Engineering Educators Bringing the World Together
2025 ASEE Annual Conference & Exposition
Palais des congrès de Montréal, Montréal, QC • June 22–25, 2025
Paper ID #47076

Motivations, Challenges, and Funds of Knowledge for Children's Engineering Learning at Public Library in Rural Communities (Fundamental)

Dr. Soo Hyeon Kim, Indiana University Indianapolis

Soo Hyeon Kim is an Assistant Professor of Library and Information Science in the Luddy School of Informatics, Computing, and Engineering at Indiana University Indianapolis. As an information and learning scientist, her research agenda has focused on transforming rural libraries as facilitators for children's engineering learning by expanding the benefits of makerspace and online space. She received her Ph.D. from Learning, Design, and Technology program at the Pennsylvania State University.

Dr. Gi Woong Choi, University of Cincinnati

Gi Woong Choi, Ph.D. is an Assistant Professor of Instructional Design and Technology. Dr. Choi received his Ph.D. in Learning, Design, and Technology from Penn State University and has a background in human-computer interaction and user experience. His current research interests include AI in Education, informal STEM learning, problem-solving, makerspaces, and educational affordances of technologies.

Ju Hui Kang, University of Cincinnati

Ju Hui Kang is a PhD student in Instructional Design and Technology at the University of Cincinnati. She has a previous background in human-computer interaction and communications, and her research interests include informal/online learning, as well as education in digital literacy and the use of social media for learning.

Motivations, Challenges, and Funds of Knowledge for Children's Engineering Learning at Public Library in Rural Communities (Fundamental)

Motivations, Challenges, and Funds of Knowledge for Children's Engineering Learning at Public Library in Rural Communities (Fundamental)

Abstract

Rural communities often lack access to engineering learning opportunities for children and caregivers. An online engineering program at rural libraries has the potential to broaden engineering participation; however, less is known about specific challenges that librarians and caregivers may experience in engaging in online engineering learning. As such, this study investigates rural librarians and caregivers' goals and challenges for providing online engineering learning for children, and identify engineering-related funds of knowledge to understand how these challenges might be addressed. A case study methodology was employed based on interviews and ideation sheets of 21 caregivers and 10 librarians as well as librarians' engagement during co-design sessions. Findings demonstrate abundant funds of knowledge acquired from rural participants' familial, community, recreational, and interactional practices that are related with skills and habits of engineering. The findings further illustrate librarian and caregivers' goals and motivations for offering engineering learning opportunities while highlighting engineering-related, online-related, and other challenges. Implications for designing a culturally responsive online engineering program that leverages rural participants' funds of knowledge are presented.

Introduction

Given that children's career aspirations towards—and away from—engineering start as early as 10, it is critical to provide opportunities to understand what engineering is from an early age [1]. However, rural districts are often excluded from federal initiatives and lack resources to implement engineering curricula [2]. Research shows that informal science education can positively impact children's engineering interest. However, programs offered in museums, hobby clubs, citizen science projects primarily serve urban or suburban community members [3]. We argue that rural libraries—often the only public institution that provides free access to learning resources—can address this challenge by positioning them as hubs to broaden engineering participation. One particularly effective yet unexplored way to facilitate engineering learning in rural libraries is through online learning. While existing endeavors have shown promise in broadening STEM participation at public libraries [4], the research that leverages the online space to strengthen public libraries' outreach programming is rarely examined. Considering that time constraints and lack of transportation are critical barriers for participation in out-of-school STEM learning opportunities [5], we contend that an online engineering program, offering take-home engineering kits, hotspots, and tablets for community members to participate via video conferencing software (e.g., Zoom), has the potential to expand the outreach educational programming at rural libraries.

This study lays the foundation for developing such online engineering program for rural children (5-11 years) and caregivers (i.e., parents, legal guardians). Prior literature suggested that different resources and skills in rural libraries can impact their ability to offer programming (e.g., fewer full-time employees, limited funding and broadband access) [6]. Library staff's anxiety towards STEM can also become a critical barrier [7], [8]. However, little is known about specific challenges that librarians and caregivers may experience in engaging in online engineering learning. As such, this study aims to first understand goals and challenges that rural library staff and families may experience in participating in engineering learning, particularly using Zoom and the Internet. We will then identify engineering-related funds of knowledge to explore how these challenges can be addressed while supporting the goals they hope to achieve. Funds of Knowledge (FoK) takes a strength-based approach to consider learners' home, cultural, and everyday experiences as valuable learning resources [9]. Our conjecture is that making connections to engineering-related FoK and supporting families and librarians discover that engineering is prevalent in everyday life will have a positive impact on helping them engage in engineering learning. As such, this study will investigate rural library staff and caregivers' goals, challenges, and engineering-related funds of knowledge to develop a culturally responsive [10], [11] online engineering program for rural children. We ask the following research questions:

1. What are rural librarians and caregivers' goals and motivations for providing engineering learning opportunities for children?
2. What challenges do rural librarians and caregivers experience in supporting children's engineering learning in online settings?
3. What are rural librarians' and families' engineering-related funds of knowledge?

Theoretical Perspectives

Broadening participation in engineering is often associated with broadening access to diverse populations to enter into the "engineering pipeline" in the future [12]. However, rural children may find the engineering pipeline unrelatable or unachievable, given that existing entry points, pathways, and potential outcomes of engineering opportunities do not connect with the needs and goals of these communities [13]. Therefore, reconceptualizing engineering entry points and pathways informed by rural community members are needed to provide engineering opportunities that they perceive as valuable [14]. This study draws on culturally responsive pedagogy [15], [16] that acknowledges multiple aspects of learners' identities and foregrounds their experiences as critical assets for learning as a theoretical lens to reconceptualize engineering entry points for rural children and envision new ways to address challenges and struggles within rural communities. More specifically, this study focuses on funds of knowledge [17] to examine the knowledge, skills, and expertise within rural librarians and families that they have developed in various aspects of their lives as important resources for developing public library engineering program.

Previous literature found several sources of funds of knowledge that support children's STEM learning in rural communities, such as dairy farming and gaining hands-on experience with machinery [18]. Lloyd [19] also demonstrated that local knowledge (i.e., water quality, rural practices), parental employment skills, and community knowledge can make science learning more relevant to rural children. Although this study did not specifically address rural children's funds of knowledge, Wilson-Lopez et al.'s [20] examined engineering-related funds of knowledge. Their research highlighted how everyday skills and expertise, acquired through familial, community, and recreational practices, facilitated the development of teamwork, systems thinking, ethical reasoning, and scientific and mathematical knowledge, which are essential for engaging in the engineering design process. While a growing body of literature suggests that funds of knowledge gained from everyday experiences, cultures, and traditions can support children's engagement in STEM learning by making STEM more culturally relevant, little research has been conducted to understand rural children's FoK that are specifically related to engineering. To fully support rural children's participation in engineering learning, it is critical to understand rural children's engineering-specific FoK, the goals they have towards engineering learning, and what challenges they might experience in engaging in engineering learning in rural communities.

Methods

A qualitative case study methodology [21] was utilized to gain an in-depth and holistic understanding of goals, challenges, and engineering-related funds of knowledge of rural librarians and caregivers who participated in Research-Practice Partnership (RPP) with the research team. All methods described in this paper received IRB approval. All names used are pseudonyms.

Participants

This study is part of a larger study that established Research-Practice Partnership (RPP) with seven public rural libraries from seven US states (Arizona, Indiana, New Mexico, New York, Ohio, Pennsylvania, Wisconsin) to co-design and implement a culturally responsive online engineering curriculum for elementary-aged children and caregivers (i.e., parents, guardians). We used personal networks and the STAR library network (https://www.starnetlibraries.org) to identify rural libraries interested in providing engineering learning opportunities. We created a list of rural libraries by confirming they served a legal service area population of less than 25,000 and/or were classified as rural fringe, distant, or remote library according to the ALA guidelines [22]. Recruitment emails were sent out, and upon receiving interest from a library, we scheduled a Zoom meeting to explain the purpose of our research program. Eight rural libraries decided to join RPP to commit three years to co-design and implement two iterations of online engineering program to children in their community. However, one library had to terminate their commitment in year 1.

Consequently, we had seven library partners that served average population of 2,431 people with average median income of $51,920. There was an average of 5 full-time staff working at each library (the smallest library had only 1 full-time staff; the largest library had 9 full-time staff). 10 rural librarians participated (see Table 1). At the end of first year, Daisy stepped down and Cindy joined. Also, Sydney and Tamara joined as backup staff. All participants were female and held various positions, such as librarian director (*n*=5), assistant director (*n*=1), library manager (*n*=1), youth services and outreach coordinator (*n*=1), library clerk (*n*=1), and children's coordinator (*n*=1). Participants mentioned having prior experience in offering STEM/STEAM programs, although none indicated having experience with engineering programs specifically.

Table 1. ***Participant Information for the Library Staff***

State	Name	Age	Work years	Academic background
OH	Wendy	47	5	Fine arts, theater, education
NY	Cindy	56	3	Chemistry, art history, comparative religions
NY	Sydney	38	2	Fine arts (sculpture)
NY	Daisy	n/a	10	Biology, K-12 teaching
AZ	Winter	57	25	Library and information science (LIS)
AZ	Tamara	n/a	n/a	Elementary education
IN	Krystal	48	20+	Education, LIS, K-12 teaching
NM	Gina	45	17	Biology, LIS, K-12 teaching
WI	Beatrice	47	8	Visual arts, K-12 teaching
PA	Penny	48	5	Theater, LIS

To recruit caregivers with elementary-aged children (5-11 years), physical and digital flyers were distributed through the libraries' networks. With the goal of broadening engineering participation, we aimed to recruit participants from underserved populations by using the libraries' extensive connections (i.e., school, church, food pantry, Big Brothers and Big Sisters program). 22 caregivers (21 mothers; 1 father) representing 21 families were recruited (see Table 2). Many families had at least one member of the household who grew up in a rural community and referred to childhood experience as reasons for returning or staying in the rural community. While we sought to recruit underserved populations, based on 10 out of 21 caregivers who disclosed demographic information including income, we know that at least several caregivers had higher-than-average income levels (6 earning higher than $100K) with female caregivers holding advanced degrees (4 holding bachelor's, graduate, or professional degrees). Although we acknowledge the lack of demographic data, we contend that caregivers in this study likely represent those most motivated to support children's learning and who frequently engage in out-of-school STEM programs at rural libraries.

Table 2. ***Participant Information for the Caregivers***

State	Name	Race	Occupation	Degree	Income
OH	Amber	White	Project Manager	5	4
OH	Harriet	White	Realtor	4	5
OH	Stacie	White	Engineering technician	3	3
OH	Betty	White	Nurse practitioner	5	5
OH	Matt	White	n/a	n/a	n/a
NY	*Sally	n/a	n/a	n/a	n/a
NY	Madeline	n/a	n/a	n/a	n/a

NY	*Perry	White	Municipal employee	3	n/a
NY	Taylor	White	Data quality analyst	4	3
NY	Willow	n/a	n/a	n/a	n/a
NY	*Karen	n/a	n/a	n/a	n/a
AZ	Tracey	Hispanic	Substitute teacher	5	1
AZ	Naomi	American Indian	Circulation supervisor	2	n/a
IN	Wanda	n/a	n/a	n/a	n/a
IN	Lucy	White	n/a	1	4
IN	*Amelia	White	Homemaker	5	4
IN	*Wynona	White	Homemaker	2	n/a
IN	*Raven	White	Medical assistant	3	2
WI	Olivia	White	Mental health coordinator	5	5
WI	Paloma	n/a	n/a	n/a	n/a
NM	Unity	Hispanic	County manager	1	2

*denotes homeschooling families; Income refers to household income before taxes (1: $25-50K, 2: $50-75K, 3: $75-100K, 4: $100-$150K, 5: $150K or more); Degree refers to terminal degree (1: high school diploma or GED, 2: some college education but no degree, 3: associate or technical degrees, 4: bachelor's degrees, 5: graduate or professional degrees)

Data Sources

Different data sources were collected for caregivers and library staff. For caregivers, we conducted interviews using a pre-developed interview protocol that explored participants' family background, motivation and goals for engineering learning, prior experience and challenges with engineering and online learning, perception and understanding of engineering, and their hobbies, interests, and areas of personal expertise. To help participants discuss about their funds of knowledge, we asked participants to complete an ideation sheet that included questions to reflect on their children and families' funds of knowledge prior to the interview. It asked them to share about areas of interests that they and their child(ren) have and tell us how these interests are pursued and supported. It further asked them to list any formal and informal STEM activities pursued by their children and family members. Given that participants were geographically dispersed and located far from the research team, interviews were conducted in Zoom and video-recorded. Each interview lasted approximately an hour and was fully transcribed. After each interview, the research team developed a summary of key responses.

For library staff, similar interview questions were asked with slight modifications to fit their context. To help librarians discuss about funds of knowledge, we adopted a community asset map developed by the Urban Libraries Council [23] that asked to brainstorm about different resources that might be relevant to engineering. We asked participants to complete it prior to the interview. After each interview, the research team developed a summary document of key responses. Seven library staff also participated in eight co-design sessions to develop our online engineering curriculum with the research team. These co-design sessions were video-recorded in Zoom and were transcribed. Any artifacts that resulted from co-design sessions (e.g., ideas from the brainstorming sessions) were also collected.

Data Analysis

All interviews were recorded in Zoom and fully transcribed by two researchers. Responses from community asset maps and ideation sheets were also transcribed. The unit of analysis was each interview, as more than one caregiver could participate in the interview when both caregivers signed up. The data were analyzed inductively to develop a set of codes. High-level codes included: goal and motivation, engineering content challenges, online challenges, personal funds of knowledge, library funds of knowledge, family funds of knowledge, and community funds of knowledge. ATLAS.ti, a qualitative data analysis tool, was used to code the interview transcripts.

To analyze participants' funds of knowledge, Wilson-Lopez et al.'s [20] coding scheme of engineering-related funds of knowledge was applied. From applying their coding scheme, we observed that codes relating to health of self and family (knowledge acquired from managing health) and transnationalism (knowledge acquired from interacting with family members in other countries) did not emerge in our dataset. Thus, these sub-codes from the original coding scheme were taken out. Instead, there were other patterns that emerged from our dataset that could not be captured with existing coding scheme. Consequently, codes for personal funds of knowledge were separated into recreational funds of knowledge and interaction funds of knowledge with new sub-codes added. The coding scheme used in this study can be found in Table 3. 20% of data was coded with all researchers to reach consensus and ensure consistency across the coding process, then the rest was coded by one researcher. Coding results from the entire dataset were then audited by the first author.

Table 3. ***Engineering-Related Funds of Knowledge Adopted from Wilson-Lopez et al.*** *[20]*

Code		**Definition**
Family	Workplace	Funds of knowledge acquired from family members who taught workplace skills
	Household management	Funds of knowledge acquired from home management (i.e., fixing, DIY, cooking, budgeting)
Recreational	Sports	Funds of knowledge acquired from doing sports or consuming sports-related content
	Popular culture and digital technologies	Funds of knowledge acquired from consuming mass media and interacting with digital technologies
	*Outdoor	Funds of knowledge acquired from outdoor observation, play, and spending time in the outdoors
*Interaction	*Everyday discussion and facilitation	Funds of knowledge acquired from answering family (or library) members' questions, discussing current events, exploring potential solutions to everyday problems, and facilitating children's interests and learning
Community	Volunteerism	Funds of knowledge acquired from providing service to the community

*denotes new sub-codes added by the research team

Findings

Goals and Motivations for Engineering Learning

Strengthening public library as a hub for STEM learning. Due to lack of resources in rural communities, librarians shared strong motivation to offer something new, as highlighted by Krystal's remark: "My library is motivated to provide all kinds of programming. I've lived in this town for 16 years now, and there's nothing going on here." As a result, librarians expressed readiness to strengthen the library as a hub for STEM learning to expand beyond traditional programming like arts, crafts, and book clubs, and keep up with the trend and demand for public libraries. Library staff also mentioned other institutional goals for the library, such as equipping library staff with STEM knowledge and skills, and fostering collaboration and partnerships within the community. Librarians shared that while library staff at their library have experience with STEM, they are not comfortable with engineering content and wanted the RPP experience to help them build confidence in the area: (Cindy) "We are limited to the resources we have and…not having funds to hire…experts. So, this is important and what you are doing absolutely we see the value of."

Positioning public library to support children's STEM career exploration. In line with the growth of STEM careers, librarians anticipated that providing engineering programming would help children see opportunities beyond their immediate environment to consider different types of jobs and pursing higher education. Winter's remark exemplifies this: "This opens our doors…for the kids to learn about different types of jobs…besides just Pinebrook [pseudonym for the city]… and you know, oh I'm going to be a waitress or I'm going to be a mechanic…All our large schools are flunking…We want our kids to know that there's things outside this world."

Supporting children's existing STEM interests and providing STEM exposure. The primary goal that most caregivers mentioned in signing up for this online engineering program was to support their children's existing interest in STEM and providing more exposure to STEM. Oliva mentioned: "I'm just kind of helping stoke the fire that I know is already there. If he wasn't interested, obviously, I wouldn't be here." Even when children's interests did not directly align with engineering, caregivers anticipated that this program would expose their children to additional possibilities for future interests, and learn about the problem-solving process in engineering. Perry's interview highlighted this: "I have no idea what she's going to, what path she's going to take in the future. But at this age, we're exposing them as much as possible."

Similar to how librarians mentioned the lack of resources as a driving motivation for offering engineering programming, several caregivers expressed the limited resources in their community motivated them to seek out and find resources for their children to provide more exposure to STEM: (Raven) "But locally, there's just not a lot, which was why I was like, oh, look another opportunity!"

Addressing homeschooling families' needs. Homeschooling families expressed that our online engineering program would help them strengthen the STEM learning aspects in the homeschooling curriculum. Perry and Raven's remarks demonstrate this: "We're always looking for new things that we can incorporate into the homeschool."; "We are so desperate for any kind of STEM. We don't have a lot of resources in our area. So if it gives them any kind of an experience, we're here for it." Olivia shared anticipation that her child would learn something from this program beyond what she and her husband could offer. Sally also echoed this perspective: "I hope she learns it [engineering] in a different way than I could teach her... I don't even know how to teach it necessarily."

While not a major motivation for signing up for the program, several caregivers also mentioned that they hope to take the engineering program as an opportunity for them to learn something new. A few caregivers mentioned library staff's invitation to join the program as influencing their decision to participate in this program.

Challenges for Supporting Children's Engineering Learning

We present engineering-related challenges, online-related challenges, and other challenges separately. For each section, librarian and caregivers' challenges are presented. To identify the participants, we used 'L' for librarians' comments and 'C' for caregivers' comments.

Engineering-related challenges. Librarians and caregivers both expressed their lack of confidence and knowledge in engineering as the most anticipated challenges for supporting children's engineering engagement. Many librarians were feeling unsure if they are qualified to provide engineering programming, as demonstrated through the use of the adjectives, such as fear, concerned, not confident, when describing how they felt about offering engineering program.

> "Like I said, very little experience with like STEM altogether, not just engineering... And we all shy away from that engineering. So I think those are, it's going to be difficult. Like when I was telling the staff about this, they were kind of concerned." (Winter, L)

Similarly, caregivers anticipated that they may face some challenges in supporting their children during engineering program due to lack of knowledge and expertise in STEM.

> "So I think the challenge there is just the lack of knowledge on my part…That's my biggest challenge, is just the lack of knowledge." (Wynona, C)

Another challenge frequently mentioned by librarians was the lack of resources, such as funding to purchase necessary materials to implement STEM program, as well as limited time and staff. In one particular library, lack of transportation was mentioned as a critical hurdle for providing STEM programming at the library.

A challenge that were most frequently mentioned by caregivers was the lack of resources to support STEM learning at the public library, the public school, and within rural communities overall, as highlighted by the interview remarks.

> "It would be cool if our library did some type of STEM program." (Olivia, C)

> "They don't have robotics, they don't have any of that…You know, unless the teacher is willing to do it, and the district is willing to support it, there's nothing. Now, there is 4H because we are a rural community…We have Girl Scouts and we have Boy Scouts…but yeah, no, huge things because the teachers aren't trained." (Tracey, C)

Online-related challenges. Several librarians and caregivers also expressed potential challenges with accessing the internet due to limited broadband access.

> "It's really bad out in the county, there's no broadband out in the county." (Krystal, L)

> "I just know that the kids that come here probably…couldn't do it from home because they probably can't afford, like the tablets and the Internet… I know some of it is just not um comfortable with computers...They don't know them very well." (Winter, L)

> "The Wi-Fi is not good. It's not good at all. I don't know why. I recently asked for a new modem not that long ago. But no, the Wi-Fi is not very good here at all." (Wynona, C)

Both librarians and caregivers shared concerns about how to nurture effective engagement in online settings. One librarian, Gina, recalled her experience during the COVID-19 pandemic, noting how it was more challenging to explain concepts in online settings. She also anticipated that managing children's behaviors would be more difficult compared to in-person settings. Wendy (L) was concerned about the potential challenge with providing facilitation to learners with different learning styles in an online setting. Penny (L) feared that people in general may try to avoid online learning entirely after too much online learning during the pandemic: "I think also with school pivoting to online, they just didn't want anymore…They wanted in-person." Similarly, caregivers shared their concern for keeping children's attention span during the online engineering program and managing multiple siblings' interaction to nurture effective online engagement: " I think that the attention span is going to definitely be an issue (Madeline, C)."

Other challenges. Caregivers further anticipated that scheduling to be a critical challenge due to multiple children in sports and other extracurricular activities, as well as juggling with multiple responsibilities in their lives, as exemplified by the comment: "Time would just be the biggest thing for us…All three of my kids are very much into sports already, so just working around the sports schedule." (Olivia, C)

Two library staff, Penny and Winter, expressed rural community members' resistance to online registration, mistrust of outsiders, and resistance towards STEM and technology as critical barriers for offering engineering programming. As a result, Penny mentioned that community members showed hesitation and lack of participation in STEM and technology-involved library programming and services.

> "I mean, sometimes rural communities are very insular, right? And it's like nobody from outside can come in here... New is scary, so we will just automatically push away maybe…But it it's just it repeatedly like, I don't know who these people are. Why would I participate in a program? …It's, it's awful. But it's there." (Penny, L)

During one of the co-design meetings, the librarians also discussed that some individuals might feel uneasy about participating in online activities due to socioeconomic challenges and concerns about their living spaces being visible on Zoom. Further, multiple sibling interaction was brought up as a potential barrier, particularly when there is only one adult at home to manage multiple children at the same time.

Engineering-Related Funds of Knowledge in Rural Communities

Findings demonstrate abundant funds of knowledge acquired from rural participants' familial (i.e., household management, workplace), recreational (i.e., sports, games), interactional (i.e., everyday discussion and facilitation), and community (i.e., volunteerism) practices that are related with skills and habits of engineering.

Household management. Both librarians and caregivers shared numerous anecdotes of gaining knowledge from home improvement and Do-It-Yourself (DIY) practices to repurpose and improve different parts of their households. Librarians shared examples of fixing household machines, making home improvements, fixing the patio, working on their vegetable gardens and yards, laying tiles, and coming up with a recipe that utilizes leftover ingredients in the refrigerator were shared to describe how they manage the household. These examples reflect several engineering practices. For instance, improving the vegetable garden involved regularly monitoring the soil condition and plant health to gather data, then analyzing this data to identify issues and make necessary adjustments, such as altering watering schedules or adding nutrients.

Caregivers also shared about home improvement and DIY practices in painting, assembling furniture, fixing things, and managing the household budget. These provided opportunities for children to build independent problem-solving skills and ownership of projects, as exemplified by Paloma:

> "We kinda let them run wild with it and figure out how they can do it on their own… And if we don't know how to fix it, we will get books and manuals on how to fix it and we like to have the kids involved with that… The kids will read the steps to us and we will work, you know, and then we'll fix it." (Paloma, C)

Similarly, Wanda and Matt (C) mentioned development of basic mathematical skills through involving her child in budgeting. Wanda described how she encouraged her son to budget within $8 to get his lunch and buy a birthday present for her sister.

Similar to Paloma's example, these moments of managing their own budget supported them to assess different options for purchasing and practice their mathematical skills to manage budget. Many caregivers shared involving their children in routine gardening activities, which afforded opportunities to make observations in the outdoors, understand plant care and seasonal changes, and develop patience and hard work. Several also mentioned examples of engaging in baking and cooking, which helped children develop a range of skills, from understanding measurements and timing to working collaboratively and creatively to work with ingredients they have to make recipes. As such, household management practices contributed to developing problem-solving skills, and hands-on understanding of how things work, understanding of the environment and food production life cycle, understanding measurements and timing, building teamwork, creativity, and analytical skills that can be applied to engineering.

Everyday discussion and facilitation. Librarians shared about their experience, offering a spectrum of STEM program, such as expedition club, LEGO club, nature club, take-and-make bags (i.e., simple kit that contains materials for arts and crafts), Minecraft club, and Discovery Space (i.e., different science stations each month). Funds of knowledge gained from every day discussion and facilitation with children and patrons in library programs informed several engineering design practices. Librarians were able to identify educational gaps through observation, brainstorm new learning opportunities for children, test various programs, and iteratively improve offerings based on community feedback and outcomes.

Caregivers also gained engineering-related funds of knowledge through their interaction in everyday discussion and facilitation with children. For instance, Wanda and Madeline described how they encourage critical thinking by turning the questions around to the child to think about how he might answer the questions first.

> "I personally try not to give my son all the answers…So, I really try to push him to be independent…like those are some of the tactics that I use at home to try to get him to expand his problem-solving skill." (Madeline, C)

Many caregivers mentioned how they would model how to answer questions when they could not be answered directly, such as using books, visiting the library, using the Internet and YouTube, and thinking carefully about the credibility of the sources. Naomi shared an example of how her son received a wooden car model for his birthday and they worked together to solve a problem with the wheels. Naomi supported her son by discussing potential solutions and encouraging him to think creatively, which helped him come up with a practical solution to keep the wheels in place. Discussing current events or interesting phenomenon they observe during family walks were also mentioned frequently. Wanda described about recent conversation they had over dinner table about astronomical events. Madeline shared that their family recently discussed about bald eagle that almost snatched up their neighbor’s dog. By answering questions, discussing current events, and exploring potential solutions to everyday problems, caregivers helped children develop curiosity and problem-solving skills that are highly applicable to engineering.

Workplace. Funds of knowledge gained from family members’ workplace was only mentioned by caregivers. Perry (C) shared that they learn about responsible logging through her husband’s work in forestry. Matt (C) shared about his grandfather who was a computer engineer and currently runs a farm, and how seeing him work in the farm helped his children learn about science and mathematical concepts, such as calculating costs and understanding volumes: “They know how many thousands of dollars it costs to do this. And then you’re getting volume when you pick the corn and what goes in, you know, how much a box can hold.” Karen and Paloma (C) also shared about how they were influenced by their fathers who taught them about how machineries work and how to fix things as they spent time together in the garage or in the field, which they are sharing with their own children. Funds of knowledge gained from family members contributed to developing engineering skills, such as ethics, resource management, science and mathematical concepts, and technical proficiency.

Games and sports. While participants mentioned examples of engaging in recreational activities, such as games and sports, there were less remarks about how they may relate to engineering-related funds of knowledge. Consequently, there are limited excerpts to present. We discuss a few examples that had explicit connection to engineering-related funds of knowledge from caregivers. One caregiver highlighted the problem-solving skills developed through gaming. Another caregiver described how sports not only promoted physical health but also often required STEM concepts.

> “Video games present a set of challenges… And one of the key capabilities that people can have is problem-solving…He would tell me, Mom, I know how to solve this because I saw somebody on YouTube doing the same thing on Lego, Marvel.” (Madeline, C)

> “She didn’t realize that could be like a STEM thing because you have to calculate like the way your body is going to move, the momentum that you’re using and stuff like that.” (Stacey, C)

Volunteerism. Many librarians also mentioned funds of knowledge that they could gather as a result of active community outreach. Similar to engineers’ resourcefulness that involves adaptability and creativity to solve problems using the available resources and developing solutions under constraints, librarians developed relational knowledge and resourcefulness by leveraging unexpected opportunities, and continuously seeking out new information and connections to develop new programming and services at the library.

> “We are limited to the resources we have… then suddenly sometimes something pops up and then we grab it…I actively go out into the community, which means that I’ll be going

to school board meetings. I will be going to town meetings and village meetings. I'll be come to Rotary. I'll be going down to the fire station. You know, I'll be going everywhere…and finding those little connections that we need." (Cindy, L)

Community funds of knowledge was expressed by only one caregiver, Paloma: "The kids …would be, helping somebody in the community, maybe clear their yard… So they'll be planning, bringing members, volunteers to come." She described various community service projects that she involved her children to participate, such as helping elderly neighbors, setting up fundraisers for the fire department, and organizing community events like spaghetti dinners. These activities involved her children in planning, organization, and teamwork, and empathy for the community, which are important qualities for professional engineers.

Discussion

This study examined rural librarian and caregivers' engineering-related funds of knowledge (FoK) with the aim to understand how FoK might address the challenges and goals for engaging children in online engineering learning program at rural libraries. Our analysis of 10 rural librarians and 21 caregivers indicates they had abundant FoK acquired from their familial, community, recreational, and interactional practices that related with skills and habits of engineering. The findings further identified librarian and caregivers' goals and motivations for offering engineering learning opportunities while highlighting engineering-related, online-related, and other challenges, which suggest several implications for designing a culturally responsive online engineering program that leverages rural participants' funds of knowledge.

Our findings builds upon previous studies of FoK related to rural children's STEM learning [18], [19], and further expands our understanding of engineering-related FoK in rural communities, which is understudied and limited in current literature. Everyday activities—such as, repurposing materials in DIY projects, playing sports or video games with family members, engaging in conversations about recent events and phenomenon related to STEM, or helping other community members—fostered essential engineering habits of mind like creativity, resourcefulness, and critical thinking. For instance, children gained knowledge about the lifecycle in nature, food production, ethical use of environmental resources while spending time with their parents outside the home to engage in home improvement and leisure activities, similar to how children learned through observation and working closely with their parents in household management in Wilson-Lopez et al. [20]. While these practices may seem mundane or unremarkable to those who engage in them, the FoK framework reveals their significance as historically rooted and layered activities. As such, our findings challenge deficit-based narratives that frame rural communities as lacking STEM resources due to limited funding, fewer educators, and geographic isolation, and highlight the need for educational programs and policies to recognize, validate, and integrate rural FoK as rich foundations for engineering learning.

This study also showed that both library staff and caregivers shared similar short-term and long-term goals for engaging children in engineering learning, primarily aiming to increase exposure to STEM and fostering children's STEM interests by providing STEM learning opportunities.

Caregivers focused on nurturing children's existing STEM interests and providing exposure to STEM fields, while library staff focused on supporting children's STEM career exploration by offering immediate STEM learning programs. Both recognized that engaging children in engineering activities could help them consider different careers, broadening the "engineering pipeline" [11]. Further, both library staff and caregivers recognized the need to address gaps in community STEM resources—caregivers sought to strengthen homeschooling curricula, and librarians were motivated to provide more resources for children by participating in this online engineering research program. Also, librarians recognized the importance of establishing public library as a STEM learning hub.

Additionally, findings demonstrate that many librarians and caregivers lacked confidence that they could effectively facilitate and support children's engineering learning, sharing hesitancy to recognize their own strength and potential as an engineering educator despite already having their own STEM capacities. This finding is in line with previous literature that illustrated library staff's anxiety towards STEM as one of the barriers for public library STEM programming [7], [8]. This study contributes to a deeper understanding that the lack of confidence among rural librarians and caregivers in engineering must be addressed by recognizing their own FoK as relevant to engineering, even if they do not initially perceive it as such [16]. Supporting both caregivers and library professionals to recognize that FoK they already have is relevant and valuable in fostering children's STEM learning is therefore critical.

Building on these findings, this study suggests several implications. First, libraries must consider how to lower the entry barriers of patrons who might be hesitant to participate in engineering program. This study demonstrated that rural librarians and caregivers' perceived lack of knowledge and expertise in engineering might be effectively addressed by leveraging engineering-related funds of knowledge. We see opportunities to leverage caregivers' and children's funds of knowledge, such as yard and garden work or home improvement, as entry points to engineering as these are areas that they have abundant funds of knowledge for engineering. By doing so, educators can offer culturally relevant engineering learning experiences that resonate with the lived experiences and funds of knowledge of rural children. We contend that this approach not only makes engineering learning more accessible and engaging for participants, but could also help lower the cultural and perceptional challenges in rural communities that our findings highlighted.

Second, library educators should provide more overt and explicit connection to bridge the gap between engineering-related FoK and engineering concepts within library-based engineering programs. Engineering-related FoK reported in this study were not readily understood by participants as skills or habits of mind that support engineering. Importantly, it is critical to help them acknowledge what they already possess are relevant to engineering. To do so, educators should frame rural families' FoK in the context of engineering and highlight the connections between everyday activities and engineering concepts. For instance, repairing home equipment or building fences could be used to illustrate material properties, force and load, and structural stability, while organizing a community event can highlight planning and systems thinking in engineering. By drawing these connections, educators can help learners see how their experiences translate into valuable engineering-specific skills and habits of mind and internalize the meaning of engineering concepts or skills reflected in their own FoK.

Third, we advocate for a shift in perspective using the FoK framework to expand rural children, caregiver, and library professionals' understanding of what counts as engineering. Broadening the definition of engineering to include problem-solving skills found in activities, such as farming, gardening, DIY projects, sports, and games helps uncover engineering thinking already present in our everyday life. Also, emphasizing engineering mindsets, such as empathy, collaboration, resourcefulness, and critical thinking—often developed through family and community engagement—can further broaden our conceptualization of what counts as engineering. Recognizing that engineering knowledge is not confined to formal education or professional expertise, but can be also found in their relational knowledge of the community and resourcefulness, can be an asset for librarians in designing library-based engineering program and for caregivers in supporting their children's engagement in engineering. By re-framing engineering in this way, it can also help librarians leverage the skills of local community members, who can serve as valuable STEM resources for library-based programs.

Limitations

Given that our interview protocols focused on multiple aspects, rather than primarily on FoK, and considering that engineering is often understood "as the application of codified scientific and mathematical principles" [20, p. 291], we may not have fully elicited how specific funds of knowledge supported participants with engineering. For instance, we anticipated that library staff may have acquired FoK from recreational activities (i.e., sports, games, hobbies), yet these types of FoK were not explicitly mentioned during the interviews in relation to engineering. In such cases, the research team did not code them. We also acknowledge that further analysis, such as investigating participants' in-situ interaction during the online engineering program, would have been helpful to understand how these FoK that were identified from this study were applied to support participants' engagement in the engineering design process. This approach represents a promising direction for future research. Furthermore, the family participants in this study only represent a subset of rural residents in the US as our analysis only included 31 rural individuals from seven rural communities in the US. Although we acknowledge that results are not generalizable based on statistical probability, we contend that caregivers in this study likely represent the typical attendees of children's engineering programs at rural libraries. Librarians in this study also agreed that the research participants reflect the typical demographic of individuals who frequently attend regular STEM programming and events at rural libraries. As such, while the study findings may have limitations in generalizability, they offer contextually relevant insights and implications for rural libraries.

Importantly, our original intent for developing our culturally responsive online engineering program—providing take-home engineering kits, hotspots, and tablets for community members to participate via video conferencing software (e.g., Zoom)—was to lower the barrier for rural families with children who do not have the transportation or the time to physically attend public library programming during normal hours. In collaboration with our seven library partners in Research-Practice Partnership, we had tried various strategies to recruit underserved populations (i.e., low-income families), but our demographic information of caregivers of this study showed that a sizable proportion of participants reflected the characteristics of affluent families. Based on our experience, we argue that future researchers and educators should create more intentional partnership with organizations that regularly serve underserved populations (i.e., weekly free tutoring program at a local church) to integrate engineering learning opportunities and broaden engineering participation.

Conclusion

There is a growing expectation for public libraries to continuously expand their roles as lifelong learning institutions to better meet the changing needs of the community. Despite deficit-based narratives that frame rural communities as lacking STEM resources, this study highlights various forms of funds of knowledge in familial, community, recreational, and interactional practices that rural librarians and caregivers can bring to support children's engineering learning. Guided by our findings, we propose to transform how children view ordinary and everyday resources available in the community as strengths through culturally responsive pedagogy. Engineering learning can occur in remarkably non-engineering-related activities in everyday life—kitchens, garages, backyards, home gardens, dinner tables, sidewalks, and so forth. With this in mind, we invite future research to further investigate different ways of developing culturally responsive engineering learning experiences. Such research should focus on how these experiences can improve children's interest, participation, and pursuit of engineering. By identifying and leveraging the funds of knowledge present in rural communities, educators can create more effective and meaningful engineering education programs that inspire the next generation of engineers.

Acknowledgement

This material is based upon work supported by the Institute of Museum and Library Services (LG-252377-OLS-22). Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the Institute of Museum and Library Services. We would like to thank our participants, and Mansi Kasar for supporting the data collection.

References

[1] J. Archer, L; Moote, J; Macleod, E; Francis, B; DeWitt, "ASPIRES 2: Young people's science and career aspirations, age 10–19," London, UK., 2020.

[2] R. S. Harris and C. Hodges, "STEM education in rural schools: Implications of untapped potential," *National Youth at Risk Journal*, vol. 3, no. 1, pp. 1–12, 2018, doi: 10.20429/nyarj.2018.030102.

[3] E. Dawson, “Equity in informal science education: Developing an access and equity framework for science museums and science centres,” *Stud Sci Educ*, vol. 50, no. 2, pp. 209–247, Jul. 2014, doi: 10.1080/03057267.2014.957558.

[4] IMLS, “STEM.” Accessed: Jan. 02, 2022. [Online]. Available: https://www.imls.gov/our-work/priority-areas/stem#:~:text=Libraries and museums are making,States program%2C and special initiatives.

[5] Afterschool Alliance, “Full STEM ahead: Afterschool programs step up as key partners in STEM education,” Washington, D.C., 2015.

[6] B. Real and R. R. Norman, “Rural libraries in the United States: Recent strides, future possibilities, and meeting community needs,” 2017.

[7] J. Y. Baek, “The accidental STEM librarian: An exploratory interview study with eight librarians,” *A National Center for Interactive Learning Report, Space Science Institute, Boulder, CO.*, 2013.

[8] S. H. Kim and A. Copeland, “Toward context-relevant library makerspaces: Understanding the goals, approaches, and resources of small-town and rural libraries,” in *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, Springer Science and Business Media Deutschland GmbH, 2021, pp. 441–457. doi: 10.1007/978-3-030-71305-8_37.

[9] L. Hogg, “Funds of knowledge: An investigation of coherence within the literature,” *Teach Teach Educ*, vol. 27, no. 3, pp. 666–677, Apr. 2011, doi: 10.1016/j.tate.2010.11.005.

[10] G. Ladson-Billings, “Toward a theory of culturally relevant pedagogy,” *Am Educ Res J*, vol. 32, no. 3, pp. 465–491, 1995.

[11] Ladson-Billings and Gloria, “Culturally relevant pedagogy 2.0: a.k.a. the remix,” *Harv Educ Rev*, vol. 84, pp. 74–84, 2014.

[12] and I. of M. National Academy of Sciences, National Academy of Engineering, *Rising above the gathering storm: Energizing and employing America for a brighter economic future*. Washington, DC: National Academies Press, 2007. doi: 10.17226/11463.

[13] M. A. Cannady, E. Greenwald, and K. N. Harris, “Problematizing the STEM pipeline metaphor: Is the STEM pipeline metaphor serving our students and the STEM workforce?,” *Sci Educ*, vol. 98, no. 3, pp. 443–460, 2014.

[14] B. B. Bevan, A. C. Barton, and C. Garibay, “Why broaden perspectives on broadening participation in STEM ?” Accessed: Jan. 01, 2021. [Online]. Available: https://www.informalscience.org/why-broaden-perspectives-broadening-participation-stem, 2019

[15] G. Ladson-Billings, “Toward a theory of culturally relevant pedagogy,” *Am Educ Res J*, vol. 32, no. 3, pp. 465–491, 1995, doi: 10.3102/00028312032003465.

[16] G. Ladson-Billings, “Culturally relevant pedagogy 2.0: a.k.a. the remix,” *Harv Educ Rev*, vol. 84, no. 1, pp. 74–84, 2014.

[17] L. C. Moll, C. Amanti, D. Neff, and N. Gonzalez, “Funds of knowledge for teaching: Using a qualitative approach to connect homes and classrooms,” in *Funds of knowledge*, Routledge, 2006, pp. 71–87.

[18] L. M. Avery, "Rural science education: Valuing Local Knowledge," *Theory Pract*, vol. 52, no. 1, pp. 28–35, Jan. 2013, doi: 10.1080/07351690.2013.743769.

[19] E. M. Lloyd, "Eliciting and utilizing rural students' funds of knowledge in the service of science learning: An action research study," University of Rochester, 2010.

[20] A. Wilson-Lopez and J. Acosta-Feliz, "Transnational latinx youths' workplace funds of knowledge and implications for assets-based, equity-oriented engineering education," *J Precoll Eng Educ Res*, vol. 11, no. 1, 2021, doi: 10.7771/2157-9288.1289.

[21] R. E. Stake, *The art of case study research*. Thousand Oaks, CA: Sage, 1995.

[22] B. Real and R. R. Norman, "Rural libraries in the United States: Recent strides, future possibilities, and meeting community needs," Jul. 2017.

[23] American Library Association, "The Engaged Library: Chicago Stories of Community Building." Accessed: Nov. 14, 2024. [Online]. Available: https://www.ala.org/tools/librariestransform/engaged-library-chicago-stories-community-building