Theory & Practice in Rural Education (TPRE)
2022, Vol. 12, No. 2, Pp. 45-70

ISSN:2642-7170
https://doi.org/10.3776/tpre.2022.v12n2p45-70

Co-designing a Rural Research Practice Partnership to Design and Support STEM Pathways for Rural Youth

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Rural students, schools, and communities have unique challenges that hinder academic achievement, growth, and opportunities, compared to other locales. While there is a need to study this community more, there is also a pressing need to bring the local community members together to support the future generation of learners in developing pathways that lead them to future career opportunities. This article focuses on how a Research Practice Partnership (RPP) can be developed in rural communities to support STEM pathways for local middle school youth. RPPs are often described as long-term collaborations between both researchers and practitioners in which the participating partners leverage research to address specific persistent problems of practice. We present findings from a developing design-based RPP focused on bringing community members and organizations together to co-design opportunities for underserved youth in rural mountain communities.

***Keywords*: rural, STEM pathway, research practice partnership (RPP), STEM mentoring, co-design, middle-school, programmable sensor technology, 3D printing**

Youth residing in rural areas often have fewer opportunities to engage with Science, Technology, Engineering, and Mathematics (STEM) through learning experiences in both in-school and out-of-school-time (OST) contexts (Arnold et. al., 2005; Saw & Agger, 2021). Youth persistence and continued engagement are common goals in STEM learning (Leos-Urbel, 2015) and can be challenging in rural settings (Saw & Agger, 2021). STEM learning interventions that are personally relevant to youth have been found to make meaningful connections between STEM learning experiences and youths' lives in their school and their community, especially for youth with low socioeconomic status and from underserved groups (Harackiewicz & Hulleman, 2010; Hulleman & Harackiewicz, 2009). Grounding science and engineering design challenges within a local STEM ecosystem can empower underserved youth to develop their narratives and understandings of their local communities (Taylor & Hall, 2013). Similarly, attending to local knowledge enables youth to see connections between emerging technologies and their local spaces, including the cultural capital they already possess (Zwiers, 2007). According to Bartko (2005), "youth who are committed to and highly active in an endeavor are more likely to continue in that endeavor, [and] see it as part of their identity." Anchoring learning in exploring phenomena and addressing locally relevant challenges enables youth to build interests from their everyday experiences and explore how STEM contributes to their lives and community (Avery, 2013; Bhaduri et al., 2018; Bell et al., 2013).

This article stems from working in a mountain community (called Mountain County) that has many of the characteristics of a rural place including youth from traditionally underrepresented groups in STEM (Saw & Agger, 2021). Specifically, this mountain community has a large population of English language learners and youth from immigrant communities, groups that have been shown in other communities to experience lower levels of confidence in their abilities and reduced participation and retention rates in STEM (Beyer, 2014; Fisher & Margolis, 2003; Fox et al., 2009). Research suggests almost one in five U.S. students attends a rural school, and very little is known about their achievements and academic growth (Johnson et al., 2021). Providing explicit opportunities for youth to relate STEM learning to their lives positively impacts interest development and persistence in the field (Harackiewicz & Hulleman, 2010). Additionally, understanding the local STEM ecosystem can help youth and parents better navigate the existing STEM opportunities and pathways and aid in developing new STEM pathways (Bricker & Bell, 2014).

To develop and support STEM opportunities for youth, one approach is to bring together community members and organizations as a Research Practice Partnership (RPP) focused on STEM opportunities for youth. In an RPP, members collaboratively develop a common body of knowledge, shared practices, and a set of values while cultivating a productive community (MacPhail et al., 2014). These partnerships working in a focused "niche" aim to offer solutions such as "educational tools, materials, and practical guidance" (Cohen & Mehta, 2017, p. 2). Our work builds on this literature to establish and study a developing design-based RPP (Coburn et al., 2013) focused on supporting youth in a rural Western US community. Thus, using RPP for taking the existing STEM ecosystem and turning it from opportunity-based to something more collaborative and eventually interconnected.

Within Mountain County, program funding is readily available due to philanthropy and other funding sources. Yet the funds are not spread equally across the county due to the funding sources being localized in the more affluent parts of the county. As a result, the main limiting factor for the various in-school and OST programming is the number of youth in the county available to participate in these programs. This creates an ecosystem where organizations compete for youth participants sometimes more than funding. Additionally, the network of opportunities is often much less visible to the students who could benefit from them. One primary goal is to create an RPP model with structures, strategies, and tools that encourage and support collaborative relationships between people and organizations across the local STEM ecosystem that serve to build and support coherent STEM pathways for local youth. This study explores what such an RPP looks like in a rural context and how, as a whole, the RPP supports rural students to see and have access to STEM career pathways.

To explore how youth engage in opportunities within the rural STEM learning landscape of this community, we identified three interacting components 1) a community partnership working together to support youth engagement in STEM career pathways, 2) in school and OST curricula where youth use emerging technologies, such as 3D printing and programmable sensor technologies, to engage in science and engineering investigations, and 3) integrated career experiences that encourage youth to make connections with local mentors in STEM and computing fields. These three components can begin to form a model that essentially outlines the partnership: e.g., integrating technology into existing in-school and OST instruction, using local community-based mentors, designing OST experiences, and brokering relationships between these people and organizations.

This article, elaborates on each of these components, how they interact, and how the partners work together to provide opportunities for youth to forge STEM learning pathways within this rural STEM ecosystem.

Background

Our work draws from prior research on STEM ecosystems and the STEM landscape in rural settings, developing and maintaining RPPs, and ways to co-design and adapt large RPPs for rural communities.

Rural STEM Ecosystems and Landscapes

Historically, rural youth faced unprecedented challenges preparing for STEM postsecondary education and careers compared to youth in urban areas (Schafft & Jackson, 2011). Often, they encounter issues of geographic isolation, lack of access to advanced coursework in STEM and related fields, and face economic challenges that hinder their educational opportunities and future employment (Ihrig et al., 2018; Brenner, 2016). Prior research has identified additional challenges that rural communities face, such as a lack of teaching and cultural resources, including libraries, zoos, and museums (Johnson et al., 2021). Tofel-Grehl and colleagues (2021) suggest the need to examine rural youth experience, understand rural educator experiences, and opportunities available to facilitate a rural educational change. We posit that youth experience seeing and embarking on different pathways through a local STEM landscape.

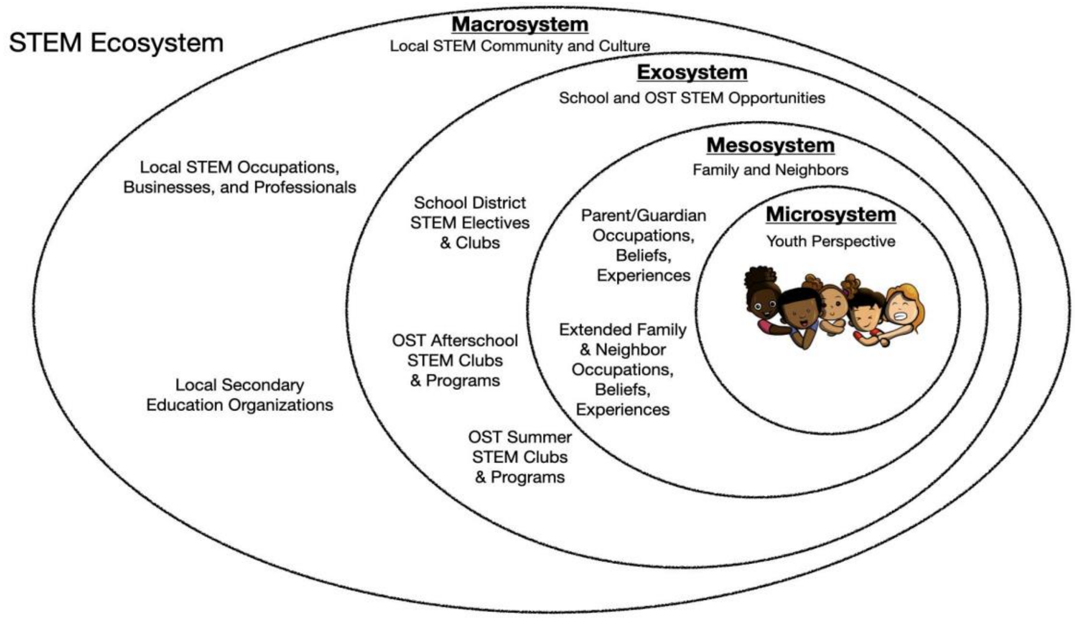
Although rural communities face several challenges, there are also assets from which rural youth, schools, and communities can potentially benefit, leading to positive achievement. Rural communities are tightly knitted, and educators tend to have closer relationships with youth and their families and communities, resulting in a better perception of youth learning needs (DeYoung, 1987; Johnson et al., 2021). Such tight-knit communities contribute to a supportive ethos in smaller communities (Johnson et al., 2021). Rural communities often have a supportive ethos but have limited in-school and out-of-school opportunities for youth (Tofel-Grehl et al., 2021). There is competition among the existing organizations that provide such opportunities to youth since they compete to work with the same small group of youth, duplicating community resources. It raises the need to consider rural STEM learning ecosystems where youth can quickly identify the opportunities available to them and take advantage to better contribute to their learning pathways.

Recent research has presented the benefits of using ecological perspectives to position different learning environments in relation to each other (Dierking et al., 2021) (see Figure 1). From that perspective, a STEM learning ecosystem comprises diverse resources—both in and out of school, where youth develop an understanding of different STEM interests and participation pathways (SIPPs) while traversing the ecosystem (Dierking et al., 2021; Falk et al., 2016). Therefore, we posit that both a STEM ecosystem and a STEM landscape perspective are essential for understanding how STEM pathways are created and sustained at the partner level

(STEM Ecosystem) and how youth and parents navigate these STEM pathways from the youth perspective (STEM Landscape).

Figure 1

Local STEM Ecosystem



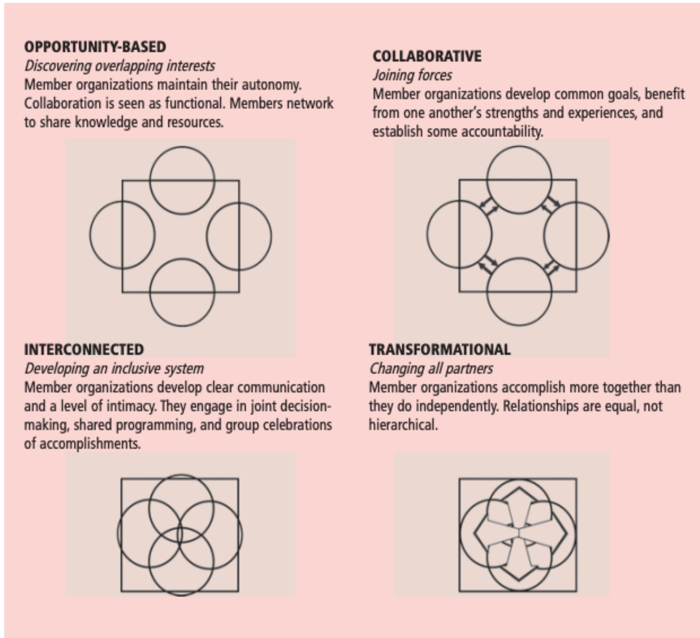
Note: Adapted from Brofenbrenner, 1995.

Research Practice Partnerships (RPPs)

According to Coburn and colleagues (2013), RPPs are often described as long-term collaborations between researchers and practitioners. The participating partners leverage research to address specific persistent problems of practice. Three types of RPPs have been identified—research alliances, networked improvement communities, and design-based RPPs (Coburn et al., 2013). Additionally, RPPs focused on educational reforms provide “organizational structure to facilitate sustained collaboration between researchers and practitioners to improve learning opportunities for students” (Henrick et al., 2017). RPPs that focus on a specific “niche” and work to create solutions such as “educational tools, materials, and practical guidance” are more successful than those that focus on larger-scale reforms and solutions (Cohen & Mehta, 2017, p. 2). Our project is working to establish and study the development of a new RPP focusing on supporting the creation and sustaining of STEM opportunities for underserved students in a rural Western US community. Henrick and colleagues (2017) identified five dimensions for effective RPPs: 1) Building trust and cultivating partnership relationships, 2) Conducting rigorous research to inform action, 3) Supporting the partner practice organization in achieving its goals, 4) Producing knowledge that can inform educational improvement efforts more broadly, and 5) Building capacity of the participating researchers, practitioners, practice organizations, and researcher organizations to engage in partnership work. Most RPPs develop through different partnership types (as in Figure 2) (Allen et al., 2020; Noam & Tillinger, 2004).

Figure 2

Partnership Typology



Note: (Allen et al., 2020; Noam & Tillinger, 2004).

The STEM Career Connections (STEMCC) project, in the second year of developing a new RPP, has progressed similarly through these typologies, starting with opportunity-based and can currently be described as a collaborative partnership. In a sense, the STEMCC model is the partnership, i.e., who is part of the ecosystem (researchers, teachers, mentors, etc.), what they are bringing to the table to support students to embark on a STEM career pathway, and how they support & complement each other in these efforts? We will expand on the development of this partnership further in this paper.

Co-design

This research builds on Yurkofsky and colleague's (2020) framework to examine how "co-design" can serve as an effective internal nurturing process for aligning partnership efforts. Co-design is a highly facilitated, team-based process where project stakeholders and researchers work together in well-defined roles. They design and iteratively refine an educational intervention to collect information on impacted educational practices and their context and engage in collaborative efforts to promote common understanding among different actors (Penuel et al., 2007; Roschelle et al., 2006). Co-design helps establish more realistic expectations and manage emergent tensions among educators, stakeholders, and researchers to work together toward an innovation goal. Within formal education, co-design involving researchers and educators can produce high-quality STEM curricula and build district and teacher capacity to implement innovative learning experiences (see, e.g., Bhaduri et al., 2019, 2021b; Chakarov et al., 2020, 2021; Penuel et al., 2007; Severance et al., 2016).

Building on prior work, our project engaged stakeholders and partners from the Mountain County community to co-design STEM learning curricula and activities for the local youth. Co-design took place over video conference meetings during the 2020-2021 school year and focused on what the future youth STEM learning experience would encompass (Bhaduri et al., 2021). These co-designed curricula have been implemented in multiple formal and informal settings in the same community.

Research Questions

The following research questions guided the development of this new RPP.

1. How can the development of collaborative relationships between community partners in a rural STEM ecosystem develop, build, and support STEM pathways that are more visible, navigable, and coherent for rural youth?
2. What tools and practices are involved in ensuring that existing and new STEM pathways are made available to youth through a developing and expansive rural RPP?

Theoretical Framework

Partnership Types

Our approach to developing a design-based RPP was inspired by prior work that suggests, in design-based RPPs, researchers and practitioners collaborate when building and studying solutions in real-world contexts while investigating ways to best support youth learning (Yurkofsky et al., 2020). Thus, taking the learnings from large urban districts and applying them to rural contexts by understanding ways to create a partnership “niche” within the context (Yurkofsky et al., 2020). Through this design-based RPP, our work emphasized the importance of practice and research by co-designing instructional materials for youth that can be implemented in-school and out-of-school (Cobb & Jackson, 2012). And finally, co-designing pathways for youth and advancing research and theory for the less studied, rural population (Johnson et al., 2021).

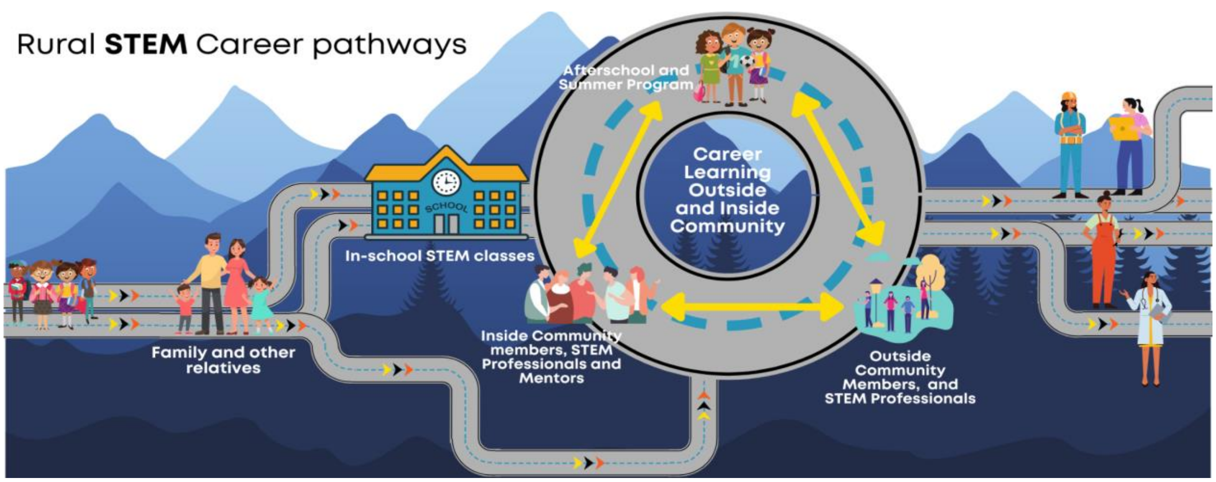
Drawing from prior work by Noam & Tillinger (2004), we use the partnership typology (see Figure 2) to describe the development of our RPP. We identified that the STEM ecosystem (see Figure 1) was rather competitive in Mountain County during our initial partnership building. Several community organizations, i.e., afterschool and OST programs, offer similar programs to youth, and the in-school curricula lacked STEM focus. Hence, the main limiting factor for the various in-school and OST programming was the number of participating youth in the county and the need for more STEM-focused curricula. As an RPP team, we identified community members and organizations with overlapping interests in creating STEM pathways for the rural youth residing in this community; in other words, it started as a functional partnership (Noam & Tillinger, 2004). After identifying common interests, this RPP focused on a common goal set by joining forces with community members and organizations to move to a collaborative partnership. The goal was to co-design STEM opportunities and access for the youth in the community and help them develop a better understanding of the STEM landscape from their perspective. While this RPP is in its second year, the aim is to move to a transformational partnership eventually. The different partners accomplish more goals together than they do when working independently. It allows all partners to change together and create equal relationships instead of maintaining a hierarchy (Noam & Tillinger, 2004). Building on this framework, our work investigates how co-designing with local partners enables youth to develop STEM applications within their everyday lives and connect with various STEM career pathways accessible in their communities.

STEM Pathways

Bricker and Bell (2014) outline STEM learning pathways as ‘constellations of situated events’ distributed across social and material spaces. From this perspective, individual youth’s interests and participation in STEM are constantly in development across their participation in various settings as they develop relationships to larger, and differing, communities and engage in material practices. We build on this framework to articulate a STEM pathway as a set of connected experiences deliberately developed to increase youths’ interest and participation in STEM opportunities local to the rural community of Mountain County. Part of this work is developing STEM experiences that are intentionally stitched together across in-school and OST learning spaces (both formal and informal) for middle school youth. Through the creation of multiple STEM-related interest pathways (see Figure 3), we place STEM learning at the center as interconnected processes developed from a constellation of situated events where youth can encounter multiple community connections to STEM and STEM careers, in afterschool programming, at summer camps, and in the youths’ middle school classroom experiences. In other words, the development of a STEM pathway means making room for youth to imagine futures impacted by STEM. By focusing on designing and investigating these STEM pathways and their development, we can explore how the larger STEM ecosystem frames access to different visions of futures for participating youth and how they perceive pathways created at the STEM landscape level from the youth perspective.

Figure 3

Rural STEM career pathways as identified in the STEMCC project



Context and Methods

This project focused on developing a rural design-based RPP that can bring various stakeholders together to create, support, and sustain opportunities for middle school youth to engage in local STEM career pathways. According to the 2020 U.S. census, Mountain County has a population of around 55,000 and covers over 1500 square miles within a remote rural area of the Rocky Mountains in a midwestern state. The school district that serves this community contains 20 schools and around 7,000 students, with the district’s minority enrollment at 55.8%.

Additionally, 38% of students are economically disadvantaged and eligible for federal free and reduced lunch. The student body of the school district is 44.2% White, 0.6% Black, 0.6% Asian or Asian/Pacific Islander, 52.1% Hispanic/Latino, 0.4% American Indian or Alaska Native, and 0% Native Hawaiian or other Pacific Islander. In addition, 2.1% of students are two or more races, and 0% have not specified their race or ethnicity. Also, 47% of students are female, and 53% are male. Of the student population, 33.9% of students are English language learners. As mentioned above, many of the current youth programs are competing for participants. Yet many youth, particularly those from minoritized populations, do not know about or have access to the full menu of options. One primary goal is to create structures, strategies, and tools for these organizations to collaborate to build and support coherent STEM pathways.

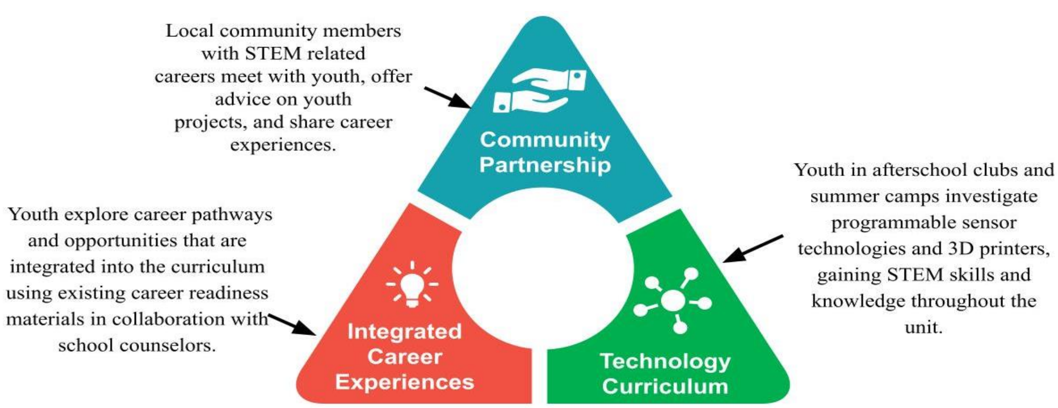
The STEMCC project is focused on developing an innovative career readiness model for both in and out of school settings that will profoundly increase the knowledge of and interest in STEM and computing careers for middle school youth within a rural mountain community who are often underserved in STEM fields. To achieve this goal, we have three integral components of the project (see Figure 4): 1) a community partnership working together to support youth engagement in STEM and computing career pathways, 2) a STEM curriculum where youth use advanced technologies (such as 3D printers or programmable sensors) to engage in science and engineering investigations and, 3) integrated career experiences that encourage youth to make personally-relevant connections with local STEM and computing occupations.

Participants

To develop an innovative STEM career readiness model, the STEMCC project has been working with local partners to bring together relevant stakeholders in the local rural community to develop relationships across the STEM ecosystem that can support existing STEM opportunities for youth and create and sustain new opportunities for youth to engage in STEM in ways that are relevant and meaningful to their local community.

Figure 4

STEM Career Connections (STEMCC) Project Overview



Local STEM Occupations, Businesses, and Professionals

The project works collaboratively with local STEM occupations, businesses, and professionals in multiple capacities. First, representatives from three local STEM-related businesses are participating in the project community STEM advisory group. Additionally, STEM professionals worked directly with youth as STEM mentors. A total of 46 STEM mentors worked with students during the 2020-2021 school year, 12 STEM mentors worked with students during the summer OST program, and 30 STEM mentors worked with students during the 2021-2022 school year. The mentors meet directly with students to make explicit connections between what students were doing in class or the OST program and how STEM is used in their local community as well as the STEM careers that exist within the local community.

Local Secondary Education Organizations

One representative from the local community college is currently participating in the project community STEM advisory group. The college offers programs leading to certification, associate's degrees, and bachelor's degrees, many of which are STEM-related and relevant to the careers offered in the local community and surrounding areas.

In-School Partner

Multiple stakeholders within the local rural school district actively participated in the project, including the school district's assistant superintendent, the college and career counselor coordinator, the career-X and Avid coordinator, two district educational technology specialists, and three STEM elective teachers from three different middle schools in the district.

Out-of-School-Time (OST) Organizations

Two organizations provide programming for OST learning experiences within the targeted rural community. One organization offers both afterschool and summer programming to youth in the community. The afterschool programming provided by this organization utilizes a club-based approach and focuses primarily on social-emotional needs and learning and partnered with the project to begin to offer STEM career-focused programming not previously offered. Through the 2021 summer program, 120 middle school youth participated in a four-week summer camp with one week dedicated to STEM and STEM career learning.

The second OST organization primarily offers after-school programming at the middle school level focused on STEM learning. During the 2020-2021 school year, five middle school youth participated in STEM project curriculum at one middle school. During the 2021-2022 school year, 64 middle school students participated in STEM project curriculum at five sites.

Youth Participants

Rural middle school youth in this community have participated in both in-school and OST project STEM activities. Youth participate in in-school STEM project activities through the STEM electives at four middle schools in the district. As a result of the work with the STEM elective teachers, around 700 middle school students participated in project STEM activities during the 2020-2021 school year, and 150 middle school students participated in project STEM activities. Project activities included designing, programming, and building sensor integrated physical computing systems; designing, revising, and creating 3D printed animal prosthetics; integrated STEM career connection lessons that were co-designed with the teachers and district college and career counselor coordinator; and engaging with local STEM mentors and guest speakers who worked with students to make explicit connections between what students were doing in class and STEM and STEM careers in their local community.

Table 1

List of data sources we collected and analyzed

Data Source Type	Description	Data Collected
Project Meeting Notes	We use the ongoing meeting notes document to keep everyone apprised of relevant information.	Every two weeks
Partner Surveys	Partners reflected on motivations for participating in the project, their experience being part of the advisory board, and suggestions for improving the experience.	After every implementation
Reflective Memos	Document what the project has accomplished over the past few months and reflect on project goals and our partnership toolkit framework. The guiding questions and key constructs for these memos are listed in Appendix A1.	Quarterly
Debrief Interviews	Elicit teacher and facilitator perceptions of the overall experience with the co-designed curriculum, resources, the collaboration, student engagement and perspective of STEM, and any other formative feedback.	Post-implementation, 9 teachers and program facilitators, 45-minute-long interviews
Semi-Structured Student Interviews	Gauge youth perspectives on the co-designed curricula and activities and elicit their perceptions of the curriculum, their understanding of the technology, knowledge of STEM in the community, and their STEM interest resulting from their participation in the unit.	Post-implementation, 4-5 youth from each implementation, students selected by teacher, 15-minute-long interviews
Focus Group	Gauge stakeholders' perception of the partnership development.	End of the year
External Evaluation Reports	Evaluation team for the STEMCC project administered surveys and conducted interviews with the main partners and STEM mentors participating in the project. This was provided as feedback to the project.	Every 4-6 months
Partner Communications	Email communications with partners were documented to track how the various relationships within the project developed over time and what tools and strategies helped cultivate these relationships	Weekly communication
Community STEM Advisory Group Meeting Notes and Observations	Detailed notes from all internal research planning meetings and detailed observation notes from advisory meetings. At meetings, stakeholders conducted activities and discussed STEM opportunities for youth leading to collective imagining of future opportunities.	Quarterly

Data Sources

We collected data in various forms from partners at different points of the partnership development and as a part of the project activities. The data sources and their description are listed in Table 1.

Data Analysis

Data were analyzed using a constant comparative method (Creswell, 2013; Glaser & Strauss, 1967). Members of the research team used open coding to analyze the data to determine what topics or themes might emerge that accurately conveyed the nature of the tools and practices involved in the development of the rural design-based RPP and the resulting youth STEM pathways (as recommended in Merriam, 2002; Saldaña, 2021; Strauss & Corbin, 1990). This qualitative analysis of each data source involved identifying themes that relate to the research questions. At least two researchers analyzed the data and discussed what they noted with the larger research team (as recommended by Merriam, 2002; Stake, 1995). The researchers then resolved any coding disagreements. Our team consolidated codes after the first coding focusing on best tools and practices for developing rural RPPs. This focus allowed us to better understand the rural space the different community partners were situated in and consider the local youth perspective.

Then by methodological triangulation (Bekhet & Zauszniewski, 2012) of the other data sources, we validated our findings and understanding of the common themes to develop the RPP resulting in rural STEM pathways for youth. Furthermore, this coding allowed us to explore the expected and unexpected lessons learned through the developing RPP. After several iterations, we agreed to document the key themes and review them after each implementation and partnership meeting. Finally, we created analytic memos noting when instances of each identified theme were explicitly evident. We then reviewed and discussed each other's memos and analysis notes and collaboratively considered their interpretations, ultimately reaching a consensus on what to include in this article (as recommended in Merriam, 2002; Stake, 1995).

Findings

Our findings are presented in the form of our two research questions.

RQ1: Collaborative Development of a Rural Design-based STEM Research Practice Partnership.

Figure 5 outlines the activities involved in the development of this new rural Research Practice Partnership that brought various stakeholders together to create, support, and sustain opportunities for middle school youth to engage in local STEM pathways.

Year 1

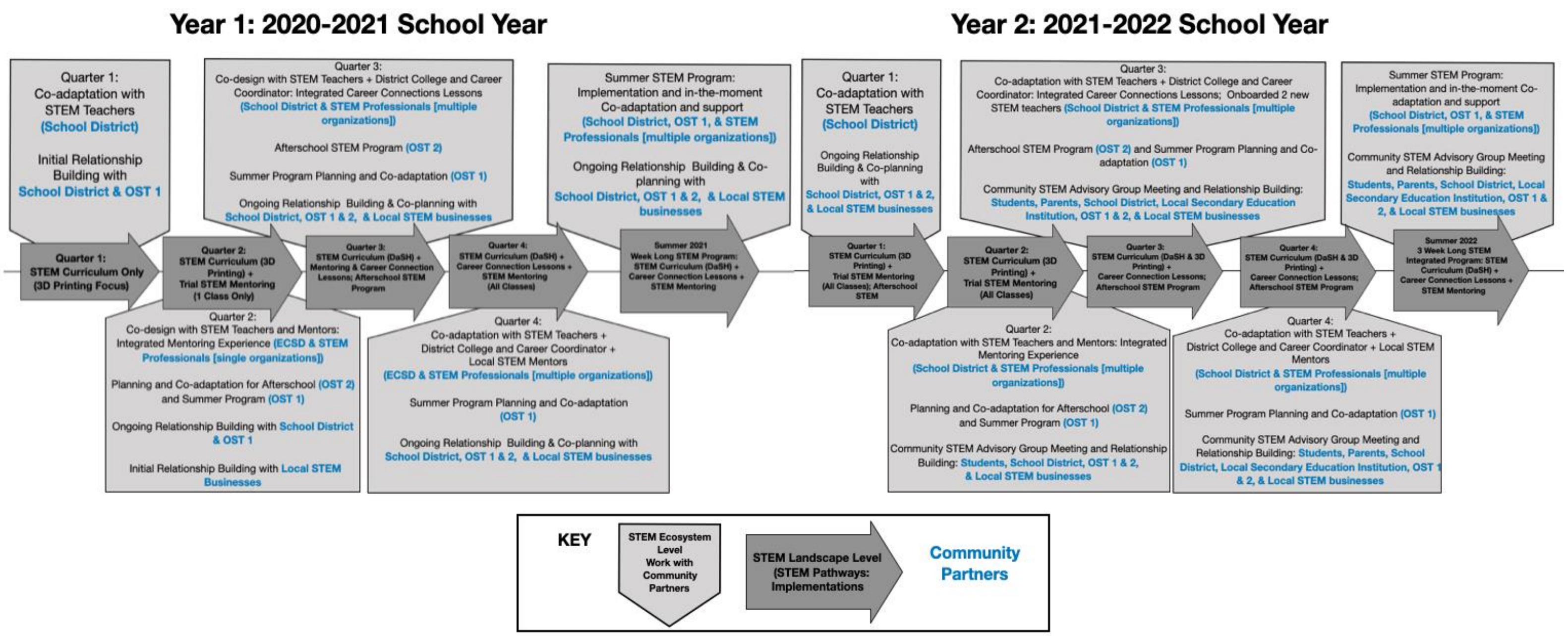
Partnership development takes time and must be viewed from a long-term lens. Developing relationships among community stakeholders, however time intensive, can result in strong collaborative partnerships. This project began with developing a previously established relationship with one of the OST organizations in the community (OST 1). Working with OST 1 served as a way into the community, and an opening to characterizing the STEM ecosystem d at the community level. It also supported us in developing a youth perspective on the STEM landscape, or opportunities and pathways. OST 1 was, and still is, one of the largest primary OST programming providers for youth in Mountain County. The organization did not, however, offer any STEM related programs. Leaders of OST1 hoped that our partnership would lead to the development of youth STEM programming of some kind. We originally planned to co-design summer STEM programming with OST 1 and work with OST 1 to identify and develop relationships with possible local STEM business partners. After developing the out-of-school STEM learning spaces, we envisioned partnering with the local school district to connect and integrate the core components of our model.

The COVID-19 pandemic made a summer program unlikely and created challenges in developing relationships with local businesses as they dealt with closures and other issues of their own. Therefore, the STEM summer program in the first year was not possible. OST 1 introduced our team to the Assistant Superintendent for the school district with whom we discussed integrating our project into middle school STEM classrooms. The Assistant Superintendent was enthusiastic about this opportunity and connected us with two middle school STEM teachers. Both teachers were excited about the opportunity to engage in co-designing, testing, and revising their STEM curriculum to include connections to local STEM occupations and STEM mentoring. As this new plan of action unfolded, we continued to work with OST 1 planning after-school programming and summer programming for the future. At this point, all the interactions were opportunity-based (see Figure 2).

Our team worked closely with the two STEM teachers, Eva and Sean (pseudonyms), whose weekly schedules included four days in-person (one-hour long session) with one day for asynchronous learning and lesson planning. Over the summer, we codesigned and adapted a 3D printing curriculum with Eva and Sean for use in their classrooms (Bhaduri et al., 2021b). The curriculum used storylining, an instructional design approach that uses students' questions to drive the lessons in ways that promote coherence, relevance, and meaning. Eva and Sean implemented this curriculum with their students in fall 2020. Each quarter, they worked with a new group of students who solved the question: "How can we support animals with physical disabilities so they can perform daily activities independently?" Students engaged in the engineering design process to develop and print prosthetic limbs for animals with disabilities using 3D modeling and printing. During quarters three and four in the spring of 2021, the research team worked with Eva and Sean to co-adapt and implement the sensor immersion unit which centered on students investigating programmable sensor systems called the Data and Sensor Hub (DaSH) (Chakarov et al., 2021), creating their own sensor data displays, and applying their knowledge of programmable sensors to local STEM problems and careers. We provided professional learning workshops, weekly group meetings between researchers and both teachers, and other as-needed support. Due to the ongoing COVID-19 pandemic, this professional learning had to be conducted entirely through remote, virtual contexts.

Figure 5

Ecosystem and Landscape Overview of a New STEM-Focused Rural Research Practice Partnership



In quarter two of fall 2020, we piloted an in-class mentoring approach where students received mentorship from a local medical research and treatment organization to embed connections between the curriculum and STEM careers. A low student-mentor ratio and working with students invested and interested in the interactions was essential for the organization to participate remotely. We found that student interest in STEM increased with the addition of the mentoring component (Bhaduri et al., 2021a).

In quarter three in the winter of 2021, the research team worked in collaboration with the school district's lead College and Career Counselor and Eva and Sean to develop and pilot a new curriculum that could be integrated into middle school students' STEM learning experiences. This curriculum focuses on developing youth's understanding of what STEM entails, how their coursework (e.g., 3D printing, programmable sensors) connected to STEM careers in their local community, and what local STEM career pathway opportunities existed. In quarter four, we support the implementation of all three components (Sensor Immersion, career connections, and mentoring curricula) into the two middle school STEM classes.

Through our relationships with the school district and OST 1, we discovered a second OST organization (OST 2) that offered STEM-focused programming in an after-school setting. The research team met with the director and program coordinator from OST 2 to discuss implementing a pilot after-school program that would adapt the sensor immersion curriculum, career connection lessons, and mentoring. OST 2 piloted the Sensor Immersion Unit and career connections at one site over five days. OST 2 leaders noted that the youth in this pilot implementation were highly engaged and interested in STEM. This began a relationship with OST 2 that has helped surface challenges previously unknown. We discovered that OST 1 and OST 2 had a longstanding and tenuous relationship as they were regularly competing for participants from the same communities. We organized a virtual meeting between the two organizations to discuss the possibility of creating connected STEM opportunities for youth that are built on each other. Both organizations were open to collaborating toward this purpose. This was the start of moving this partnership from an opportunity-based partnership toward a collaborative partnership (see Figure 2).

Our team continued to work with OST 1 to plan for the summer 2021 programming, a four-week summer camp where each week would have a different focus. Together, we planned a week-long STEM-focused learning experience designed to be inclusive, accessible, and engaging for all youth regardless of ability, home language, or experience level with programming. The week integrated the sensor immersion, career connections, and mentoring curricula into the summer camp context. This required a collaborative working relationship between OST 1 and our team to conduct training for the summer staff, recruit educators, recruit local STEM professionals to be youth mentors, and train the camp's high school-aged youth interns.

During the STEM week, youth learned how to build and program the DaSH, investigated STEM careers related to computing and sensor usage, and met with mentors three times. In these activities, participating youth brainstormed projects using the DaSH that could solve locally relevant problems such as: creating an early warning system to detect wildfires using temperature, soil moisture, and CO_2 sensors; a wildlife fence system using a sound sensor to wildlife close to the road and alert motorists and local wildlife rangers; a system to find someone who is lost in the wilderness or in an avalanche; and creating a smart garden that uses sensors to monitor the environment and automatically control the moisture-level, temperature, and humidity.

After the STEM week, youth and staff were interviewed and provided feedback on the experience. The youth noted:

> "I loved the coding. I think it was a fun way to learn."
>
> "I liked the programming and getting to wire the sensors."
>
> "It's just cool to like, piece together stuff, puzzle it, make it kind of your own. And then for it to actually like, do something and work, it's really cool."
>
> "I feel like I learned a lot. It can be useful in the future for a STEM career. Like, I can think back to this or know how I programmed it."
>
> "I learned that a STEM job is really fun and you use a lot of technology."

During the interviews, the summer camp staff noted:

> "Watching the kids present their projects at the end of the week was a highlight. Getting to see how much they learned."
>
> "The entire class created a video to showcase their project about a system that could tell you when a class is being too loud for the library. It was cool seeing the whole class come together to work on that."
>
> "The enrichment activities were really fun and engaged the kids and connected back to the programming."
>
> "I think kids will notice sensors in the real world more, I know I have."
>
> "They are going to take away that they can do this [coding and wiring] and that they were able to figure it out."
>
> "As the week went on the kids got more and more engaged."
>
> "I had kids who I thought would be challenging gain confidence in themselves and their abilities."

Through the planning and implementation of the STEM week of summer camp, we also improved our partnership with OST1 and established additional relationships with local STEM professionals. Based on this feedback, OST 1 and the research team are working to fully integrate STEM learning experiences across the entire upcoming 2022 summer camp. This experience exemplifies the possibilities when partners and stakeholders see and experience the value of providing rich ongoing STEM experiences for youth in their community. It can lead to increased partner engagement and commitment and the development of more shared partnership goals.

Year 2

We are currently still in year 2 of the partnership and are here reporting on the ongoing developments thus far. In year 2, we expanded the STEM programming offered by OST 2 and the STEM classes offered at the middle schools within the partnering district. Working with the local school district, two additional middle school STEM teachers joined the project, extending the student impact of the partnership. We are continuing to work with the college and career counselors and coordinators to refine the career connection lessons integrated directly into youth STEM learning experiences to make explicit connections between their STEM experiences and local STEM careers and career pathways. Through the partnership with the school district the assistant superintendent introduced us to the two district education technology specialists, with who we have been collaborating closely within the work with the middle school STEM teachers and have together worked toward the goal of building capacity in the district to support teacher implementation of project related curricula and STEM mentoring experiences.

The partnership has been able to bring together OST 1 and OST 2 to coordinate STEM learning opportunities between after-school and summer programming. OST has been collaborating with the research team and local STEM businesses to plan for a three-week-long summer camp with fully integrated STEM components such as the DaSH, STEM mentoring with local STEM professionals and businesses, and explicit career pathway connections. OST 2 has since expanded their STEM learning programming to follow a storyline format, integrate STEM career pathway learning opportunities, and utilize local STEM businesses for STEM mentorship and STEM learning opportunities at sites outside of the after-school program.

Additionally, through the direct collaboration with the individuals in the school district, OST 1, and OST 2 we have been able to develop new relationships across the STEM ecosystem leading to the formation of a STEM community advisory group bringing together multiple stakeholders within the community including individuals from the school district, OST 1, OST 2, parents, students, community leaders, and multiple local businesses and STEM professionals, some who have served as STEM mentors and some who are participating in the partnership for the first time. This group is working to better understand the local rural STEM ecosystem and support existing STEM pathway opportunities and identify opportunities to develop new STEM pathways that traverse the entire STEM ecosystem. This points to the partnership becoming a more collaborative partnership and possibly moving toward an interconnected partnership (see Figure 2).

RQ2: Tools and Practices to Support Rural STEM Pathways for Youth

As a result of the collaborative work of the partnership, multiple tools and practices have been developed and utilized to cultivate the relationships between community stakeholders participating in the partnership. These tools and practices are described below.

STEM Pathway Development Tools

Several STEM pathways development tools emerged from our initial years of the RPP. These tools include the following components:

1. **Survey of the existing STEM ecosystem.** We realized that it is crucial to identify who is already providing STEM experiences for students in the community (i.e., informal science organizations, and businesses that engage in outreach). We aim to create STEM experiences valuable to rural youth, the local community, and our research team. The team worked with community members to develop an initial Community Asset Map to depict the existing STEM ecosystem. It would enable youth to realize the STEM opportunities available and help define their STEM pathways.
2. **Co-designed Curricula and Career Connections Lesson Activities**. The co-designed curricula and Career Connections lesson activities include 1) iteratively refined in-school and OST curricula built around focal phenomena and integrating place-based sensor-integrated and 3D printing activities, and 2) guides to help facilitators and mentors from

local businesses support youth in these learning activities. The 3D printing curriculum focused on using 3D design, 3D printing, and augmented reality to design prosthetics for disabled animals. The sensor immersion curriculum focused on youth investigating programmable sensor systems, creating their own sensor data displays, and applying their knowledge of programmable sensors to local STEM problems and careers. The professional development had to be conducted completely through remote, virtual contexts due to the pandemic. Our team provides professional learning workshops, and ongoing professional development through just-in-time meetings as needed to support the teachers, mentors, and other partner organizations. Toward this effort, our team has worked to revise and refine STEM curricula and STEM career activities for both in-school, afterschool, and summer camp contexts, and support the adaptation of the curricula for either in-person or remote learning.

3. **Newsletter for ongoing communication between partners.** The research team along with input from the school district, and both OST partners compiled two newsletters during year 1 of the partnership. The goal is to disseminate our project updates through these newsletters to participating organizations/individuals and members of the local community. In spring 2021, the first newsletter included our project accomplishments and thanked every individual who participated, volunteered, and supported the goals of the partnership activities. During the 2020-2021 school year, we shared how students, teachers, and organizations within the county came together intending to increase youth knowledge, interest, and engagement with STEM career pathways. Through the work of these partners, more than 700 middle school students had the opportunity to engage in STEM and computing learning experiences, connect to STEM careers in both their local community and the wider world, and integrate mentoring experiences with STEM professionals.
4. The fall 2021 newsletter included highlights from summer and fall 2021 and future project goals. We shared how over 120 youth met with local STEM mentors in the summer camp. They investigated local phenomena using their individually programmed sensor systems and learned about STEM career pathways. There were other highlights from the fall 2021 implementation of the 3D printing unit and how different guest speakers and mentors interacted with participating students to support their animal prosthetics design. We also presented updates from our first STEM community partnership meeting and our plans to continue to meet and bring community members together. The newsletter, developed collaboratively with partners and stakeholders, has served to keep partners and community members informed and engaged in the project as there are many components to the partnership and not all stakeholders are directly involved in every component. Partners have also shared the newsletter with the youth and parents they serve to increase community engagement and excitement for STEM opportunities being developed and offered in the community.

STEM Pathway Development Practices

We identified the following key practices crucial for developing STEM pathways for rural youth by involving local community partners.

1. **Laying the foundation for community partnerships.** It is essential to clarify the goals and capacities of each partner in the RPP involved in developing the STEM pathways. We created a one-page document to define the rural STEM Pathway development innovation goal, directed to the partnership audience. Furthermore, we learned about the partner's work/goals and shared goals and identified alignments between the partner's goals and our project goals to create mutually beneficial relationships. We provided as many details about the ask for involvement as possible. Our team set up a communication structure to determine the point of contact, mode, and frequency of check-ins, and ways to share existing resources developed to serve our targeted rural community. Furthermore, we identified potential partnerships organizations and partners to serve as STEM mentors. We reached out to likely partnership organizations/individuals our teachers have already had positive outreach experiences. We asked school leadership, teachers, etc., to make first introductions between our project and contacts they have worked with successfully before. This formed the foundation for the community partnership and the gradual development of youth STEM pathways.
2. **Building community partnerships.** After, the initial foundation of the partnership **building**, we engaged partners in activities that best suited their individual and organizational goals. Our team created a program that works for all participating organizations by determining their needs. These often-included scheduling needs, language supports, programming opportunities for all youth. We also noted the needs of the mentor organization, like having a small student-mentor ratio, working with an engaged student audience, minimizing time and impact on their workday. Then, we implemented different structures for student-mentor experiences based on the setting. For example, during virtual mentor meetings, we required more organization: agendas, tips for engaging with middle schoolers, preparing students for mentor meetings, e.g., preparing questions in advance, preparing to share updates on their classwork. But when meeting in person/during summer, many of these supports seemed too rigid and unnecessary. Our team also realized the necessity to find opportunities for the partners to provide support. STEM professionals can support youth with curriculum projects, share related career experiences often tying back to the community, provide access to stories and resources related to topics of interest to the students, and correspond via email with students. We realized it was important to offer ways for partners (teachers, mentors, etc.) to share ongoing reflections before and during the implementation and ideas for co-development of activities. From the data collected, our partners reflected on how they appreciated constant communication and regular project updates. Most of them were excited to continue being involved with the project to support the bigger goal that the RPP was working towards.

Discussion

This project is continuing to work toward generating theory, resources, and research data on how to develop collaborative rural community partnerships and support teachers and OST facilitators to provide effective and engaging STEM learning experiences. These experiences emphasize relevant opportunities for diverse students to make connections to and generate interest in local STEM careers and career pathways within the STEM ecosystem in Mountain County. Developing community partnerships has revealed some long-standing issues between two of the OST programs within the context of the small rural community. The project has impacted these after-school programs in a positive and constructive way through intentional communications and a renewed spirit of cooperation. Hence, in such developing RPPs there always arises a need for bridging and buffering between partners. This involves facilitating the connection between partner organizations and creating protective spaces for those working in the partnership to keep possible contradictory guidance, policy, or leadership at bay.

Furthermore, from this developing design-based RPP we gathered that partnership building takes time, and commitment from stakeholders occurs when they see value in the partnership and the resulting STEM pathway opportunities (Coburn et al., 2013). We noticed that partner organizations and individuals find this partnership to give back to their community. For instance, a handful of the STEM professionals/mentors grew up and did their schooling in the local community and went outside this Mountain County for future STEM college degrees. On completion of their degree, they returned to the community and found a way to give back to the community by sharing their experiences with youth and encouraging them to realize the opportunities available in their community. They are also actively involved in supporting us brainstorm ways to develop other possibilities for the local youth. This allows for accessing the local resources to identify and develop the STEM Ecosystem and eventually STEM Landscape for the future generation of youth in the community.

This work also enabled us to realize the need to tap into and build on the relationships and contacts of the local stakeholders. It is especially important in a rural context where most of the stakeholders know each other and what is going on in the community. During the initial partnership building process, it is vital to identify potential partnerships organizations and partners to serve as STEM mentors, focusing on relevant and achievable goals for the partnership. It allows stakeholders to see progress and move forward together as a collaborative team and contributes to a “niche” reform rather than large-scale reforms (Yurkofsky et al., 2020). There can be instances when potential partners we contacted do not get back, but we should not get discouraged from reaching out to these partners or continuing the efforts of developing STEM opportunities and access for underserved youth.

Conclusion and Implications

This article presents the benefits and challenges of developing a rural design-based Research Practice Partnership (RPP) to create STEM opportunities and access for youth in the local STEM Ecosystem. It presents through the process of co-design with local stakeholders, the RPP was able to stitch together various learning experiences (i.e., career connection lessons, STEM mentoring, and STEM focused curricula) to create opportunities for students to explore local STEM Careers and career pathways. This RPP utilized the existing STEM ecosystem and identified ways to turn it from opportunity-based to a more collaborative and eventually interconnected ecosystem. The paper also presented that co-design can be one strategy for creating opportunities for rural youth to engage with STEM in ways that are specific to their communities. This paper describes the use of co-design to develop opportunities for youth in rural communities to engage with STEM. These findings outline contributions to youth STEM engagement and awareness of STEM career pathways and opportunities. It also highlights the power of co-design with multiple stakeholders and partners in helping to develop local capacity and develop RPP relationships. While these findings worked for Mountain County, we believe that the RPP needs to be studied further to be able to generalize to other communities.

Two possible future directions of work identified through this work include the need for sustaining the partnerships and including families as part of developing pathways. To this point, it has been difficult to involve parents directly in the partnership due to challenges related to the COVID-19 pandemic. Currently, two parents have been invited to participate in the project community STEM advisory group. Moving forward, the project is working to involve more parents and caregivers directly in project planning and activities.

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Acknowledgements

We thank the anonymous reviewers for their valuable suggestions and feedback. This material is based upon work supported by the National Science Foundation under Grant No. 1948709. We thank our collaborators on these grants for their constant feedback and support. This work would not have been possible without the teachers, students, and administrators of the participating school districts for their patience with data collection and supporting this research, even during the pandemic.

Appendix

A1. Guiding questions and Key Construct for the Reflective Memo:

Guiding questions:

1. How has our work centered the problem of developing powerful learning experiences for youth (in and out of school) that ignite interest in STEM and computing and develop career connections?
2. What kinds of local partnerships can make that more of a possibility? (Penuel et al., 2020).

The **key constructs** involved in these memos are

1) Bridging: facilitating connections with initiatives and other operating parts of the partner organizations.

2) Buffering: creating protective spaces for those working in the project that keeps possible contradictory guidance, policy, or leadership at bay.

3) Shared tools involve development of tools used for asynchronous, ongoing collaboration, including capturing decisions and feedback for improvement. (Yurkofsky et al., 2020)

4) Informal support: Ongoing work that helps partners as they implement youth learning experiences that are not captured in other representations of the partnership. Ex. Helping with a technological issue.

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