REVIEW

Informal STEM Learning: The State of Research, Access and Equity in Rural Early Childhood Settings

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Abstract

Even though 22 percent of Americans live in rural areas, rural locations have repeatedly been overlooked as research sites. Rural settings represent areas rich in early childhood STEM education research opportunities, yet very little rural STEM education research exists. This review highlights the limited extent of informal STEM learning research in rural early childhood settings as well as the impact that rurality has on teacher engagement and rural school STEM accessibility. A model that promotes active and collaborative partnerships between informal learning practitioners, community entities, and early childhood teachers represents an effective way to advance access to, equity in, and research about informal STEM learning experiences in rural settings. To foster this engaged learning paradigm, researchers must seek to develop and nourish meaningful relationships between informal STEM partners and schools in rural areas.

Introduction

Approximately 22 percent of the U.S. population, or nearly sixty million people, currently live in rural areas (United States Census Bureau 2014),[1] yet the scarcity of research related to rural education has been noted for

1 Reflecting the complex nature of rural settings, slight variation in descriptive rural statistics may be found across sources.

decades in comprehensive literature reviews (Arnold et al. 2005; DeYoung 1987; Kannapel and DeYoung 1999; Stapel and DeYoung 2011; Waters et al. 2008). The editor of the *Journal for Research in Mathematics Education* even went so far as to call the lack of focus on rural education an "attention deficit disorder" in published research (Silver 2003). With nearly 19 percent of America's schoolchildren attending rural public schools (Showalter et al. 2017), rural settings represent areas rich in STEM education research opportunities (Avery 2013; Avery and Kassam 2011). Yet rural specific issues, such as distance to services and access to professional development in STEM fields, create barriers that often prevent rurally located teachers and students from having equitable access to STEM learning opportunities (Banilower et al. 2013; Goodpastor et al. 2012).

The need for this review arises from the limited extent of informal STEM learning research in rural early childhood settings as well as the impact that rurality has on teacher engagement and rural school STEM accessibility. Recognizing the value rural areas provide as STEM research sites and capitalizing on the strengths of closely connected rural communities is helpful in addressing the accessibility and equity concerns detailed in this review. Additionally, collaborative partnerships that bridge formal and informal learning experiences represent an important mechanism for addressing access and equity in rural early childhood settings.

Background

Rural Settings—Underrepresented in the National Conversation

Though research about informal learning settings is not uncommon, a significant report on formal-informal collaborations made no specific mention of rural examples (Bevan et al. 2010). The value of learning science in informal environments is well recognized, but an informed approach for ensuring equity is essential in order to fully engage nondominant groups, including those in low-income and rural areas (Fenichel and Schweingruber 2010). While urban locales share similar challenges, rural locales have a way of magnifying certain challenges and opportunities that differ from urban locales. Informal STEM learning experiences are unevenly distributed with rural communities typically underserved, which, given the educational impact of informal learning experiences, may further contribute to placing rural students at a long-term economic disadvantage (Matterson and Holman 2012). Children's museums, which typically have a strong STEM focus, are amongst the fastest growing types of museum, yet in a recent survey of children's museum professionals, only five percent of respondents were from rural locations (Luke and Windleharth 2013). Worse, the outreach activities of large metropolitan museums run the risk of embracing urban-centric assumptions, which may align poorly with rural experiences.

Given the centrality of community and place to rural areas, rural children's museums have the potential to serve as an anchor in the broader learning ecosystem of rural communities, including formal and informal learning collaborations (Luke and Garvin 2014), serving to connect across disciplines and even generations. But while 22 percent of Americans live in rural areas (United States Census Bureau 2014), only twelve percent of children's museums are located within rural areas (Association of Children's Museums 2015). This highlights yet another need for increased access to rural STEM learning experiences. In particular, a survey of research in children's museums concluded that 56 percent of the research was conducted at only seven museums (all in large metropolitan areas) and only approximately four percent of the research involved teachers (Luke and Windleharth 2013), emphasizing the need for additional research specifically related to the role of museums for early childhood education and teacher collaborations in rural settings.

Developing interdisciplinary learning ecosystems that utilize existing and new partnerships (communities-schools-universities) has the potential to foster significant resiliency factors in the face of the many barriers to informal STEM learning that exist in rural settings. A recent National Research Council report (Bell et al. 2009) highlighted the overlapping goals of schools and informal (non-school) settings in science learning and the complementary role that informal settings can play in supporting learning progressions. The report emphasized that informal STEM learning experiences have the potential to be designed specifically to align with the K–12 science and math curriculum goals, even when the experiences may

be infrequent (Bell et al. 2009). This type of intentional alignment could significantly enhance the impact of the informal STEM learning experience. However, despite recognition of the tremendous learning potential stemming from collaborations between informal learning organizations and schools, there is relatively little research on these types of collaborations in rural early childhood settings (Avery 2013; Avery and Kassam 2011). This is surprising given the close-knit nature of most rural communities, where collaboration between local industry, business, artists, and K–12 educators should be easier than in metropolitan centers (cf. the case of Meriwether Lewis Junior-Senior High School in Howley et al. [2010] for an example of a rural math educator using community relations to craft connections of mathematics to place).

Rural Schooling—Then and Now

The reasons for the exclusion of rural areas from current research date as far back as the 1900s and are inextricably linked to location, social position, politics, and poverty (DeYoung 1995). During the 19th century and early 20th century, schooling was rural for a majority of Americans, as one-room schoolhouses were the norm (Theobald 1991, 1997). Over the course of the 19th century and extending to the present, American schools and modern life simultaneously institutionalized a more industrialized and one-package-fits-all model. The contracts issued by many schools and districts to engage efficiency programs modeled after business applications suggests that the industrial model persists. As part of this movement, schools underwent a shift from one-room schools to a more factory-based style of education that made it easier for teachers to be monitored, curriculum to be standardized, students' progress to be tracked, and the education process to be governed by qualified education experts instead of local community members (Smith 1999). Consolidation became a further expression of the push toward efficiency, standardization, and "bottom-line" thinking in the mid-to-latter 20th century (Herzog and Pittman 1999; Howley 1991). The consolidation experiment is an especially salient example of how following the same model as urban or suburban schools did not solve rural schooling's issues. Indeed, the impact of large organizational scale and high transportation-to-instructional expenditures may be creating more problems than they are solving.

Rural schools face continued challenges today. In particular, rural schools experience lower income bases, difficulty in attracting and keeping teachers, lack of access to quality professional teacher development, and decreased access to informal STEM experiences for students, families, and teachers in rural regions (Avery 2013; Avery and Kassam 2011; Goodpastor et al. 2012; Herzog and Pittman 1999; Monk 2007; Schafft and Jackson 2011). Children in rural schools are identified for special education services more often and for gifted services less often than their non-rural peers (DeYoung 1993; Pendarvis and Wood 2009; Seal and Harmon 1995). Adult commutes are longer (and accordingly, transportation expenses are greater), and children living in rural areas often experience longer bus rides to and from school (Seal and Harmon 1995) than their non-rural counterparts. As teachers in rural schools are often the school's sole representatives of their content area, the issue of professional isolation creates a concern that is specific to rural schooling (Monk 2007). Additionally, teachers in rural schools have reduced access to quality professional development (Monk 2007). For example, only 11 percent of rural schools provided one-on-one science-focused coaching to science teachers compared to 30 percent in urban schools (Banilower et al. 2013). These circumstances create educational risk factors for both students and teachers, and highlight the need to foster resiliency factors in underserved rural regions (Malloy and Allen 2007). Resiliency factors, which enable people to be successful in the face of adversity, create protective mechanisms that help mitigate risk factors and are essential in overcoming high-risk educational conditions (Henderson and Milstein 2003; Krovetz 1999; Malloy and Allen 2007). These descriptors illuminate the need for increased access to informal STEM learning experiences for children and teachers alike, but also create considerable challenges in reaching the rural areas that would most benefit from increased informal STEM learning opportunities.

Barriers to Rural STEM Accessibility and Equity

Despite improvements in transportation (and communication technologies), getting rural schools and families to access places of informal learning is still difficult (Ellegard and Vilhelmson 2004). Dubbed the "friction of distance,"

transport to informal learning events is impacted by distance and ease of reaching a location (Ellegard and Vilhelmson 2004). Increased access to funding for informal STEM learning events and transportation to reach them is an ongoing and pressing issue for rurally located schools (Schafft and Jackson 2011; Sipple and Brent 2008). Even when an informal STEM organization is regionally accessible, rural schools are sometimes unable to pay for even a short bus ride (Hartman and Hines-Bergmeier 2015). Charging admission fees in impoverished rural regions also presents serious accessibility issues, as many families and school districts are unable to afford even a modest admission fee (Hartman and Hines-Bergmeier 2015). The recently launched "Museums for All" initiative, co-sponsored by the Association for Children's Museums and the Institute for Museum and Library Services, is an important new direction for ensuring access and equity regardless of economic status. Beyond financial and geographic challenges, a deep connection to home and community cultures and contexts needs to be woven throughout the fabric of STEM informal learning experiences in order to achieve true equity for underrepresented or non-dominant groups such as rural communities (Fenichel and Schweingruber 2010).

Additionally, distrust of outsiders is a common characteristic in rural areas, making gaining entry to rural settings a challenging prospect (Hartman 2013; Seal and Harmon, 1995). Historically, rural residents' perception was that outsiders came to make them more like the rest of the world and to offer suggestions for improvement and change, and this made them wary and distrustful of people who are considered outsiders (Cooper et al. 2010; Edwards et al. 2006; Hartman 2013). In informal learning settings, this idea may be more specifically defined as social exclusion (Sandell 1998). Described as a breakdown in the links between individuals and their connections to the community, state services, and institutions, social exclusion is a concern in rural areas (Sandell 1998). Even when an educational STEM entity is associated with long-time local residents, overcoming issues created by rural residents' cultural view of outsiders and the theory of social exclusion present ongoing challenges for places of informal STEM learning (Hartman and Hines-Bergmeier 2015). Also challenging is the fact that, in rural communities, education and educational institutions are often perceived by community members as "one-way tickets" out—a tool for preparing children for jobs elsewhere, and thus espousing a set of values contrary to that of the close kinship and connections held in rural communities (Corbett 2007). Recruiting talent away from communities is perceived as yet another form of resource extraction, sometimes called "brain drain." Strategies to overcome these barriers involve innovative, cross-contextual learning fostered by collaborative partnerships.

Cross-Contextual Learning in Early Childhood Settings

Early Childhood Education refers specifically to the time of rapid growth and development during the ages of three to eight (Follari 2011; Morrison 2015). Children in this age group are characterized by their willingness to take risks, curiosity about the world around them, and desire to be actively engaged in learning experiences (Follari 2011; Morrison 2015). Learning experiences that foster creativity, critical thinking, problem solving, and a view of the world that is globally-minded and interdisciplinary are essential for children in the early years (Semmel 2009). Importantly, informal learning settings are places that encourage both independent and group exploration, are inherently play-based, and emphasize hands-on learning. These environments are designed to foster a high level of engagement and represent a model that is developmentally appropriate for young learners (Bell et al. 2009; Semmel 2009).

Though data from rural areas are scarce, research data that document bridging the gap between school and informal learning show promise for revolutionizing the way schools and community organizations interact to improve learning for children (Avery and Kassam 2011; Behrendt and Franklin 2014; Bevan et al. 2010; Duran et al. 2009; Fallik et al. 2013). Distinctions between "school math" or "school science" and "real math/science" may lead many students to develop negative dispositions toward STEM inquiry (Braund and Reiss 2006). Cross-contextual learning is a term for bridging the gap between the learning that occurs at school and the learning that happens informally at places such as museums, libraries, and/or parks (Fallik et al. 2013). By building upon experiences that occur in informal settings, classroom teachers are better able to create meaningful, engaged learning experiences

in formal settings (Behrendt and Franklin 2014; Fallik et al. 2013). However, effective cross-contextual learning is challenging for teachers and places that provide informal learning experiences for children (Avery 2013; Avery and Kassam 2011; Fallik et al. 2013; Russell et al. 2013).

Early childhood teachers often have limited content knowledge of math and science, which contributes to low self-efficacy in math and science teaching and to decisions to devote less classroom time to teaching science (Murphy et al. 2007; Schneider et al. 2007; Ma 2010); conditions that impede cross-contextual learning. Effective cross-contextual learning is important, because recent research suggests that bridging the gap between formal and informal settings shows the most promise for both increased student gains and early childhood teacher comfort with STEM topics (Avery and Kassam 2011; Behrendt and Franklin 2014; Fallik et al. 2013). By engaging in collaborative partnerships, rural classroom teachers and informal STEM educational entities may capitalize on opportunities to increase STEM literacy and interest through informal STEM learning experiences (Bell et al. 2009; Russell et al. 2013). This is especially important in rural areas where access to traditionally recognized venues for informal learning opportunities, such as museums, are scarce (Avery and Kassam 2011; National Research Council 2015). To truly engage in cross-contextual learning that impacts the learning of young children in rural areas, collaboration between stakeholders is the essential ingredient (Bell et al. 2009; Russell et al. 2013).

Strength in Collaborative Partnerships

Rural areas have a strong sense of community, and the people living there feel strong family and community ties (DeYoung 1995; Goodpastor et al. 2012; Schafft and Jackson 2011; Vaughn and Saul 2013). Additionally, despite the challenges rural schools face, teachers who work in rural schools often report high levels of job satisfaction and professional collegiality (Howley and Howley 2006; Monk 2007). Given concerns associated with outsider distrust in rural settings (Cooper et al. 2010; Edwards et al. 2006; Hartman 2013), leveraging community entities and place-based teachers as partners in advancing informal STEM learning presents a strong and sustainable model in rural areas (Avery 2013; Avery and Kassam 2011; Fenichel and Schweingruber 2010; Goodpastor et al. 2012). Rural areas offer real-life, immediate access to outdoor learning experiences that are not readily available in urban and suburban school settings (Avery and Kassam 2011). Collaborative partnerships between teachers and informal STEM practitioners that capitalize on the unique environmental offerings of rural areas may impact STEM learning in an authentic, hands-on way that makes learning come to life for young children within the context of their own backyards.

To realize the full potential of already well-connected rural communities, balancing organizational and individual motivations of participants is important (Malm et al. 2012). As teachers serve as bridge builders between all stakeholders, they are essential members of collaborative partnerships, and especially in rural areas (Vaughn and Saul 2013). With the added component of distrust of outsiders, this makes community and teacher involvement in collaborative partnerships especially important for advancing informal STEM research and accessibility in rural areas (Avery 2013; Avery and Kassam 2011; Goodpastor et al. 2012). Informal learning partnerships in rural settings should be created from the ground up with rural partners involved from the beginning and serving as leaders in the process.

Looking to the Future

With more than a fifth of the U.S. population living rurally (U.S. Census Bureau 2014), the education research community and United States educational policy have an obligation to make sure that young children have access to high-quality STEM experiences, both in school (formal) and out of school (informal). Given the highly engaged and curious nature of children in the early years, early childhood settings provide important sites to explore the characteristics and impact of informal STEM learning in new and innovative ways. A model that promotes active and collaborative partnerships between informal learning practitioners, community entities, and classroom teachers represents an effective way to advance accessibility, equity, and research for informal STEM learning experiences in rural early childhood settings (Avery 2013; Avery and Kassam 2011; Goodpastor et al. 2012). The key to this engaged learning paradigm is fostering strong collaborative partnerships that capitalize on the strengths of rural areas

and the educators who live there, and researchers must therefore develop and nourish meaningful relationships between rural, informal STEM partners and schools. Increased research usually brings increased funding, and both are needed to help end the pervasive cycle that keeps rural informal STEM learning both underfunded and underrepresented in the research literature. Twenty-first century demands for rurally located resources and opportunities (e.g., alternative energy sources) suggest that STEM talent and knowledge of rural places may be key to the future prosperity of the United States, and that talent must be nurtured beyond the walls of school buildings and from a very young age. The creative talent necessary for meeting those needs will include knowledge and understanding of rural place and communities, as well as of science and mathematics. Educational research has an important role to play in both bridging the gap between current realities and future prospects and in making community partners of formal and informal learning environs.

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