Growing Together: How a PreK Gardening Professional Development Program Influences Teaching Practices

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Abstract

The importance of high-quality early childhood STEM and nutrition programs is well-established by both education and health researchers. Additionally, the connection between poverty, food insecurity, poor health, and academic underperformance has been extensively documented. This convergent mixed-methods study explored the impact of a professional development program for preK teachers, aimed at enhancing their ability to integrate science, mathematics, nutrition, and literacy through garden- and food-based science lessons. Quantitative survey results revealed significant improvements in the application of instructional best practices across multiple domains following the program. Furthermore, focus group discussions highlighted that modeling the use of new resources played a key role in boosting teachers' confidence in delivering integrated STEM, nutrition, and literacy lessons in their classrooms.

1. Introduction

Health and education researchers alike have described a cyclical relationship among poverty and food insecurity, poor health, and under-achievement in school [1]. Educators across disciplines agree that early childhood interventions have strong potential to result in lifelong benefits when children are exposed to high-quality educational programs [2]. Seeds to STEM (S2S) is a preschool (preK) intervention aimed at fostering understanding, growing, and eating healthy food to respond to the national need to address disproportionate rates of poor nutrition, health, and educational achievement among populations. Substantiated by two decades of research is the positive influence of garden-based teaching and learning on academic achievement and social emotional outcomes. S2S advances this research by offering an integration of current instructional best practices in preK inquiry-based STEM and literacy teaching and learning. Thus, the purpose of this convergent mixed-methods study was to examine the impact of the S2S professional development (PD) program on preK teachers' classroom instructional practices. Two research questions (RQs) were addressed. RQ1: Did preK teachers report significantly more frequent use of classroom instructional best practices across science, nutrition, mathematics, and literacy after participating in S2S PD? RQ2: How did preK teachers describe the impact of S2S PD on their classroom instructional practices?

2. Addressing food insecurity through early STEM education

In 2021, 6.2% of United States (U.S.) households with children, equivalent to 2.3 million families, experienced food insecurity. Food insecurity poses significant risks to children's physical and mental well-being and adversely affects their academic achievement and long-term prospects [3]. In the U.S., food insecurity does not impact all children equally, as racial and ethnic inequities significantly influence children's likelihood of facing hunger, with children in families of color experiencing the highest rates [4]. A common response to food insecurity is the purchase of inexpensive, processed foods. According to the most recent data, 79% of households served by Feeding America reported relying on the least expensive options, while 23% indicated gardening as a strategy to enhance food security [4].

A comprehensive study involving Head Start teachers highlighted gardening as a highly effective educational tool [5]. Teachers recognized its potential to combine physical activity and fine motor skills with literacy, science, and mathematics, while also fostering positive, lifelong eating habits [5]. Research further shows that eating behaviors developed in early childhood influence food preferences and eating patterns into adulthood [6]. Early sensory engagement with vegetables increases the likelihood that children will try those foods later, and repeated exposure to

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nutrient-dense foods during early childhood has been linked to significant reductions in long-term obesity rates [6,7]. Additionally, involving children in growing fruits and vegetables enhances their recognition of these foods, increases consumption variety and quantity, and fosters openness to trying new foods [7]. Importantly, research indicates that early knowledge in science and mathematics is a stronger predictor of academic success than literacy, particularly for children from historically underserved communities [8].

Despite this evidence, many preK teachers report needing additional support to teach inquiry-based STEM and nutrition lessons, extending beyond mealtime activities [9]. Integrating these topics into the curriculum is essential, as inquiry-based STEM education supports language development by introducing foundational techniques such as "observe, predict, and check, then form new questions," which helps to expand children's vocabularies [10]. Encouraging curiosity through prompts such as "What if" or "I wonder" helps children to express ideas, engage with materials, and collaborate with peers. These approaches emphasize that inquiry-based STEM learning and math skill development significantly improve preK literacy, an important factor for kindergarten readiness.

3. Context of the study

Supported by funding from the National Institutes of Health (NIH), Seeds to STEM (S2S) is designed to support preschool children, their families, and teachers to make informed and healthy food choices through inquiry-based lessons in nutrition, STEM, literacy, and garden education. The curriculum is being implemented in two major U.S. cities, Philadelphia, PA, and Los Angeles, CA, targeting families with children aged 3–5 and their preK teachers. Developed in alignment with Head Start Health standards and Next Generation Science Standards (NGSS) for early childhood education, the S2S curriculum includes 16 inquiry-based lessons organized into four central themes: 1) Food Fundamentals, 2) Healthy Choices, 3) Cycles in the Garden, and 4) Real-World Connections.

Drawing on research and extensive museum-based educational practices, S2S incorporates three key pedagogical approaches: 1) inquiry-based, play-centered STEM teaching and learning [11]; 2) the use of play, curiosity, and role-playing to engage young learners [12]; and 3) a strengths-based approach to education [13]. The program aligns with the National Association for the Education of Young Children standards for high-quality early education, which include fostering self-concept and autonomy, promoting physical and social integration, developing age-appropriate skills, and valuing community input and respect [12]. A deliberate focus is placed on engaging families in their children's learning process, enhancing child development, and extending the program's intended educational impacts.

4. Methods

Two cohorts of S2S preK teacher participants engaged in this convergent mixed methods research study [14] after they completed the program. Data from surveys (quantitative) and focus groups (qualitative) were used to answer the two research questions and were given equal priority (QUAN + QUAL).

4.1. Surveys

PreK teachers (N=62) working in Philadelphia and Los Angeles participated in a retrospective pre-post survey asking about their use of classroom instructional practices in science (15-items), nutrition (12-items), mathematics (14-items), and literacy (16-items) both before they began the program and after their completion. A retrospective pre-post survey is administered to participants after completion of a program and it asks survey takers to answer questions twice in one sitting; first from a pre-intervention perspective and second based on their post-intervention perspective [15]. Retrospective pre-post surveys have demonstrated their effectiveness for accurately capturing participant growth in non-cognitive domains [16]. Each survey used in this study is on a 4-point frequency scale (1=Rarely: 1-2 times a month or less; 2=Sometimes: 1-3 times a week; 3=Daily: 4-5 times a week; 4=High Frequency: More than once a day). All surveys have undergone a rigorous and iterative validation study [17] that used both qualitative and quantitative data sources to demonstrate high levels of content, response process, consequences of testing, and internal structure validity evidences aligning with the *Standards for Educational and Psychological Testing* [18]. PreK survey respondents were primarily female (98%) and those who responded to the racial and ethnic demographic question identified as African American or Black (47%) or Latina (31%). Their preK teaching experience ranged from 1 to 40 years. Their retrospective pre- and post- scores were averaged and compared within content areas using dependent samples t-tests to look for growth in instructional practices use.

4.2. Focus groups

To answer RQ 2, a purposeful sample across the two cohorts of preK teachers implementing S2S from Philadelphia (n=12) and Los Angeles (n=11) participated in a total of 15 focus groups. S2S staff working directly with the preK teachers on program implementation in classrooms assisted with

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recruitment. A focus group interview protocol with structured open-ended interview questions [19] was formulated to help better understand the impacts of S2S on teachers as they engaged with the programming. Group level analysis was conducted with focus group interview transcripts treated as the main unit of analysis [19]. Five researchers engaged in Cycle 1 coding by independently reading transcripts and assigning codes by passage, using *in vivo* coding when appropriate [20]. Research team members discussed initial codes, generated new codes, and refined *in vivo* codes that were similar in meaning. To further reduce the number of initial codes, the researchers engaged in pattern coding (Cycle 2) to group them into an overarching narrative around teachers' perspectives of S2S [20]. Four themes were identified (see Findings). All five researchers reviewed final theme descriptions to check that they represented focus group interview results and selected exemplar quotes.

5. Findings

Following a convergent mixed methods research approach, quantitative and qualitative findings are shared independently [14]. Integration of findings is shared through meta-inferences presented in the Discussion section.

5.1. RQ1: PreK teachers' classroom instructional practices growth (quantitative)

S2S preK teacher participants reported significantly more frequent use of classroom instructional best practices across all four content areas after participating in PD:

- Literacy – $t(59) = 5.04$, $p < 0.001$
- Mathematics – $t(56) = 6.63$, $p < 0.001$
- Science – $t(59) = 6.93$, $p < 0.001$; and
- Nutrition – $t(57) = 9.17$, $p < 0.001$.

All effect sizes were large ($\eta^2 = 0.301$ literacy, 0.440 mathematics, 0.449 science, 0.596 nutrition) with a range of 30.1% to 59.6% of the variance in classroom instructional practices growth reported due to S2S PD. Additionally, Figure 1 shows practical significance in growth across content areas. For literacy, science, and mathematics, preK teachers reportedly averaged using best practices "Sometimes" before S2S PD and increased to an average of "Daily" after. Although nutrition practices use reportedly grew the most, teachers continued to report using nutrition instructional practices the least at both pre- (low "Sometimes" average) and post-survey (high "Sometimes" average).

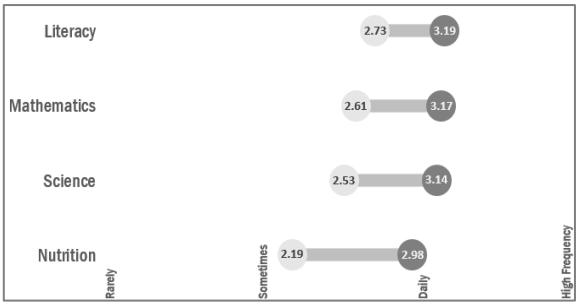

Figure 1. Practical Significance in PreK Teachers' Growth Across Content Areas

5.2. RQ2: Understanding the impact of S2S (qualitative)

Four themes emerged from focus group interviews among preK teachers' descriptions of the impact of S2S: 1) *Increased resources for teachers*; 2) *Greater exposure to hands-on learning experiences*; 3) *Modeled integration of content areas;* and 4) *Positive impact on teacher practices.* Theme descriptions and supporting preK teacher quotes are outlined in Table 1. The first two themes relate, in that by providing S2S participants with teaching and learning materials (Theme 1), participating teachers and their students had greater exposure to a variety of fruits and vegetables, gardening tools and seeds, and animals, thereby facilitating hands-on learning experiences (Theme 2). In turn, students were more willing to try new things (taste, touch, smell), asked more questions about what they were experiencing (observing, feeling, tasting), and had an increased interest in and excitement for learning.

The last two themes were also related, in that S2S program staff modeling best instructional practices in preK teachers' classrooms (Theme 3) impacted teachers' confidence and knowledge in the four main content areas (literacy, math, science, and nutrition) (Theme 4). PreK teachers across the focus groups described the importance of program instructors explicitly demonstrating "how" to integrate multiple content areas and actually use the provided resources in the classroom environment. By observing the S2S staff members participating in the lessons themselves, many of the focus group participants shared how the S2S program emphasized the importance of science and nutrition, allowed them to increase the time they spent teaching these subjects, and expanded the instructional strategies already in their toolbox. Additionally, some described an increase in their own science and nutrition content knowledge as a result of their participation (e.g., how to grow certain types of plants, strategies to engage families in STEM learning). Further, some focus group participants expressed a willingness to try out the integration strategies modeled by S2S instructors after seeing the positive effect on students' engagement and learning.

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Table 1. Four Themes and Supporting Exemplars of Impact of GHP

Theme	Definition	Exemplars
Increased resources for teachers. (100%, *n*=15)	Provided teaching and learning materials to under resourced classrooms.	• **Tools:** "It's just being able to have access to some of the tools that we are given compared to not having them at all. That helps out a lot." (LA, FG 4) • **Resources:** "I love the fact that you guys give us resources for us to grow the children's repertoire as far as knowledge…So we have these resources. (LA, FG 2)
Greater exposure to hands-on learning experiences. (100%, *n*=15)	Introduced to new, hands-on learning experiences that initiated students' trying new things, questioning and increased interest in learning.	• **Exposure:** [The students are] "not exposed to the fruits and vegetables that she's bringing…they're like 'What is that?' It helped to open up, I think, the mental capacity of the children, seeing things they may not see at home." (LA, FG 1) • **Try new things:** "They were exposed to like seeds and they engaged in it by really like trying it. They like majority of them….They ate it even like my one year old, he was eating and I just was like, 'Wow.'" (PHL, FG 3) • **Interest:** "The kids talk among each other and ask tons of questions pertaining to the worms. 'What do they eat? Why do this?'" (PHL, FG 1)
Modeled integration of content areas. (86.67%, *n*=13)	Explicitly demonstrated classroom how to integrate the teaching of math, literacy, science, and nutrition in the classroom with preK students.	• "Anything [the GHP instructor] does. It covers math, science, you know, literacy. Yeah, it covers all the areas. And kids…they're learning." (LA, FG 1) • "But you also come, and you teach us how to use those resources." (PHL, FG 2) • "I keep harping on the modeling piece of it. But for us...that was key. Once [the GHP instructor] came and showed us how to do that lesson, we were able to take it and extrapolate" (PHL, FG 5). • "[The GHP instructor] will bring like a bag of seeds, then it makes me wanna incorporate that into my lesson...We're gonna read a story. We're gonna count how many seeds we have, and it just keeps going from there...I believe that it has influenced our teaching" (LA, FG 6).
Positive impact on teacher practices. (100%, *n*=15)	Modeling of instructional practices in the classroom led to positive teacher learning and attitude outcomes.	• **Teaching confidence:** "So now we're much more confident in bringing in the worms and doing activities with the worms, bringing in different types of vegetables and fruits for the kids. We do taste tests." (PHL, FG 5) • **Re-seeing science:** "I think the program in itself honestly has really put a boost on [science] with the particular [GHP instructor] that comes to our school. She has done so many little activities and I was like, you know, I thought about that, and I didn't even think of it as science." (LA, FG 1) • **Teacher knowledge:** "…I can't grow things right. But [the GHP instructor] gave me some tips on how to help things grow. Maybe these particular seeds need to be shaded a little more…and when she came last week all the plants are growing… (PHL, FG 2) • **Instructional practices:** "Before [GHP], I think I followed the curriculum to the letter more. And now I'm thinking out of the box. I'm thinking of ways to extend the [lessons], of ways that the students can do things at home." (PHL, FG 4)

Note. LA = Los Angeles, PHL= Philadelphia, FG = focus group.

6. Discussion and meta-inferences

While S2S is in its early stages of programming, both quantitative and qualitative results suggest a strong and meaningful impact on preK teachers' use of best instructional practices across both Philadelphia and Los Angeles. Integrated findings from this study suggest two primary meta-inferences: 1) Positive impact across content areas and 2) Need for high-quality preK teacher STEM and nutrition PD.

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6.1. Positive impacts across content areas

Rooting S2S programming in inquiry-based STEM teaching and learning [11] focused on stimulating play and curiosity in early learners [12] using a strengths-based approach [13] appears to have had positive impacts on preK teachers' instructional practices across content areas (literacy, math, science, nutrition). This is evidenced by both statistical findings and teacher explanations. Quantitatively, statistically significant growth in use of instructional practices for all content areas were reported by preK teachers from pre-S2S to post-S2S, with the most growth seen in nutrition and science. Qualitative findings help to better understand these findings as nearly all focus group participants reported increases in confidence (87%) and knowledge (93%). Teachers explained that S2S coaches direct modeling of content integration in the classroom "was key" (PHL, FG 5) as it encouraged teachers to "incorporate [integrated instructional approaches] into [their] lesson[s]" (LA, FG6). Teachers further said this modeling led to their increased science and nutrition teaching confidence, thereby promoting greater levels of instruction in these content areas.

6.2. Need for high-quality preK teacher STEM and nutrition PD.

The focus of the S2S PD addressed a clear need highlighted in prior research on preK teacher education: providing support for teaching inquiry-based STEM and nutrition lessons, both during mealtime and in other contexts [9]. Collectively, quantitative and qualitative results from this study demonstrate it should still be a priority in early childhood educational settings.

Implementation of nutrition instructional strategies was by far the least frequent by preK teachers in comparison to the other content areas pre-S2S. While nutrition instructional practices saw the largest growth over time, they still lagged behind literacy, math, and science at post-S2S. Teachers noted a critical need for nutrition education resources and expressed how "access to some of the tools…given [through S2S] compared to not having them at all…helps out a lot" (LA, FG 4).

It is noted that, without the adequate nutrition educational resources preK teachers identified, such as fruits, vegetables, seeds, or worms that S2S provided, best nutrition education instructional practices simply cannot be achieved. But when sufficient resources and effective training are provided, this study demonstrated preK teachers and their students are eager to engage, explore, and extend their learning.

7. Conclusion

The S2S PD demonstrates the transformative potential of integrating nutrition, garden, and food-based education into early childhood settings, particularly in urban areas with high rates of food insecurity and underrepresentation of students pursuing STEM fields. Findings from this study underscore the S2S significant impact on preK teachers' use of best instructional practices across literacy, math, science, and nutrition. As discussed, quantitative data revealed large effect sizes for growth in these areas, with nutrition showing the most substantial improvement, though still lagging in frequency compared to other subjects. Importantly, findings also align with existing literature emphasizing the importance of inquiry-based STEM education in fostering academic readiness and long-term success [8, 10]. Data from focus group discussions highlighted the important role of resource availability and hands-on professional development in empowering teachers to deliver integrated, inquiry-based lessons that inspire curiosity and engagement among young learners.

While the early success of S2S highlights its potential, we must again note that it also points to the persistent need for robust resources and tailored support for nutrition education, as teachers consistently identified this area as requiring additional tools and guidance. Addressing these gaps is essential to fully leveraging the benefits of integrated STEM and nutrition education, particularly for communities facing health and educational challenges [7,9]. The inquiry-based framework of S2S provides a replicable model for advancing excellence in early childhood education [11, 13]. Future research should explore longitudinal outcomes of such programs, assessing their sustained impact on children's health, academic achievement, and family engagement. By continuing to prioritize high-quality PD and resource allocation, initiatives like S2S can contribute meaningfully to fostering healthier futures for all children.

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