Developing A Professional Learning Program for Informal STEM Education Facilitators

Christina Baze[1], Sanlyn Buxner[2], Erin Turner[2], Christopher M. Rendes[2], Seneca Beth Miller[2], and Ricardo Valerdi[1]

[1]Department of Systems and Industrial Engineering, University of Arizona

[2]Department of Teaching, Learning, and Sociocultural Studies

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While there is a robust literature and corpus of knowledge around teacher professional learning (PL) in formal K-12 education, much less is known about informal education professional learning (PL), particularly for implementing STEM practices. Informal educators, such as facilitators in afterschool programs and summer camps, often do not have formal training in STEM practices, pedagogy, and youth development (e.g., Allen & Crowley, 2017; Fenton et al., 2019; NRC, 2015). The *Growing Mathletes* project is contextualized inside of an informal education program at the intersection of baseball, mathematics, and growth mindset to support youth math learning and growth mindset development through a novel context. We are an interdisciplinary team working to provide facilitator PL and support to successfully implement the *Growing Mathletes* curriculum in a variety of informal education settings. Here we describe the design principles for informal STEM education we constructed from the literature, our PL model, and preliminary findings from studying an afterschool implementation of the *Growing Mathletes* program during Fall 2021 and Spring 2022. We close with a discussion of these findings and what they mean for our program and PL design principles.

Background

The literature around both informal STEM educator PL and hybrid PL was reviewed and used to realize five design principles which guided the development of our PL program. These design principles are explained and linked to the relevant literature below.

Facilitators Should Have Opportunities to Actively Engage with the Content as a Learner

A clear focus on content is a critical feature of PL (Desimone, 2009; Freeman, Dorph, & Chi, 2009; National Research Council [NRC], 2015; Wilson, 2013). Content delivery should include modeling of approaches (Tran et al., 2013), direct instruction (Wilson, 2013), and

experiential learning (Webster-Wright, 2009; Wever Frerichs, Fenton, & Wingert, 2018). Moreover, active learning experiences and collective participation greatly enhance PL experiences (e.g., Fenton et al., 2019; Wilson, 2013).

Informal Education Facilitators May Need Extra Pedagogical Support

Informal educators are often untrained in teaching, such as volunteer docents (Allen & Crowley, 2017; Tran et al., 2019), after-school facilitators (NRC, 2015), and out-of-school facilitators (Fenton et al., 2019). These educators may need specific support to develop effective pedagogical skills. Specifically, informal educators often require support to understand the nature of learning, motivation, student-centered and inquiry teaching, and youth developmental needs (e.g., Allen & Crowley, 2017; Tran et al., 2019; Wilson, 2013). These educators often need additional training to develop equitable instructional methods (Szelei et al., 2020; Yerrick & Beatty-Adler, 2011) and ways to foster youth growth mindsets (Atwood, 2010; Dweck, 2008). Informal educators may need content, processes, and practices support to understand and be able to teach STEM material (Freeman et al., 2009; NRC, 2015; Tran et al., 2019) and particular attention to educator attitudes toward and comfort with STEM content (Freeman et al., 2009; Wilson, 2013).

Professional Learning for Educators should Include Repeated Cycles of Learning, Experience through Enactment, and Reflection

Effective PL constitutes a continuous pathway and significant duration (Desimone, 2009; Heimlich et al., 2021; Wilson, 2013). This learning pathway should include iterative cycles of learning, practice, and feedback with reflection (e.g., Allen & Crowley, 2017; Wever Frerichs et al., 2018). Reflection is among the most important aspects of successful iteration (e.g., Sanford & Sokol, 2017; Tran et al., 2019; Webster-Wright, 2009).

Professional Learning Programs should be Situated in the Community of Practice within the Organization

For PL to result in changing and improving practice, it should include on-the-job learning within a professional community of practice (Sanford & Sokol, 2017; Tran et al., 2019; Wever Frerichs et al., 2018). This includes situating PL in the context of the organization (Webster-Wright, 2009; Freeman et al., 2009), grounding it in the mission and values of the organization (Sanford & Sokol, 2017), and training close to the practice of the organization (Wilson, 2013). Importantly, successful PL relies on an organizational culture supportive of learning (Tran et al., 2013).

Hybrid Professional Learning Environments should use Virtual and In-Person Contexts to Complement One Another

Hybrid learning environments are an effective and flexible option for PL (Fenton et al., 2019; Lobley & Ouellette, 2013; Wever Frerichs et al., 2018). Virtual and in-person components should work together to form a coherent, structured, and flexible curriculum to support successful hybrid PL (e.g., Istenič Starčič, 2008; Lobley & Ouellette, 2013). Virtual components should include access to on-demand resources (e.g., Heimlich et al., 2021; Istenič Starčič, 2008; Freeman et al., 2009; Sanford & Sokol, 2017).

Methods

The *Growing Mathletes* program used for this study integrates math, baseball, and growth mindset through activities meant to link concepts and be implemented in after-school or summer informal education settings. The overall methods are guided by design-based implementation research (DBIR). DBIR is a collaborative, iterative approach to organizing research and development activities in ways that support effective implementation and sustainability (Penuel

& Martin, 2015; Roschelle, Knudsen, Hegedu, 2010). A central aim of DBIR is to address potential challenges related to the implementation of educational innovations via close partnerships and ongoing collaborations. Through this work, we use DBIR to guide iterative cycles of systematic inquiry that produce evidence related to the effectiveness and usability of project training and activities to inform program refinements. In this paper, we focus on materials and training for facilitators as well as their implementations, feedback, and reflections.

Data used to understand facilitator training and implementation both qualitative and quantitative. Data were collected from two facilitators in the first year of implementation; Facilitator A participated in both Fall 2021 and Spring 2022, while Facilitator B participated fully in Fall 2021 but had to leave the project after the Spring 2022 training. Both facilitators worked at different Boys and Girls Clubs in afterschool programs serving youth who attended urban elementary and middle schools. Data sources included structured observations using the Dimensions of Success (DoS) Observation Protocol (Shaet al., 2014) and semi-structured interviews.

Selected sessions were scored using an adapted DoS protocol; we chose to only score eight of the 12 dimensions based on the goals of our project, and only in sessions featuring lessons we expected to yield robust observational data across these dimensions. For example, the Base Running lesson features a physical activity where youth run the bases in a straight path and a banana pattern (adding a bend to their running path to eliminate the need to slow down to turn), and compare their running time between both running strategies. Observation of this activity shows how well the facilitators engage youth in both “hands-on” and “minds-on” activity (Engagement in STEM dimension) and support math learning (STEM Learning dimension). This

data includes nine sessions led by Facilitator A across Fall 2021 and Spring 2022, but only four sessions led by Facilitator B in Fall 2021.

Semi-structured interviews were conducted after the initial training before implementation, midway through implementation (when possible; Fall 2021 only), and after implementation each semester by an external evaluator for the project. These interviews were intended to elicit facilitator reflections and feedback about the training and support, curriculum and materials, and program impact. Facilitators were asked to complete implementation logs after each session using a Google Form structured to gather their reflections on how the session went, how prepared the facilitator felt, and youth outcomes such as learning and engagement. As with the DoS observations, Facilitator B did not participate in Spring 2022 and no interviews nor implementation logs were collected that semester from Facilitator B.

Analysis of all data sources was conducted by at least two members of the research team and included meetings for determining intercoder agreement. Two members of the research team conducted DoS observations and scores were reconciled through meetings comparing scores and evidence to determine final scores. Analysis of DoS was descriptively comparing each facilitator's combined scores for each selected lesson on eight focal dimensions. We developed and iteratively refined a qualitative codebook from data sources from facilitators' own voices (e.g., interviews and implementation logs) from the first year of data collection. This codebook attends to instances where facilitators identified challenges to implementation, changes and adaptations to the program, facilitator learning as a result of our professional learning program, facilitator's existing understanding and funds of knowledge, and successes and positive stories resulting from *Growing Mathletes*.

Preliminary Findings

Preliminary results from the first year of data collection of facilitators at two different Boys and Girls Clubs reveal key findings around i) the effectiveness of the PL, ii) their perceptions of youth math learning, and iii) successes and opportunities for improvement in implementation.

Effectiveness of the Professional Learning

Interviews show that facilitators showed agency by making the curriculum their own through changes and adaptations appropriate to their youth or their context (i.e., each Boys and Girls Club) and providing feedback about their PL. Facilitator B most often identified the initial training as a source of their learning about the *Growing Mathletes* curriculum and content, for example, “Although kind of lengthy, the video showed to me on the first day of training about growth and fixed mindset really hit home for me and could possibly have a similar effect on the youths.” Facilitator A often sought information from external sources, such as Google: “[O]n the back of the baseball card, there was some stuff that I didn't know, and it wasn't in [the facilitator guide] so I looked it up myself.” Both facilitators understood the math and mindset content (with mixed understanding of baseball concepts) and felt confident and prepared in implementing the curriculum and both facilitators frequently identified time management or time constraints as challenges to implementation.

Facilitator Perceptions of Youth Math Learning

Both facilitators also spoke to the ways they noticed their youth making connections within the curriculum and learning the math content. Facilitator A often spoke to youth learning in the context of giving feedback on the lessons. For example, in her Fall 2021

mid-implementation interview, Facilitator A explained how her youth were successfully completing the activities, even when they included a heavy math component:

> *I think that the math heavy base activities are working really well. Like the coin drop, when they had to throw the dice to get their batting average, stuff like that. When we do the Strike Zone, the math heavy baseball kind of subjects … are I think going really well because they're easy to understand. Some of the kids may struggle in some of the components, like, 'Why is it this (-2, -8)? Why are they negative?' Then their friends and their groups would explain to them. Or they can look at the PowerPoint slide and see, 'Oh, okay, now I understand because this quadrant [on the coordinate plane] is (negative, negative).'*

Facilitator B most often mentioned that his youth were learning math. For example, in his post-implementation interview, he noted:

> *The kids, they're just getting each session as we move forward, they're just getting more and more comfortable in understanding the concepts of what we're doing and why we're doing it. They're wrapping their heads around the driving questions and they're getting the math and I couldn't ask for a better class.*

These are key examples of how the facilitators reflected on their youths' successful learning of the math content in the *Growing Mathletes* curriculum.

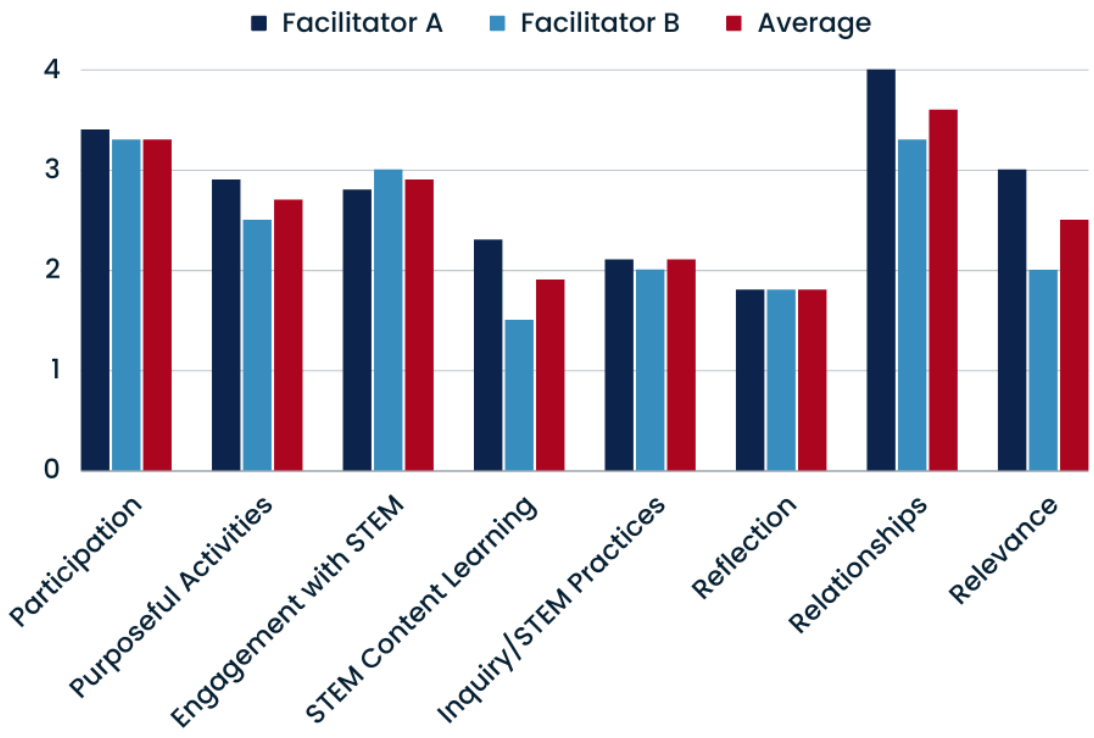
Successes and Opportunities for Improvement in Implementation

Preliminary analysis of DoS ratings (Figure 1) show that both facilitators did well in engaging youth in equitable participation, purposeful activities, and STEM; and they consistently showed positive relationships with youth. DoS ratings suggest facilitators need more professional development to better support youth content learning, use extended reflection, and engage youth

in math practices. Site differences were seen in how the facilitators made the curriculum relevant to youths' lives outside of the project.

Figure 1

DoS Scores by Focal Dimension



Based on the DBIR framework, the support team updated the training to include more facilitator planning and practice implementation as well as more intentional practice of math instructional strategies. Additional data collection has since occurred at three summer camp sites (Summer 2022) and one new Boys and Girls Club site (Fall 2022), including 12 new facilitators. Data analysis is currently underway for these sites, and additional data collection is planned at two additional sites with up to seven new facilitators in Spring and Summer 2023. With the inclusion of this data, an expanded manuscript will be produced and submitted to a peer-reviewed journal.

Discussion and Further Revisions

These findings largely align with what was found in the literature around PL program development. We saw how our PL supported facilitator agency, or autonomy, which Allen & Crowley (2017) described as a guiding principle for inquiry-based learning in PL contexts and important for learning and motivation. The National Research Council also described the importance of "taking advantage of staff experience and expertise" (NRC, 2015, pg. 29) in developing effective PL. Others have also found that a focus on content during in-person training workshops is essential for effective PL (Clark et al., 2019; Desimone, 2009; Sanford & Sokol, 2017; Wilson, 2013).

Our findings also suggest a need for further revisions to our PL program, specifically in enabling facilitators to better support youth content learning, use extended reflection, manage time and behavior, and engage youth in math practices. First, we see a need for more pedagogical support during initial training, specifically including theories of learning (Garst et al., 2014) and STEM processes (Freeman et al., 2009), as well as more on-demand resources modeling instructional strategies around extended reflection, productive struggle, and collaborative youth engagement in math practices (Clark et al., 2019). Second, we need to provide more frequent and extended reflective coaching sessions with facilitators to address issues during implementation (Fenton et al., 2019; Garst et al., 2014; Sanford & Sokol, 2017; Tran et al., 2019; Webster-Wright, 2009). We also need to provide more opportunities for facilitators to collaboratively share, reflect, and brainstorm with other facilitators (Istenič Starčič, 2008; NRC, 2015; Wever Frerichs et al., 2018; Wilson, 2013), such as through group coaching. Third, we are revising our PL model to include explicit training around managing youth, in terms of both behavior management and time management. We expect these changes will result in better

engagement of youth in math practices by keeping them on task and allowing facilitators to dedicate more time to youth-centered activities rather than on behavior management or facilitator-centered speaking.

The five design principles for informal STEM educator PL described here offer a substantive framework for developing an effective PL program. Through design-based implementation research (DBIR), we are iteratively developing an evidence-driven PL program that has shown preliminary promise for effectively supporting our facilitators in delivering the *Growing Mathletes* curriculum. While the PL program needs further revision, these revisions fit within the design principles we developed from the literature, suggesting that these design principles offer a strong framework for designing PL. This work has strong implications for supporting informal STEM learning centers to improve their programming through evidence-based PL.

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