 1 visualizes the theoretical framework emerging from this community case study, depicting how RTSEs engage in relationship work across three interconnected dimensions of rural social space: geographic (addressing physical isolation), economic (connecting to workforce opportunities), and demographic (serving diverse populations). At the center, RTSEs build vital connections between students, support services, and educational pathways through integrated relationship work. This model emerged from our analysis of RTSE lived experiences and

illustrates how relationship-centered transfer navigation operates within broader institutional and policy contexts.

This theoretical framework directly informs our research questions, which examine:

(1) How do RTSEs in Wyoming build and maintain relationships that help students navigate technical STEMM transfer pathways?
(2) How does relationship work operate across dimensions of rural social space?
(3) How do RTSEs help students build navigational capital that bridges local knowledge systems and academic frameworks?
(4) What institutional structures support or hinder relationship-centered transfer support?

By focusing on relationships as the primary mechanism of rural transfer, we address previous gaps in understanding how rural educators facilitate student success across complex educational landscapes.

This framework connects to our community-based assessment methodology by recognizing that meaningful program development emerges through relationships across stakeholder groups (Kemmis and McTaggart, 2005). Rather than treating different groups as siloed entities, this approach identifies common ground in both barriers and support needs while building capacity for sustainable solutions through relationship networks (Wenger, 2000). The relationship-centered transfer navigation framework thus provides both a theoretical lens for analysis and a practical approach to rural technical STEMM education development.

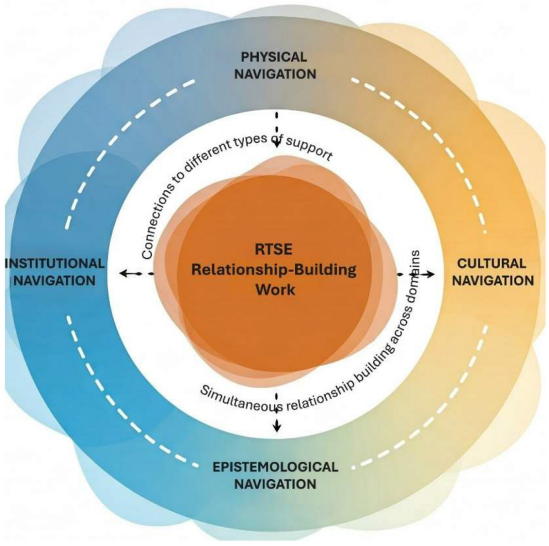

FIGURE 1
Rural technical STEMM educator (RTSE) support ecosystem model. Model depicts multidimensional relationship work across geographic, economic, and demographic dimensions based on analysis of RTSE lived experiences.

Methodology

Community-based case study approach

Rural STEMM education ecosystems require investigation approaches that can surface both unique contextual challenges and universal elements that connect across institutions (Beach and Öhrn, 2021). Traditional top-down analysis at the institution-level often fails to capture the complex interactions between place, resources, and relationships that shape rural educational pathways. This study employs a community-based assessment approach to examine how various stakeholders within Wyoming's rural postsecondary transfer ecosystem support student navigation through technical STEMM career-learning pathways. A community-based assessment approach, drawing on Kemmis and McTaggart's (2005) critical participatory action research framework, recognizes that meaningful program development must emerge through collaborative dialog across stakeholder groups. Recent research examining rural CTE needs assessment demonstrates how this approach allows communities to articulate how their "practices, their understandings of their practices, and the conditions under which they practice" shape educational opportunities and barriers (Kemmis and McTaggart, 2005, p. 563; McBride, 2024).

The ecosystem lens extends this participatory framework by examining how various components—including faculty support networks, student services, transfer partnerships, and professional development opportunities—interact within rural contexts. Rather than treating different stakeholder groups as separate constituencies functioning in standalone programs, this approach helps identify common ground in both barriers and support needs while building co-creative capacity for sustainable solutions (Wenger, 2000). This is particularly crucial in rural settings where limited resources demand innovative, collaborative approaches that serve multiple populations across multiple locations and dimensions.

By examining Wyoming's postsecondary STEMM transfer ecosystem through the lived experiences of RTSEs and rural social space and intersectionality theories, this study reveals how geographic, economic, and demographic dimensions interact to both constrain and enable rural STEMM education (Reid et al., 2010). The community-based participatory methodology portrays how rural identity intersects with other social categories to create shared experiences across seemingly disparate communities (Sansone, 2023). As Corbett (2000) argues, rural spaces generate distinct forms of social and cultural capital that institutions must recognize to effectively serve their communities. This grounding allows us to identify both place-specific adaptions emerging from local contexts and universal elements that can inform STEMM education more broadly. Understanding this interplay between unique rural contexts and shared experiences is crucial for developing sustainable, equity-minded approaches that honor local knowledge while building collective capacity across rural institutions (Koricich et al., 2022).

Participant selection and context

Both purposeful and convenience sampling was used to recruit participants from eight Wyoming counties representing diverse

geographic regions across the state. Participants were recruited through existing networks established via a statewide professional development program facilitated by the land-grant university. Initial contacts at each institution helped identify additional RTSE participants, creating a snowball sampling effect. Selection criteria required participants to be actively engaged in technical STEMM education in rural settings, either as faculty, staff, administrators, or workforce development professionals. Between January and October 2022, 42 RTSEs representing community colleges, tribal college administration, and workforce development programs were recruited to participate (see Table 1). This sample provided a diverse range of perspectives across institution types, roles, and experience levels (experience ranging from 1 to 35 years; 44% female, 56% male). Disciplines represented included engineering, chemistry, physics, biological sciences, exercise science, psychology, computer science, medical sciences, and mathematics.

We acknowledge that participants' prior engagement in professional development and voluntary response to recruitment may reflect selection bias toward educators who are already invested in student support work. This self-selection is consistent with Lincoln and Guba's (1985) understanding of the naturalistic inquiry process, where engaged participants who can provide rich, experiential knowledge are actively sought. Additionally, as Tracy (2010) notes, participant self-selection can be valuable in participatory research approaches by creating conditions for "catalytic validity"—where research generates insight, action, and potential change through engagement with participants most invested in the topic. Rather than limiting our findings, this participant selection allowed for deeper exploration of relationship work from those actively practicing it, consistent with the study's community-based participatory approach.

TABLE 1 Participant demographics across institution types (N = 42).

Institution type	Role	Number	Percentage
Rural-serving community colleges	Faculty–natural sciences	16	38
	Faculty–applied sciences	4	10
	Faculty–mathematics	5	12
	Faculty–social sciences	4	10
	Student services staff	6	14
	Administration	1	2
Tribal college	Faculty	1	2
	Administration	1	2
Workforce development non-profit	Administration	2	5
	Rural training and support educators	2	5

Additional demographic characteristics: 44% female, 56% male; experience range 1–35 years. Geographic distribution includes 5 rural community colleges, 1 tribal college, and 2 workforce development organizations. Disciplines represented include engineering, chemistry, physics, biological sciences, exercise science, psychology, computer science, medical sciences, and mathematics. Percentages rounded to nearest whole number. Some participants serve in multiple roles beyond their primary designation.

Data collection procedures

Data collection involved a combination of focus groups and in-depth interviews, each lasting between 60 and 90 min (Krueger and Casey, 2014). Focus groups were conducted in person at each community college campus, with follow-up individual interviews offered via Zoom. Questions were developed to explore participants' roles, work experiences, influences, and challenges, with specific attention to relationship-building practices and transfer support mechanisms. Interview protocols explored participants': (1) roles and work with STEMM students; (2) experiences supporting student transfer; (3) recruitment and admission practices; (4) interactions with administration and policy; (5) practices for building connections across institutional boundaries; (6) networks of support; and (7) strategies for navigating rural contexts. The semi-structured format allowed for exploration of emergent themes while maintaining consistency across participants.

Data analysis process

Data analysis followed van Manen's (1997) hermeneutic phenomenological approach, which involves a dynamic interpretive process moving between parts (individual experiences) and whole (collective meaning). All focus groups and interviews were recorded, transcribed verbatim, and verified for accuracy. Initial analysis involved immersion in the data through repeated readings of transcripts to gain a holistic understanding of participants' experiences. Thematic analysis was then conducted using both holistic and detailed reading approaches. First-cycle coding identified significant statements and key phrases that revealed aspects of the phenomenon. Second-cycle coding clustered these into broader thematic categories representing shared patterns of experience. Throughout analysis, a hermeneutic circle approach was maintained—moving between individual narratives and emerging patterns, testing interpretations against the data, and refining understanding of the essential structures of RTSE experiences. Particular attention was paid to how relationship work manifested across geographic, economic, and demographic dimensions of rural social space.

Trustworthiness strategies

To enhance the trustworthiness of this study, several strategies were employed that align with hermeneutic phenomenological approaches. First, I maintained a detailed audit trail documenting all methodological decisions, analytical processes, and evolving interpretations throughout the research process. This documentation included field notes from each focus group, memos during analysis, and reflective journal entries that tracked the development of interpretations. Throughout data collection and analysis, I engaged in systematic reflexivity by maintaining a

journal documenting my positionality as a researcher with prior experience in rural technical education contexts. This reflexive practice helped me acknowledge and examine how my own experiences, assumptions, and theoretical orientations might influence my interpretations of participants' narratives. As van Manen (1997) suggests, self-awareness is essential in hermeneutic phenomenology, as the researcher becomes an instrument of interpretation.

Prolonged engagement with both the research context and data further strengthened trustworthiness. Having spent seven years in Wyoming's rural community college system prior to this study, I brought contextual understanding that aided interpretation while requiring vigilant attention to assumptions. This engagement continued through multiple readings of transcripts and iterative coding cycles, allowing patterns to emerge organically from the data. Rich, thick description has been incorporated throughout the findings to ground interpretations firmly in participants' own words and experiences. By providing detailed accounts of the contexts, participants' perspectives, and illustrative quotes, I enable readers to evaluate the transferability of findings to their own contexts. This approach aligns with van Manen's (1997) emphasis on presenting lived experiences in ways that resonate with readers' understanding.

Findings: relationship work in rural transfer pathways

Analysis of interviews and focus groups with RTSEs across Wyoming revealed three interconnected themes that shape rural technical education: (1) the integration of geographic, economic, and demographic factors; (2) the need for intersectional support systems; and (3) the central role of relationship-building in student navigation and success. The following sections explore each of these themes in greater depth, highlighting the lived experiences and perspectives of RTSEs working to build sustainable, equitable pathways for rural students pursuing technical STEMM careers.

Navigating geographic-economic-demographic integration

RTSEs consistently described how physical distance, limited industry access, and population diversity create overlapping challenges requiring integrated solutions. The physical isolation of rural institutions impacts both access and cultural connection. As one RTSE noted: "We are a different bio-region...our students are many of which are allied with the Greater Yellowstone Ecosystem by bioregionally or culturally they're more similar in aspects to Bozeman, or different part to Billings, so they look at Laramie as another universe." This cultural and geographic disconnect profoundly impacts students' comfort with transfer pathways. These distance barriers particularly impact specialized programs, as another RTSE noted: "When we had the advising days...students found that to be helpful...getting their introduction to an advisor, and what they would need to do to transfer." The scarcity of local options often means students must choose between living away from home, choosing from expensive for-profit online options, or delaying their postsecondary education.

Resource scarcity compounds these geographic challenges. An RTSE described how isolation limits access to industry connections and experiential learning opportunities comparing to his experience to his previous non-rural appointment: "We had pharmaceutical companies. We had biotechnology companies. And we had medical schools within 10-min drive. These are places where students can go and do an internship...We don't have that here." This lack of proximity to industry partners particularly impacts technical STEMM education, where hands-on experience and local industry are key motivators to STEMM interest and experience necessary for students to be invested in introductory and prerequisite science and math coursework. The effects of geographic isolation extend beyond students to impact faculty experiences as well. Some RTSE faculty cite sabbaticals taken in faraway institutions to remain relevant in the field. Other faculty recount the isolation they feel on their campuses. As one instructor shared: "I almost never leave the science building...I probably know like 10% of the people on campus." Another noted: "I don't find connectivity...I find connectivity in smaller groups like this, where you can really be invested in the perspective of every person at the table. And I don't find that that's something that happens often." This professional isolation can limit opportunities for collaboration and innovation.

Population diversity adds complexity to these geographic and economic challenges. As one Tribal College administrator explained: "We used to have classes here, but it was all under the University of Wyoming...but our tribe and students weren't really benefiting from it because all the money would go back to the institutions, and they wouldn't help with the operational costs or anything like that." The data suggests that successful rural education requires not just overcoming distance barriers, but reimagining how educational services can be delivered effectively within rural contexts while maintaining local control and economic benefit.

Building intersectional support networks

The data revealed how successful rural institutions develop holistic support systems addressing intersecting student needs. Mental health and basic needs emerged as foundational priorities. As one administrator shared, "We formed what we call psychologically informed environment...if the moms feel safe when they're in our space...there's a place where that stuff goes." This emphasis on psychological safety extends beyond the traditional bounds of counseling, encompassing executive functioning and life skills development. In the words of another participant, "When you are struggling with the impacts of poverty, your brain is really impacted...things like emotional regulation and ability to organize and plan...you can't think about that cause you're thinking about food and gas and shelter." These insights reveal the profound impact of poverty on the mental well-being of rural students.

Family support structures emerged as crucial, particularly for parent learners. These issues demand coordinated solutions that recognize their interdependence. As one RTSE observes, "We have

moms that will commute a hundred miles one way to get to the program and they don't have reliable transportation." Another notes the delicate balance of family dynamics: "You might have your family members around you and you might rely on them to provide childcare and then you get in a fight with them and then they won't provide childcare." The financial needs of rural students extend far beyond tuition, with one administrator starkly stating, "Our average mom is at 30% of the federal poverty level...that's like a family size of three—mom and two kids making $500 a month." Navigating this complex web of challenges requires a holistic approach that addresses these needs in harmony.

Yet not all institutions have developed effective strategies to meet this array of support needs. Some RTSEs express frustration with inadequate institutional responses, lamenting, "They're [i.e., the administration] is not going to hold you accountable for it [i.e., mentoring or advising students]. I think that this is only going to get worse for us [i.e., RTSE faculty viewed as 'student-centered']." Others, however, have implemented comprehensive support systems that serve as models of excellence. The specialized non-profit demonstrates a deep understanding of the rural context, proactively engaging students: "We really view it as a conversation, we are trying to give the mom as much information about the training and what the calendar will look like so she can make a plan." These contrasting approaches reflect how institutional priorities and resources can determine the trajectory of student support.

Cultural integration efforts proved vital for student success. Rural institutions demonstrate unique approaches to integrating diverse knowledge systems to serve their communities effectively. One tribal college administrator articulated this integration challenge: "When tribal colleges were created, they figure that our history was just as important as any other history in the world. Then, they started bringing in courses, instructors, and consultants that were knowledgeable about Arapaho culture, Blackfeet culture, and others." This intentional weaving of traditional knowledge with academic content creates richer learning experiences that resonate with local contexts.

Experiential learning models emerge as a key mechanism for knowledge integration. Faculty described success with hands-on approaches: "He does his labs out to these buffalo pastures out there. They go out and follow the buffalo and see how they wallow and stuff like that, and certain seeds get stuck in their fur they transport them." Another instructor noted: "I want them to enjoy it. This is what I'm hoping, you know, better prepare them. Or even if it's not a scientist, maybe they can think a little bit better." These experiential approaches help students connect different knowledge systems while developing practical skills. The data suggests successful rural education requires intentional integration of multiple knowledge systems in ways that honor local contexts while preparing students for broader opportunities.

Relationship-centered navigation practices

RTSEs consistently emphasized how relationship-building enables successful navigation of both academic and technical knowledge systems in rural education. Trust-building practices form the foundation of this work, particularly in bridging different knowledge systems. As one RTSE affirms, "It's really important to us to build a relationship driven organization...the first thing that we do when a student reaches out, it's just listen." This listening-first approach helps educators understand how to connect academic content with students' lived experiences. Another faculty member emphasized making science more accessible: "I want my students to all feel that same way, like the science isn't something those European men do, and something that is this body of knowledge that we all do."

Mentoring approaches extend beyond traditional advising to integrate industry and academic knowledge. One faculty member described: "They are the work that we do...but I feel as though maybe it falls more under like a mentor...you made this connection through being in a class with them where they feel comfortable coming to you and you're advising based off what you know in your career or having helped past students." This mentoring includes helping students see practical applications, as another instructor noted: "Try to get them thinking about why even care about this, how does this matter, how is it important in their lives?"

Network development proves vital for connecting students to industry while maintaining academic rigor. One RTSE described building these connections: "I bring in a ton of guest speakers from the industry. And I find that to be really helpful because it one, provides students with a very basic network that I think they don't tend to think about until they're at what they think is their end point." These industry relationships help students see how academic knowledge translates to career opportunities. The integration of different knowledge systems through relationships extends to family support. One program described their comprehensive approach: "Home visits are also part of that... for us to understand the mom's environment and what are the barriers that maybe we don't hear that also exist in her life...we also do like a mom and kid night." This family-centered approach recognizes that successful knowledge integration must account for students' full life contexts.

RTSEs emphasized how relationship maintenance requires innovative delivery approaches across rural spaces. Mobile and distributed services emerged as a key strategy for overcoming geographic barriers. One RTSE working with the Arapaho Tribe described successful mobile programming: "We took trucks up there. We had instructors go up there. And that was very, very successful. We had a great, great relationship." This mobility extends to flexible scheduling that accommodates complex rural lives. As one faculty member explained: "If somebody work in a part-time job...I'll schedule 'em for drives in the morning...if you know vice versa, they have something going on at home...I try really hard to adjust the drive schedule as much as I can to accommodate whatever they have going on." This flexibility extends to program completion timeframes: "It really goes from being a group focused to being more individual focused. We'll keep working with that mom as long as she needs."

This relationship-centered navigation allows RTSEs to maintain high standards while being responsive to student needs. As one administrator noted: "We're not thinking of the industry training...we're investing in our students. Really our hope is that everyone walks away with that credential. But we're not afraid to go a different route if it's really clear that it's not working."

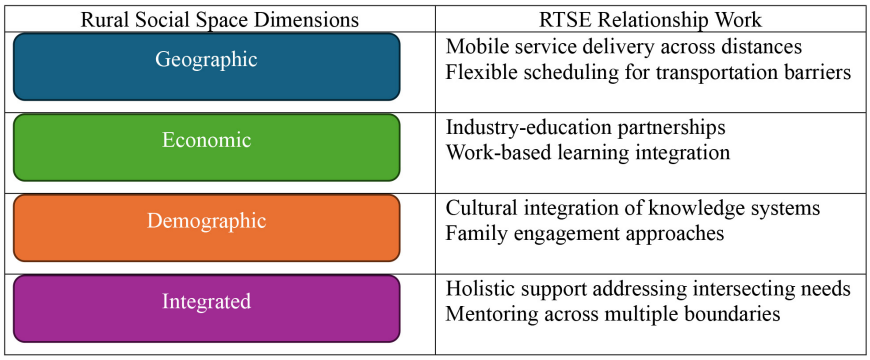

FIGURE 2
Rural social space dimensions and RTSE relationship work.

This flexible yet rigorous approach characterizes successful relationship-building in rural technical education.

Summary of findings: an integrated framework

Analysis of interviews and focus groups with RTSEs across Wyoming revealed how relationship work forms the infrastructure of rural technical STEMM education. Our findings demonstrate how RTSEs operate simultaneously across geographic, economic, and demographic dimensions to help students navigate complex educational landscapes. The data reveals that successful rural STEMM education requires integrated relationship networks that address intersecting barriers while honoring local contexts and knowledge systems.

As shown in Figure 2, the relationship work of RTSEs operates across all dimensions of rural social space, with specific strategies emerging to address unique challenges within each dimension. This integrated framework emerged directly from our analysis of RTSE lived experiences and illustrates how relationship-centered transfer navigation manifests in practice. These findings demonstrate how relationship work forms the core mechanism through which rural technical STEMM education operates. Rather than separate strategies addressing isolated challenges, successful RTSEs engage in an integrated approach that recognizes the interconnected nature of geographic, economic, and demographic factors in rural contexts. This integrated relationship work enables students to develop the navigational capital necessary to traverse educational pathways while maintaining vital connections to their communities and cultures.

Discussion

This community-based assessment reveals RTSEs engage in complex relational work operating simultaneously across geographic, economic, and demographic dimensions to help students traverse educational barriers. Through rural social space theory (Reid et al., 2010) and rural intersectionality theory (Sansone, 2023), our findings demonstrate that successful rural STEMM education emerges through integrated supports addressing both universal challenges while honoring local contexts.

The deeply relational nature of RTSE work extends Corbett's (2009) conceptualization of rural education as inherently boundary-crossing. RTSEs serve as cultural brokers between local knowledge systems and broader academic frameworks, supporting Means et al.'s (2016) findings about bridge-building in rural student success. This study reveals how this bridging work operates simultaneously across multiple dimensions—geographic (addressing physical isolation), economic (connecting to workforce opportunities), and demographic (serving diverse populations).

The findings extend Koricich et al.'s (2022) work on rural-serving institutions by illuminating how RTSEs navigate institutional tensions between maintaining academic standards and responding to local needs. This builds on Stone's (2014, 2017) research by demonstrating how rural contexts demand innovative approaches to combining academic and technical instruction. Our analysis reveals that successful rural technical STEMM education requires "integrated support ecosystems"—coordinated networks addressing mental health, family dynamics, and cultural contexts while building vital technical skills.

Several important limitations contextualize these findings. While our community-based case study approach provided rich insights, the focus on a single rural state system and post-COVID timing limits generalizability. The study's reliance on self-reported experiences could be strengthened through additional data sources, and our timeframe didn't allow for longitudinal tracking of how RTSE experiences shift across academic years. Future research could explore how these integrated support ecosystems manifest in different rural settings and how they can be effectively scaled while maintaining local responsiveness. Longitudinal studies examining student outcomes could help identify which aspects of these support systems most directly impact success.

Implications

The complex relational work of RTSEs reveals critical opportunities for reimagining educational support across institutional, systemic, and policy levels. At the institutional level, these findings recommend supporting integrated support networks that address students' multifaceted needs. Institutions

should revise faculty roles to recognize the expanded relational work of rural educators, creating flexible delivery models that account for geographic and family constraints. This approach requires integrating local knowledge systems and cultural contexts directly into STEMM curriculum, ensuring academic rigor while honoring local experiences.

At the system level, educational frameworks must evolve to support rural technical education. Funding formulas need redesign to account for rural delivery costs, and educational systems should create incentives for industry-education partnerships. Developing shared support networks across institutions can maximize resources and create comprehensive support ecosystems. New assessment frameworks must capture the nuanced ways students navigate educational challenges. State and national policymakers play a crucial role in supporting rural technical STEMM education. Increased funding for programs and infrastructure is essential. Policymakers should develop flexible compliance frameworks that recognize rural educational contexts, support innovative delivery models, and establish clear rural education research priorities.

Conclusion

Like desert flora that develop extensive root systems beneath seemingly barren landscapes, Wyoming's rural STEMM education ecosystem thrives through intricate networks of relationships that connect across vast distances. This study reveals how relationship work forms the living infrastructure of rural technical STEMM education—creating pathways for knowledge to flow between dispersed communities, institutions, and knowledge systems. Key findings demonstrate that successful rural technical STEMM education requires integrated support systems addressing mental health needs, family dynamics, and cultural contexts while building vital technical skills. Rather than viewing rural spaces through a deficit lens, this ecological perspective recognizes how distance and dispersion can foster relational adaptations similar to how desert plants develop unique mechanisms for survival and mutual support. Just as desert ecosystems depend on interconnected root networks invisible to casual observers, rural technical STEMM education relies on relationship capacities often undervalued by traditional metrics and funding models. The path forward requires deliberate investment in relationship-building capacity—creating time, resources, and recognition for the vital connective work RTSEs perform. Institutions must nurture these relationship networks through flexible policies, professional development focused on relationship skills, and assessment frameworks that value connection-building alongside traditional outcomes. By strengthening the relationship infrastructure of rural technical STEMM education, we can better support both the unique adaptations emerging from local contexts and the universal relational elements that connect across rural spaces.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the author, without undue reservation.

Ethics statement

The studies involving humans were approved by the Institutional Review Board for the Protection of Human Subjects, University of Wyoming. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

RM: Writing – original draft, Writing – review and editing.

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Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author declares that Generative AI was used in the creation of this manuscript. The author discloses that no generative artificial intelligence (AI) tools were used in the research, data collection, or primary analysis of this study. In the manuscript preparation phase, Claude 3 (Anthropic) was used for reference checking and reduction of word count. All substantive content, including analysis, interpretations, and conclusions, was authored by the human researcher. The AI contributions were limited to technical manuscript review tasks and were verified by the author.

Publisher's note

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