frontiers | Frontiers in Education

TYPE Original Research
PUBLISHED 17 April 2025
DOI 10.3389/feduc.2025.1569489

OPEN ACCESS

EDITED BY
Hobart Harmon,
Kansas State University, United States

REVIEWED BY
Elaine Westbrook,
Montana State University Billings, Billings, United States
Jayne Downey,
Montana State University, United States

*CORRESPONDENCE
Devan A. Jones
✉ jonesdevan789@gmail.com

RECEIVED 31 January 2025
ACCEPTED 31 March 2025
PUBLISHED 17 April 2025

CITATION
Jones DA (2025) Integrating STEM education in sustained deep rural schools: innovative strategies for multi-grade, multi-subject classrooms.
Front. Educ. 10:1569489.
doi: 10.3389/feduc.2025.1569489

Integrating STEM education in sustained deep rural schools: innovative strategies for multi-grade, multi-subject classrooms

Devan A. Jones*

University of South Carolina, College of Education, Child Development Research Center, Columbia, SC, United States

Sustained Deep Rurality (SDR) represents an extreme form of rurality, characterized by geographic isolation, small school populations, and limited access to resources. Despite these challenges, SDR educators play a crucial role in advancing STEM education in multi-grade, multi-curricular classrooms. This study investigates how SDR K-8 teachers in the Northern Rocky Mountain region implement STEM education amid constraints such as professional isolation, limited funding, and diverse student needs. Using narrative interviews and small story analysis, the research identifies three key strategies: (1) Planning for Multiple Grades and Subjects, (2) Multi-Subject Connections and there Contribution to Integrating STEM in SDR classrooms, and (3) Necessity and Utilization of Local Resources. Findings reveal that SDR educators employ innovative, place-based STEM methodologies, incorporating local ecosystems, agriculture, and industry to create relevant and engaging learning experiences. This study highlights the resilience and ingenuity of SDR teachers, offering insights into how STEM education can be effectively adapted for the most remote and underserved students, ultimately promoting educational equity in extreme rural contexts.

KEYWORDS

sustained deep rural, science, technology, engineering, and mathematics (STEM), rural, qualitative, narrative

Introduction

Amid vast prairies where open skies meet rolling fields, education, and innovation form a unique narrative. In rural communities, a vital, distinctive facet of the global educational landscape unfolds, rooted in tradition and a close relationship with nature. These communities embody a way of life deeply rooted in tradition and a profound connection to the natural world, shaping unique educational challenges and opportunities (Keller and Owens, 2020).

This study sought to explore the experiences of SDR multigrade, multi-subject K-8 teachers in the Northern Rocky Mountain region of the U.S. as they incorporated STEM pedagogies into their teaching practices. Through narrative interviews and small story analysis, the study aimed to answer a key question: *What experiences do SDR teachers in multigrade, multi-subject classrooms report influencing their integration of STEM education?* By highlighting their voices, the study sought to deepen the understanding of education in extremely rural areas and offer insights to advancing rural STEM education and promote educational equity.

Sustained deep rurality (SDR)

Rurality is not just a physical location; it is a concept that shapes identity and worldview, influencing how individuals think, learn, and engage with knowledge. It goes well beyond mere geography. As Tieken (2014) argues, rurality is more than just a place; it is intertwined with an individual's identity and profoundly impacts their perspectives. Building on this notion, Crumb et al. (2023) emphasized the rich diversity within rural communities. From Indigenous and migrant farming populations to families with deep generational ties to the land, "rural" encompasses many cultural experiences. This broader understanding of rurality reinforces the value of community-based approaches to education that honor and build upon these diverse locations and perspectives.

Despite the push to acknowledge that rurality extends beyond geography, numerous studies tend to adhere to the definitions provided by the National Center for Education Statistics (NCES) (Thier et al., 2021), or various governmental bodies when discussing rural areas (Gashi Nulleshi and Tillmar, 2022). These governmental entities often present differing perspectives on what constitutes rurality in their publicly accessible resources. Unfortunately, the prevailing notion tends to characterize rurality simply as the antithesis of urban living, a perspective that can be problematic as it casts rural areas in a negative light (Hartman et al., 2022), or merely based on distance from urban areas. The lack of a unified definition within the U.S. government, particularly regarding extremely rural areas, further complicates efforts to represent rural experiences accurately (Salemink et al., 2017).

For example, the NCES (2023) defines a Rural-Remote locale as an area more than 25 miles from an Urbanized Area and over 10 miles from an Urban Cluster. However, this classification does not account for the vast differences between a community just outside this threshold, and one located 50 or 75 miles away. When considering areas of extreme rurality, there are often no definitions beyond the categories and descriptors of "Rural-Remote," which in turn limits the acknowledgment of extremely rural areas on the rural spectrum.

Many rural organizations have attempted to address the limitations of traditional definitions of extreme rural areas by introducing the term "frontier." Among these organizations, the Montana Small Schools Alliance (MSSA) and the National Rural Health Association (NRHA) have worked to redefine these areas as "frontier" schools, emphasizing their unique challenges (Harmon and Morton, 2010; Wilger, 2016). In Montana, a frontier school is defined as a school district with 200 or fewer students, situated in a county with a population density of five or fewer people per square mile. This definition was originally established to meet federal requirements for allocating funds under the Small, Rural School Achievement Program (Harmon and Morton, 2010), not for accurate representation of extreme rural areas.

The NRHA, on the other hand, uses the term "frontier" to describe a segment of the population along a rural continuum, with frontier areas representing the most remote locations. In some states, the term is even equated with wilderness designations (Wilger, 2016). However, despite these efforts to define rural and frontier areas, these classifications fail to consider the deep-rooted cultural values, traditions, and historical influences that shape these communities.

The colloquially adopted definition of frontier originated from Frederick Jackson Turner's thesis on American Frontierism (1894). European colonizers have historically used it to depict aspects of American settlement as they expanded into remote territories (Turner, 1893; Prescott, 1978). However, it is essential to understand the term's etymology, which connotes "borderland" or the region of a country that fronts on another country, disregarding the presence and significance of indigenous peoples as the original custodians of the land.

Therefore, for this discussion, the author chose to refrain from using this definition due to its oversight of indigenous perspectives and introduce the term Sustained Deep Rurality (SDR). Sustained Deep Rural (SDR) areas are highly remote and geographically challenging locales that are smaller and more isolated than typical Rural-Remote regions. The remoteness of SDR areas is not solely defined by distance from larger population centers but also by the difficulty of access. Due to their isolation, SDR areas often maintain strong cultural values and traditions, with residents maintaining a deep connection to their environment and self-sufficient lifestyles, setting them apart from conventional rural classifications.

Moving beyond the general label of "Rural-Remote" is essential for these extremely rural areas, as Slama (2004) noted that "residents in rural America fall on a spectrum in terms of their alignment with mainstream culture and their commitment to rural values" (p. 9). SDR regions are significant for their distinct lifestyles rooted in traditional values. Understanding rurality requires examining the unique traits of each region (Harmon and Morton, 2010), for example, the sparsely populated Mountain West contrasts sharply with North Dakota's open plains and the mountainous areas of Appalachia. These differences in landscape, economy, and culture help uniquely situate SDR areas within the broader rural spectrum.

Using inclusive and culturally respectful language when discussing diverse rural areas demonstrates an appreciation for the unique identities and experiences of each community, which reflect a broad spectrum of ethnic, racial, and cultural backgrounds. This study examined school sites within Sustained Deep Rurality (SDR) locales, where the terms "sustained" and "deep" were intentionally chosen to emphasize the cultural dimensions of rurality.

The descriptor 'sustained' encompasses the enduring sustainability of individuals, multi-generational families, and community members residing within that geographical area. This sustainability extends to the educators within these communities who strive to preserve and impart the rural way of life to successive cohorts. "Education is seen as a vehicle for supporting sustainability in rural and regional contexts, with research indicating that sustainable community development requires a depth of human, social, cultural and economic capital" (Van Rensburg et al., 2015, p. 15).

Additionally, the definition of SDR draws inspiration from the metaphorical expression "roots run deep," which is associated with extremely rural communities. This phrase symbolizes a profound connection, attachment, and reverence for one's heritage, traditions, and geographic origins. It evokes a profound sense of belonging, historical consciousness, and cultural identity that has been deeply ingrained and passed down through successive generations. It signifies the enduring and intrinsic ties that bind rural communities to their land, history, and shared values.

Finally, it was important to go beyond the typical notions of "Rural-Remote" because the targeted communities in this study are so remote they often occupy one-room, multi-subject, multigrade school houses. Philip et al. (2017) speak specifically to a 'deep rural' versus

'shallow rural' divide. In this article, they spoke about the vast divide between various types of ruralites and urban settings. This study reinforces the concept of SDR areas extending beyond educational settings and into other rural avenues.

National studies often overlook Sustained Deep Rural (SDR) schools, perceiving them as remnants of the "one-room" or "country" school (Harmon and Morton, 2010). However, these schools play a vital role in education. According to the U.S. Department of Education's Common Core data, 662 K-12 public schools enroll 100 or fewer students each, collectively educating hundreds and employing over 3,300 teachers (U.S. Department of Education, National Center for Education Statistics, Common Core of Data, 2023). These figures underscore the significant yet often unnoticed contributions of SDR schools.

A common characteristic of SDR schools is the prevalence of multigrade classrooms, where a single teacher instructs students across multiple grade levels and curricula in one room (İlter, 2015). The term "multi-subject" indicates that educators are responsible for implementing different subject areas across all grade levels rather than focusing on just one. This creates unique teaching environments where teachers must be resourceful and creative when teaching all subjects, curricula, and grade-level standards throughout the school year.

Since these educators teach multiple grade levels and subject areas, obtaining precise data on the number of such classrooms is challenging, as the classroom composition shifts yearly based on enrollment, and teachers often report grade levels separately. Due to limited recent U.S. research on multigrade teaching, this study incorporated insights from earlier domestic scholars and international sources.

Integrative STEM education

Within the context of Sustained Deep Rural (SDR) K-8 teachers in extremely rural, multigrade, multi-subject schools in the Northern Rocky Mountain region, integrative STEM education serves as a powerful tool that connects students' lived experiences with broader opportunities. For this study, integrative STEM education is defined as,

> the application of technological/engineering design-based pedagogical approaches to intentionally teach content and practices of science and mathematics education through the content and practices of technology/engineering education. Integrative STEM education is equally applicable at the natural intersections of learning within the continuum of content areas, educational environments, and academic levels (Wells, 2016).

By adopting an integrative STEM education approach that unites multiple disciplines, educators can cultivate essential cognitive skills such as deductive reasoning, logical inquiry, solution-oriented thinking, and innovative problem-solving (Larraz-Rábanos, 2021). This aligns with the Next Generation Science Standards (NGSS) principles, which emphasize the blending of disciplines to effectively address complex, real-world problems. Recognizing the interconnected role of science, technology, engineering, and mathematics within STEM education is crucial for promoting holistic problem-solving and interdisciplinary learning (Kaldaras et al., 2021).

Integrative STEM education in SDR areas

Integrative STEM education fosters critical thinking, problem-solving, and adaptability, aligning with rural communities' unique cultural and cognitive traits. More than just a tool for academic success, it bridges local identity with the demands of a modern, interconnected workforce (Starrett et al., 2022). This connection is particularly important in rural areas, where STEM education can drive economic growth and innovation (Bacovic et al., 2022).

However, rural communities often face significant disparities in STEM educational opportunities and outcomes (Avery, 2013; Ebenezer et al., 2018). To address this, some rural educators actively blend learning with community engagement. Educators collaborate with local professionals, engineers, and scientists to provide students with hands-on experiences and real-world applications of STEM (Margot and Kettler, 2019). Doing so reinforces the idea that STEM is not just an abstract concept found in textbooks but an integral part of rural life and livelihood (Harris and Hodges, 2018).

However, despite these efforts, rural educators often face unique challenges when integrating STEM, such as limited funding, geographic isolation, and a lack of professional collaboration, which make reflection and innovation more difficult (Gardner et al., 2019; Curran and Kitchin, 2021). Despite these "rural school problems" (Biddle and Azano, 2016), schools can demonstrate flexibility and responsiveness in STEM decision-making (Preston, 2021). Establishing interdisciplinary learning ecosystems and forming strategic partnerships can help rural communities build resilience and expand informal STEM learning opportunities (Hartman et al., 2017). Furthermore, despite geographic limitations, rural educators consistently find creative ways to deliver high-quality STEM education by leveraging alternative resources and strategies (Masinire, 2015).

Rural settings are ripe for integrative STEM education due to their cultural, environmental, and socio-economic traits (Qiao and Zhou, 2020). Rural students contribute their own real-life experiences to STEM education. Recognizing and preserving these unique rural life experiences is vital for successful integration. As Avery and Kassam (2011) highlight, rural students benefit from perceiving the relevance of science in their daily lives. Lessons that establish connections between STEM education and students' everyday experiences enhance their understanding and success in science (Kennedy and Odell, 2014).

Building on this idea, integrative STEM education not only strengthens these real-world connections but also provides additional benefits, such as increased student motivation, interdisciplinary learning, and greater community involvement (Darling-Hammond et al., 2020). By emphasizing real-world connections within local contexts and cultural sensitivity, these approaches empower students to contribute meaningfully to their communities (De Mars et al., 2022).

Furthermore, integrative STEM has the potential to address societal challenges like economic booms and busts often faced in rural areas (Harris and Hodges, 2018). Rural schools play a vital role in their communities, making them an ideal setting for integrative STEM programs. When these programs align with the local community, they foster sustained engagement that reflects rural characteristics. Recognizing the diversity within rural communities, educators must incorporate culturally relevant content and consider local knowledge systems when designing relevant projects (Qiao and Zhou, 2020). By involving community members, students gain a deeper understanding

of their environment and community needs (Margot and Kettler, 2019).

This collaborative approach strengthens community ties, validates students' cultural backgrounds, instills a sense of civic responsibility, and empowers students to contribute meaningfully to their local contexts (Bernsen et al., 2022). Further, this approach allows students to engage with real rural issues requiring knowledge and skills from various fields, enabling them to comprehensively grasp interconnected concepts within a rural context (Bernsen et al., 2022). Such interdisciplinary education boosts academic achievement and equips students with the adaptability to tackle complex challenges from multiple angles, fostering critical thinking and problem-solving abilities (Razi and Zhou, 2022).

Teachers in SDR areas often confront substantial barriers that limit access to essential resources, including quality educational opportunities. To bridge these gaps, one might consider how the implementation of integrative STEM education in SDR areas not only addresses educational disparities but also taps into the unique cultural and cognitive frameworks shaped by rurality.

Methods

This study sought to explore the experiences of SDR multigrade, multi-subject K-8 teachers in the Northern Rocky Mountain region of the U.S. as they incorporated STEM pedagogies into their teaching practices. Through narrative interviews (Mueller, 2019) with educators and small-story narrative analysis (Georgakopoulou, 2013) of their stories, the research aimed to uncover valuable insights into the strategies rural teachers used when implementing STEM integration. By examining how these educators addressed known barriers such as resource limitations, limited support structures, and time constraints, the study revealed experiences and strategies that may help other teachers in similar rural settings support STEM instruction.

Narrative inquiry design

This study utilized a narrative inquiry approach, which is defined as "the process of listening to, honoring, constructing, and reconstructing stories about the depth and breadth of human experience" (Mueller, 2019, p. 3). Narratives are a key way humans make sense of their experiences (Jonassen and Hernandez-Serrano, 2002), with stories typically representing human attempts to find clarity or closure (Polkinghorne, 1995). A key feature of narrative research is giving storytellers agency, contributing to social justice by amplifying marginalized voices (Lathrop et al., 2022).

Conducting narrative research requires careful listening and interpretation of participants' experiences (Behar, 1996), with a single thoughtful question allowing for an uninterrupted flow of storytelling (Mas-Alcolea and Torres-Purroy, 2021). Researchers analyze aspects like language and emotions to gain deeper insights (Fenton and Langley, 2011) while protecting the integrity of the storyteller's original intent (Josselson, 2011).

Pioneers in educational narrative research, Connelly and Clandinin (1987, 1988, 1990), argue that humans are "storytelling organisms" and that studying narratives helps us understand how people experience the world. In education, narrative research transforms personal and societal narratives, positioning teachers, learners, and researchers as both storytellers and characters (Connelly and Clandinin, 1990). This makes narrative research especially useful for exploring the experiences of Sustained Deep Rural (SDR) STEM educators, as it captured the nuances of their challenges and contributions (Riessman, 2008) and offered insights into their motivations, philosophies, and resiliency factors (Gallo, 2020; Clandinin et al., 2007; McCormack et al., 2016). Furthermore, it empowered SDR STEM educators by giving them a platform to voice their often-overlooked perspectives (Nordin et al., 2023).

Limitations of narrative inquiry

Researchers must consider the limitations of narrative inquiry. One primary limitation is the lack of control researchers have over interviews. Instead of steering conversations toward specific topics, the direction is shaped by participants' emphasis (Gerber et al., 2020), leading to inconsistencies and difficulty in ensuring standardized data collection (Waters et al., 2018).

Another challenge in narrative inquiry is its inherent subjectivity, as both researchers and participants bring personal perspectives that may shape the findings. To mitigate this, researchers must engage in reflexive practices to acknowledge and communicate their biases (Peshkin, 1988, 1991; Teo, 2008; Sutton and Austin, 2015). Compounding this limitation, the "Hawthorne Effect" can further influence results by prompting participants to alter their behavior when they are aware of being observed, potentially distorting the authenticity of their narratives (McCambridge et al., 2014; Campbell et al., 1995; Oswald et al., 2014). Nevertheless, despite these challenges, narrative research remains a powerful tool for capturing rich, nuanced experiences and deepening understanding of individual stories and broader social phenomena (Gudmundsdottir, 2001; Wolgemuth and Agosto, 2019).

Setting/recruitment

This study focused on K-8 teachers in multigrade, multi-subject settings in the Northern Rocky Mountain region of the U.S., specifically in SDR areas, who were actively implementing STEM pedagogies. The states that were selected were Wyoming, Montana, Idaho and Colorado. The researcher selected the Northern Rocky Mountain region due to the cultural, geographical, and economic similarities. The Rocky Mountain region itself often includes Nevada, Utah, and New Mexico in the definition. However, the researchers excluded those states from the study because they differed vastly in cultural, geographical, and economic identities.

The study focused on school district data collected from the National Center for Educational Statistics (NCES) for the 2022–2023 academic year, prioritizing schools in Colorado, Idaho, Montana, and Wyoming with 50 or fewer students and ten or fewer teachers, aligning with the current SDR demographic.

Thirty-eight schools met the desired demographic criteria. After identifying these priority schools, the researcher conducted further investigation on each one to verify its operational status and gather contact information for all teachers. The researcher contacted 94 teachers, asking for their participation in the research project. Eight individuals responded to these outreach efforts. Among them, two declined to participate, and one response came from a principal,

explaining that although the school was still active, it had closed temporarily that year due to a lack of enrollment. Of the three participants who declined, each shared contact information for potential participants. However, despite efforts to reach out, none of the referred contacts chose to participate in the study.

The researcher recruited two additional participants during the 2023 National Rural Education Association (NREA) conference. The researcher recruited the remaining three participants through personal connections to other individuals already participating in the study. It is worth mentioning that the two participants recruited through personal connections did not initially meet the specific criteria regarding the number of students and teachers in their schools. Nevertheless, they were deemed eligible to participate since they met the study's overall criteria.

The researcher reviewed school websites to confirm that participants were implementing STEM, even though no specific STEM framework was required. Evidence of integrative STEM education was collected from participants using various online accessible resources, including artifacts such as program outlines, initiatives, and STEM-related partnerships. Additionally, images, videos, and other materials highlighted student engagement in hands-on experiments, project-based learning, and technology integration.

Participants were not intentionally required to adhere to a specific integrative STEM education framework. This allowed educators to remain open to how they personally interpreted "STEM education" and applied it to their unique teaching environments. Given the diverse interpretations and approaches to STEM education, no restrictive definition was imposed on teachers. Since precisely defining STEM education would not contribute to addressing the research question, it was deemed unnecessary as long as its presence was evident.

Upon completion of the study, teachers received a $100 Amazon gift card as an expression of gratitude. Interviews were scheduled between February 10th through February 28th, 2024, and considered teachers' professional and personal schedules. No consent form was needed because this study was exempt. Verbal consent was obtained before each interview and documented in the recorded audio.

Participants

The selected participants spanned four states, ranging from the Great Prairie region to the tops of the Rocky Mountains. Participants were not excluded based on age, gender, race, level of education, or religion. Participants were asked to choose pseudonyms to obtain a "nuanced form of anonymity" (Miyazoe and Anderson, 2011, p. 184).

With 10 participants in the study, the appropriateness of the sample size for qualitative research was considered. However, Chase (2005) suggests that using narrative design, a qualitative method centered on personal stories, naturally limits the scope of research. Bryman (2012) argues that a broader qualitative study generally requires more interviews. Ultimately, 10 participants was an adequate number for this narrower study, and ensured a robust selection for in-depth qualitative research with a broad spectrum of viewpoints.

For the study, participants had to meet the inclusion criteria:

- Must currently be a K-8 public school teacher in a multigrade, multi-subject classroom.
- Must be teaching in a rural-remote area as defined by the NCES and in the Northern Rocky Mountain area.
- Must be implementing STEM pedagogies.

The participants in this study were a diverse group of ten educators, each with different levels of experience, who worked in schools across Idaho, Colorado, Montana, and Wyoming. With 11 years of experience, Angela Tuga taught 2nd and 3rd graders in Idaho. Her school was nestled in snow-dusted hills, surrounded by windy roads and cows grazing near the playground.

Participants in Montana where Antoinette, with 12 years of experience, taught 4th-8th graders, and Lucy, in her second year, taught K-3rd grade subjects in an unincorporated area. Their school, located in a tree-lined basin, had buffalo roaming peacefully just beyond the recess fence.

Sidney, located in Montana, brought 8 years of experience to her role teaching K-8 students. Her school was the most remote Sustained Deep Rural area visited. The window offered a wide view of the sun kissed golden prairie, outstretched in all directions. The students played outside alongside a herd of antelope that meandered through the playground, and even with being the only adult on sight, Sidney cherished the unique setting where she taught.

In Colorado, Mrs. G, a seasoned educator with 37 years of experience, taught 2nd and 3rd graders. Her deep love for her school and students was evident as she shared stories of the "old" schoolhouse, which boosted having a bowling alley on the second floor.

GiGi, also located in Colorado and with 16 years of experience, taught 3rd-5th grades, while Tennille, in her second year of teaching, covered K-2 subjects. Their school sat at the top of a steep, winding dirt road, making it the hardest to reach. Despite being close to a metropolitan area, the terrain made access extremely challenging. Proud of its 150-year history, the school still used the original one-room schoolhouse building today.

In Wyoming, Brooklyn, with 11 years of teaching experience, taught all K-5 subject areas. Her school was at the base of a mountain and surrounded by a large fence. She smiled when asked about the fence and explained, "It keeps the bears out."

While Elizabeth, with 16 years of experience in another Wyoming school, taught math, science, and STEM to 5th-8th graders at a PreK-12 school. She spoke about how she enjoyed sharing such a close community atmosphere with all the students in her town.

In addition, Jackie, with 16 years of experience, taught 2nd and 3rd graders also at a PreK-12 school in Wyoming, which was being rebuilt at the heart of town. She explained that the school was placed there "for just that purpose. It was at the heart."

These educators work in schools of varying sizes and locations, each offering a unique educational environment shaped by its geographical and community context across Idaho, Colorado, Montana, and Wyoming.

Refer to Figure 1 for the complete Participant Recruitment Flow Chart.

Tables 1–3 detail the demographics of the selected participants.

Data collection

Data was collected using an unstructured narrative interviewing format. These interviews are designed to be an open and conversational exploration of individuals' experiences, thoughts, and emotions (Jovchelovitch and Bauer, 2000). For several reasons, narrative research can be valuable for researching rural STEM (Science, Technology, Engineering, and Mathematics) educators. Rural STEM

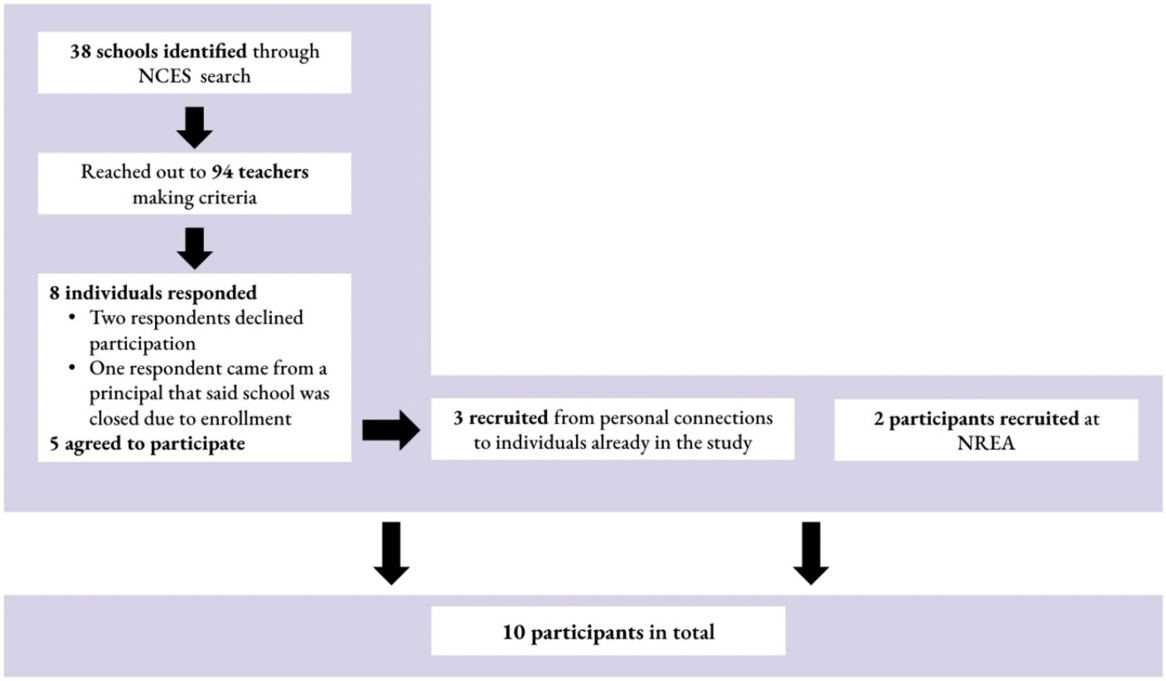

FIGURE 1
Participant recruitment flow chart.

TABLE 1 Participant personal demographic.

Pseudonym	Years in education	Grades taught/Subject area(s)
Angela Tuga	11 years	2nd and 3rd all subject areas
Tennille	2 years	K-2 all subject areas
Antoinette	12 years	4th-8th grade all subject areas
Sidney	8 years	K-8 all subject areas
Mrs. G	37 years	2nd and 3rd all subject areas
GiGi	16 years	3rd – 5th all subject areas
Brooklyn	11 years	K-5 all subject areas
Elizabeth	16 years	5th-8th grade, math, science, STEM
Jackie	16 years	2nd and 3rd all subject areas
Lucy	2 years	K-3rd all subject areas

TABLE 2 Participant school demographic.

Pseudonym	# of students	# of students in building	# of teachers in building
Angela Tuga	13	47	3
Tennille	2	11	2
Antoinette	9	13	2
Sidney	5	5	1
Mrs. G	6	33	9
GiGi	9	11	2
Brooklyn	13	20	2
Elizabeth	43	98	21
Jackie	10	101	15
Lucy	4	13	2

Two of the schools exceed ten teachers due to their K-12 structure. However, ten or fewer teachers taught grades K-8.

educators often encounter unique challenges and opportunities that quantitative methods alone cannot fully capture. Narrative research allows one to delve deeply into teacher experiences (Riessman, 2008), contextualizing how they navigate these challenges and contribute to STEM education in rural areas.

This approach allows educators to share their personal stories, experiences, and insights (Gallo, 2020). Understanding their narratives can provide valuable insights into teacher motivations, teaching philosophies, and the resiliency factors driving their commitment to STEM education in rural settings (Clandinin et al., 2007; McCormack et al., 2016).

Throughout the interviews, the researcher asked probes (Rubin and Rubin, 2005) such as, "Can you tell me more about…?," "How did you decide…?" and "How did you determine…?" These questions encourage deeper reflection and clarify without veering off-topic (Gorden, 1987; Russell, 2013). The researcher conducted all interviews in person to preserve the intimate nature of narrative inquiry. This method was preferred over remote options like Zoom to maintain a deep personal connection with each participant. No strict time limit was imposed on participants during the interviews, allowing them the freedom to speak openly and explore topics in depth, even if it meant diverging from the main discussion. This approach, using narrative interviews, facilitated an organic exploration where participants could authentically express their experiences and perspectives openly.

One of the key aspects of narrative interviews is the absence of interruptions or redirections (Jovchelovitch and Bauer, 2000). This

TABLE 3 Participant school location demographic.

Pseudonym	State	Population of town	Distance from nearest urbanized area according to NCES definition
Angela Tuga	Idaho	617	38.7 miles
Tennille	Colorado	249	11.1 miles
Antoinette	Montana	Unincorporated	31.5 miles
Sidney	Montana	106	19.8 miles
Mrs. G	Colorado	54	43.7 miles
GiGi	Colorado	249	11.1 miles
Brooklyn	Wyoming	300	31.7 miles
Elizabeth	Wyoming	272	46.5 miles
Jackie	Wyoming	254	26.3 miles
Lucy	Montana	Unincorporated	31.5 miles

An urbanized area is defined as a territory with a population of 2,500–50,000 people.

lack of structure encourages participants to share their stories in their own words and at their own pace. This allows them to delve into personal truths and reflections without external influence. On average, each interview lasted approximately 90 min before naturally coming to a conclusion, often marked by a reflective coda where participants summarized their thoughts or feelings on the topic discussed (Jovchelovitch and Bauer, 2000). This timeframe provided ample opportunity for participants to articulate complex narratives and share meaningful insights based on their experiences.

Data analysis

As outlined in Figure 2, interviews were transcribed using Otter.ai and manually refined for clarity (Burnard, 1991). Field notes were also incorporated to capture participant reactions, such as laughter or discomfort, providing additional context. Cleaned transcripts were returned to participants for member checking, following Guba and Lincoln's (1989) protocol.

Once approved, open coding (Glaser and Strauss, 1967) was applied to identify excerpts aligning with predetermined codes: small story, rural perspective, STEM, science, resources, and community. These codes were developed by prioritizing recurring key spoken concepts and drawing from earlier research sections. The researcher then employed small story analysis (Bamberg and Georgakopoulou, 2008), a method used to explore how individuals use storytelling in their daily lives to view individual perspectives, social interactions, and cultural contexts. This approach was particularly relevant to understanding the experiences of SDR STEM educators, with the goal of identifying effective strategies and concepts to enhance STEM education.

Small stories

As distinct from larger stories, small stories highlight smaller life episodes that may seem trivial but contribute to the overall narrative (Georgakopoulou, 2006). For example, a large story about moving to a new state includes smaller stories like finding a home or packing belongings. These small stories are essential in shaping the larger narrative, offering important details about a person's life. In this research, the small story analysis approach allowed the researcher to look beyond broader topics like 'rural education' or 'STEM education' and examine the individual actions that enable STEM teaching in SDR settings.

Small stories encompass three key levels of analysis—ways of telling, sites, and tellers—which form the autobiographical foundation of narratives (Georgakopoulou, 2006). These levels are vital in this study, revealing intertextual links highlighting commonalities, pluralities, and differences (Georgakopoulou, 2006). This analysis offered valuable insights into the research topic's complexities (De Fina and Georgakopoulou, 2019).

"Ways of Telling" focuses on how stories are communicated and shaped by sociocultural factors and language choices, including recurring patterns, plot structures, and roles (Bamberg and Georgakopoulou, 2008; Georgakopoulou, 2013). Whereas "Sites" refers to the social spaces where stories occur, influencing language and interactions (Blommaert et al., 2005), and examining these sites helps explore how social contexts shape narratives. "Tellers" are the individuals sharing their stories, with their roles influenced by personal, social, and cultural identities (Georgakopoulou, 2006). Understanding tellers' identities is crucial for analyzing small stories and their connection to identity. Focusing on tellers reveals their perspectives, voices, and the social and cultural contexts influencing their narratives (Georgakopoulou, 2006).

Small Story analysis provides a deeper understanding of the story dynamics and the context (Maynard, 2021). Analyzing small stories uncovers patterns and themes that contribute to theoretical frameworks in future qualitative research (Bleakley, 2005).

Subjectivity

The researcher's interest in this topic stems from personal experience as an educator within this specialized group, having developed and implemented STEM-based lessons designed for multigrade, multi-subject, SDR settings. Their perspective on education was shaped by their upbringing in the Northern Rocky Mountain area, within a family that strongly emphasized learning and the value of quality education, particularly for rural minority students. Experiencing limited access to advanced educational opportunities further reinforced a commitment to expanding learning prospects in rural areas.

Acknowledging potential biases, the researcher approached this study with an awareness of how personal background and cultural influences may shape interpretations. By acknowledging their own subjectivity, they were able to approach participants' experiences with sensitivity and empathy, building trust and ensuring accurate representation of their perspectives.

While shared experiences with the study's participants provided valuable insight, maintaining an awareness of these influences helped ensure a balanced and objective research approach.

Results

This section explored the experiences of Sustained Deep Rural (SDR) multigrade, multi-subject K-8 teachers in the Northern Rocky

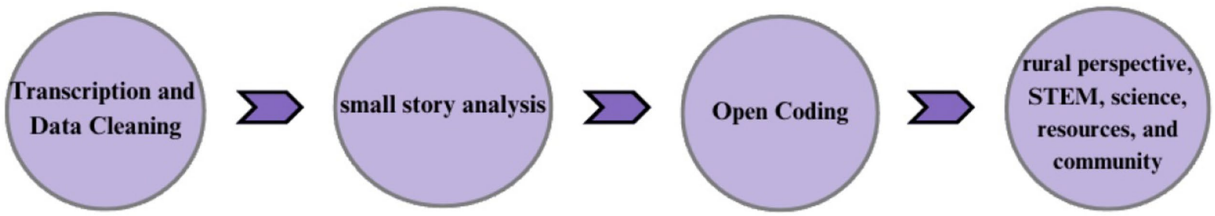

FIGURE 2
Qualitative analysis procedure.

Mountain area, focusing on various factors that influenced their integration of STEM (Science, Technology, Engineering, and Mathematics) education in the classroom. These teachers developed and implemented comprehensive plans to effectively manage the challenges of teaching multiple grades and subjects simultaneously. They employed cross-subject integration techniques to blend STEM concepts with other disciplines, creating a cohesive and interconnected learning experience. Additionally, they identified and incorporated a range of materials and digital resources to enrich the learning environment, ensuring that students received a high-quality STEM education.

Planning for multiple grades and subjects

> *One of the great things about teaching rural, it's small. Teaching this type of student and student group, you can do so much more—Angela Tuga.*

The first finding related to what impacts teachers' STEM instruction was that they must consider how to teach multiple grade levels and curricula within the same classroom. Across the participants in this study, educators skillfully showcased their capacity to tackle various challenges and obligations related to managing multiple grade and subject levels within the same classroom. Although they may not have spoken directly about the connection between these considerations and teaching STEM, it became clear that considering these multiple needs influenced all their teaching.

Brooklyn explained that integrating subjects by grade level simplified her teaching in an SDR school. She finds it more manageable to cover subjects collectively, stating, "*Integrating subjects is a lot easier out here… it just makes things so much easier when you can.*" For science, she selects one grade's standards each year, rotating them over time: "*I just pick one grade of science standards… Last year, we did fourth grade; this year, we are doing fifth.*" This approach helps her balance multiple grade levels despite limited support, ensuring all core subjects are covered efficiently.

Tennille emphasizes the challenge of managing multiple grade levels in a multi-age classroom, explaining that scripted curricula designed for single grades are impractical: "*One of the key factors in a multi-age classroom is not to teach one-grade level curriculum because you have three different grades.*" She describes the district's push for structured programs, which work well for single-grade teachers but not for her situation: "*In a multi-age classroom, I cannot teach three different scripted reading programs.*" Instead, she adapts by pulling apart curricula and balancing whole-group and small-group instruction to meet students' diverse needs.

Antoinette shared how she learned to navigate teaching in an SDR school by observing an experienced multigrade teacher. She adopted the strategy of selecting a science content area and differentiating instruction: "*I had to pick a content area in science and differentiate the content to meet the different levels of learning.*" However, she did stress that she must teach students at their specific grade levels in math, and how she manages this multi-grade level instruction was through rotations. "*One of the students or several students come to your teaching table while the others do independent math… Then you rotate until each student gets a lesson with you.*" She acknowledges the challenge of balancing attention among students but strives to keep everyone engaged with meaningful tasks.

Jackie explained how she navigates teaching a multigrade classroom by integrating subjects where possible and rotating standards yearly, "*So many times you can integrate, and with me I just flip-flop the standards every year.*" She dismisses concerns about students missing certain topics if they transfer schools, believing foundational concepts will be reinforced later in a students education. However, in alignment with Antoinette's views, she also sees math as more rigid and manages it through small group rotations: "*I have groups of kids… one is eight lessons ahead, another in the middle, and one that takes two days per lesson.*"

Lucy reflected on the challenges of teaching multiple grades and how mentorship helped her adapt. Initially overwhelmed, she sought guidance from a veteran SDR educator. "*I got to sit in this classroom and just see how she structured everything… and I just thought, yeah, I could do that.*" However, balancing multiple curricula felt daunting once in the role, "*Then you get in here, and you have the four different curriculum books… it's just intimidating and scary.*" A co-teacher helped her prioritize essential content, distinguishing "*need to know*" from "*nice to know.*" She now manages her classroom through structured rotations, balancing direct instruction, independent work, and learning apps to accommodate different age groups. The majority of the collected narratives verbalized this type of classroom rotation method, which played a significant role in how STEM education was taught.

Although teachers may have general strategies for how to teach in an SDR school, Antoinette describes how her teaching approach shifts each year based on her student numbers and grade levels. Her first year was extremely unique and especially challenging, "*I had one student the whole year… It was the toughest thing I ever did in teaching.*" As her class continued to expand the next few years, she struggled to meet everyone's needs, "*Even though it's only three kids, there's not much I can teach them together. They are all at such different levels. I have to get creative sometimes.*" She felt overwhelmed by her third year, with eight students across several different grade levels, "*I do not know how to do this. I do not know how to meet everybody's needs.*" Recognizing the difficulty, the school hired a part-time teacher to assist with ELA, allowing Antoinette to focus on math.

However, she still managed science and technology alone in the afternoons.

Gigi however, immediately embraced the diverse needs of her multigrade classroom as an opportunity to create engaging, experiential learning experiences. She emphasizes hands-on, immersive teaching, "*I feel like what we are best at is this crafting of experiences for our kids.*" She transforms lessons into interactive activities, such as setting up a "*mountain man camp*" in the classroom with furs and rock pillows to bring history to life. Her integrative approach extends across different subjects, and incorporates theater and music, "*We put on plays about what's happening in social studies and science… we have songs about the branches of government.*" This creative, student-centered approach fosters excitement and deep learning for all grade levels in her classroom.

Sidney took a different approach with her students and prioritized fostering independence in her multigrade classroom by using rubrics to guide students' work, "*I give them a rubric and say these are the things that it needs to have, but they can do it any way they want.*" She has adapted her approach over the years to accommodate diverse grade levels and curricula, finding rubrics the most effective tool. Encouraging student autonomy is essential in her classroom, as she explains, "*It's important that they are able to be independent… because I may not always be available if I'm working with another grade at that time.*" This approach empowers students to take ownership of their learning.

Lucy also emphasized student engagement in her classroom, but through a collaborative approach. For science, Lucy used whole-group instruction, differentiating for assessments while teaching as a whole class, "*We create one lesson plan… but the lesson itself is usually split into one to two groups.*" This approach fostered leadership, with older students taking charge in STEM activities while younger ones actively participated, gaining exposure and experience to concepts that may be taught at a higher grade level.

Across participants, managing multiple grade levels and subject areas within the same classroom emerged as a key factor influencing their pedagogical approaches. Despite the challenges inherent in teaching a multigrade, multi-subject class, educators explored effective and innovative ways to integrate subjects, foster independence, and promote collaborative learning environments.

Multi-subject connections and there contribution to integrating STEM in SDR classrooms

> *I think sometimes that accessibility to things lessens the creativity—Tennille.*

A second theme that emerged from teachers' descriptions of factors influencing their STEM integration was their use of multi-subject connections. These connections deepen students' understanding of STEM education concepts and demonstrate their relevance and applicability across different educational subject areas. Additionally, integrating STEM education with other subjects promotes collaboration among students and encourages them to see the interconnectedness of various disciplines within academics and their lives. Gigi emphasizes the importance of curriculum integration in a multi-age elementary setting, "*It makes a lot of sense to focus your curriculum through the lines of social studies and science and to let the reading, writing, and mathematics integrate and follow that.*" She found strict schedules and compartmentalized teaching ineffective, especially across multiple grade levels, "*There's just not enough hours in the day to do it all and to do it well.*" Instead, she integrated various subjects, such as when studying the Plains Indians, where students participated in mapping, reading nonfiction and fiction, studying novels, storytelling, and conducting research. This approach allowed for deeper exploration and more meaningful learning experiences.

Elizabeth also described an integrative project facilitated by a local university that spanned multiple grade levels and encompassed various curricula and standards. She outlined how she used the phenomenon of raising trout to accommodate the varying needs of different grades, standards, and curricula within the project.

> *So long ago, I lined up as much [curriculum to grade levels] as I could. I do earth science in the fall, physical science middle of the year, and then life science in the spring…The different components [of trout in the classroom] that I can connect for all of my classes is given [on how to incorporate with each grade level]. It does not take long, and you are like, oh, I can do that for this group, and I can do this for that group.*
>
> *So, third grade does life cycles right, and so these [trout] came as eggs. So we can watch that. But they have looked at the life cycle of fish, and we have done some different stuff with that.*
>
> *Fourth grade talks about adaptations. So I can use the trout for adaptations when I get there. Fifth grade does a lot with water. I could go pretty much any angle I wanted to. They have water filtration and keep pollution out. My sixth graders I do a lot of things like unicellular and multicellular and different classifications and what does it mean for something to be living versus nonliving, and all those things are sixth graders.*
>
> *Seventh grade, I do not do as much in life science. But I'm tying in a little bit. I do a lot of heat transfer with them. Which is interesting with them [trout] because you want to keep them colder, not warmer. So, you have to keep their temperature regulated, like between 50 to 55 degrees, which makes sense because they are gonna be released into cold water, so we can use that a little bit there. Then eighth grade is more ecosystems and invasive species and those interactions.*

Although content integration required some planning, Elizabeth appreciated the autonomy to implement it in ways that worked best for her SDR school. "*So one of the best things about where I work and being in a rural setting is the autonomy to make integration happen when I can or want to.*" This freedom allows Elizabeth and her fellow SDR educators to tailor instruction to their students' unique needs and interests, promoting a more holistic and relevant learning experience.

In addition to the autonomy teachers have in SDR schools, Brooklyn also spoke to the ease of integration due to smaller class sizes:

> *We do cooking. It can be embedded into almost every curriculum. I was talking about [community member], I've had her grandson. Well, she comes in and she does cooking with the kids. So in town, they cannot do that, but we can do it because we have our own kitchen. She brings in all the supplies, and we always integrate*

> *fractions. So the kids are doing their fractions, and they are pulling in the chemistry…So they get to do kind of special things like that.*

Despite the benefits that content integration brings to students, Elizabeth noted that this approach is not always embraced by others in SDR schools or educators. She explains that while some educators embrace interdisciplinary teaching, others struggle with or resist the approach, "*If they do not understand integration and how powerful that can be, it can be hard…There are others that do not necessarily see the value in it, and that is frustrating.*" Despite these challenges, she remained focused on working with those educators open to collaboration.

Through these narratives, teachers explained how multi-subject connections create powerful learning experiences. They also highlighted factors like teacher willingness and class size, which can either support or hinder these connections. Despite challenges such as time constraints and competing educational demands, SDR educators are dedicated to finding creative ways to teach multi-subject activities that enhance students' learning.

Necessity and utilization of local resources

> *We can go and do whatever matches our curriculum—Gigi.*

A third factor that impacted how SDR educators integrate STEM education into their classrooms was the availability of, and ingenuity with, local resources. The teachers' resourcefulness extended beyond material acquisition to include innovative strategies for leveraging local resources and community partnerships to support the diverse needs of their students.

Tennille reflected on how their school's small size, often seen as a weakness, is actually a strength. She emphasized the flexibility and opportunities it provided, "*Well, that's kind of a cool strength because now we can take our kids everywhere.*" With only a handful of students, transportation is simple, allowing for "*25 field trips a year.*" She shared how their community-based approach fosters hands-on learning, whether exploring forests, meadows, or even a local cave. Rather than seeing limited access to traditional resources as a setback, Tennille embraces the opportunity to "*create our own resources*" in ways that uniquely support their school and community.

She continues to discuss the unique STEM opportunities her students experience by living in an SDR environment and the resources it provides, "*We just see the forest and nature as like an extension of our classroom and our schoolyard.*" She incorporates hands-on activities such as raising butterflies, bees, chicks, and ducks, all while linking students to local ecosystems. She brings in lessons that connect weather, engineering, and time-based changes to outdoor learning, which include a project where students take weekly photos to observe seasonal shifts, "*Every Friday, we go outside, and we take a photo in the exact same spot.*" Tennille emphasizes how the natural resources and surroundings make STEM education engaging and accessible for her students.

Gigi echos and emphasizes the unique advantages of place-based education, which are made possible by her school's small size. She describes how their "*walking field trip form*" allows for spontaneous exploration, "*If we can walk there, we can go at any given point in time.*" This flexibility enables students to engage directly with their known environment, whether examining landforms during mud season, collecting rock samples, or studying forest ecology. She highlights the freedom to move learning beyond the classroom, stating, "*We do not need to be in here, which is nice.*" Additionally, the small class size allows for frequent field trips without needing buses, making hands-on, curriculum-aligned experiences a regular part of their education. "*I've had way more field trips than anybody else that I've ever heard of,*" she notes, underscoring the breadth of experiential learning opportunities available to their students.

Lucy also spoke about the local resources and the unique opportunities they are afforded because of her small class size.

> *The local parks and rec department, they have a bunch of ski equipment. Then, if they have the equipment, they also have the instructors. They took care of everything. So they come here on Fridays. Last school year, we did it four times, but with the lack of snow, we are down two days this year. So our second session is this Friday. But they come out and bring the kids from here to [local ski slope], which is just down the road. It takes less than two minutes. So then they give the kids instructions and how to get on all their equipment and how to ski and then go out there for five minutes, and it's the entire building.*

Similarly, utilizing the resources available in their immediate environment, Mrs. G creatively adapted to her school's geographic limitations by using local outdoor spaces for hands-on learning, "*We use what we have, we go outside.*" Lacking access to traditional educational venues like museums, she engages students with real-world observations, such as studying nests in trees and discussing life cycles. She connects local phenomena with broader scientific concepts, fostering a deeper understanding of ecology, "*We go to [local area]… we talk about the history, geology, plants, and animals.*" Mrs. G encourages students to compare their environment to other places, helping them appreciate the uniqueness of their surroundings while reinforcing scientific concepts. "*When we are in Denver, what do we see that's different? Animals, okay, why cannot the rattlesnake survive here? The diamondbacks survive up there in the mountains, and we talk about the comparisons, things as simple as that.* ".

Like other educators, Antoinette views the geographic location as an advantage, providing unique STEM opportunities for her students. She shared an example of a local resort hosting an astronaut who gave a private session for her class, "*We got to listen to him speak about what it was like to be an astronaut and what he thought of the privatization of NASA.*" This intimate session, where students had the chance to ask questions, was made possible due to the smaller size of the school, which would not have been possible with larger institutions. Antoinette emphasizes how this local community partnership brings exceptional learning experiences to her students.

Angela Tuga also shared a story about how the local community members and the location of the school allowed for a unique learning experience.

> *So, for one year, we did a science night. We did different stations, we did what it feels like to blast off into space…We also had [community member] come out. He's an astronomer, and he brought his telescope. Kids get to go outside because it was a night sky. It was a beautiful night outside, and look at the stars, and it just so happened that the International Space Station flew over. So we are in a rural community. There's no light pollution. It was beautiful.*

By actively engaging with local resources, Elizabeth notes that she is able to make tighter local connections between the students' knowledge and the content:

> *So my eighth graders had the Grand Canyon, which I think a lot of textbooks use as a good illustration of geologic time. And I taught that for a year or so. But around here, we have lots of canyons where you can see the geologic layers and see all these different pieces. My brother was drilling well, and he would talk about all the different layers he was going through. Those types of things, if I can talk about drilling a well for your cows, or just your house, that means more to my students. It's not this canyon faraway, that they may, or may not see. So I really have shifted from this, like, oh, expose the kids to all these cool things. Well, yes, but I start with what they know. Because if I start with something just way out there, their attention will not last past a day or two, versus if it's real and they can see oh, yeah, that's important to get water for my cows or for my house.*

Finally, Sidney shared a story about how a local community member unknowingly contributed to the learning experiences at the school. "*We had a community member find a praying mantis and thought it would be cool to show the kids,*" Sidney recalled. "*They are always dropping skulls and bugs at the school for us to look at.*" The mantis was placed in a tank for a few days, but soon after, a student noticed something unusual. "*One day, a student saw that there were lots of little bugs in the tank. We quickly found out that the praying mantis was pregnant, which was nuts!*" This unexpected discovery sparked an engaging lesson for the students, demonstrating how community contributions can enhance classroom learning in exciting and unexpected ways.

Despite the challenges posed by geographic isolation, these educators have leveraged their unique contexts and resources to foster innovative learning opportunities. Through creative approaches, teachers have cultivated engaging learning environments that empower students to thrive. These narratives highlighted the immense potential of SDR schools to deliver high-quality education tailored to their student's specific needs and interests.

The narratives shared by these SDR teachers offer valuable insight into the factors influencing the integration of STEM education in their classrooms. Given the multigrade, multi-subject nature of their classrooms, these teachers carefully consider how to integrate different content areas and make the most of available resources to bring STEM education to life. Leveraging their unique contexts, resources, and community partnerships, these educators are paving the way for equitable access to quality STEM education, ensuring that all students have the opportunity to develop essential skills for success in the modern world no matter where they live geographically.

Discussions and implications

> *I'm glad to know that somebody is telling these stories because there's some cool stuff happening out here—Elizabeth.*

Rural areas face significant challenges in providing equitable STEM education, which is critical for economic growth (Bacovic et al., 2022; Avery, 2013). Sustained Deep Rural (SDR) regions especially experience these challenges, as schools often serve small populations with limited resources. Research on how teachers in these highly rural areas navigate these constraints is limited (Ihrig et al., 2022), largely because SDR areas are often grouped within broader rural categories, masking these communities' unique needs and conditions (Harmon and Morton, 2010).

Despite these obstacles, SDR educators exhibit notable flexibility in their approach to STEM education. Rural teachers often face isolation and resource scarcity, but they can be more adaptable in their decision-making compared to their urban counterparts (Preston, 2021). Teachers in SDR settings are tasked with multigrade, multi-subject classrooms, where they are responsible for students of varying ages and academic levels in a single room. This type of instruction presents unique challenges for integrating STEM subjects effectively.

However, this study revealed that SDR teachers, though constrained by many factors, demonstrate creativity and adaptability in their teaching practices. They often use multi-subject teaching strategies, connecting STEM concepts with other subjects to make lessons more engaging and relevant, and leverage local resources. These approaches facilitate a deeper understanding of STEM and maximize the resources available in rural settings. Additionally, SDR teachers benefit from greater autonomy in their curriculum design, which allows them to tailor their teaching to the specific needs of their students and the local environment. This flexibility in instructional decisions stands in contrast to the more rigid structures found in many urban districts.

Moreover, SDR educators frequently leverage local resources, such as community partnerships, natural phenomena, and local industries, to enrich their STEM lessons. For example, teachers might organize field trips or invite local professionals to engage students in hands-on, real-world STEM applications. This practice enhances students' understanding of STEM and strengthens ties between schools and their communities, providing opportunities for students to connect with potential future careers in STEM fields.

While SDR teachers demonstrate remarkable resourcefulness and innovation in integrating STEM education, there are still significant resource and access gaps in the research. Teachers often lack sufficient professional development training in STEM teaching strategies, and rural students may not have the same access to STEM extracurricular programs as their urban counterparts. Targeted initiatives, such as increased funding, tailored professional development, and expanded community partnerships, are needed to address these disparities and ensure equitable access to high-quality STEM education for all rural students. The discussion will analyze the findings in the context of existing literature and future research implications.

Assets and barriers of STEM integration within multigrade, multi-subject instruction

A significant challenge identified by SDR educators is the necessity of teaching multiple grade levels and subjects in one classroom. Multigrade instruction is a common educational model in rural and low-population areas globally, where it serves as a pragmatic solution to limited resources and small student populations (Kartal and Güven Demir, 2023; Checchi and Paola, 2018). The literature suggests that interdisciplinary approaches can facilitate cooperative learning and student engagement (Jensen et al., 2015). This aligns with this study's findings that SDR teachers employ integrative instructional methods to accommodate multigrade classrooms.

However, multigrade instruction presents distinct obstacles for STEM education despite its pedagogical benefits. Participants described difficulties balancing varied standards, curricula, preparing diverse instructional materials, and accessing professional development relevant to their specific teaching context. These findings reinforce prior research suggesting that STEM professional development opportunities in rural areas are often scarce, limiting teachers' ability to stay current with advancements in STEM education and instructional best practices (Durr et al., 2020; Howley and Howley, 2005; Oliver, 2007; Rude and Brewer, 2003; Weitzenkamp et al., 2003; Kelly and Fogarty, 2015). To address these challenges, teachers in this study adopted strategic approaches such as alternating subject emphases each year, identifying subjects conducive to integration, and leveraging available resources to supplement STEM instruction (Margot and Kettler, 2019; Harris and Hodges, 2018).

Despite constraints, participants demonstrated remarkable adaptability in structuring their classrooms to support STEM learning. Their experiences highlighted the importance of flexible and innovative teaching practices when overcoming barriers associated with multigrade instruction, further emphasizing the need for targeted professional development and resource allocation to support SDR educators.

Multi-subject connections as a catalyst for STEM learning

Another key finding was the role of multi-subject connections in STEM integration. Teachers used interdisciplinary approaches to enhance STEM understanding and practical applications, aligning with research showing that multi-subject learning fosters cognitive flexibility, deepens understanding, and strengthens knowledge application (Eshaq, 2024).

Compared to their urban and suburban counterparts, SDR educators showed more autonomy in designing multi-subject instruction due to minimal district oversight, aligning with prior research showing that rural educators have greater flexibility in adapting curricula (Preston, 2021). Participants viewed this autonomy as an advantage, allowing them to tailor instruction and integrate STEM concepts. As Angela Tuga stated, "*We have the freedom to do a lot more… We can do what we want.*"

Additionally, SDR teachers leveraged their geographic proximity to scientific phenomena, enabling them to conduct spontaneous field trips and place-based learning experiences, reinforcing Masinire's (2015) findings on the benefits of experiential STEM education in rural settings. This study's findings suggested that SDR educators' autonomy and ability to integrate STEM education across disciplines enhanced the learning experiences and provided students with a more holistic understanding of STEM principles.

Utilizing local resources to enhance STEM learning

The strategic use of local resources is the third significant factor influencing STEM education in SDR classrooms. Teachers consistently reported incorporating elements of their local environment to create authentic, place-based STEM learning experiences. This aligned with prior research emphasizing the importance of locally responsive decision-making in rural STEM education (Preston, 2021).

Participants described leveraging natural resources, community partnerships, and local industries to supplement STEM instruction. For instance, Elizabeth detailed her experience raising trout in her classroom, integrating STEM concepts across multiple grade levels, and providing students with real-world applications of their learning. Similarly, Jackie and Mrs. G emphasized the importance of connecting students with local professionals in STEM fields, reinforcing Henry's (2019) assertion that community involvement strengthens educational outcomes.

The ability to build relationships with local organizations and professionals also addressed resource limitations, a persistent challenge in SDR education. Many rural schools lack access to STEM extracurricular programs, such as clubs, family engagement events, and internships (Banilower et al., 2018; Saw and Agger, 2021). However, the participants in this study described how strong community networks helped mitigate these limitations by facilitating guest speakers, hands-on projects, and locally relevant STEM initiatives. Jackie noted, "*We can get people in from the community at any time… It gives them the opportunity to talk about what they do and see if the kids are interested in engineering from a young age.*"

Despite these advantages, challenges remain in ensuring equitable access to high-quality STEM education for all SDR students. While teachers demonstrated ingenuity in utilizing local resources, broader systemic efforts, such as increased funding, targeted rural STEM initiatives, and expanded professional development, are needed to address long-standing disparities in STEM education opportunities.

Implications for practitioners

It is essential to recognize the resourcefulness and adaptability of SDR teachers in their STEM educational practices despite the challenges posed by their geographic locations. SDR teachers effectively utilize local resources and community partnerships to enrich STEM education, drawing upon their communities' unique assets to foster academic success. This approach benefited not only rural educators but also provided valuable insights for teachers from other contexts. By observing how SDR teachers integrate community resources, teachers from diverse settings can learn practical strategies to enhance their professional growth and create supportive learning environments.

SDR educators also require professional developments tailored to their unique needs. Due to geographic constraints, many rural teachers face limited collaboration and professional development opportunities. Previous research shows that limited access to training and developmental resources put SDR educators at a disadvantage (Hartman et al., 2022; Karnopp, 2022). This emphasizes the need for professional development programs tailored to their specific challenges and teaching environments. Such programs should be designed to meet educators' specific challenges in remote areas, equipping them with the necessary skills and resources to thrive.

Additionally, SDR mentorship is critical, as rural educators often rely on peer support due to limited preservice training focused on rural issues. Mentorship fosters collaboration, professional growth, and best practice exchange, all of which are essential components for overcoming challenges in rural education. Investing in mentorship for SDR educators could improve effectiveness, and benefit students by enhancing STEM integration across grades and subjects.

Implications for research

The National Rural Education Association's (NREA) 2022–2027 research agenda emphasizes spatial and educational equity, focusing on policy, teacher recruitment, community partnerships, and health and wellness (Hartman et al., 2022). However, additional investigations are needed to explore significant impacts of resources, funding, and community involvement on student learning, as these factors also play a crucial role in ensuring equitable educational opportunities in rural areas. One key area of study is the advancement of integrative STEM education in SDR classrooms. Educators have implemented creative strategies, such as partnering with local experts, incorporating hands-on environmental projects like watershed tracking, and using real-world problem-solving to enhance student engagement. Evaluating these approaches could provide deeper insights into how STEM education can be adapted to support student success in rural communities.

Another crucial area is the role of community resources in supporting educational success. Research shows that community involvement enhances student engagement and achievement, but further studies are needed on the specific impact of local partnerships (Belete, 2024). Understanding how these collaborations affect outcomes is vital for policymakers and educators.

Finally, the perception of SDR areas in academia needs attention. These areas have often been overlooked and undervalued, but throughout this study the rich cultural and social connections were highlighted. Recognizing the uniqueness, separate from other rural areas, is crucial for addressing SDRs specific needs. Further research should explore how the academic community can better support SDR educators and their contributions.

Conclusion

In these SDR schoolhouses, teachers take on multiple roles, often serving as community advocates, lunch servers, principals, curriculum directors, and professional development providers. Against a backdrop of playgrounds filled with laughter, dirt, and unkempt grass, teachers are navigating complex terrain, striving to deliver high-quality education while fostering essential integrative connections between STEM education and rural life. They are relying on local communities for support, demonstrating resilience by making the most of available resources and what they have learned works.

Unfortunately, the voices of rural educators often remain unheard, overshadowed by broader educational conversations. This study aimed to disrupt this silence, amplifying the experiences of the countless teachers working tirelessly in SDR regions. By focusing specifically on these areas, which are often overlooked in broader rural educational studies, the research fills a crucial gap in understanding the unique challenges SDR teachers face when integrating STEM education. This study emphasized the importance of listening to the voices of SDR educators, providing a deeper understanding of the innovative strategies they used to integrate STEM education successfully. It highlighted how teachers creatively navigated challenges by leveraging their autonomy, local resources, and community support. This study emphasized the need for targeted professional development to help teachers succeed in providing quality STEM education, despite the constraints they face.

These rural areas have long been dismissed as the "land of misfits," a sentiment powerfully expressed by one participant. Yet, this study aimed to show that SDR education should no longer be overlooked as an isolated outpost in academia. Instead, they are a diamond in the rough that can shine brightly with the proper support and attention. These regions, once ignored and dismissed in education, have now proven that they are not only worthy of attention but demand to be valued, supported, and never forgotten again.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by Clemson University Institutional Review Board. 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

DJ: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research and/or publication of this article. This research was supported in part by the Institute for Measurement Methodology in Rural STEM Education Postdoctoral Research Fellowship (IMMERSE-PRF - NSF#2222499) through NSF Directorate for Education and Human Resources STEM Education Postdoctoral Research Fellowships program.

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 no Gen AI was used in the creation of this manuscript.

Publisher's note

References

Avery, L. M. (2013). Rural science education: valuing local knowledge. *Theory Pract.* 52, 28–35. doi: 10.1080/07351690.2013.743769

Avery, L. M., and Kassam, K. (2011). Phronesis: Children's local rural knowledge of science and engineering. J. Res. Rural. Educ., 26, 1–18. Available online at: http://jrre.vmhost.psu.edu/wpcontent/uploads/2014/02/26-2.pdf

Bacovic, M., Andrijasevic, Z., and Pejovic, B. (2022). STEM education and growth in Europe. *J. Knowl. Econ.* 13, 2348–2371. doi: 10.1007/s13132-021-00817-7

Bamberg, M., and Georgakopoulou, A. (2008). Small stories as a new perspective in narrative and identity analysis. doi: 10.1515/TEXT.2008.018

Banilower, E. R., Smith, P. S., Malzahn, K. A., Plumley, C. L., Gordon, E. M., and Hayes, M. L. (2018). Report of the 2018 NSSME+. The National Survey of Science & Mathematics Education. Available online at: http://horizon-research.com/NSSME/wp-content/uploads/2020/04/Report_of_the_2018_NSSME.pdf

Behar, R. (1996). The vulnerable observer: Anthropology that breaks your heart: Beacon Press.

Belete, Y. (2024). The link between students' community engagement activities and their academic achievement. *Educatione* 3, 61–84. doi: 10.58650/educatione.1358541

Bernsen, N. R., Crandall, M. S., Leahy, J. E., and Biddle, C. (2022). How far to go? Community influences on youth educational aspirations in rural, resource-dependent places. *RSF* 8, 189–207. doi: 10.7758/RSF.2022.8.3.08

Biddle, C., and Azano, A. P. (2016). Constructing and reconstructing the rural school problem: a century of rural education research. *Rev. Res. Educ.* 40, 298–325. doi: 10.3102/0091732X16667700

Bleakley, A. (2005). Stories as data, data as stories: making sense of narrative inquiry in clinical education. *Med. Educ.* 39, 534–540. doi: 10.1111/j.1365-2929.2005.02126.x

Blommaert, J., Collins, J., and Slembrouck, S. (2005). Polycentricity and interactional regimes in "global neighborhoods". *Ethnography* 6, 205–235. doi: 10.1177/1466138105057557

Bryman, A. (2012). Social research methods. *4th* Edn: University Press Inc.

Burnard, P. (1991). A method of analysing interview transcripts in qualitative research. *Nurse Educ. Today* 11, 461–466. doi: 10.1016/0260-6917(91)90009-Y

Campbell, J., Maxey, V., and Watson, W. (1995). Hawthorne effect: implications for prehospital research. *Ann. Emerg. Med.* 26, 590–594. doi: 10.1016/S0196-0644(95)70009-9

Chase, S. (2005). "Narrative inquiry: Multiple lenses, approaches, voices" in The sage handbook of qualitative research. eds. N. K. Denzin and Y. S. Lincoln. *3rd ed.)* ed (Thousand Oaks, CA: Sage).

Checchi, D., and Paola, M. D. (2018). The effect of multigrade classes on cognitive and non-cognitive skills. Causal evidence exploiting minimum class size rules in Italy. *Econ. Educ. Rev.* 67, 235–253. doi: 10.1016/j.econedurev.2018.10.003

Clandinin, D. J., Pushor, D., and Orr, A. M. (2007). Navigating sites for narrative inquiry. *J. Teach. Educ.* 58, 21–35. doi: 10.1177/0022487106296218

Connelly, F. M., and Clandinin, D. J. (1987). On narrative method, biography and narrative unities in the study of teaching. *J. Educ. Thought* 21, 130–139. doi: 10.55016/ojs/jet.v21i3.44199

Connelly, F. M., and Clandinin, D. J. (1988). Teachers as curriculum planners: Narratives of experience: Teachers College Press.

Connelly, F. M., and Clandinin, D. J. (1990). Stories of experience and narrative inquiry. *Educ. Res.* 37, 175–189. doi: 10.1080/03323315.2018.1465839

Crumb, L., Chambers, C., Azano, A., Hands, A., Cuthrell, K., and Avent, M. (2023). Rural cultural wealth: dismantling deficit ideologies of rurality. *J. Multicult. Educ.* 17, 125–138. doi: 10.1108/JME-06-2022-0076

Curran, F. C., and Kitchin, J. (2021). Documenting geographic isolation of schools and examining the implications for education policy. *Educ. Policy* 35, 1191–1229. doi: 10.1177/0895904819864445

Darling-Hammond, L., Flook, L., Cook-Harvey, C., Barron, B., and Osher, D. (2020). Implications for educational practice of the science of learning and development. *Appl. Dev. Sci.* 24, 97–140. doi: 10.1080/10888691.2018.1537791

De Fina, A., and Georgakopoulou, A. (2019). The handbook of narrative analysis: John Wiley & Sons.

De Mars, A., Taken Alive, J., Ortiz, M., Ma, Z., and Wang, M. (2022). Educators' perspectives on factors impacting STEM achievement in rural indigenous student-serving schools. *Rural Educ.* 43, 24–36. doi: 10.35608/ruraled.v43i1.1207

Durr, T., Kampmann, J., Hales, P., and Browning, L. (2020). Lessons learned from online PLCs of rural STEM teachers. *Rural Educ.* 41, 20–26. doi: 10.35608/ruraled.v41i1.555

Ebenezer, J., Kaya, O. N., and Kasab, D. (2018). High school students' reasons for their science dispositions: community-based innovative technology-embedded environmental research projects. *Res. Sci. Educ.* 50, 1341–1365. doi: 10.1007/s11165-018-9735-6

Eshaq, H. A. (2024). The Effect of Using STEM Education on Students Mathematics Achievement. *Journal of Pedagogical Research* 8, 75–82.

Fenton, C. G., and Langley, A. (2011). Strategy as practice and the narrative turn. *Organ. Stud.* 32, 1171–1196. doi: 10.1177/0170840611410838

Gallo, J. (2020). Against the grain: narratives of rural Teachers' professional lives. *Rural. Educ.* 41, 1–13. doi: 10.35608/ruraled.v41i2.862

Gardner, K., Glassmeyer, D., and Worthy, R. (2019). Impacts of STEM professional development on teachers' knowledge, self-efficacy, and practice. *Front. Educ.* 4, 4:26. doi: 10.3389/feduc.2019.00026

Gashi Nulleshi, S., and Tillmar, M. (2022). Rural proofing entrepreneurship in two fields of research. *Int. J. Entrep. Behav. Res.* 28, 332–356. doi: 10.1108/IJEBR-05-2021-0323

Georgakopoulou, A. (2006). Thinking big with small stories in narrative and identity analysis. *Narrat. Inq.* 16, 122–130. doi: 10.1075/ni.16.1.16geo

Georgakopoulou, A. (2013). Small stories and identities analysis as a framework for the study of im/politeness-in-interaction. *J. Politeness Res.* 9, 55–74. doi: 10.1515/pr-2013-0003

Gerber, N., Biffi, E., Biondo, J., Gemignani, M., Hannes, K., and Siegesmund, R. (2020). Arts-based research in the social and health sciences: Pushing for change with an interdisciplinary global arts-based research initiative. *In Forum: Qualitative Social Research* 2, 1–15.

Glaser, B., and Strauss, A. (1967). The discovery of grounded theory: strategies for qualitative research. Sociology Press.

Gorden, R. L. (1987). Interviewing: strategy, techniques and tactics: The Dorsey Press.

Guba, E. G., and Lincoln, Y. S. (1989). Fourth generation evaluation. Thousand Oaks, CA: Sage Publications.

Gudmundsdottir, S. (2001). "Narrative research on school practice" in Handbook of research on teaching, vol. 4. ed. V. Richardson (New York: Macmillan), 226–240.

Harmon, H. L., and Morton, C. (2010). Frontier schools in Montana: challenges and sustainability practices. A research Report

Harris, R. S., and Hodges, C. B. (2018). STEM education in rural schools: implications of untapped potential. *National Youth-At-Risk J.* 3, 3–12. doi: 10.20429/nyarj.2018.030102

Hartman, S. L., Hines-Bergmeier, J., and Klein, R. (2017). Informal STEM Learning: The state of research, access and equity in rural early childhood settings. *Science Education and Civic Engagement* 9, 32–39.

Hartman, S., Roberts, J., Schmitt-Wilson, S., McHenry-Sorber, E., Buffington, P. J., and Biddle, C. (2022). National Rural Education Association Research Agenda–2022-2027: a closer look at the research priorities. *Rural Educ.* 43, 59–66. doi: 10.55533/2643-9662.1349

Henry, W. (2019). Identifying and allocating resources for learning improvement: a study of sustainably improving rural schools. *Theory Pract. Rural Educ.* 9, 61–73. doi: 10.3776/tpre.2019.v9n1p61-73

Howley, A., and Howley, C. B. (2005). *High-quality teaching: providing for rural teachers' professional development* (AEL policy brief). Available online at: http://files.eric.ed.gov/fulltext/ED484929.pdf

Ihrig, L., Assouline, S. G., Mahatmya, D., and Lynch, S. G. (2022). Developing students' science, technology, engineering, and mathematics talent in rural after-school settings: rural educators' affordances and barriers. *J. Educ. Gift.* 45, 381–403. doi: 10.1177/01623532221123786

İlter, İ. (2015). The metaphors of primary school teacher candidates regarding the concept of a combined classroom. *Primary Educ. Online* 14, 1450–1468.

Jensen, J. L., Kummer, T. A., and Godoy, P. D. (2015). Improvements from a flipped classroom may simply be the fruits of active learning. *Life Sci. Educ.* 14:ar5. doi: 10.1187/cbe.14-08-0129

Jonassen, D. H., and Hernandez-Serrano, J. (2002). Case-based reasoning and instructional design: using stories to support problem solving. *Educ. Technol. Res. Dev.* 50, 65–77. doi: 10.1007/BF02504994

Josselson, R. (2011). "Bet you think this song is about you": whose narrative is it in narrative research? *Narrative Matters* 1, 33–51.

Jovchelovitch, S., and Bauer, M. W. (2000). "Narrative interviewing" in Qualitative researching with text, image and sound: a practical handbook, eds. M. W. Bauer and G. Gaskell. (London: SAGE) 57–74.

Kaldaras, L., Akaeze, H., and Krajcik, J. (2021). Developing and validating next generation science standards-aligned learning progression to track three-dimensional learning of electrical interactions in high school physical science. *J. Res. Sci. Teach.* 58, 589–618. doi: 10.1002/tea.21672

Karnopp, J. (2022). Uncovering rural educators' secret agency. *Rural. Educ.* 43, 34–46. doi: 10.55533/2643-9662.1324

Kartal, A., and Güven Demir, E. (2023). Multi-grade teaching: experiences of teachers and preservice teachers in Turkey. *Hungarian Educ. Res. J.* 13, 170–188. doi: 10.1556/063.2022.00132

Keller, E. M., and Owens, G. P. (2020). Traditional rural values and posttraumatic stress among rural and urban undergraduates. *Plus One* 15:e0237578. doi: 10.1371/journal.pone.0237578

Kelly, N., and Fogarty, R. (2015). An integrated approach to attracting and retaining teachers in remote and remote parts of Australia. *J. Econ. Soc. Pol.* 17:1.

Kennedy, T. J., and Odell, M. R. (2014). Engaging students in STEM education. *Sci. Educ. Int.* 25, 246–258.

Larraz-Rábanos, N. (2021). Development of creative thinking skills in the teaching-learning process. London: IntechOpen.

Lathrop, B., Kasambira-Emerson, M. M. R., Squires, V., and Santibañez, S. (2022). Empowering communities that experience marginalization through narrative. In *Narrative Ethics in Public Health: The Value of Stories*. (Cham: Springer International Publishing), 35–45.

Margot, K. C., and Kettler, T. (2019). Teachers' perception of STEM integration and education: a systematic literature review. *Int. J. STEM Educ.* 6, 1–16. doi: 10.1186/s40594-018-0151-2

Mas-Alcolea, S., and Torres-Purroy, H. (2021). Shadowing and narrative interviewing combined: The advantages of using an observational method in higher education research. In *Theory and Method in Higher Education Research*. Emerald Publishing Limited. 161–172.

Masinire, A. (2015). Recruiting and retaining teachers in rural schools in South Africa: insights from a rural teaching experience programme. *Aust. Int. J. Rural. Educ.* 25, 2–14. doi: 10.47381/aijre.v25i1.91

Maynard, K. (2021). *American mythology: How storytelling shapes modern cultural perceptions* (Doctoral dissertation, Marshall University).

McCambridge, J., Witton, J., and Elbourne, D. R. (2014). Systematic review of the Hawthorne effect: new concepts are needed to study research participation effects. *J. Clin. Epidemiol.* 67, 267–277. doi: 10.1016/j.jclinepi.2013.08.015

McCormack, C., Ambler, T., Martin, B., Waite, K., and Wilson, A. (2016). Narrative-based evaluation demonstrates the value of a higher education professional learning network. *Stud. Educ. Eval.* 50, 79–87. doi: 10.1016/j.stueduc.2016.07.003

Miyazoe, T., and Anderson, T. (2011). Anonymity in blended learning: who would you like to be? *Educ. Technol. Soc.* 14, 175–187.

Mueller, R. A. (2019). Episodic narrative interview: capturing stories of experience with a methods fusion. *Int J Qual Methods* 18. doi: 10.1177/1609406919866044

NCES (2023). Locale classifications and criteria. Available online at: https://nces.ed.gov/programs/edge/docs/locale_definitions.pdf

Nordin, H., Almeida, T., and Wiberg, M. (2023). Designing to restory the past: storytelling for empowerment through a digital archive. *Int. J. Des.* 17, 91–104.

Oliver, J. S. (2007). Rural science education. In S. K. Abell and N. Lederman (Eds.), *Handbook of research on science education (1)*. Routledge.

Oswald, D., Sherratt, F., and Smith, S. (2014). Handling the Hawthorne effect: the challenges surrounding a participant observer. *Rev. Soc. Stud.* 1, 53–74. doi: 10.21586/ross0000004

Peshkin, A. (1988). "Virtuous subjectivity: in the participant observer's I's" in The self in social inquiry: researching methods. eds. D. N. Berg and K. K. Smith (Newbury Park: Sage), 267–281.

Peshkin (1991). *The color of strangers, the color of friends*. University of Chicago Press.

Philip, L., Cottrill, C., Farrington, J., Williams, F., and Ashmore, F. (2017). The digital divide: patterns, policy and scenarios for connecting the 'final few' in rural communities across Great Britain. *J. Rural. Stud.* 54, 386–398. doi: 10.1016/j.jrurstud.2016.12.002

Polkinghorne, D. E. (1995). Narrative configuration in qualitative analysis. *Int. J. Qual. Stud. Educ.* 8, 5–23. doi: 10.1080/0951839950080103

Prescott, J. R. V. (1978). Boundaries and Frontiers. Croom Helm: Rowman and Littlefield.

Preston, T. (2021). A look back: ongoing dilemmas for rural schools. *Phi Delta Kappan* 103, 6–7. doi: 10.1177/00317217211065819

Qiao, X., and Zhou, X. (2020). Research on the integration of STEM education into the rural elementary school science curriculum: an example from rural elementary schools in Western China. *Best Evid Chin Edu* 5, 581–590. doi: 10.15354/bece.20.ar034

Razi, A., and Zhou, G. (2022). STEM, iSTEM, and STEAM: what is next? *Int. J. Technol. Educ.* 5, 1–29. doi: 10.46328/ijte.119

Riessman, C. K. (2008). Narrative methods for the human sciences: Sage.

Rubin, H. J., and Rubin, I. S. (2005). Qualitative interviewing (2nd ed.): the art of hearing data. London: Sage.

Rude, H. A., and Brewer, R. D. (2003). Assessment of professional development systems: improving rural special education services. *Rural Spec. Educ. Q.* 22, 20–28. doi: 10.1177/875687050302200404

Russell, B. H. (2013). Social research methods: Qualitative and quantitative approaches: Sage.

Salemink, K., Strijker, D., and Bosworth, G. (2017). Rural development in the digital age: a systematic literature review on unequal ICT availability, adoption, and use in rural areas. *J. Rural. Stud.* 54, 360–371. doi: 10.1016/j.jrurstud.2015.09.001

Saw, G. K., and Agger, C. A. (2021). STEM pathways of rural and small-town students: opportunities to learn, aspirations, preparation, and college enrollment. *Educ. Res.* 50, 595–606. doi: 10.3102/0013189X211027528

Slama, K. (2004). Rural culture is a diversity issue. *Minnesota Psychologist* 53, 9–12.

Starrett, A., Irvin, M. J., Lotter, C., and Yow, J. A. (2022). Understanding the relationship of science and mathematics place-based workforce development on adolescents' motivation and rural aspirations. *Am. Educ. Res. J.* 59, 1090–1121. doi: 10.3102/00028312221099009

Sutton, J., and Austin, Z. (2015). Qualitative research: data collection, analysis, and management. *Can. J. Hosp. Pharm.* 68, 226–231. doi: 10.4212/cjhp.v68i3.1456

Teo, T. (2008). From speculation to epistemological violence in psychology: a critical-hermeneutic reconstruction. *Theory Psychol.* 18, 47–67. doi: 10.1177/0959354307086922

Thier, M., Longhurst, J. M., Grant, P. D., and Hocking, J. E. (2021). Research deserts: a systematic mapping review of U.S. rural education definitions and geographies. *J. Res. Rural. Educ.* 37. doi: 10.26209/jrre3702

Tieken, M. C. (2014). Why rural schools matter: UNC Press Books.

Turner, F. J. (1893). The significance of the frontier in American history. *State Historical Society of Wisconsin.*

U.S. Department of Education, National Center for Education Statistics, Common Core of Data (2023). Public Elementary/Secondary School Universe Survey, 2022–23 v.1a; Public Elementary/Secondary School Universe Survey Geographic Data (EDGE), 2022–23 v.1a. Available online at: https://nces.ed.gov/ccd/

Van Rensburg, H., Noble, K., and McIlveen, P. (2015). Influencing pre-service teachers' intentions to teach in rural locations. *Aust. Int. J. Rural. Educ.* 15-24, 15–24. doi: 10.47381/aijre.v25i1.92

Waters, T. E. A., Köber, C., Raby, K. L., Habermas, T., and Fivush, R. (2018). Consistency and stability of narrative coherence: an examination of personal narrative as a domain of adult personality. *J. Pers.* 87, 151–162. doi: 10.1111/jopy.12377

Weitzenkamp, D. J., Howe, M. E., Steckelberg, A. L., and Radcliffe, R. (2003). The GOALS model: rural teacher preparation institutions meeting the ideals of a PDS through educational technology. *Contemp. Issues Technol. Teach. Educ.* 2, 574–585.

Wells, J. G. (2016). PIRPOSAL model of integrative STEM education: Conceptual and pedagogical framework for classroom implementation.

Wilger, S. (2016). Definition of frontier. National Rural Health Association Policy Brief.

Wolgemuth, J. R., and Agosto, V. (2019). "Narrative research" in The Blackwell encyclopedia of sociology. eds. G. Ritzer and C. Rojek, vol. *1-3* (Hoboken, NJ: John Wiley & Sons, Ltd).