# Family Makers: Online Engineering Program for Underserved Children and Caregivers at Rural Libraries

The research team from Indiana University Purdue University Indianapolis (IUPUI) and University of Cincinnati—with eight rural libraries, rural engineers, and the Association for Rural and Small Libraries (ARSL)—seeks $499,941 from the National Leadership Grants program to conduct a three-year applied research project from 2022 to 2025. This study addresses NLG program *goal 1* (build capacity for serving the education needs) and *objective 1.1* (develop replicable library programs to support learning) by strengthening rural libraries' capacities for outreach educational programming, online facilitation skill, and culturally-relevant engineering program for underserved children. This project responds to educational inequities of underserved rural children by developing a new outreach approach at rural libraries through online space and supporting rural library staff to become learning facilitators. Toward this, we investigate: **How can rural libraries facilitate culturally-relevant engineering learning in online settings for underserved children (5-10 years) and caregivers?**

This research aims to understand specific challenges rural library staff and underserved families experience, identify effective approaches that they need for engaging in an online engineering program, and develop and disseminate ready-to-use, open-source digital content for an online engineering program that rural libraries can adopt to support underserved children and caregivers. As a result of our implementation research through two iterations across eight rural library settings, the primary outcome will be a culturally-relevant online engineering program—which will be entitled ***Family Makers***—that includes curricula for six online engineering programs and digital resources, a list of materials (i.e., materials, hotspots, tablets), and webinars to support rural libraries across the nation to implement online engineering programs. We expect the project to enhance underserved children and caregivers' engineering interest and practices. Rural library staff's online facilitation skills and understanding of the engineering design thinking process will also be enhanced. In so doing, rural libraries will be positioned to help democratize engineering learning opportunities to socially marginalized communities.

## PROJECT JUSTIFICATION

### Need 1: Broaden underserved children's participation in engineering learning through a new outreach educational programming through online space at rural libraries

Diversifying who gets to participate and contribute to engineering, regardless of social positions, is a national imperative [1]. 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 [2]. However, rural districts are often excluded from federal initiatives and lack resources to implement engineering curricula [3,4]. Further, rural children living in poverty are marginalized from learning opportunities. Considering that 9.3 million children attend a rural school and one in six lives below the poverty line nationwide [3], addressing the challenges of underserved rural children is an obligation that deserves the national attention. Research shows that informal science education can positively impact children's engineering interest. However, underserved children typically have 6,000 fewer hours of enrichment activities compared with children from the middle-class [5]. Programs offered in museums, hobby clubs, citizen science projects primarily serve urban or suburban community members [6–8]. 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 is through online learning. While IMLS has funded many projects to expand STEM education [9], the research that leverages the online space to strengthen public libraries' outreach programming is rarely examined. For instance, public libraries have offered STEM outreach (e.g., STEM exhibitions, mobile makerspaces, kits) to serve citizens with physical and social barriers [10–13]. While public libraries have taken a leadership role during the COVID-19 pandemic to embrace online technology to virtualize existing programs and support with distance learning to mitigate widening achievement gaps and academic declines [14,15], the online program as a form of outreach is almost non-existent. This is unfortunate because online space provides abundant learning opportunities through connection, feedback, and sharing of expertise in openly-networked manner and the opportunity to expand learning from a fixed physical setting to anywhere, anytime [16,17]. This research aims to fill this important gap and bolster the benefit of online learning by taking culturally-relevant pedagogy [18,19] as a theoretical framework to provide online engineering learning to rural children and caregivers. Our work will provide a timely research-based online engineering program that rural libraries can adopt during normal hours as well as when online learning is required.

To do so, it is imperative to investigate challenges that rural library staff and underserved families experience and identify effective approaches that they need for online engineering learning. Underserved families are less visible in library educational programming, which has been echoed by all eight rural library partners in this project. While factors such as time constraints and lack of transportation are critical barriers [20], further work is needed to interrogate the cultural barriers and specific challenges they may have when libraries offer engineering programs in online settings. Unique challenges at

rural libraries must also be considered. 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) [21]. Library staff's anxiety towards STEM can also become a critical barrier [22,23]. Our preliminary study, *Empowering Rural Libraries as Sites for Children Informal Learning through Making*, funded by Indiana University, also showed that rural library staff generally lacked STEM competencies and informed the urgent need to support them in applying their existing assets and skills (e.g., community partnerships) to STEM programming [24].

As such, this study will investigate the physical and cultural barriers that underserved families and rural library staff experience towards online engineering learning to develop a culturally-relevant online engineering program for rural children. Engineering design thinking is foregrounded in our approach because it is a critical mindset that children must learn to prepare for the future in which many workforces are expected to be replaced by automation and robots [25]. Further, engineering design thinking in increasingly being integrated in Library and Information Science programs to support library professionals to deal with "wicked" problems (e.g., ambiguous) and develop solutions that lead to positive change [26–28]. In so doing, the study will enhance both underserved children's and rural library staff's understanding of engineering design thinking and help them become active problem-solvers beyond their participation in this study.

**Need 2: Strengthen the social support and cultural relevance of rural engineering for underserved children**

Learning is a social activity, mediated by interactions with social, material, technological, and situational resources [29]. Existing efforts to bring resources to the learners (e.g., kits, home delivery) still lack in providing appropriate facilitation, which is critical in developing high-order thinking skills (e.g., problem-solving skills) [30]. Research indicated that even when underserved learners had the same access to technologies, the educational benefits were less than learners with higher socioeconomic status due to the types of activities (drill vs. analysis). Furthermore, underserved families are often challenged to provide the "social envelop" that influence the quality of scaffolding and modeling from caregivers [30]. Thus, future library outreach programming to bring engineering resources to the learners must provide social facilitation in addition to material and technological resources. Our conjecture is that the combination of online space and the library staff's remote facilitation can help address this need.

Our project further strengthens the social aspect by situating the engineering learning program as a family activity rather than just for children. Given that caregivers can tacitly and explicitly structure learning opportunities for their children [31], bringing in caregivers is a necessary and effective strategy. Projects supported by the IMLS STEMeX grant demonstrated promising intergenerational STEM learning results at public libraries [32–34]. However, less is known about how intergenerational participation can be facilitated in virtual at-home environments with rural library staff. Avery [35] found that parents' expectations for educational attainment are lower in rural communities. Therefore, our study will attend to caregivers' values towards education and provide guidance—including prompts to ask their children [33,36] and support to familiarize with objects and tools [37]. We argue that caregivers' participation in online programs can increase their confidence in engineering to support children's future engineering interest.

Broadening participation in engineering is often associated with broadening access to diverse populations to enter into the "engineering pipeline" in the future [38]. However, underserved 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 [39]. Therefore, reconceptualizing engineering entry points and pathways informed by underserved rural community members are needed to provide engineering opportunities that they perceive as valuable [1]. Thus, our approach to building a culturally-relevant online engineering program will support learners to: (1) connect with visible and relevant entry points and pathways to rural engineering informed by digital content representing lived experiences of rural engineers, (2) design for the rural community by utilizing engineering design thinking tailored for children through open-ended maker activities, and (3) celebrate rural engineering solutions that underserved children and caregivers designed. We expect that when children in this research find relevance and connect with rural engineers who are like themselves, they are more likely to develop interest and engage in engineering activities in the future.

**Need 3: Disseminate an online engineering program that serves rural libraries across the nation**

A new research-informed library outreach programming will not make a lasting change to practice if the developed resources are not easily accessible or promoted to reach a broader impact. To make our project findings accessible to rural libraries, this research aims to develop a suite of digital resources in an online toolkit entitled *Family Makers*—featuring different types of rural engineering and technical professionals' stories and pathways, "a day in the life of an engineer" videos, as well as curricula, design journal, technology and facilitation guides—for rural library staff to easily access, choose, and readily adopt when they provide online engineering programs. Further, rural library staff needs to understand the value of

providing online engineering programs to underserved children at rural libraries. Therefore, *Family Makers* toolkit will provide worked examples with underserved families and rural library staff and advance our understanding of how lived experiences of rural engineers facilitate engineering learning for underserved families. We expect that various resources in *Family Makers* online toolkit can motivate rural library staff to value and commit to try the online engineering program. Finally, an intentional dissemination effort will be planned to reach a broader audience, which will include providing online webinars and training through ARSL and State Libraries.

## PROJECT WORK PLAN

### Project Goals and Research Questions

The goals of this research are to:

1. Understand specific challenges rural library staff and underserved families experience and identify effective approaches for engaging underserved children and caregivers in online engineering programs,
2. Develop ready-to-use, open-source digital content for a culturally-relevant online engineering program for underserved children and caregivers that can be easily adopted and facilitated by rural library staff, and
3. Disseminate a research-based online engineering program that serves rural libraries across the nation to provide outreach engineering learning programming to underserved children and caregivers in rural communities.

The study addresses the research question: **How can rural libraries facilitate culturally-relevant engineering learning in online settings for underserved children and their caregivers?** Four sub-research questions will guide our research:

- **RQ1** (Understand Phase): What challenges do rural library staff face in designing and implementing online engineering programs for underserved children and caregivers?
- **RQ2** (Develop Phase): How can a culturally-relevant online engineering program be developed in rural libraries to overcome the identified challenges and support underserved families with children?
- **RQ3** (Test & Revise Phase): To what extent can an online engineering program support underserved children's development of engineering interest and practices and enhance rural library staff's understanding of engineering design thinking and online facilitation?
- **RQ4** (Replicate & Disseminate Phase): To what extent can the online engineering program generalize to different rural libraries and underserved families? What, if any, modifications are necessary?

### Target Groups and Expected Outcomes

The primary audiences are the rural library staff who want to build an online engineering program for underserved children. Eight rural library partners are from CA, AR, WI, IN, OH, AR, MA, and PA. Rural library staff will develop understanding of engineering relevant to rural contexts and develop engineering design thinking and online facilitation skills to serve underserved children. The secondary audiences are underserved children (5-10 years) and caregivers who participate in this project. Participating family members will develop increased engineering interest and practices. The project team also anticipates several mid-term outcomes by developing a research-informed online engineering program toolkit that features a suite of digital resources for rural library staff to easily access and readily adopt. As a result, underserved families are expected to seek out additional engineering resources from rural libraries, engage in at-home engineering conversation and activities, and attend other ongoing programs at their local libraries. Further, rural library staff will be better equipped to implement *Family Makers* independently to more families and will be prepared to apply engineering design thinking approach in their roles. In the long-term, as more rural library staff implement *Family Makers*, there will be an increased public appreciation of rural libraires as hubs for broadening engineering participation for underserved children and families.

### Theoretical Framework and Our Approach

***Culturally-Relevant Pedagogy****:* Our pedagogical approach to engage learners in engineering is through culturally-relevant pedagogy [18,19] that acknowledges multiple aspects of learners' identities and foregrounds their experiences as critical assets for learning. Our goal is to create an online engineering program that recognizes what is present in the community and transforms them into strengths. As such, our approach will be asset-based, internally-focused, and relationship-driven. By taking an asset-based approach [40], we will actively listen to rural library staff and underserved children and build on multiple forms of capital (i.e., aspirational, linguistic, familial, social, navigational, resistant) that they exhibit as strengths and resources. Culturally-relevant programs have supported children to take up more agency and responsibilities [5,45].

When making closely related to social and community that enabled children to contribute to a bigger social purpose through their projects, forms of engagement were expansive towards critical, connected, and collective ends [46–49]. We will focus on designing culturally-relevant online engineering program that centers on children's everyday making practices, as making has shown promising results to engage learners in out-of-school settings, including library-based makerspaces and learning labs [41,42]. Our work is aligned with efforts to promote equitable making practices [43,44] to broaden the conceptualization and practices of making and using them as legitimate learning resources for engineering. Children have the ability to notice, create, and solve their own problems, but many educational environments put children in a situation where adults set their inquiries. Not only will we use stories of rural engineers to make engineering relevant to rural children, but in our open-ended maker learning experiences, children will take a leadership role to identify a community problem, produce their own inquiries, brainstorm, test, and refine solutions as they apply the engineering design thinking approach.

***Research-Practice Partnership (RPP):*** We have secured partnership with eight rural libraries from eight states—Plumas CL (CA); Tyrone Snyder PL (PA); Kingsville PL (OH); Stuttgart PL (AR); Rushville PL (IN); Wayland Free PL (MA); Page PL (AR); Plum Lake PL (WI). Our relationship with rural library partners will be RPP. We learn from previous IMLS research that RPP with rural librarians comes with challenges [50]. However, despite the foreseeable challenges, we argue that RPP is greatly needed to support capacity building of rural library staff and the development of more usable solutions informed by professional practices [51]. RPP meetings will provide opportunities to establish a shared understanding, continuously negotiate roles and expectations, engage in community asset mapping, understand engineering design thinking, apply effective frameworks for programming (e.g., Connected Learning Framework), engage in co-design sessions, share project outcomes and progress, and build consensus before implementation. We have already started the relationship-building process by sharing our project goals and program design with eight rural library partners. Although it is not included in the activities below, monthly RPP meetings will be present throughout all project phases except during the iterative co-design cycles in which we will have bi-weekly RPP meetings (occurring every two weeks).

**Research Phase 1: Understand (Year 1/ August 2022 – June 2023)**

***Goals:*** Phase 1 aims to understand rural library staff and underserved children (5-10 years) and caregivers' challenges for online engineering learning and identify effective approaches for engaging underserved families in online engineering programs through rural libraries. Phase 1 addresses Need 1 and RQ1.

***Activities:*** See the schedule details including the Institutional Review Board (IRB) in **Supportingdoc1** and **Scheduleofcompletion**. We will obtain feedback on our data collection instruments for all the activities mentioned below from our AB members before conducting the research activities.

- **A review of literature**. We will conduct literature review in three areas: (1) pedagogical considerations for culturally-relevant engineering, (2) best practices and strategies for engaging children and families in engineering programs, and (3) effective facilitation strategies for synchronous online programs.

- **Study with library staff.** We will conduct online interviews with 10 rural library staffs who serve elementary-aged children in our 8 rural library partners. Interview data will help to understand rural library staff's perception of engineering, best practices for facilitating engineering programs, their experience working with underserved children, as well as challenges and resources for providing online engineering programs.

- **Study with caregivers.** We will conduct 10 caregiver interviews via phone call or Zoom, who will be recruited online via existing networks within 8 rural library partners. We will establish a semi-structured interview protocol to understand underserved families' expectations for engineering learning and library programming, reasons and challenges for visiting (and not visiting) the local library, specific challenges for online learning, routine family hobbies or interests that we can draw upon in our program as cultural assets.

- **Study with rural engineers**. (1) Interviews – The project team secured partnerships with several rural engineering industries that will participate in interviews and digital content creation. Leveraging our partnerships, we will conduct interviews with 10 rural engineers or technical professionals who grew up in rural areas with racial and economic diversity to understand how and why they become interested in engineering and examples of pathways they took to become who they are. Interviews will help us identify core engineering practices and mindsets that they think are critical in preparation for the future workforce of rural engineers. (2) Digital content creation – Recruited engineers will create "a day in the life of a rural engineer" video at their current workplace using their

mobile phones or GoPro cameras from the research team to describe engineering problems they address and how they work with tools and others to develop solutions. Videos and interview data will be edited to create digital content representing lived experiences of rural engineers, which will be used in the online engineering program.

***Data analysis:*** Research activities will be audio-recorded or video-recorded and transcribed. During the RPP meetings, we will collect observations in the form of field notes. Adopting the grounded theory approach [52], we will conduct a thematic analysis using the constant comparative method [53] to analyze the transcribed data using a qualitative data analysis software, ATLAS.ti. We will develop a codebook based on our research goals and RQs and engage in line-by-line coding to conduct a thematic analysis. Inter-coder reliability will be conducted.

***Expected outcomes:*** Challenges and barriers of rural libraries and underserved families for online engineering learning will be identified, with guidelines and strategies for culturally-relevant online engineering. Digital contents representing rural engineers' lived experiences will be developed. Core engineering concepts will be identified.

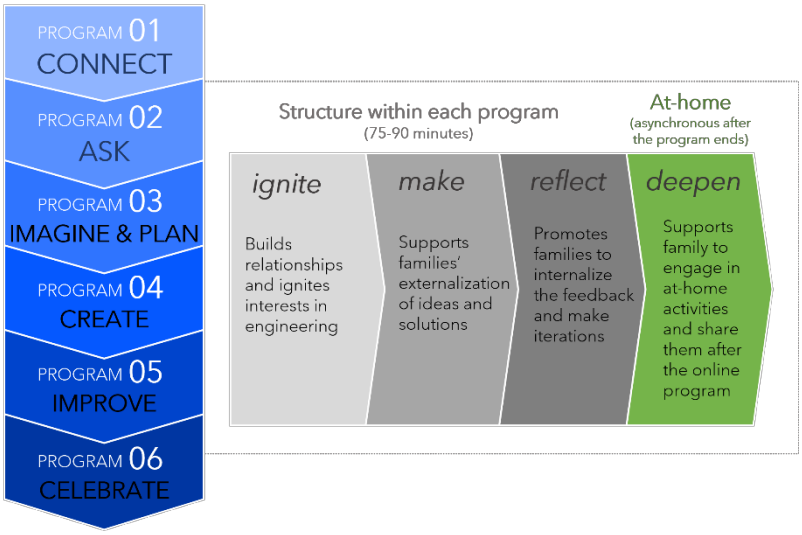
**Research Phase 2: Develop (Year 2/ July 2023 – December 2023)**

***Goals:*** The goal is to develop a culturally-relevant online engineering program, *Family Makers,* with rural library partners informed by findings from Phase 1. We will co-design curricula for six online programs, design journal, technology and facilitation guidelines, and digital resources so that *Family Makers* can be ready-to-use and easily adopted and facilitated by rural library staff. Phase 2 addresses Need 2 and RQ2.

***Activities:***

- **Librarian Training.** The first two RPP meetings will provide librarian training before the iterative co-design cycle. The training will focus on understanding and engaging in engineering design thinking exercises and exploring strategies to support families' making process. PI Kim will lead the training session with prior experience in leading design thinking workshops while working as an industrial design engineer and supporting engineering experts in their communication strategies to engage children to relate to engineering.

- **Iterative co-design cycle 1.** The project team and eight rural library staff will co-design Iteration One of *Family Makers* that includes a series of six online engineering programs (each program, 75-90 minutes). Our choice to develop a series program is intentional to move away from the "keychain syndrome" [54] in which learners engage in similar activities instead of moving to more complex projects. Six programs will have the sequential structure of: (1) Connect, (2) Ask, (3) Imagine and Plan, (4) Create, (5) Improve, and (6) Celebrate. This structure adopted the Engineering is Elementary (EiE) process [55]—ask, imagine, plan, create, improve—and added Connect and Celebrate. Within each online program, we will provide appropriate contents and prompts for children and caregivers to engage in three types of activities—ignite, make, reflect. After each online program, families will be encouraged to participate in deepen activities. Deepen activities are at-home activities that families can independently do asynchronously at home to deepen what they explored during the online program, which will be shared in a private online group (e.g., Facebook group). It will promote families' everyday engineering participation and sharing between families, and further connect families to existing resources or ongoing programs at the rural library.




Building on existing frameworks (e.g., Family Engagement Toolkit, ConnectedLib, Making+Learning), we will use co-design sessions to identify a few community problems that may be relevant and interesting for our families and prepare educative materials that learners can utilize as thinking tools to apply engineering design thinking. We will bring in rural library partners' expertise in family literacy and community engagement in the development of *Family Makers*. We will also discuss how to insert digital content created in Phase 1 (e.g., rural engineers' stories) to make rural engineering

relevant to children. An example of the six online engineering programs with the described structure can be found in **Supportingdoc2**. After completing the co-design cycle, we will discuss with investigate to what extent the iterative co-design cycle influenced rural library staff's knowledge of engineering design thinking and supported them to apply the engineering design thinking approach.

- **Pilot test/ evaluation/ revision.** We will conduct a pilot test with two families who will not be our research participants using convenience sampling approach from personal networks. Video-recordings of the pilot test sessions will be evaluated by the external evaluator. Pilot test data and formative evaluation will be used to revise *Family Makers*, which will be evaluated by the Advisory Board members before we finalize Iteration One.

- **Recruitment of family participants for Phase 3 and distribution of kits.** Eight library partners will distribute recruitment emails using their networks (e.g., library listserv, newsletter, networks with local school, YMCA, church). We will recruit five English-speaking families with elementary-aged children per library, following the Federal Poverty Level Income guideline (total of 40 families across 8 libraries). A family unit can have diverse structures and will be defined by the participants. Program details and the logistics will be provided. We will also identify a tentative period to offer *Family Makers*. After recruitment, kits will be distributed to families.

***Data analysis****:* Zoom video-recordings, artifacts, and chat transcripts from the RPP meetings will be collected. We will create field notes after each RPP meeting. Data will be analyzed following the analytical approach described in Phase 1 to understand and document how a culturally-relevant engineering program was developed.

***Expected outcomes****:* Iteration One of *Family Makers*, consisted of a series of six online engineering programs with digital resources, will be developed. A list of materials (e.g., hotspot, tablet, craft supplies) will be identified. Areas of improvement for *Family Makers* program will be identified and revised. Rural librarians report of development of understanding in engineering design thinking is also expected.

**Research Phase 3: Test & Revise (At 4 libraries/ Year 2/ January 2024 – August 2024)**

***Goals:*** In Phase 3, we will test and revise Iteration One of *Family Makers* by implementing it across four rural libraries (i.e., Plumas CL, Tyrone Snyder PL, Kingsville PL, Stuttgart PL) involving 20 families (five per library) in order to design Iteration Two of *Family Makers*. Phase 3 addresses Need 2 and RQ3.

***Activities:***

- **Implementation of six online engineering programs.** The research team and library partners will implement and co-facilitate the programs; however, the level of support from the research team will decrease over time. The fading of the research team support will serve to test the sustainability of our efforts. In addition to Zoom recordings of six programs, pictures of artifacts and video-records of families' engagement in the online community during *Deepen* as well as records of families' communication in the online group will be collected. Informal communications with participants (e.g., emails, text messages) will be collected. After implementing each program, the project team will revise the next program based on the observation of families' engagement.

- **Pre-and post-surveys** will be administered to each child and library staff at the initial and final online engineering program. Children will take the first three sub-scales of the Upper Elementary S-STEM Survey. We will use this 5-point Likert Scale to examine whether our online engineering program impacted children's attitudes toward engineering. The internal consistency and reliability for the three sub-scales were: math (.85), science (.83), engineering and technology (.84) [56]. Library staff will complete a modified T-STEM (Teacher Efficacy and Attitudes toward STEM) survey, which had construct reliability above .87 [57].

- **Post-program debrief** (app. 5 min) will be conducted after each program with all participating families per program to discuss what they learned, enjoyed, and disliked and what they hope to learn more during the program, which will be video-recorded in Zoom. Rural library staff will also debrief about their online facilitation experience.

- **Post-program surveys** will be administered to each child, caregiver, and library staff at the end of each program. We will use the Engagement in Science Learning Activities scale [58] to examine behavioral, cognitive, and affective engagements during *Family Makers*. The surveys intended for children will feature modified language.

- **Exit interviews** (app. 30 min) will be conducted with each family after the completion of *Family Makers*. The interview protocol will include artifacts or researcher-selected video clips from the Zoom recordings from the six programs to support participants' reflection of their own learning experiences. Additionally, we will conduct exit interviews with each rural library staff to understand how their experience of collaboratively designing and facilitating the online engineering program influenced their level of confidence towards facilitating engineering programs and online facilitation skills, as well as future interest to implement *Family Makers* and perceived usefulness of *Family Makers* to serve underserved families with children.

- **Iterative co-design cycle 2.** After analysis findings from phase 3 are complete, we will engage in iterative co-design cycle 2 to design iteration Two. The same activities in iterative co-design cycle 1 will occur.

- **Recruitment of family participants and distribution of kits.** The same activities in Phase 2 will occur.

***Data analysis:*** For quantitative data, pre- and post-mean scores will be compared via paired sample t-tests or nonparametric tests, as appropriate. Independent samples *t* tests will be conducted for post-program surveys. Qualitative data will be analyzed in phenomenological and interpretive ways. Findings will be used to design Iteration Two.

To understand to what extent the online engineering programs supported families' development of engineering interest and practices **(first part of RQ3)**, we will conduct interaction analysis [59] based on video records of the six programs and conduct a thematic analysis based on families' exit interviews. We will create content logs [59] of all six programs, including any activities during *Deepen*. Case studies of families' online engineering learning experience will be developed to show how engineering practices and interest were supported or hindered by the various components of the *Family Makers* program. We will create design timelines [60] to summarize families' artifacts from online engineering programs over time. We will attend to families' conversations when they express confidence in engineering concepts, provide new ideas and solutions in their engineering design thinking, or express tensions and shifts in engagement pattern among family members. Exit interviews, post-program surveys and debriefs will be analyzed in tandem.

*Family Makers* will be refined through our findings that can be employed by other rural libraries in Phase 4. To understand to what extent engagement in *Family Makers* enhanced rural library staff's understanding of engineering design thinking and online facilitation skills **(second part of RQ3)**, the video-records of the online programs, iterative design cycle 2, and field notes will be analyzed. Similarly, we will create content logs to note any shifts in library staff's confidence and interest toward engineering and when and how shifts in facilitation occurred. Exit interviews, post-program surveys and debriefs will be analyzed in tandem.

***Expected outcomes:*** Iteration One will be vetted and context-relevant to rural libraries and underserved children (5-10 years) across four settings. Areas of improvement for *Family Makers* program will be identified and revised to develop Iteration Two. We will develop case studies of family participation and rural library staff's online facilitation. We expect participating families to report their development of engineering interest and practices and rural library staff to report their development of understanding in engineering design process and online facilitation.

**Research Phase 4: Replicate & Disseminate (At 4 libraries/ Year 3/ September 2024 – July 2025)**

***Goals:*** The primary goal is to develop the final online engineering program toolkit, entitled *Family Makers*, by testing and revising Iteration Two of *Family Makers* at four other rural libraries (i.e., Rushville PL, Wayland Free PL, Page PL, Plum Lake PL) with specific considerations for its successful replicability and dissemination at a broader level. *Family Makers* online toolkit will feature a suite of digital resources for rural library staff to easily access and readily adopt. Another critical goal is to disseminate and promote *Family Makers* toolkit to practitioners and researchers nationally. Phase 4 addresses Need 3 and RQ4.

***Activities:***

- **Replication.** The same research activities described in Phase 3 will be implemented. Phases 1-3 are designed to maximize adaptability, replicability, and scalability by continuously revising *Family Makers* based on evaluation that are built-in to the project on a program-to-program, library-to-library, and year-to-year basis. Every phase of the project is designed to move toward replicability and scalability. In Phase 4, we will focus on to what extent *Family Makers* educative materials can be used by our new library partners and new families.

- **Dissemination.** In addition to ongoing dissemination, dissemination efforts will include generating training

materials for pre-conference workshop at ARSL and hosting online webinars which will be promoted through ARSL and State Libraires. ARSL and Indiana State Library have already committed to support the project team. We will reach out to other State Libraries from Phase 3 to prepare dissemination across various States. Surveys will be disseminated to webinar participants through open feedback period to receive feedback from diverse rural libraries that did not participate in our project (minimum 50 survey responses expected). Surveys will also be distributed at the pre-conference workshop to explore the perceived effectiveness and areas of improvement and consideration. Finally, expert interviews will be conducted with Advisory Board members and ARSL members (5 members) to explore the level of scalability.

***Data analysis:*** The same data analysis activities in Phase 3 will occur to test Iteration Two and develop the final *Family Makers* toolkit. Independent samples t tests will be conducted for survey data from open feedback period from the webinars and ARSL pre-conference workshop. Expert interview data will be audio-recorded and/or video-recorded, transcribed, and thematically analyzed, following the methods outlined in Phase 1 to understand the level of scalability of *Family Makers*.

***Expected outcomes:*** *Family Makers* online engineering program toolkit will be publicly available on our project website. This toolkit will include ready-to-use, open-source digital content documenting experiences and pathways of rural engineers, curricula for six online engineering programs, design journal, facilitation and technology guides, and webinars to support replication across rural libraries in U.S. We expect rural library staff across the nation accessing *Family Makers* toolkit and registering for the ARSL conference and online webinars, which will lead to increased interest in implementing *Family Makers* at their own rural libraries.

**Potential Issues and Alternative Approaches:** Families may miss a program or leave the study. We expect to limit these issues by scheduling program times with all recruited families in advance. We also expect that the online format will limit families' struggle to find daycares for other siblings who do not meet the targeted age range. To encourage family participation, we plan to provide abundant materials to accommodate for multiple siblings. Although intergenerational participation is emphasized in *Family Makers*, we also recognize that caregivers may not be able to participate at all times. We will be flexible towards different family situations and expect some families to choose to have an older sibling participate instead of a caregiver. We expect technological components in the *Family Makers* (e.g., hotspots, tablets) missing or damaged, and some to likely not be returned. To alleviate this issue and encourage attendance, an honorarium will be provided to each family for the completion of all research activities and for returning the kits in the same manner received. All activities will take place online to ensure that research is least impacted by conditions during the pandemic.

**Logic Model:** See **Supportingdoc3** for how project activities will lead to project outcomes.

## PROJECT RESOURCES: PERSONNEL, TIME, AND BUDGET

**Project Personnel:** Project team will be led by *Soo Hyeon Kim* (PI, IUPUI) in collaboration with *Gi Woong Choi* (Co-PI, U of Cincinnati) and *Andrea Copeland* (Co-PI, IUPUI). PI Kim has research expertise on family engineering learning and rural library makerspaces. This research builds on the successes of Kim's ongoing collaborative research, DRL1759259, that supports families' at-home engineering participation [61] and MG-77-16-0137-16 in which Kim worked as part of the team to provide STEM workshops for families in rural communities [33,62,63]. The proposed study will focus on extending the family engineering learning efforts to online settings, which is an area that lacks prior literature, and examines how rural libraries can facilitate engineering learning opportunities. Kim brings engineering design and design thinking expertise from her prior academic and professional experience to lead the iterative design cycles. Kim teaches an MLIS course on makerspaces and informal learning that involves students using design thinking methods to implement maker programming and facilitate informal learning programs. Co-PI Choi's research expertise is on online learning technologies and tablet-mediated collaboration. With expertise in informal collaborative STEM learning [64,65], online learning and MOOCs [66,67], Choi will lead the design of the online engagement and facilitation for this project and develop the measurement items based on his expertise in mixed-methods approach. Choi either has taught or is currently teaching: Tools for Online Learning; Educational Game Design; Learner and User and Experience Design and Research. Co-PI Copeland's research is on co-creation of community repository. Co-PI Copeland will lead focus group and support relationship building in RPP sessions with her expertise in developing sustainable infrastructures of support between communities and institutions [68–70]. To develop the online engineering program, we will adopt our work on transforming maker programs into online settings [71] and utilize findings from our current study exploring how academic and public libraries have transitioned from physical to online makerspaces during the pandemic [72].

**Students:** This project will fund one doctoral student and two graduate students.

**Partner Libraries:** A strong partnership is formed with eight rural libraries. **(1)** Lindsay Fuchs, a county librarian at Plumas CL, CA. **(2)** Debbie Winlock, a library manager at Page PL, AZ. **(3)** Clara Timmerman, an assistant director at Stuttgart PL, AR. **(4)** Nicole Kirchoff, a director at Rushville PL, IN. **(5)** Danielle M. Weiser-Cline, Youth Services and Outreach Coordinator at Kingsville PL, OH, **(6)** Jennifer Powell, a director at Tyrone Snyder PL, PA. (7) Hope Decker, a director at Wayland Free Library, NY. **(8)** Emilie Braunel, a library director at Plum Lake PL, WI. See **Supportingdoc4**.

**Advisory Board (AB)**: AB consisted of experts in rural libraries and informal STEM learning will convene in a virtual meeting once per year to provide diverse perspectives and synergistic input on the development of project activities and data collection instruments and the evaluation of the program design, data analysis, findings, and mid-course corrections. They will also be individually reached out according to their expertise. **(1)** *Kathy Zappitello*, Past President of ARSL, will advise on the replicability and sustainability of our online engineering program. **(2)** *Amy Koester*, the Vice President/ President-elect for the Association for Library Services to Children (ALSC) and the Learning Experiences Manager at Stoke PL, will advise on culturally-relevant engineering program for undeserved children. **(3)** *Kyungwon Koh, PhD*, an associate professor at UIUC with expertise in digital youth and makerspaces in libraries, will advise on the design and evaluation of the digital resources and the online facilitation. **(4)** *Adam Maltese, PhD*, a professor at IU with expertise in family STEM learning, will advise on the design and implementation of the *Family Makers*. See **Supportingdoc5**.

**External Evaluator**: *James Diamond, PhD*, an Assistant Professor at JHU and the faculty lead for the program in Digital Age Learning and Educational Technology will be an external evaluator to provide formative feedback on the online engineering program curricula for each Iteration and the final curricula prior to implementation. See **Supportingdoc6**.

**Rural Engineers**: See **Supportingdoc7** for partnership with rural engineers and institutional support for recruitment. (*We have received email confirmation from three other industries; however, we have not yet received a formal support letter at the time of submitting the proposal*.) We will create more partnerships in the engineering industries that are most represented in rural America. We are currently reaching out to organizations (e.g., NGCP) that have networks with industry partners, mentors and professional organizations to support with recruitment, which will be ongoing until the grant starts.

**ARSL:** ARSL will support with promotion and dissemination of the project outcomes, webinars and training workshops through ARSL website and offer a pre-conference workshop to train rural library staff to prepare and implement *Family Makers* online engineering programs (see Kathy Zappitello's letter in **Supportingdoc5**).

**State Libraries:** We will further strengthen our dissemination effort and training of rural library staff by communicating project outcomes and providing online webinars through State Libraries. Indiana State Library have already committed to support the project team (see **Supportingdoc8**). We will reach out to other State Libraries from Phase 3.

**Time:** It will run from August 1, 2022 to July 31, 2025. See **Schedule of Completion.**

**Budget:** Total $499,941: Funds are requested for (1) salary and fringe benefits for the project team (IUPUI: one PI, one co-PI, two GAs; U of Cincinnati: one co-PI, one PhD student); (2) data collection equipment and materials (including mobile devices, hotspots); (3) participant incentives and stipends for rural library partners, rural engineers, external evaluator, AB members, and ARSL; (5) travel support; and (6) indirect costs at 58.5% of MTDC. See **Budge**t and **Budget justification**

## DIVERSITY PLAN

Underserved population that are served by our current rural library partners—across eight different states—represent racial and ethnic diversity (see **Supportingdoc4**). We will also attend to diversity as it relates to social economic class, ability, mobility, and sexual orientation in our recruitment of all participants and rural engineers to include a diversity of perspectives [73]. The culturally-relevant learning approach will recognize that rural Americans' experiences are not shaped by ruralness alone, but by diverse micro-cultures in which they live. Incorporating diverse types of rural engineers, different cases of online engineering programs at multiple rural settings and embedding feedback from advisory board members with diverse areas of expertise will ensure that diversity is at the center of this project. Also, the research team will coordinate with Indiana University' Center for Rural Engagement to learn the specific challenges in rural communities. We acknowledge that there is no one-size-fits-all approach to supporting underserved rural families' engineering participation. The research team will be mindful of the tendency to oversimplify the complexities of rural life. To mitigate the challenges of accessing the internet in rural communities, we will also leverage existing infrastructures (e.g., Infrastructure bill, Emergency Broadband Benefit) and provide grant opportunities and grant writing resources in our final toolkit to help rural library staff prepare appropriate technology to implement *Family Makers*.

## PROJECT RESULTS

**Evaluation Plan:** Seven evaluation activities are planned. **(1)** AB will examine the projects' process, timeline, and outcomes. Prior to each AB meeting, project findings will be shared to receive recommendations for improvement. **(2)** We will engage in ongoing evaluation of the educative materials in *Family Makers.* We will collect formative data, in the form of 5-point Likert scale, from families at the end of each program to assess whether they perceived improvement in their engineering interest and understanding. We will examine families' interaction in *Family Makers* and in the *Deepen* phase to evaluate if the structure and the educative materials are appropriate, interesting, and supportive. **(3)** An external evaluator will provide formative evaluation on each Iteration and the final curricula of *Family Makers* prior to the implementation. **(4)** To evaluate the validity and reliability of our findings, we will check inter-coder reliability. For interaction analysis, we will create analytical accounts of families' development of engineering practices with design timelines that include texts and screenshots from the video-records to provide a "thick description." We will hold multiple video-viewing sessions to confirm findings. **(5)** To evaluate the impact of the RPP on rural librarians' understanding of engineering design thinking and online facilitation skills, we will collect formative data, in the form of 5-point Likert scale, to assess whether librarians perceived improvement in their competencies as a result of the program, in addition to analyzing exit interview and video-based interaction data. **(6)** The project website will collect analytics about site visits and usage as another means of evaluating impact. **(7)** Finally, we will provide a summative evaluation in the final report.

**Dissemination Plan**: Our dissemination will be ongoing and throughout all phases to reach practitioner and scholarly communities at the local, state and national levels. The project website will share project progress and findings, which will be shared at partner library websites, popular social media (e.g., Programming Librarian Interest Group) and ARSL website. We will present findings in practitioner-oriented journals (e.g., *Public Libraries Magazine*) and local/ state librarian e-newsletters. We will also communicate research findings through conferences (e.g., ARSL, PLA, ALA, AERA, ICLS) and educational research and library professional journals (e.g., *Public Library Quarterly*, *Journal of Engineering Education, Children and Libraries*). Additionally, ARSL will work with the research team to provide a pre-conference workshop. We also plan to reach out to ALSC and ALA's STEM in Public Libraries through our AB member's networks to strengthen the dissemination (see Amy Koester's letter in **Supportingdoc5**). We will offer professional development programs through State Libraries. The Advisory Board will support the dissemination of research findings via their extensive networks.

**Sustainability Plan:** The sustainability at the local level depends on the successful Research-Practice Partnership. The team included efforts (i.e., iterative design cycle, training programs, fading of university facilitation) to strengthen the capacity of rural library partners to lead *Family Makers* independently. State Library PD programs and online webinars will help increase library staff's awareness of the online engineering program and support them to implement them at their libraries by accessing the *Family Makers* materials on our website. *Family Makers* curricula, digital resources, training materials for rural library staff, case studies, and the evaluation report will be published on our website, where they will continue to be available for free, shared under a Creative Commons non-commercial license. PIs have experience in building sustainable community solutions. For instance, Copeland's 3D virtual reality model to preserve Indianapolis' oldest Black church, Bethel, is still in use after five years because of the partnership between the community group and heritage organizations.

## NATIONAL IMPACT

80.5% of public libraires are rural and small-town libraries [74] and about1.5 million rural children live in poverty [75]. Providing a new outreach educational programming that overcomes barriers to serve underserved rural children will directly make a national impact. *Family Makers* toolkit—grounded in practice by involving rural library staff to co-design and provide input in every phase of the project—will contribute to a research-based program for how to engage underserved rural children and caregivers in culturally-relevant online engineering learning and how to support rural library staff to facilitate online engineering learning. The project design and outcome measures ensure that our culturally-relevant online engineering program is tested and refined through several cycles across different library settings, allowing for greater replicability and scalability. *Family Makers* toolkit, which will be freely accessible under a Creative Commons license and promoted by various partners on our project, will contribute to national dissemination and increase public appreciation of rural libraries as hubs for broadening engineering participation for underserved children and reposition rural library staff as facilitators of learning. In addition to expected short-term outcomes, our project will further support underserved families to seek out additional engineering resources from rural libraries, engage in at-home engineering conversation and activities, and utilize existing library resources and attend other ongoing programs at their local libraries. Through this project, rural library staff are also expected to implement *Family Makers* independently to more families and will be better equipped to apply engineering design thinking approach in their future roles (see **Supportingdoc3**). Consequently, our project will address the national need to lift geographical and cultural barriers that high population of underserved rural children experience to engage in engineering learning and position rural libraries as a key institution to democratize engineering learning opportunities.

**Schedule of Completion: Year 1**

| Phase | In charge | Activities | Year 1 | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2022 | | | | | | 2023 | | | | | | |
| | | | J | A | S | O | N | D | J | F | M | A | M | J | J |
| Understand | U | IRB application (before grant begins) and approval | | | | | | | | | | | | | |
| | U | Hire GA | | | | | | | | | | | | | |
| | U/ L | Research-Practice Partnership (RPP) monthly meeting | | | | | | | | | | | | | |
| | U/ L | Recruit families (5 per library) | | | | | | | | | | | | | |
| | U | Literature review | | | | | | | | | | | | | |
| | U | Develop research instruments | | | | | | | | | | | | | |
| | U | Advisory board feedback on data collection materials | | | | | | | | | | | | | |
| | U | Interviews with 10 rural library staff | | | | | | | | | | | | | |
| | U | Interviews with 10 caregivers | | | | | | | | | | | | | |
| | U | Interviews with 10 rural engineers | | | | | | | | | | | | | |
| | U | Digital content creation of "A day in the life of a rural engineer" | | | | | | | | | | | | | |
| | U | Analysis of phase 1 | | | | | | | | | | | | | |
| | U | Share reports from Phase 1 to rural library partners | | | | | | | | | | | | | |
| | U | Full advisory board virtual meeting | | | | | | | | | | | | | |
| | U | Submit year 1 grant report to IMLS | | | | | | | | | | | | | |

*U: University/ L: Library

**Schedule of Completion: Year 2**

| Phase | In charge | Activities | Year 2 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2023 | | | | | 2024 | | | | | | |
| | | | A | S | O | N | D | J | F | M | A | M | J | J |
| Develop | U | Librarian Training | | | | | | | | | | | | |
| | U/ L | Iterative co-design cycle 1 to develop Iteraiton One of Family Makers | | | | | | | | | | | | |
| | U/ L | RPP meetings (three months used for iterative co-design cycle 1) | | | | | | | | | | | | |
| | U | Pilot test Iteration One of Family Makers (2 families) and revise | | | | | | | | | | | | |
| | U | Evaluator feedback on pilot test | | | | | | | | | | | | |
| | U | AB member feedback on Iteration One of Family Makers | | | | | | | | | | | | |
| | U | Analysis of phase 2 | | | | | | | | | | | | |
| | U | Purchase materials and prepare Family Makers kits | | | | | | | | | | | | |
| | U | Recruit families; schedule time and distribute kits for Iteration One | | | | | | | | | | | | |
| Test & Revise | U/L | RPP meetings (two months used for iterative co-design cycle 2) | | | | | | | | | | | | |
| | U | Librarian and youth pre-survey | | | | | | | | | | | | |
| | U/L | 1st Family Makers session & debrief & survey | | | | | | | | | | | | |
| | U/L | 2nd Family Makers session & debrief & survey | | | | | | | | | | | | |
| | U/L | 3rd Family Makers session & debrief & survey | | | | | | | | | | | | |
| | U/L | 4th Family Makers session & debrief & survey | | | | | | | | | | | | |
| | U/L | 5th Family Makers session & debrief & survey | | | | | | | | | | | | |
| | U/L | 6th Family Makers session & debrief & survey | | | | | | | | | | | | |
| | U | Librarian and youth post-survey | | | | | | | | | | | | |
| | U | Librarian and family exit interviews; return kits | | | | | | | | | | | | |
| | U/L | Iterative co-design cycle 2/ RPP meetings | | | | | | | | | | | | |
| | U | Pilot test Iteraiton Two of Family Makers and revise | | | | | | | | | | | | |
| | U | Evalator feedback on pilot test | | | | | | | | | | | | |
| | U | AB member feedback on Iteration Two of Family Makers | | | | | | | | | | | | |
| | U | Recruit families; schedule time and distribute kits for Iteration Two | | | | | | | | | | | | |
| | U | Analysis of phase 3 | | | | | | | | | | | | |
| | U | Share reports from Phase 2-3 to rural library partners | | | | | | | | | | | | |
| | U | Full Advisory Board virtual meeting | | | | | | | | | | | | |
| | U | Submit year 2 grant report to IMLS | | | | | | | | | | | | |

*U: University/ L: Library

**Schedule of Completion: Year 3**

| Phase | In charge | Activities | Year 3 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2024 | | | | | 2025 | | | | | | |
| | | | A | S | O | N | D | J | F | M | A | M | J | J |
| Test & Revise | U/L | RPP meetings (two months used for iterative co-design cycle 2) | | | | | | | | | | | | |
| | U | Pilot test Iteraiton Two of Family Makers and revise | | | | | | | | | | | | |
| | U | AB member feedback on Iteration Two of Family Makers | | | | | | | | | | | | |
| | U | Recruit families; schedule time and distribute kits for Iteration Two | | | | | | | | | | | | |
| | U | Analysis of phase 3 | | | | | | | | | | | | |
| | U | Submit year 2 grant report to IMLS | | | | | | | | | | | | |
| Replicate & Disseminate | U | Librarian and youth pre-survey | | | | | | | | | | | | |
| | U/L | 1st Family Makers session & debrief & survey | | | | | | | | | | | | |
| | U/L | 2nd Family Makers session & debrief & survey | | | | | | | | | | | | |
| | U/L | 3rd Family Makers session & debrief & survey | | | | | | | | | | | | |
| | U/L | 4th Family Makers session & debrief & survey | | | | | | | | | | | | |
| | U/L | 5th Family Makers session & debrief & survey | | | | | | | | | | | | |
| | U/L | 6th Family Makers session & debrief & survey | | | | | | | | | | | | |
| | U | Librarian and youth post-survey | | | | | | | | | | | | |
| | U | Librarian and family exit interviews; return kits | | | | | | | | | | | | |
| | U | Analysis of Phase 4 | | | | | | | | | | | | |
| | U | Generate training materials for workshops and webinars | | | | | | | | | | | | |
| | U | Host online webinars through ARSL and State Libraries | | | | | | | | | | | | |
| | U | Provide open feedack period through webinars | | | | | | | | | | | | |
| | U | Expert interviews with AB and ARSL members (5 total) | | | | | | | | | | | | |
| | U | Pre-conference workshop at ARSL | | | | | | | | | | | | |
| | U | External evaluator feedback on the final curricula | | | | | | | | | | | | |
| | U | Full advisory board virtual meeting | | | | | | | | | | | | |
| | U | Revise Family Makers program by applying all the feedback from above | | | | | | | | | | | | |
| | U | Submit year 3 grant report to IMLS | | | | | | | | | | | | |
| Ongoing activities | U | Family Makers online engineering program design and refinement | | | | | | | | | | | | |
| | U | Development and update of website | | | | | | | | | | | | |
| | U | Advisory board consultation (if needed) | | | | | | | | | | | | |
| | U | Data analysis and evaluation | | | | | | | | | | | | |
| | U | Develop and disseminate research | | | | | | | | | | | | |

*U: University/ L: Library

# Digital Products Plan

## Type

Following content, resources, and assets will be collected/created:

- A public project website with contact information and de-identified results in the form of publications and educational resources (e.g., curricula for online engineering program)
- Materials for online webinars and training programs for library professionals in Year 3
- An internal project data depository only available to the research team through the secure data storage system which will contain all raw data, analyzed data, publication, and resource drafts.

All hardware and software will either be provided by the Indiana University and University of Cincinnati (e.g., computer workstations, Microsoft Office suite) or hosted on a secure server (e.g., Qualtrics, SPSS, Atlas.ti). The project will make use of Microsoft Office and other authoring tools to create and format educational resources and other digital materials for dissemination. Any generated data will be stored in the secure data storage repository. The public project website will be hosted by the Indiana University and/or University of Cincinnati. HTML, PDF, DOCX (Microsoft Word), PPTX (PowerPoint presentations), MPE, MP4 or MPEG using default resolutions of the recording software, XLS (Microsoft Excel), SPSS, JPEG, TIFF (Photos), and HTML forms will be used.

## Availability

The project website will be the main venue for disseminating the digital products from the project. We will make our journals and conference proceedings available via ScholarWorks, Indiana University's digital repository.

We will provide basic metadata tag for all educative materials on the project website. We will adhere to existing metadata standards such as use Dublin Core.

## Access

The intellectual property status of digital products will be licensed under a Creative Commons Attribution-Noncommercial 4.0 International 4.0 (CC BY-NC 4.0). We have chosen this CC license because it is our team's intent to make our digital products as widely distributable and reusable as possible. The license provides the freedom for public to use the works, share copies of the works, and adapt (e.g., remix, transform, and build upon the material), but not for commercial purposes. We have chosen this CC license because we want different libraries or other potential users to be able to adapt the materials to their local needs.

Our organization will assert ownership right on appropriate attribution and credit to ensure that the creators of digital products receive the credit. To achieve this, a summary of the terms and conditions of the Creative Commons Attribution 4.0 - International license will be included in all materials. Users of our digital products must give appropriate credit, provide a link to the license, and indicate if changes were made.

Given that this project involves a vulnerable population (i.e., youth), we will take precautions to ensure privacy and safety. First, the primary data will be stored electronically in a password protected computer and OneDrive (which encrypts files and required two-factor authentication). Only research collaborators will have access to a shared folder inclusive of research data and research notes. Second, all identifying data will be kept confidential, and any data that will be shared outside of the project will use pseudonyms and generic demographic data (e.g., ethnicity, age, and gender). For the purpose of sharing photographs or videos, the research team will only share participants' images if received consent or share when only non-identifiable features will be shown (e.g., the backs of heads).

**Sustainability**

Any digital products developed during and after the completion of this project will be hosted in a secure storage. We have unlimited storage, and it is FERPA/HIPPA compliant. Upon completion of the project, all educative materials will be publicly available in the project website which will be hosted by the Indiana University and/or University of Cincinnati. Family Makers curricula, digital resources, training materials for rural library staff, case studies, and the evaluation report will be published on our website, where they will continue to be available for free, shared under a Creative Commons non-commercial license.

## Data Management Plan

### Data Types, Estimated Amount, Intended Uses, Methods, and Time of Collection

The types of data collected in this project are described below. Details of these activities can be found in Supportingdoc1.

- interview data with 10 rural library staff, 10 caregivers, 10 rural engineers to understand challenges of rural library staff and underserved families and identify approaches for online engineering learning in Phase 1 (approximately 30-hour long audio/video recordings, chats, informal communications with participants such as emails)
- digital content created by 10 rural engineers to represent lived experiences of rural engineers and technical professionals in the *Family Makers* curriculum (approximately 10-hour long audio/video recordings)
- observational data from RPP meetings in all phases to understand rural librarians' development of understanding in engineering design thinking (approximately 80-hour long audio/video recordings, fieldnotes, artifacts, chats, informal communications with participants)
- observation of pilot tests of each iteration of *Family Makers* (two families per iteration) in Phase 2 and 3 to develop a culturally-relevant online engineering program at rural libraries (approximately 6-hour long audio/video recordings, fieldnotes, artifacts, chats, informal communications with participants)
- observation of participants' interaction at 6 *Family Makers* online engineering programs at 8 rural libraries in Phase 3 and 4 to develop the final *Family Makers* toolkit through replication (approximately 144-hour long audio/video recordings, fieldnotes, artifacts, chats, informal communications with participants)
- pre- and post-survey at the initial and final online engineering program in Phase 3 and 4 with: (1) each child to understand their development of engineering interest and practices, and with (2) each rural library staff to understand their development of engineering design thinking and online facilitation skills (approximately 16 pre- and post-surveys from rural library staff and 80 pre- and post-surveys from children).
- post-program survey and 5-min debrief after each online program with family participants in Phase 3 and 4 to understand what they enjoyed and disliked and make necessary modifications to the program (approximately 240 post-program surveys and 1-hour long audio/video recordings, artifacts, chats, informal communications)
- exit interview data in Phase 3 and 4 with: (1) each family to understand their development of engineering interest and practices (30-min per family, approximately 20-hour audio/video recordings), and with (2) each rural library staff to understand their development of engineering design thinking and online facilitation skills (30-min per staff, approximately 4-hour audio/video recordings).
- Expert interview data in Phase 4 with 5 members from ARSL and the Advisory Board to understand experts' perspectives on the level of scalability of *Family Makers* (30-min per expert, approximately 150-min recordings).
- Survey data in Phase 4 from rural library staff who engaged with online webinars and ARSL pre-conference workshop to receive feedback from diverse rural library staff that did not participate in our project (minimum 50 survey responses expected).

The types of data generated from this project are:

- *Family Makers* toolkit that includes curricula for six online programs and digital resources (i.e., videos documenting lived experiences of rural engineers, design journal, facilitation and technology guides) and a list of materials (i.e., tools, craft materials, hotspots, tablets) at the completion of the project to make *Family makers* accessible to a broader audience to support with further dissemination and sustainability of our project outcomes.
- Worked examples with underserved families and rural library staff and advance our understanding of how lived experiences of rural engineers facilitate engineering learning for underserved families.
- Webinars, training workshops, and pre-conference workshop at ARSL generated in Phase 4 to support rural library staff to understand the value of providing online engineering programs to underserved children at rural libraries and prepare them to implement *Family Makers* across the nation.

### Data Protection and Documentation

The proposed study will collect sensitive information (e.g., names, zip codes, email addresses, ages, gender, phone numbers, ethnicity) and involve a vulnerable population (i.e., children) and multiple forms of data. To ensure safe protection and documentation of data, the recommendations of data privacy of the IRB offices at Indiana University and/or University of Cincinnati will be followed. Identifiers associated with data will be linked to participants' names on a digital spreadsheet that will be located on a password-protected computer and OneDrive (which encrypts files and requires two-factor authentication). Subjects will only be identified by unique IDs or pseudonyms. All identifying data will be kept confidential from our reports, and any data that will be shared outside of the project will use pseudonyms. Only research collaborators who have passed the IRB CITI training, the university child abuse training, and other necessary trainings will have access to research data. The project team will also share anonymized data with the IMLS evaluator. The IMLS evaluation team will not have access to subjects' names nor the codebook that links names with pseudonyms. Additionally, when the research team analyzes data that cannot be made non-identifiable such as video records, they will work in a space in such a way that other people cannot access.

All subjects will sign consent forms to participate in this study. For children, legal guardians will sign consent forms. Legal guardians will have the opportunity to consent to showing their children's photographs or videos during educational conferences, residential or online classes, or identifiable photographs being shown in journals. In the consent form, we will also provide the option of blurring participants' faces or only showing non-identifiable features (e.g., the backs of heads). The codebook spreadsheet will also note which legal guardians consented to showing their photographs or video in conferences, journals, or reports. Oral assent will be given to children who are participating in the study. The recruitment and consent will not happen in face-to-face format, only through emails. The PIs will administer the informed consent process by sending the consent forms. The consent form is written in plain, simple English at eighth grade level as recommended in the Indiana University and/or University of Cincinnati consent form template. All identifying information will be stripped from data prior to the analysis. Outside members will not have access to identifiable images, unless participants agree to share their images on the consent forms.

**Data Management Tools**

All data will be stored on the Indiana University and/or University of Cincinnati's secure servers. The non-identifiable and identifiable data will be stored for 10 years. HTML, PDF, DOCX (Microsoft Word), PPTX (PowerPoint presentations), MPE, MP4 or MPEG using default resolutions of the recording software, XLS (Microsoft Excel), SPSS, JPEG, TIFF (Photos), and HTML forms will be used. All videos and images will use manufacturer default settings. The surveys and qualitative analysis will be administered through institution-hosted analysis tools. It is not anticipated that there will be a need for any specialized technologies. Products for dissemination will be available on the project website that is hosted by the Indiana University and/or University of Cincinnati. Metadata such as qualitative data coding schemes and variable labels will be coded using established software formats and standards. All data and metadata will be stored in encryption-protected computers and OneDrive (which encrypts files and requires two-factor authentication). The encryption protocol ensures that if someone accesses a hard drive or external drive, he or she cannot view any files with the secure encryption key. Analysis of data will be disseminated via publications, conference proceedings and presentations, practitioner reports, and blog posts, which will occur throughout and after the completion of the project.

**Data Preservation and Sharing**

Access to raw data such as audio/video recordings, transcripts, interviews, and survey responses will not be shared to outside members due to IRB privacy restrictions. Upon completion of the project, the project team, rural library partners, and advisory board will identify which project data are of long-term interest for archiving and preservation. For data that would be substantially less meaningful if de-identified, we will archive the data and associated metadata on an internal server where data will be managed by project staff. Materials will be anonymized or de-identified as appropriate, converted to searchable pdf document format. The data will be preserved for ten years after the completion of the project. The final products of this project will be of interest to library professionals, engineering and STEM educational researchers, partner libraries, and other informal learning program administrators. The intellectual property status of digital products will be licensed under a Creative Commons Attribution-Noncommercial 4.0 International 4.0 (CC BY-NC 4.0). We have chosen this CC license because it is our team's intent to make our digital products as widely distributable and reusable as possible.

**Reviewing the Data Management Plan**

We will review this data management plan once every 6 months to ensure privacy, confidentiality, and security of the data. The research team also permits study-related monitoring, audits, and inspections by The Indiana University Institutional Review Board (IRB) and University of Cincinnati as part of the Data Safety Monitoring Plan.

## Organizational Profile

Organizational Description

Indiana University is a major multi-campus public research institution, grounded in the liberal arts and sciences, and a world leader in professional, medical, and technological education.
Indiana University's mission is to provide broad access to undergraduate and graduate education for students throughout Indiana, the United States, and the world, as well as outstanding academic and cultural programs and student services. -Board of Trustees, 2014

Indiana University–Purdue University Indianapolis (IUPUI), a partnership between Indiana and Purdue universities, is Indiana's urban research and academic health sciences campus.
IUPUI's mission is to advance the state of Indiana and the intellectual growth of its citizens to the highest levels nationally and internationally through research and creative activity, teaching and learning, and civic engagement. By offering a distinctive range of bachelor's, master's, professional, and Ph.D. degrees, IUPUI promotes the educational, cultural, and economic development of central Indiana and beyond through innovative collaborations, external partnerships, and a strong commitment to diversity.

The Indiana University School of Informatics and Computing at IUPUI fosters a broad and interdisciplinary view of informatics and uses this view to explore and expand knowledge in informatics education and research. Along with the many schools and departments located on the Indiana University Purdue University urban Indianapolis campus, the School is firmly committed to a welcoming environment, a diverse faculty and student body, and to efforts which support Indiana's economic development.

The mission of the Indiana University School of Informatics and Computing is to excel in education, research, and civic engagement in the field of informatics, an integrative discipline which advances knowledge in computing, information, and media technologies; the implications those technologies have for individuals and society; and their application to any field of study adapting to the challenges of the Information Age.