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From Seeds to Harvest in Seven Weeks: Project-Based Learning with Latina Girls and Their Parents

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Abstract: This study examines the impact of a culturally responsive, garden-based STEM program designed for Latina girls (grades 5–6) and their parents. The "Our Plot of Sunshine" project integrates Family Project-Based Learning with garden education to create meaningful STEM engagement opportunities. Drawing on the science capital, science identity, and community cultural wealth frameworks, the program leverages families' cultural and linguistic resources while developing science knowledge and identity. Nineteen families from low socioeconomic schools participated in three pilot implementations across two Western U.S. cities. Using a mixed-methods approach with repeated measures over 19 weeks, the study tracked changes in participants' science identity, interest, and career aspirations. Results showed significant increases in science identity and career aspirations, with effects maintained at three-month follow-up. While interest/enjoyment showed positive trends, changes were not statistically significant. Parent ratings of program elements were consistently higher than daughter ratings, though both groups reported strong engagement. The successful integration of bilingual instruction emerged as a particularly valued program component. These findings suggest that family-centered, culturally responsive garden education can effectively support Latina girls' STEM identity development and future orientation, while highlighting the potential of leveraging family and cultural resources in STEM education.

Keywords: science education; project-based learning; STEM education; garden-based education; Latina girls; science identity

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1. Introduction

The persistent underrepresentation of women and Latiné communities in STEM fields represents a critical challenge in American education and workforce development. Despite making up a growing percentage of the U.S. population, Latina women remain significantly underrepresented across most STEM disciplines, from university enrollment to professional careers (Crisp & Nora, 2012; National Center for Science and Engineering Statistics, 2023; National Science Foundation, National Center for Science and Engineering Statistics, 2021). This disparity not only limits individual opportunities but also deprives the STEM workforce of diverse perspectives and talent essential for innovation and problem solving. To this point, Strategic Goal 1 in the National Science Foundation's (2022) strategic plan for 2022–2026 is to "Empower STEM talent to fully participate in science and engineering"

(p. 30) and includes objectives to increase the involvement of communities underrepresented in STEM and to "grow a more diverse STEM workforce to advance the progress of science and technology" (p. 32).

Multiple factors contribute to this underrepresentation of Latinas in STEM. In the K-12 educational system, there is limited access to science education (Blank, 2013) in general and, more specifically, science education through bilingual education (Suárez, 2020). As Latinas proceed from K-12 education into higher education, there is a significant lack of representation and role models within STEM careers, which can lead to a sense of isolation and lack of mentorship opportunities (Mendieta, 2023). Cultural stereotypes and biases can also play a significant role, as Latina women may face discrimination or have their abilities underestimated due to gender and ethnic stereotypes (Verdugo-Castro et al., 2021). Additionally, there might be a lack of resources and support systems, such as scholarships, networking opportunities, and institutional support, which are crucial for success in STEM fields (Bravo & Stephens, 2023).

Research indicates that early intervention is crucial, particularly during the middle school years when many students, especially girls and minoritized communities, begin to form lasting attitudes toward science and mathematics that influence their future academic and career choices (Archer et al., 2012). Despite increasing opportunities for engagement with STEM and recognition of the value of a diverse workforce, there remains persistent underrepresentation of minorities in STEM fields, leading to an "urgent need for concerted efforts to promote inclusivity" (Dormer, 2023, p. 1).

Traditional approaches to addressing these disparities have often focused solely on students, overlooking the crucial role that families, particularly parents, play in shaping educational outcomes. This oversight is especially significant in Latiné communities, where family involvement and cultural values are deeply intertwined with educational aspirations and achievement (Moll et al., 1992). Furthermore, many existing STEM programs fail to recognize and leverage the rich cultural capital, language, and knowledge that Latiné families bring to educational settings (Habig et al., 2021; Rincón & Rodriguez, 2021; Yosso, 2005). Rincón and Rodriguez (2021) highlight the role that engaging families in STEM learning has, and how leveraging cultural and linguistic resources enhances Latina students' science identities.

The Our Plot of Sunshine project addresses these challenges through an innovative approach that integrates project-based learning, garden-based learning, family engagement, and cultural responsiveness. By engaging fifth- and sixth-grade Latina girls alongside their parents in hands-on gardening activities, the program creates an environment where scientific learning becomes a family endeavor, building upon existing community strengths while developing new skills and understanding. This approach aligns with recent research highlighting the effectiveness of culturally responsive, family-centered interventions in promoting STEM engagement among underrepresented groups. This is an area of research that is underexplored with diverse and bilingual populations, as most studies have focused on predominantly White or higher-income participants (D. Williams, 2018).

2. Theoretical Framework

Our study integrates science capital, science identity, and Community Cultural Wealth (CCW) as complementary theoretical lenses for examining STEM engagement among Latina girls and their families.

2.1. Science Capital and Science Identity

Science capital encompasses an individual's accumulated science-related resources, including knowledge, experiences, attitudes, and social connections (Archer et al., 2014). Rather than viewing scientific literacy in isolation, this framework recognizes how science engagement is embedded within broader social and cultural contexts. It includes not only scientific knowledge, but also science-related social networks, everyday engagement with science, and an understanding of science's value (Archer et al., 2012).

Science identity refers to how individuals see themselves, and believe others see them, as someone who engages with and belongs in science (Carlone & Johnson, 2007). It develops through both personal experiences with science and social interactions that validate one's role as a science learner or practitioner (Kim et al., 2018). According to Gee (2000), science identity emerges from the recognition of oneself and by others as a "certain kind of person" in science-related contexts. This process of identity formation is especially important during early adolescence, as students start to explore their academic interests and consider potential career paths (Archer et al., 2010). Research suggests that developing a strong science identity is especially important for students from underrepresented groups, as it can help them persist in STEM fields despite potential challenges or stereotypes they may encounter (Hazari et al., 2013).

The relationship between science identity and science capital is bidirectional. Science identity emerges from self-categorization and identification with particular groups or roles (Stets & Burke, 2000). A strong science identity can drive the accumulation of science capital through increased participation in scientific activities and pursuit of science-related opportunities (Vincent-Ruz & Schunn, 2018). Similarly, access to science capital—through resources, experiences, and supportive networks—can nurture the development of science identity.

Research shows that science capital is not fixed but flexible, with the potential to grow through intentional interventions, particularly during pre- and early adolescence (DeWitt & Archer, 2015). This highlights the significant role of targeted educational experiences and family involvement in enhancing science capital (Archer et al., 2015).

2.2. Community Cultural Wealth

Yosso's (2005) Community Cultural Wealth (CCW) framework identifies six distinct forms of capital that communities of color possess and utilize. Aspirational capital represents the ability to maintain hopes and dreams for the future, even in the face of obstacles. Linguistic capital encompasses the intellectual and social skills attained through communication experiences in more than one language. Familial capital comprises the cultural knowledge cultivated among family that carries a sense of community history, memory, and cultural intuition. Social capital consists of networks of people and community resources. Navigational capital includes the skills of maneuvering through social institutions. Finally, resistance capital represents the knowledge and skills fostered through oppositional behavior that challenges inequality. Together, these intersecting forms of capital contribute to identity formation, shaping how individuals understand themselves and their roles within their communities and broader society. More recently, Yosso and Burciaga (2016) have expanded the CCW framework, calling on us to reclaim our histories and to be intentional about recovering community cultural wealth. Habig et al. (2021) drew from Yosso's CCW theory and discuss the need to disrupt deficit narratives in informal science education by applying CCW theory to youth learning and engagement. In recent years, an increasing number of studies have used CCW as a framework. Denton et al. (2020) conducted a systematic literature review of 33 studies using CCW in science, technology, engineering, and mathematics education. They found that most of the studies focused on higher education and used qualitative research methods and provided valuable insight into how asset-based frameworks are being interpreted in the field.

2.3. Integration of Frameworks and Application to Latina Families in STEM

The integration of science capital, science identity, and CCW provides a comprehensive lens for understanding and supporting Latina girls and their families in STEM education. This three-part framework recognizes that Latina families bring valuable resources to STEM learning environments, while acknowledging how identity formation and capital accumulation mutually reinforce each other (Yap et al., 2024). The intersection of these frameworks reveals multiple pathways through which families can support their daughters' STEM engagement.

When families' aspirational capital aligns with science capital and identity formation, their hopes for their daughters' futures intersect with STEM opportunities, helping girls envision themselves as future scientists and engineers. Linguistic capital serves as an asset in scientific discourse and identity development, particularly when bilingual students can engage with scientific concepts in multiple languages, potentially developing unique perspectives that strengthen their identification with science. Research by Civil (2016) demonstrated that leveraging bilingual students' language skills in mathematics instruction improved their problem-solving abilities and confidence. Through familial capital, science learning is supported by intergenerational knowledge transfer and provides role models that contribute to science identity formation, particularly in areas such as gardening, cooking, and sustainability. Through qualitative research in Mexican–American communities in Arizona, Moll et al. (1992) introduced the concept of "funds of knowledge," emphasizing that students' household knowledge can be a valuable resource in education.

The findings from Galindo et al. (2018) reinforce the importance of culturally responsive educational interventions that build upon existing family strengths. Fernández et al. (2023) discuss how that familial capital is re-created in higher education settings in ways that support Latino/a students pursuing STEM majors. Linguistic capital is further developed when STEM programs are provided in Spanish. Leman et al. (2023) studied the impact on kindergarten through fifth-grade students, their parents, and mentors when participating in a STEM outreach program that centered the use of Spanish. Social capital plays a crucial role by expanding science learning opportunities through community connections and shared resources, while also providing access to STEM mentors and role models who can reinforce positive science identities (Morales-Chicas et al., 2022; Saw, 2020).

Navigational capital enables families to support their daughters in accessing STEM education resources and opportunities, while also helping them persist in developing their science identities within potentially challenging institutional contexts (Bueno, 2024). A study by Chemers et al. (2011) and another by Morales-Chicas et al. (2022) highlighted that mentorship positively impacts the persistence of minority students in STEM fields. Through resistance capital, girls and their families are empowered to persist in STEM despite systemic barriers, contributing to the development of resilient science identities that can withstand and challenge stereotypes and obstacles (Yosso, 2000). Jimenez (2024) refers to this resistance capital as a cultural asset that supports Latina leadership.

This integrated theoretical framework guides our approach to family engagement in STEM education in several ways:

1. We recognize and build upon existing family strengths and knowledge while acknowledging how these assets contribute to both capital accumulation and identity formation.

2. We celebrate diverse forms of expertise and ways of knowing, understanding that science identity can develop through multiple cultural pathways.
3. We create opportunities for families to leverage their various forms of capital in support of their daughters' STEM engagement while nurturing positive science identities.
4. We foster environments where science capital, science identity, and community cultural wealth can grow simultaneously, recognizing their interconnected nature.
5. We acknowledge the dynamic interplay between identity development and capital accumulation, understanding that strengthening one often reinforces the other.

This integrated approach recognizes that successful STEM engagement for Latina girls involves not only building knowledge and resources (science capital) and leveraging community strengths (CCW), but also developing robust science identities that allow them to see themselves as legitimate participants in STEM fields. The majority of previous work on shaping science identity and career aspirations has focused on high school and college students. The present study expands on the literature by examining these topics at a younger developmental period, specifically elementary and middle school. The middle school period may be especially impactful because it is when children begin exploring their own interests and selecting some of their own coursework and extracurricular activities. This may shape their science identity and aspiration for future science careers. Furthermore, Denton et al. (2020), in their systematic literature review of research in STEM which used the CCW framework, found few studies that used quantitative methods, with most using qualitative methods and others using mixed-methods approaches. This present study used a robust quantitative approach, addressing a current gap in the research.

3. Literature Review

3.1. Project-Based Learning in STEM Education

Project-based learning (PBL) is a student-centered pedagogical approach where learners actively engage with real-world, authentic problems and meaningful projects over an extended period (Bell, 2010; Hmelo-Silver, 2004; Larmer & Mergendoller, 2015). Essential elements of effective PBL include a challenging problem or question, sustained inquiry, authenticity, student voice and choice, reflection, and a culminating celebration (Blumenfeld et al., 1991; Krajcik & Shin, 2014; Thomas, 2000). This approach transforms learning by making the project the primary driver of learning rather than using projects simply to demonstrate previously learned content (Ertmer & Newby, 1993).

Within STEM education, PBL shows particular promise when it creates opportunities for students to develop deep conceptual understanding through hands-on experiences while engaging in authentic practices of the discipline (Freeman et al., 2014; Beier et al., 2019). According to Krajcik and Blumenfeld (2006), PBL is characterized by student engagement in real-world investigations where they pursue solutions to nontrivial problems by asking and refining questions, debating ideas, making predictions, designing plans and/or experiments, collecting and analyzing data, drawing conclusions, and communicating their findings. Research indicates that compared to traditional instruction, PBL can enhance student achievement, motivation, critical thinking, collaboration skills, and ability to apply knowledge in new situations (Johnson & Johnson, 2018).

The effectiveness of PBL in STEM education has been well documented for traditionally underrepresented students. A comprehensive review by Thomas (2000) found that PBL can lead to increased student engagement, improved content understanding, and enhanced critical thinking skills when implemented with appropriate scaffolding and support. Capraro et al. (2016) demonstrated in their study of a diverse urban district that sustained STEM PBL implementation led to significant improvements in student achievement, with particularly positive impacts for historically underserved students. Their research suggests that PBL can be especially effective when it connects to students' lived experiences and community contexts.

3.2. Garden-Based Learning

Garden-based learning (GBL) represents a powerful approach for engaging students and families in authentic STEM experiences. GBL extends beyond teaching about food sources, integrating lessons across multiple disciplines including environmental studies, mathematics, science, and language arts (Klemmer et al., 2005). This educational approach leverages gardening activities to enhance student learning across multiple domains, transforming outdoor spaces into dynamic classrooms where students interact directly with nature (Desmond et al., 2004).

Research demonstrates both direct and indirect positive outcomes from GBL (D. R. Williams & Dixon, 2013). School-based gardening activities provide students with opportunities for inquiry-based learning grounded in real-world experiences (Papadopoulou et al., 2020; Corson, 2003), while fostering deeper understanding of academic concepts and promoting personal growth. Studies have documented numerous benefits including improvements in physical, mental, and socio-emotional health among participants (Blair, 2009; Mastropieri & Scruggs, 2018).

Academic benefits of GBL are particularly noteworthy. Graham and Zidenberg-Cherr (2005) identified multiple content areas that showed improvement through garden-based curriculum integration, with nutritional health, environmental studies, and STEM concepts showing most growth. Klemmer et al. (2005) found that school gardens provided valuable opportunities to practice language arts, mathematics, and science in authentic contexts that engage students in multiple ways of learning.

Beyond academic achievement, GBL shows significant impact on student engagement and social development. Skelly and Bradley (2007) demonstrated positive social and behavioral outcomes, with teachers observing improvements in student motivation, enthusiasm, and sense of community. Riggs and Lee (2022) also found that experienced teachers who use GBL reported more engaged students in science and having higher science self-perceptions than no-GBL students. Students reported an increased sense of responsibility and more positive environmental attitudes after participating in garden programs (Conte, 2022). In a YMCA summer camp experience for fourth to six grade children, Heim et al. (2009) found that 95.6% of the children enjoyed learning in the garden setting, with high percentages reporting enthusiasm for growing and preparing their own food (97.8% and 93.4%, respectively).

Multiple qualitative studies have documented increased student enthusiasm for learning through GBL. Elementary and middle-grade students showed particular excitement about hands-on garden exploration (Faddegon, 2005), and studies reported improved interpersonal relations among participants (Dirks & Orvis, 2005; Murphy & Schweers, 2003). This enhanced sociability through gardening activities provides additional motivation for learning while building community connections.

While evidence suggests benefits of GBL, our understanding is limited as most studies have been carried out with predominantly White participants (Lohr et al., 2022). While the number of gardens in US schools rose from 2006 to 2014, unfortunately, gardens are significantly less common in schools with higher percentages of students eligible for free and reduced lunches (a measure of SES) (L. Turner et al., 2016). Greater opportunities for and more research on GBL with diverse children could have promising results. For example, in an analysis of their data for gardening projects at 22 schools, Lohr et al. (2022) concluded the following:

> Regardless of past school garden exposure, however, fifth-grade students, females, and those who identify as Latino/a (Hispanic) reported that school garden programming improves their learning. Latino/a (Hispanic) students who participate in school garden programming also indicated feeling a greater sense of connection to their teachers and peers at school.

3.3. Cultural Relevance in STEM Education

Cultural relevance in STEM education extends beyond mere inclusion of diverse examples to encompass a deeper understanding and validation of students' cultural identities, experiences, and ways of knowing. Ladson-Billings (1995) established three critical components of culturally relevant pedagogy: academic success, cultural competence, and critical consciousness. For Latina students, culturally relevant STEM education acknowledges and builds upon their cultural and linguistic resources while challenging inequitable educational practices.

Research has demonstrated several key outcomes of culturally relevant approaches in STEM education. Studies have shown increased student engagement and participation, with Tan and Calabrese Barton (2009) documenting how culturally responsive approaches transformed science learning participation among minority students. Academic achievement gains have been documented by Lee and Buxton (2013), particularly among English language learners in science classrooms. Their research demonstrated that culturally relevant pedagogical approaches, when combined with appropriate linguistic support, led to improved science and literacy achievement.

The integration of cultural relevance in STEM education requires thoughtful consideration of curriculum design, instructional strategies, and assessment practices. Effective culturally relevant STEM education acknowledges the fundamental role of students' cultural backgrounds while maintaining high academic expectations and developing critical perspectives about the scientific enterprise.

4. Program Description

The "Our Plot of Sunshine" program we created fostered an integrated learning community through garden-based activities that engage Latina girls and their parents in collaborative STEM experiences at local schools. The core structure features Family Project-Based Learning (FPBL) sessions, where parent–daughter dyads (one parent with one daughter) spend 90 min engaged in hands-on science activities. This was followed by 30 min Conversation Groups for parents and daughters in separate rooms. Each group was facilitated by a member of the research team. This approach leverages both science capital (Archer et al., 2012) and community cultural wealth (Yosso, 2005) through targeted discussions and activities.

The overall challenge in the FBPL was to produce a small garden where seeds are sown in order to harvest food for a culminating celebration in seven-weeks. This challenge involved choices of seeds (from plants such as bok choy, radish, arugula, and lettuce), specific plans for where the seeds would be planted, caring for and measuring the growing plants, and the harvest. In addition, there were experiences to deepen understanding about soils and structures and functions of plants. For example, parents and daughters were given small plants and magnifying glasses to examine plant roots, and through discussion, surface area was introduced. Then, on a thin plastic cutting board, families were challenged to use Play-Doh to create a root system that had the most surface area. While "doing" is important for the development of science capital, thinking, talking, and developing concepts are equally important. The project-based learning framework in design and implementation stressed (a) discussion before action and then (b) exploration before explanation. After challenges were presented, materials were withheld until families had sufficient time to discuss the challenge and how to meet it. Instructions were given in both English and Spanish and families could converse in a language of their choice. This opportunity to use language is critical for both linguistic and concept development. After the explorations—the first-hand experiences, which created shared understandings—the activity was discussed, and in this explanation phase, concepts and terminology were introduced. Parents and daughters both engaged equally in the activities; it was not a situation where daughters did the activity and parents watched. The curriculum was designed by the research team and included culturally responsive topics and pedagogies. For example, the choice of seeds to plant expanded as families shared information about plants that had cultural significance.

Informed by the CCW framework, Conversation Groups provide dedicated spaces for exploring cultural connections to science, discussing bilingual advantages in STEM careers, and building science identity. Parent groups focus particularly on developing strategies to support their daughters' STEM interests and aspirations, while student groups explore science careers and concepts through culturally relevant contexts. These conversations were always grounded in at least one specific area of CCW, for example, focusing on aspirational or navigational wealth and both the parents and the girls became familiar with the language of CCW.

4.1. Family Project-Based Learning

The theoretical foundation of the program integrates multiple frameworks, building from PBL approaches (Bell, 2010; Blumenfeld et al., 1991) to incorporate both language learning theory and cultural wealth perspectives. This integration reflects a deliberate evolution from traditional PBL to address the specific needs and strengths of bilingual learners (Lucas & Grinberg, 2008) and their families through the development of Family Project-Based Learning (FPBL).

A critical theoretical intersection occurs between Halliday's (1993) Language-Based Theory of Learning and Yosso's (2005) Community Cultural Wealth framework. This synthesis recognizes language as both a cognitive tool and a cultural asset, acknowledging how linguistic practices serve dual roles in learning and identity development. Within this integrated framework, bilingualism and cultural linguistic practices are viewed as valuable resources that enhance both scientific understanding and community connections (Schleppegrell, 2004).

The FPBL approach (Figure 1), derived from our previous work with Problem-Based Enhanced Language Learning (PBELL) (Rillero et al., 2018), leverages these theoretical foundations to create learning experiences that validate and build upon families' linguistic capital while supporting science learning (Maxwell-Jolly & Gandara, 2006). This perspective recognizes that language acquisition and use occur within specific sociocultural contexts, where heritage languages and cultural communication patterns contribute significantly to learning and identity formation (Wellington & Osborne, 2001).

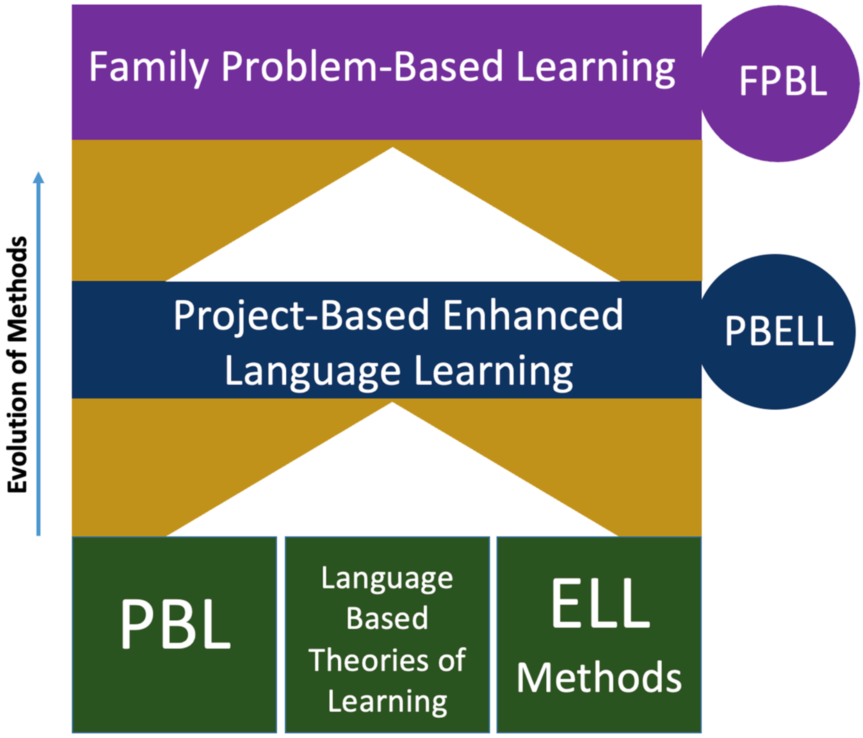

Figure 1. The evolution of the FPBL.

4.2. Learning Sequence for FPBL

The "Our Plot of Sunshine" project centers on a driving challenge that engages Latina girls and their parents: planning, growing, and harvesting food from seeds within a seven-week timeframe for a culminating tostada party. Each parent–daughter dyad is assigned one square foot of growing space, creating an authentic context for applying scientific practices while working toward a meaningful goal. This project structure aligns with key elements of effective Project-Based Learning (PBL), including a challenging problem, sustained inquiry, authenticity, and a culminating celebration (Bell, 2010; Blumenfeld et al., 1991).

The learning sequence integrates scientific tools and practices through a carefully structured progression. Beginning with science notebooks/garden journals (Gilbert & Kotelman, 2005; Klentschy, 2005), each dyad documents their journey from seed selection and garden planning through harvest. This documentation process supports both scientific thinking and family collaboration as participants explore fundamental questions: What can we grow from seeds in seven weeks? How do we maximize our small space? What foods would be best for our tostada party? The sequence moves through observation and measurement of plant growth, investigation of plant structures and functions, and analysis of environmental factors, all within the authentic context of growing food for a shared celebration.

The project culminates in the harvest and tostada party celebration, with families sharing their growing journey through graphs and stories. This structure exemplifies key PBL principles while leveraging the unique potential of garden-based learning. As documented by Heim et al. (2009), such garden programs can achieve high levels of engagement, with over 95% of students reporting enjoyment in learning and working in the garden. The combination of a clear challenge, family collaboration, hands-on investigation, and a meaningful culminating event creates a powerful context for both scientific learning and cultural connection.

5. Research Methods

5.1. Study Context and Participants

This study reports on the pilot implementations of three gardening programs examined across two Western U.S. cities. Nineteen families completed one of the three pilot programs, with participants recruited from eight Title 1 schools. Parents completed the demographic survey, with the following results. All parents considered their daughters as Latina and themselves as Latiné/o/a. Of the girls, 61.1% had Spanish and 38.9% had English as a first language. About 33.3% of participants reported speaking Spanish at home, 38.9% English, with the remainder (27.8%) speaking both English and Spanish at home. The average age of the participating parent was 39.8 years old, and 83.3% were female. For parents' first language, 76.5% indicated it was Spanish and 23.5% English. About 22.2% of the parents had not finished high school and 33.3% reported high school as their highest degree. About 92.8% said their daughter was receiving free or reduced lunches. About 27.7% reported a family income of less than $15,000, 5.5% up to $29,999, 38.9% up to $44,999, 11.1% up to $59,999, 0% up to $74,999, 0% up to $89,999, 5.6% up to 104,999, and 11.1% above $105,000, reflecting a range of socioeconomic circumstances.

5.2. Data Collection Procedures

We incorporated diverse assessment methods to comprehensively measure program impact. Participants began by providing demographic information, followed by a series of assessments using 5-point Likert-scale surveys (ranging from 1 = strongly disagree to 5 = strongly agree). Our survey measures were extrapolated and adjusted from previous researchers, such as the Child and Adolescent Social Support Scale (CASS) (Malecki et al., 2000; S. L. Turner et al., 2004), as well as measures used by Martin and Mullis (2012) and Silander et al. (2018). They were then piloted (in English and Spanish) and revised prior to use in our study. We conducted measurements at four key points: program initiation, mid-program (week 4), program completion (week 7), and a delayed posttest three months after program completion. This extended longitudinal approach enabled us to track both immediate program effects and the sustainability of changes over time. Questions about the program were included in the mid- and post-surveys. These items were designed to evaluate the sustainability of participant engagement, enabling us to determine whether initial enthusiasm was maintained or diminished during the program's latter half.

To maintain data integrity, participants completed their assessments independently, a practice that research has shown enhances the reliability of program evaluations involving multiple stakeholders (Holtrop et al., 2008). The inclusion of a three-month follow-up assessment provided valuable insights into the durability of program effects beyond immediate completion. This comprehensive assessment approach provided detailed insights into both immediate program impacts and longer-term effectiveness.

6. Results

This section presents findings from our quantitative analysis of program impact, examining changes in participants' science-related attitudes over time and perspectives from both daughters and parents about program elements. We first present results from three key measures—science identity, interest/enjoyment, and career aspirations—tracked across four time points. We then examine participant feedback about specific program components, comparing daughter and parent perspectives at mid-program and post-program points.

Three scales were constructed to measure girl participants' science identity, interest/enjoyment, and career aspirations. All scales showed good internal consistency (α = 0.82–0.89). A series of repeated-measure ANOVAs were conducted to examine changes over time. Repeated-measure analysis helped address the limitations of the small sample size by allowing each participant to serve as their own control, reducing variability and increasing statistical power. This approach enhances the ability to detect meaningful changes over time by accounting for within-subject differences rather than relying solely on between-group comparisons. Additionally, repeated measures maximize the use of available data, improving the validity and reliability of the findings despite the limited number of participants.

The Science Identity scale showed significant increases over the study period: $F(3,54) = 4.82$, $p = 0.004$, $\eta^2 = 0.21$. Post hoc comparisons revealed significant increases from baseline to week 7 ($p = 0.008$) and to the three-month follow-up ($p = 0.002$), as well as from week 4 to the follow-up ($p = 0.015$).

The Career/Future scale also showed significant improvement over time: $F(3,54) = 2.76$, $p = 0.046$, $\eta^2 = 0.13$, with significant increases observed between baseline and the three-month follow-up ($p = 0.032$) and between week 4 and follow-up ($p = 0.028$). While the Interest/Enjoyment scale showed slight increases through week 7, the overall changes were not statistically significant: $F(3,54) = 1.94$, $p = 0.128$, $\eta^2 = 0.09$. Figure 2 displays the trajectories of these three measures over the 19-week study period.

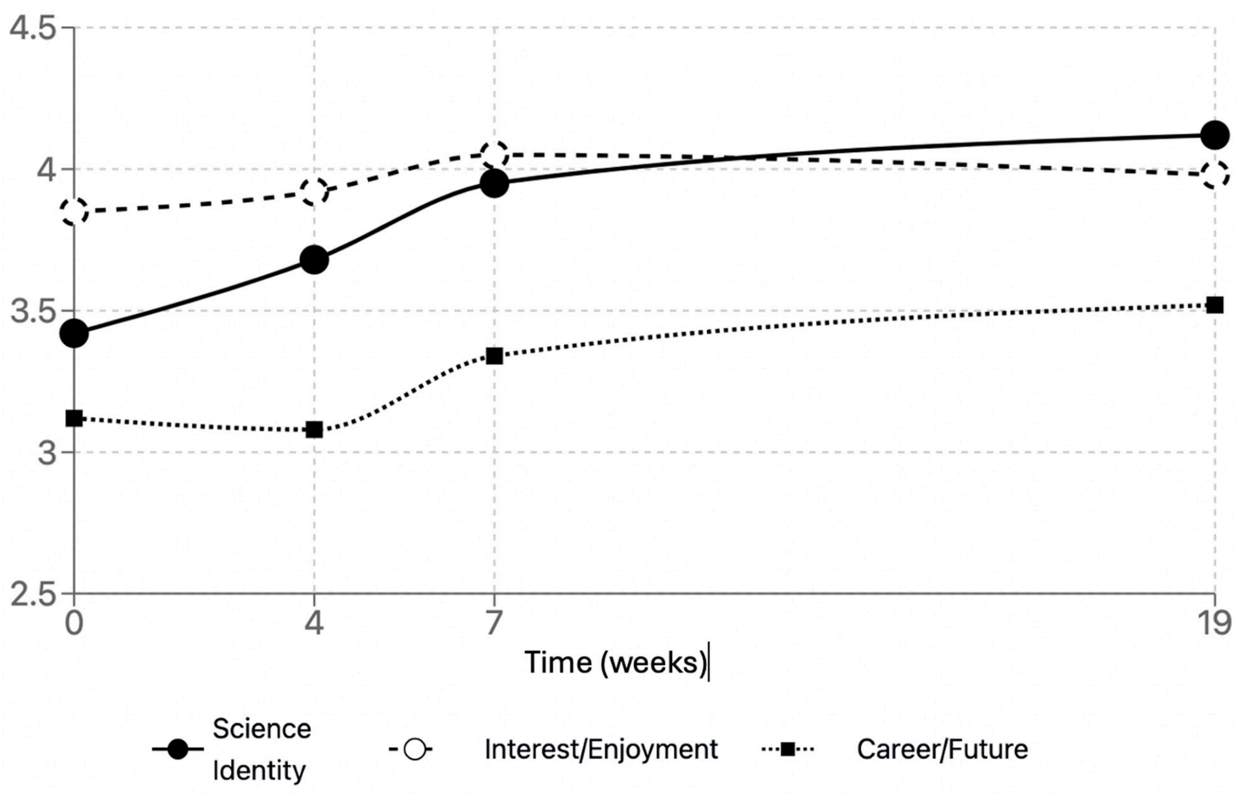

Figure 2. Changes in science identity, interest, and career aspirations over time.

Parent and daughter perspectives on the program were captured through mid-program and post-program surveys (Tables 1 and 2). Results indicate consistently positive views, with daughter means ranging from 3.65 to 4.44 and parent means ranging from 4.38 to 4.94. For daughters, the highest-rated aspect was the program's use of both Spanish and English ($M = 4.44$), while parents most strongly endorsed recommending the program to a friend ($M = 4.94$). Comparing daughters' mid-survey to post-survey responses, two items showed modest increases and one remained constant, with the remaining items showing slight decreases, though none of these changes reached statistical significance.

Table 1. Daughter means and standard deviations for mid- and post-survey perspectives.

Item	Daughter Mid-Mean	*SD*	Daughter Post-Mean	*SD*
1. I benefited from participating in this program.	4.06	1.30	3.76	1.31
2. Participating with my parent/s in this program strengthened our family.	4.13	0.99	4.06	1.06
3. It was a good experience to be able to observe other families doing the same science activities as us.	4.25	0.75	4.06	0.80
4. I would recommend this program to a friend.	4.19	1.07	4.12	0.96
5. The use of both Spanish and English in the program was a good thing.	4.44	0.93	4.44	0.77
6. The program created a supportive environment where I felt comfortable participating.	4.06	0.90	4.00	1.03
7. I enjoyed the program's science activities.	4.38	0.99	4.18	1.00
8. I learned a lot from the program's science activities.	4.38	0.74	4.12	0.83
9. I like the topic for our 7-week program.	4.31	0.92	4.16	1.00
10. The science activities promoted interaction between me and my parent.	4.25	1.03	3.94	0.83
11. I learned a lot during the Girl Conversation Groups.	3.94	1.09	4.19	0.88
Because of the program, I feel greater support from my parents for my science learning.	3.88	0.93	3.65	0.97
The program helped me develop a greater interest in science.	3.88	0.78	4.18	0.94

Table 2. Parent means and standard deviations for mid- and post-survey perspectives.

Item	Parent Mid Mean	*SD*	Parent Post Mean	*SD*
1. I benefited from participating in this program.	4.69	0.58	4.63	0.79
2. Participating with my daughter in this program strengthened our family.	4.44	1.00	4.50	0.71
3. It was a good experience to be able to observe other families doing the same science activities as us.	4.38	1.05	4.69	0.68
4. I would recommend this program to a friend.	4.88	0.33	4.94	0.24
5. The use of both Spanish and English in the program was a good thing.	4.75	0.66	4.63	0.79
6. The program created a supportive environment where I felt comfortable participating.	4.63	0.78	4.63	0.79
7. I enjoyed the project's science activities with my daughter.	4.63	0.60	4.81	0.53
8. I learned a lot from the project's science activities.	4.63	0.60	4.69	0.58
9. I like the topic for our 7-week project	4.75	0.43	4.88	0.33
10. The science activities promoted interaction between me and my/daughter.	4.63	0.70	4.69	0.58
11. I learned a lot during the Parent Conversation Groups.	4.31	0.98	4.50	0.71
I enjoyed the discussion with other parents.	4.25	1.03	4.38	0.93
I think my daughter benefited from participating in this program.	4.69	0.58	4.69	0.68
My participation in the program gives me ideas about how to work on science with my daughter.	4.63	0.78	4.56	0.86
The program helps me develop knowledge of resources that support my daughter's interest in science.	4.56	0.70	4.50	0.87

Table 2. *Cont.*

Item	Parent Mid Mean	*SD*	Parent Post Mean	*SD*
The program helps me learn about my daughter's abilities in science.	4.50	0.71	4.56	0.79
The program helps me learn about my daughter's interests in science.	4.44	0.70	4.63	0.79
The program increases my ability to support my daughter's interest in science.	4.44	0.86	4.38	0.99

Analysis of parallel items between parent and daughter post-surveys revealed consistently higher parent ratings, with statistically significant differences on most items. Only three items showed no significant parent–daughter differences: program strengthening family bonds, bilingual program delivery, and learning from Conversation Groups. These patterns suggest strong overall program engagement while highlighting some differences in how parents and daughters experienced program elements.

Parent and Daughter Views

Table 1 displays the daughter mid-survey and post-survey items and Table 2 displays parent mid-survey and post-survey items. The results suggest overall positive perspectives, with the lowest mean for girls at 3.65 and the lowest parent mean at 4.41. For parents, the item with the highest mean (4.94) was about recommending the program to a friend, while for daughters it was the use of both Spanish and English in the program (4.44). While comparing daughters' mid-survey to post-survey responses, two items showed modest increases and one remained constant, with the remaining items showing slight decreases; however, none of these changes were statistically significant. Parallel items between the parent and daughter post-survey are numbered from one to eleven in the table. On the post-survey, parent means were always higher, and these were statistically significant for all items except for 2, 5, and 11.

Parent responses (Table 2) were notably more positive overall, with means consistently above 4.25 and many exceeding 4.50. Parallel items between the parent and daughter post-survey are numbered from one to eleven in the table. On the post-survey, parent means were always higher, and these were statistically significant for all items except for 2, 5, and 11. The highest-rated item was recommending the program to a friend, which scored 4.88 at mid-program and 4.94 at post-program. Parents particularly valued the program's bilingual nature (4.75 mid, 4.63 post), their daughter's participation benefits (4.69 both mid and post), and the program topic (4.75 mid, 4.88 post). Similar to the daughter results, parent ratings showed slight decreases from mid- to post-survey for most items, though they maintained strongly positive responses throughout. Parents' lowest-rated item was still notably high at 4.38 (enjoying discussions with other parents).

7. Discussion

The results of this study demonstrate the potential of family-centered, culturally responsive garden-based learning to support Latina girls' STEM engagement and identity development. The significant increase in science identity over time, maintained through the three-month follow-up, suggests the program's effectiveness in helping participants see themselves as capable science learners. This finding aligns with previous research on the importance of early identity development in STEM (Vincent-Ruz & Schunn, 2018) and demonstrates how garden-based learning can provide an accessible entry point for developing a scientific concept of self (Lohr et al., 2022).

The growth in career/future orientation scores is particularly noteworthy, as it indicates the program's potential to influence longer-term STEM engagement. This increase, significant at the three-month follow-up, suggests that participants began to see STEM careers as viable options for their futures. The garden context may have helped make abstract STEM concepts more concrete and relatable, allowing participants to envision themselves in STEM roles. Research further supports the role of school garden programs in fostering connections to STEM learning, particularly for Latina students, who reported greater connections to teachers and peers through gardening activities (Lohr et al., 2022). This aligns with research demonstrating that family engagement can positively influence students' STEM career trajectories (Bueno, 2024; Fernández et al., 2023).

While interest/enjoyment showed positive trends without reaching statistical significance, the consistently high ratings across time periods suggest sustained engagement throughout the program. This maintained interest aligns with previous research showing high engagement levels in garden-based learning (Heim et al., 2009; Papadopoulou et al., 2020). Further, integrating culturally responsive approaches within garden-based STEM programs has been shown to increase student engagement and identity formation in science (Riggs & Lee, 2022; Gülhan, 2023). These findings highlight the garden as a setting that supports active, hands-on learning, which is often more engaging than traditional classroom approaches (Graham & Zidenberg-Cherr, 2005).

The role of gender and ethnicity combined warrants attention, as the participants in this study—Latina girls—consistently showed strong engagement and positive perceptions of the program. This is particularly encouraging given the well-documented disparities in STEM participation and interest among Latina students (Bravo & Stephens, 2023). By providing culturally responsive, family-centered experiences, the program appears to have created an inclusive and supportive environment that empowered participants to see themselves as capable STEM learners. This aligns with broader efforts to address equity in STEM education by fostering early confidence and interest among underrepresented groups (Jimenez, 2024).

The disparity between daughter and parent ratings, with parents consistently rating program elements higher, merits consideration. This pattern might reflect different expectations and experiences between generations, or perhaps indicates areas where the program could better bridge intergenerational perspectives. However, the high ratings from both groups suggest strong overall program engagement. Similar trends have been observed in family-centered STEM programs, where parental support plays a crucial role in reinforcing science identity and aspirations (Morales-Chicas et al., 2022; Saw, 2020).

The successful integration of bilingual instruction and cultural relevance appears to have resonated strongly with participants, as evidenced by the highest daughter ratings for the program's use of both Spanish and English. This finding supports the value of leveraging linguistic capital, as described in the community cultural wealth framework (Yosso, 2005). Recent studies highlight the importance of bilingual education in STEM settings, emphasizing that linguistic capital can enhance comprehension, engagement, and identity development (Leman et al., 2023; Suárez, 2020). These results highlight several implications for practice. The study demonstrates the importance of sustained family engagement in STEM learning and underscores the value of culturally and linguistically responsive approaches. The findings reveal the potential of garden-based contexts for developing science identity and illustrate the effectiveness of combining hands-on activities with cultural connection. Research indicates that culturally relevant pedagogy, when integrated with science learning, improves both academic performance and long-term interest in STEM (Rincón & Rodriguez, 2021; Yap et al., 2024).

Future research would benefit from examination of the long-term impact of such programs on academic and career trajectories and how specific program elements contribute to observed outcomes. Additionally, exploring how this model might be adapted for other cultural contexts and age groups could expand its potential impact. Finally, research is needed to better understand the mechanisms through which garden-based learning supports science identity development and how these can be optimized for diverse learners.

8. Conclusions

This study demonstrates the effectiveness of integrating family engagement, cultural responsiveness, and garden-based learning to support Latina girls' STEM development. Through the "Our Plot of Sunshine" project, we found that a carefully structured program incorporating these elements could significantly enhance participants' science identity and future career aspirations, with effects persisting three months after program completion.

The program's success in engaging both daughters and parents highlights the value of leveraging family and community resources in STEM education. The consistently high ratings of the program's bilingual approach underscore the importance of incorporating linguistic capital as a resource rather than treating it as a barrier. The garden-based context proved effective in making STEM concepts accessible and meaningful within participants' cultural frameworks.

These findings have important implications for addressing the persistent underrepresentation of Latina women in STEM fields. By integrating project-based learning with cultural wealth perspectives, programs can create environments where diverse students not only learn science but come to see themselves as legitimate participants in scientific endeavors. This understanding points toward educational approaches that recognize and build upon the rich resources that students and families bring to STEM learning, potentially opening new pathways for broadening participation in STEM fields.

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