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Understanding Racially Minoritized Girls' Perceptions of Their STEM Identities, Abilities, and Sense of Belonging in a Summer Camp

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Abstract: Informal science education researchers have become increasingly interested in how out-of-school spaces that offer STEM (science, technology, engineering, and math) programs inform learners' STEM achievement, interests, and affective outcomes. Studies have found that these spaces can offer critical learning and developmental opportunities for underrepresented racially minoritized (URM) students (Black, Latinx, low socioeconomic status) in STEM subjects. Shifting away from the *leaky STEM pipeline* analogy, researchers have posited contemporary understandings to explain why the minoritization of URM girls persists. Informal learning environments such as STEM summer camps are being studied to assess how URM girls experience and interact with STEM in novel ways. These environments can inform the research field about how URM girls' perceptions of their STEM identities, abilities, efficacy, and belonging in STEM develop as they engage in those spaces. This mixed-method study used a multiple-case-study approach to examine how aspects of URM middle school girls' STEM identities positively changed after participating in a one-week, sleep-away, single-gender STEM summer camp held at a university in the Southwestern U.S. Drawing on intersectionality and STEM identity, we used ecological systems theory to design our research study, examining how URM middle school girls narrate their STEM identities in this informal learning environment. Using quantitative analyses and deductive coding methods, we explored how elements of girls' STEM identities were shaped during and after their participation in the STEM summer camp. Findings from our study highlight (1) quantitative changes in girl participants' STEM identities, sense of belonging in STEM, and perceived STEM ability belief, (2) qualitative results supporting our quantitative findings, and (3) how the intersectionality of participants' race and gender played a role in their STEM identities. This study points to the potential of STEM informal learning camps as a way of developing and fostering URM girls' STEM identities.

Keywords: girls in STEM; informal science learning; underrepresented girls; minoritized girls in STEM; STEM identity; STEM learning; middle school; belonging in STEM; efficacy in STEM; intersectionality

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1. Introduction

Gender equity in STEM (science, technology, engineering, and mathematics) education and the American workforce have been of long-standing concern, with a hyper-focus on the underrepresentation of Black and Hispanic girls and women in STEM fields. While women, people of color, and Hispanics have made notable strides in the past decade in both STEM workforce representation and higher education participation [1], significant equity disparities persist, spanning all stages of education and exacerbating the issue of underrepresentation over time [2]. Intersectionality, a concept defined by Cole [3] as illuminating the implications of multiple categories of group membership (as cited in Ireland et al. [4]), can offer a framework for comprehending the educational inequities experienced by Black and Hispanic students throughout their STEM trajectories. This understanding contributes to their underrepresentation in advanced STEM high school courses, STEM degrees, and, ultimately, STEM fields.

Delving into the challenges marking the educational journey for all Black and Hispanic students in the American public education system, it becomes evident that systemic issues contribute to their underrepresentation in STEM fields. Black and Hispanic K–12 students grapple with more significant challenges, such as limited access to teachers who rank highly on measures of teacher quality, such as experience or licensure examinations [5,6] At the high school level, specifically, Black and Hispanic students are significantly underrepresented in advanced math and science courses [7]. Additionally, those attending the poorest high schools have the least access to physics, computer science, statistics, and calculus, including Advanced Placement for all four subjects [7].

For Black and Hispanic girls, inequities such as limited access [8] in American public K–12 education are compounded by unique structural challenges [4,9] and stereotypes [10] encountered in school settings. It is not surprising that, as they grow into women, they attain a proportionally smaller share of STEM degrees compared to their White peers—a trend persisting through master's and doctoral levels [1,7]. We agree with most STEM educational equity scholars [11–15] that middle school emerges as a critical juncture in this trajectory, given the pivotal nature of middle school years in shaping STEM identities. Thus, our research study prioritizes this age group, specifically underrepresented racially minoritized (URM) girls.

1.1. Underrepresented Racially Minoritized (URM) Girls

For the remainder of this paper, we retire using terms like "underrepresented" and "minority" to use the contemporary phrase "Underrepresented Racially Minoritized (URM)" to underscore the marginalization of people of color in American systems [16]. Historically, institutional racism has shaped their presentation, definition, and STEM opportunities [16]. The term "minoritized" is employed by critical scholars to highlight persistent dynamics contributing to lower societal status [17]. URM girls in STEM face challenges in efficacy, identity, belonging, and overall self-efficacy [14,18]. Investing in positive STEM identities is crucial, but inherent flaws in the STEM education system disproportionately affect URM and female students, subjecting them to racism, sexism, and structural obstacles [19] influencing their STEM perceptions. While students in their primary years frequently display an enthusiasm for learning science [20], this interest often diminishes during the transition to high school [6]. The complexities of race, gender, and, at times, socioeconomic status intensify the challenges URM girls encounter, underscoring the importance of examining their STEM identity through an intersectional lens, especially during their middle school years outside of school settings. This sets the stage for our research purpose and questions.

1.2. Research Purpose and Questions

Given that URM girls frequently encounter racialized and gendered microaggressions in their school math and science classes, often feeling unwelcome [21–23], it raises the question of how their experiences in learning STEM subjects outside of school influence their STEM identity, especially at the middle school juncture. Therefore, this study explores the STEM identity development of underrepresented racially minoritized (URM) middle school girls within an informal STEM learning environment. Recognizing the necessity of understanding both formal and informal STEM experiences, we aim for more comprehensive perspectives of URM girls' STEM trajectories during these critical identity-forming years.

Our goal is to equip researchers and educators with insights capable of transforming teaching practices and learning environments to better support URM girls during their identity-formative middle school years. Moreover, we aim to investigate various affective factors, including belonging in STEM, efficacy in STEM, and STEM ability belief, to discern their influence on the development of STEM identity. Our particular emphasis was on exploring the intricate interplay of these factors with the racial and gender intersectionality of URM girls. Our research questions are as follows:

1. How does participation in a week-long informal STEM learning camp shape the development of underrepresented racially minoritized (URM) middle school girls' STEM identities?
2. How do URM girls narrate the interaction of their intersectional identities with their developing STEM identity?

We argue that the development of STEM identity among middle school URM girls is complex and multi-layered, inseparable from the intersectionality of their racial and gender identities.

This paper centers the experiences of underrepresented minoritized middle school girls within informal STEM learning settings, advocating for an extension of the literature to explore the inseparability of affective factors of STEM identity and intersectionality during URM girls' critical middle school identity-forming years. Guided by ecological systems theory [24,25] as a strategic methodological approach (see Research Context), we collected and analyzed interview and ethnographic data from a community-based nonprofit's established week-long, all-girls (grades 7–9) summer STEM camp at a prominent private university in the Southwestern U.S., post the COVID-19 pandemic, where Black and Hispanic (i.e., URM) girls constituted the racial and ethnic majority. Our research design and implementation aimed to provide participants with a safe space to be creative, inquisitive, and culturally authentic as they engaged in STEM activities.

In the following sections, we articulate the theoretical framework guiding our study and conduct a thorough review of the existing literature. Subsequently, we present both our quantitative and qualitative findings, culminating in a summarized discussion. We also address the study's limitations and offer specific recommendations for cultivating STEM identities among underrepresented racially minoritized (URM) middle school girls in informal settings, with the aspiration that our insights may be effectively applied in formal school settings.

2. Theoretical Framework

This study is grounded in STEM identity and intersectionality. According to Avraamidou [26], there is a pressing need to adopt intersectionality as a framework when studying science identity, or in our case "STEM identity".

2.1. STEM Identity

In this study, we define STEM identity as encompassing what individuals express and do while engaging in STEM activities [27–30]. Kang et al. [14] elucidated STEM identity "as a young person coming to see both her current and possible future selves in STEM" (p. 420) and viewed STEM identity "as manifested through youth's positive relationship with, positioning and expressed interest toward STEM and STEM-related career" (p. 420). Moreover, a secure STEM identity extends beyond just an affirmation of self-capacity; it encapsulates the nuanced interrelations of aspects like race and gender [31–35].

2.2. Intersectionality (Race and Gender)

Drawing from the foundational work of Malcom and colleagues in 1976, who coined the term "double bind", we acknowledge the compounded challenges encountered by women of color in STEM, arising from intertwined barriers of race, gender, and class [21]. The life, education, and professional experiences of a woman of color are distinct from those of a White woman or a Black man. Instead of viewing these factors in isolation, researchers recognize their intertwined nature, which leads to an opportunity and achievement disadvantage in STEM education, as highlighted by McGee [16]. This notion is referred to as intersectionality.

Intersectionality involves considering all aspects of a student's identity (e.g., race/ethnicity, culture, gender, and related issues of power and privilege) to understand their lived experiences [3,36–38]. The relevance of intersectionality is paramount in deciphering the obstacles URM girls face in STEM education. Ireland et al. [4] posited that Black women and girls' experiences are not nuanced enough but are hidden in the aggregated data. Therefore, their intersectional experiences in STEM classes are often overlooked, misunderstood, and, worse, dismissed. Intersectionality has adversely impacted URM girls' emotional well-being in public education. Take Black girls, who are often negatively stereotyped, impacting their self-esteem and self-perceptions [39]. Black and Hispanic girls often tread in educational terrains where their cultural practices might diverge from predominant school norms [39,40]. This pushes URM girl students into positions of powerlessness, further marginalizing them within their math and science classes [38,41].

By acknowledging the theoretical underpinnings of intersectionality with STEM identity, educators and researchers can comprehend the complex challenges URM girls face [26], especially during middle school. More importantly, they can design learning environments that support youth who learn along racialized, gendered, and class-influenced pathways [42].

3. Review of the Literature

The "leaky STEM pipeline", initially popularized by Blickenstaff [43], marked a pivotal moment in the 30 years' worth of scholarship that provided explanations for the absence of women of color in STEM. Evolving into a broader discourse on equity in STEM discussed earlier in this paper, the core issues of underrepresentation persist. Today, critical scholars in STEM education argue that "STEM" is a dynamic social construct, its meaning shaped by various stakeholders such as educators, families, students, policymakers, and researchers [29] (p. 327). This perspective has prompted more dismantling and accountability of systems of power by scholars like Baber [44], Joseph [45], King and Pringle [46], and McGee [16].

More recent literature reviews [4,9,26,47] emphasize the unique experiences of URM students in STEM education and their consequent impact on STEM identity. While existing literature reviews shed light on various aspects of STEM identity or informal STEM learning for broader groups (and combinations thereof), we contend that a more focused exploration, binding STEM identity with intersectionality for underrepresented racially minoritized girls during their critical middle school identity formation years, is needed. This narrower examination builds on prior syntheses of the literature, aiming to address the risk of URM girls' stories and experiences being lost in aggregated data [4,47]. Our literature review synthesizes three primary components of existing scholarship relevant to our study: (a) understanding STEM learning in informal environments, (b) identifying affective factors of STEM identity (belonging in STEM, efficacy in STEM, and STEM ability belief), and (c) highlighting middle school's role in shaping STEM identity.

3.1. Understanding STEM Learning in Informal Environments

Over 80% of K–12 students spend their time in out-of-school (OST) activities, including afterschool programs, museums, and libraries, with over 7 million children participating in the U.S. alone [48]. The literature on students' STEM experiences in informal settings is broad, ranging from studies of their environments, achievement, and effectiveness to student engagement and STEM domain interaction to variations in STEM identities.

Environments and effectiveness. Informal learning environments, particularly in OST, are recognized for their diversity [49]. Despite their potential, the outcomes of informal STEM programs remain mixed, with disparities in access affecting URM girls [47,50,51]. We were particularly interested in understanding these settings for URM middle school girls, drawing on the work of Brown et al. [52], Lave and Wenger [53], and Guzey et al. [54], as they offer social interaction and collaborative opportunities across multiple STEM domains. For instance, informal learning settings can be fruitful for Black girls, who often find academic success in out-of-school contexts [11,55]. Furthermore, settings like STEM summer camps can enable authentic activities, allowing URM girls to engage with peers and role models from minoritized backgrounds who provide support and inspiration [9,46,56].

Student engagement and STEM domain interaction. Banks et al. [57] emphasizes that the majority of lifelong learning occurs in these informal settings, fostering increased STEM engagement [58]. Highlighting specific domains within informal STEM learning can also help us understand students' experiences in those settings. For instance, informal math learning is traditionally focused on academic performance metrics [59,60]. Yet, a growing interest in place-based math education outside conventional classrooms is emerging [61] These environments hold the potential for kindling mathematical reasoning, even when participants might be unaware of their active mathematical engagement [62,63]. Informal science learning is more robust, flexible, and engaging for learners of all ages, spanning museum visits and outdoor interactions [64].

Math, science, and STEM identities. Informal science environments are acknowledged for bolstering students' identities as science learners [65]. Recent research has explored the STEM identities of URM girls in diverse informal contexts, including after-school programs or summer STEM camps [14,66,67]. However, these studies often lack segmentation by race, age, grade-level group, or gender, posing challenges for generalization in informal learning contexts.

STEM identity development, particularly for URM middle school girls, encompasses multifaceted dimensions, with math and science identities playing integral roles [68]. Individual perceptions of math and science capabilities intersect with societal expectations, race, and gender. The dynamic nature of math identity is reflected in students' evolving beliefs and perceptions [69,70]. Scholars have also linked robust mathematical identity in girls to improved performance, increased participation, and enhanced resilience [71,72]. Gholson and Martin [73] highlight the influence of social circles and personal agency in shaping the mathematical identity of Black girls.

Further support for the significance of diverse experiences in shaping science identities comes from Brickhouse's [31] multiple-case study on Black middle school girls' science engagement patterns, along with recent investigations into afterschool STEM clubs [30] and community-centric informal science programs [27]. However, Çolakoğlu et al. [9] argue that while informal STEM learning opportunities hold promise in cultivating positive STEM identities, they frequently fall short in reaching underserved students, perpetuating inequities. Building on the diverse literature discussing STEM identity in informal settings, we now identify the specific affective factors we explored to understand URM middle school girls' STEM identity formation and intersectionality.

3.2. Identifying Affective Factors of STEM Identity

Conducting a thorough review of 13 peer-reviewed publications, Çolakoğlu [9] and colleagues explored STEM identity formation in informal learning environments for URM students. Their synthesis considered factors such as competence, performance, recognition, supportive relationships, sense of belonging, agency, interest, and attitudes, encompassing diverse informal learning contexts with variations in duration, program format, and participant ages. To begin narrowing our scope, we first reviewed the literature on the constructs of belonging, efficacy, and ability belief to determine our methodological approach.

Belonging in STEM. For URM girls in STEM, the concept of "belongingness" plays a crucial role, as highlighted by Baumeister and Leary [74], influencing interpersonal relationships. The challenges faced by Black girls in STEM, including racism, tokenism, and sexism, underscore the importance of belonging [46,75,76], and interventions should employ culturally responsive teaching [77,78]. McGee [16] proposes that pairing URM STEM students with mentors from similar backgrounds can enhance academic belonging. It is essential to recognize that belonging in STEM for URM girls goes beyond academic integration; it involves acknowledging and validating their intersectional identities, encompassing race, gender, culture, and more [26].

Efficacy in STEM. Grounded in Bandura's [79,80] theory, our study incorporates self-efficacy as a key factor of girls' STEM identities, emphasizing its role in task performance and future success. In STEM education, self-efficacy denotes a student's confidence in completing science- or math-related tasks. Specific efficacy theories, including Bandura's [80], have shaped the understanding of STEM efficacy in other studies [81]. Young et al. [82] highlighted the development of Black girls' self-efficacy when confidently engaging as scientific community members. Collins et al. [36] proposed that, particularly for students of color, understanding STEM self-concept (a form of self-efficacy) involves the interplay of cultural context, racial identity, and gender, cultivated through reciprocal interactions among psychological factors, individual behaviors, and the external environment. While self-efficacy in STEM gauges personal belief in capabilities, for URM girls, it intricately intertwines with their intersectional identities, potentially influencing their STEM ability belief positively or presenting challenges.

STEM ability belief. Math ability beliefs profoundly impact students' perceptions of their mathematical skills in a broader context [83]. The enduring consequences of students' perspectives on math capabilities have been emphasized in prior research [83–86]. Furthermore, Seo et al. [87] identified students' perceived mathematical abilities as positive predictors of future STEM career achievements, while Rice et al. [88] established a connection between substantial support from families, teachers, and peers and favorable views about math skills. For Black students, math ability beliefs significantly influence their engagement in extracurricular STEM activities outside of school [82]. Next, we review the literature on middle school as a pivotal phase for shaping STEM identities among URM girls, influencing their long-term engagement with STEM fields [2,89].

3.3. Highlighting Middle School's Role in Shaping STEM Identities

The significance of the middle school years is underscored by the noticeable decline in science enthusiasm during the transition to high school, amplifying the critical nature of this developmental period [11,13–15,33]. Shifting interests in middle school strongly correlate with subsequent pursuits in STEM fields, reflecting the influential role of this phase [28,90]. Research consistently highlights middle school as a formative period, shaping students' self-perceptions in mathematics and science [32,68] and serving as a critical juncture for deciding whether to pursue a STEM path [11]. Despite the initial enthusiasm for science observed in primary years, this interest often diminishes as students transition to high school, bearing lasting implications for their sustained engagement in STEM-related pursuits [6,28,90].

Our research focus delves into the affective dimensions of STEM identity, focusing on underrepresented racially minoritized middle school girls participating in an all-girls STEM summer camp. We believe this work will contribute to how stakeholders can effectively engage URM middle school girls in STEM subjects and improve their environments to develop and foster sustained STEM identities. Next, we present our methodology to understand how URM middle school girls developed their STEM identities during the camp, emphasizing the interaction of their intersectional identities.

4. Methodology

4.1. Research Context

This study employed a convergent mixed-methods approach [91] to explore changes in aspects of Black and Hispanic, or URM, girls' STEM identities. The project consisted of an existing one-week residential STEM camp by a local nonprofit. The camp was held at a leading private university in the southwestern U.S. during the summer of 2022. The program's activities (refer to Table 1) were organized under daily overarching themes to make learning more meaningful and culturally relevant.

Table 1. Summary of summer camp activities aligned to observed outcomes.

Course	Description/Duration	Observed Outcome	Ecological System Level
Academics	2 h/day previewing the upcoming school year's math and science concepts and promoting improved Algebra 1 readiness led by experienced, certified teachers	Math–science efficacy, overall efficacy, ability belief	Microsystem Mesosystem
Career	30 min/day developing 21st Century career skills and interacting with a featured STEM woman career speaker	Interest, identity, belonging	Microsystem Mesosystem
Creativity	1.5 h/day completing collaborative STEM project-based tasks that promote creative and critical thinking and grit led by experienced, certified teachers and industry women	Math–science efficacy, overall efficacy, ability belief	Microsystem Mesosystem
Leadership	1 h/day cultivating 21st Century leadership skills in small group mentoring sessions that build self-management, interpersonal skills, and growth mindset led by high school and college females	Identity, belonging	Microsystem Mesosystem
Service	30 min/day fostering self-awareness, empathy, and emotional intelligence through community building and citizenship, culminating in a summative service	Belonging, ability	Mesosystem Macrosystem
Counseling	Small-group sessions that focus on social–emotional well-being and are led by a licensed social worker or guidance counselor	Identity, belonging	Microsystem Mesosystem Chronosystem
Mindfulness	45 min/day providing exposure to healthy lifestyle choices, including mindfulness and/or movement activity	Identity	Microsystem Chronosystem

Note. Chronosystem includes outside factors occurring in the backdrop of the summer camp (COVID-19 pandemic, social justice movements).

4.1.1. Ecological Systems Theory to Inform Program Design

Ecological systems theory provides a valuable framework for designing informal STEM learning programs to observe adolescent girls' identities in middle school [24]. It emphasizes the significance of dynamic and supportive human connections between students, their peers, and adults, underscoring the role of communities in creating informal learning environments like our STEM summer camp [24,25]. Initially, Bronfrenbrenner [25] theorized that child development is a complex system of relationships where the child is at the center and impacted by multiple nested levels of the surrounding environment. Bronfenbrenner's theory posits five concentric circles of influence on child development: the microsystem (closest and most impactful), mesosystem (interconnections between microsystems), exosystem (indirect impact), macrosystem (culture and societal influences), and chronosystem (patterns of life events) [25] (See Figure 1). To address these levels, we carefully designed activities within our research project (See Table 1).

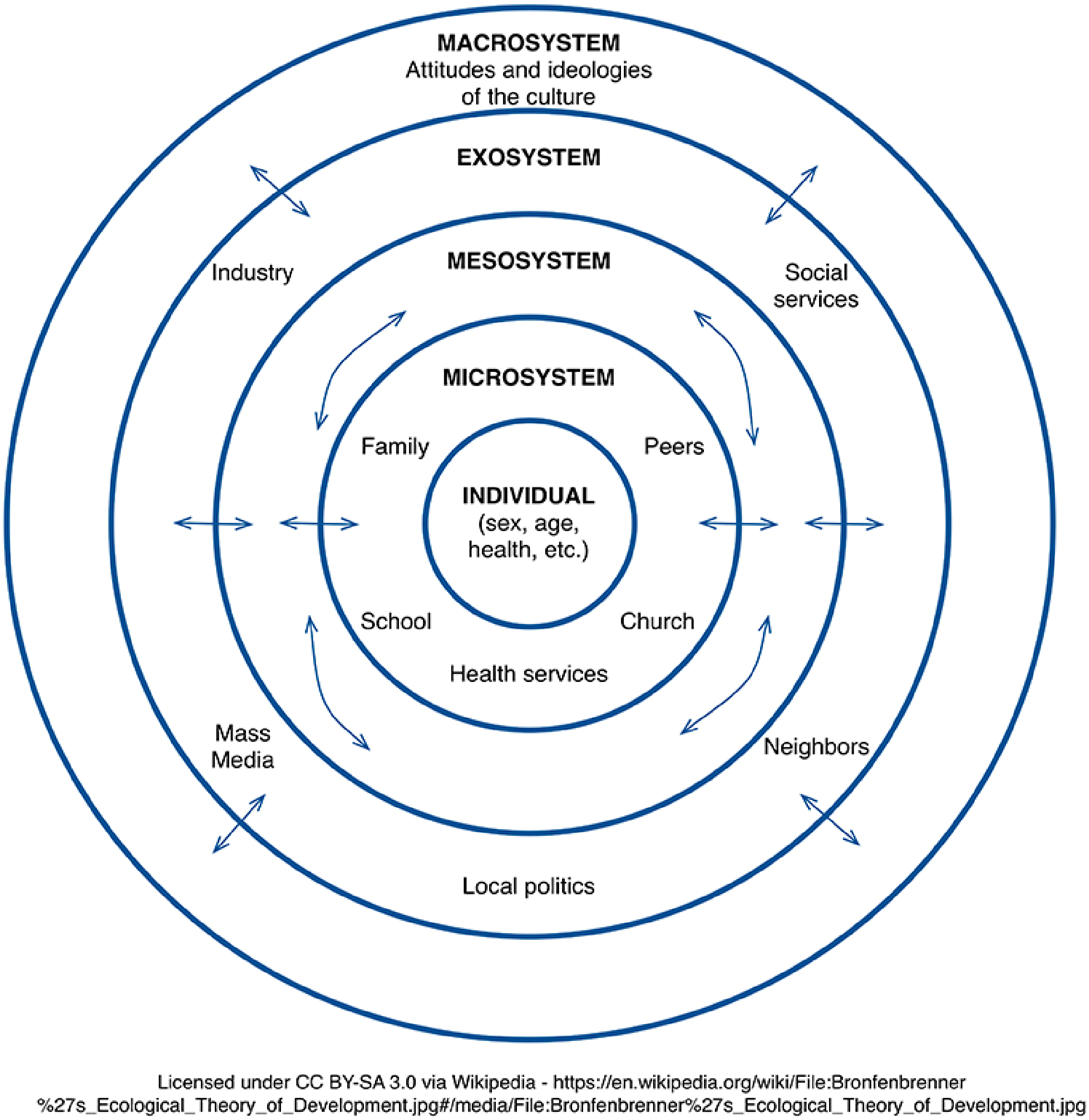

Figure 1. Ecological systems theory. https://en.wikipedia.org/wiki/Social_ecological_model#/media/File:Bronfenbrenner%27s_Ecological_Theory_of_Development_(English).jpg (accessed on 1 November 2023).

Microsystem Considerations. Central to our observations at the microsystem level was the direct and tangible engagement of the girls within the university environment (serving as the informal STEM learning setting). This encompasses their relationships with peers, educators, counselors, researchers, and the local community. To best support each girl's distinct microsystem, students were required to complete a demographic questionnaire upon enrollment. This process furnished insights into various background factors, such as their local neighborhoods and the type of schools they attended. Intentionally, the nonprofit's staff sought out mentors, volunteers, and educators to mirror the racial and cultural backgrounds of these participants as much as possible. Activities designed with this perspective in mind included core academic classes, extracurricular games, small group counseling sessions, recognition ceremonies, and other self-development activities.

Mesosystem Considerations. Venturing into the mesosystem level, we took note of the intersections between the individual microsystem elements and how they influenced the girls' interactions within their peer groups and with adults at the camp. A notable finding was the profound impact of their previous educational experiences. For instance, those from all-girls schools seemed to have a distinct advantage, potentially stemming from year-round exposure to STEM education. In contrast, girls from coeducational backgrounds required an adjustment period to this single-gender STEM camp environment. To bridge the gaps arising from such diverse backgrounds, we conducted a comprehensive family orientation session via Zoom. This session aimed to set expectations, discuss safety measures, introduce families to staff and research team members, review the camp schedule, and primarily foster a sense of belonging before the camp commenced.

Chronosystem and Macrosystem Considerations. The overarching effects of the global COVID-19 pandemic, undeniably, were a significant chronosystem event, permeating the camp's context. Though the camp and university had lifted some of the strict COVID-19 protocols, onsite testing on the first day ensured safety. Beyond the immediate pandemic concerns, the broader societal backdrop was equally influential. Given the intersectionality of our participants, factors such as the "Black Lives Matter" movement and the ongoing debates surrounding the teaching of "critical race theory" and "LGBTQ inclusion" in public education became relevant in the macrosystem. We considered how these distal factors, referring to societal influences, could adversely shape the girls' sense of belonging and participation in the camp. To address these concerns, we implemented small group counseling sessions and integrated mindfulness activities such as yoga and meditation. This holistic approach aimed to provide a supportive environment amidst the complex interplay of global and societal influences.

4.1.2. Summer Camp Context

The curriculum for the summer camp was designed with ecological systems theory to address the "whole girl", and summer camp has been held at various universities since 2010. The researchers' university Institutional Review Board (IRB) granted this study's ethical approval, and parental consent was obtained. As previously mentioned, it is essential to note that this study occurred during the COVID-19 pandemic. Despite precautionary measures, several participants and staff members contracted the virus during camp, resulting in an unforeseen halt after four days.

Girls were actively recruited from various settings, including co-ed and all-girls public, private, and public charter middle schools throughout a major metropolitan city. Additionally, recruitment efforts extended to public libraries, predominantly Black churches, cultural centers, youth groups, and other venues where URM girls congregate. A partnership between the nonprofit hosting the camp and another nonprofit statewide school network was instrumental in recruiting 30 girls from local all-girls schools; the remaining 29 participants attended co-ed schools. Recruitment efforts also included social media campaigns targeting relevant online groups like Facebook parent groups.

In total, 59 girls participated in the program. The demographic breakdown was as follows: 54% identified as Black, 27% as Latina, and 19% as other (a combination of biracial, White, and Asian). Significantly, 88% of the participants qualified for free or reduced-price public-school lunches. Most girls were monolingual English speakers (78%), while 13% were bilingual (English and Spanish). The socioeconomic status (SES) of the schools the participants attended was another factor of interest. Notably, 85% of the girls hailed from Title 1 designated schools, wherein at least 40% of the students come from low-income families. The grade level reported represented the grade the girls were rising into for the 2022–2023 school year, with approximately 90% of the girls entering 8th and 9th grade. Table 2 presents a detailed breakdown of the participants' demographics based on either co-ed or single-gender school type.

Table 2. Descriptive statistics of participants.

School Type Characteristic	Coed School		Single-Gender School		Total Sample	
	n	%	*n*	%	*n*	%
Gender						
Female	29	49.2%	30	50.8%	59	100%
Race						
Black	18	30.5%	14	23.7%	32	54.2%
Hispanic/Latinx	6	10.2%	10	16.9%	16	27.1%
Other *	5	8.5%	6	10.2%	11	18.6%
Language						
English only	24	40.7%	22	37.3%	46	78.0%
Spanish only	1	1.7%	4	6.8%	5	8.5%
English and Spanish	4	6.8%	4	6.8%	8	13.6%
FRL status						
Non-FRL	2	3.4%	5	8.5%	7	11.9%
FRL	27	45.8%	25	42.4%	52	88.1%
School SES Status						
Non-SES school	9	15.3%	-	-	9	15.3%
SES school	20	33.9%	30	50.8%	50	84.7%
Grade Level						
6th	1	1.7%	1	1.7%	2	3.4%
7th	4	6.8%	-	-	4	6.8%
8th	15	25.4%	15	25.4%	30	50.8%
9th	9	15.3%	14	23.7%	23	39.0%

Note. FRL = free or reduced lunch; SES = socioeconomic status. * = Asian American and White.

4.2. Measures

Camp participants were administered a Qualtrics® questionnaire to gauge their STEM identity outcomes before and after the camp. The survey instrument included six measured outcomes: STEM identity, overall efficacy, STEM beliefs about self, STEM ability belief, math–science efficacy, and sense of belongingness in STEM. For the associated Cronbach's alphas for each measure, see Table 3. They ranged from 0.6 to 0.78, aligned to alphas reported by the instrument developers [35]. Reviewing the correlations, we noticed that STEM beliefs about self were too similar to STEM ability beliefs and efficacy, so we dropped that measure for our analysis. Table 4 gives a sample item and the number of items on each measure.

Table 3. Cronbach's alphas.

Construct	Pre-Test	Post-Test
STEM Identity	0.61	0.60
Overall Efficacy	0.73	0.72
STEM Ability	0.68	0.68
Math–Science Efficacy	0.72	0.72
Belonging in STEM	0.74	0.74

Table 4. Overview of constructs, instruments, and example items.

Construct	Number of Items	Instrument	Example Item
STEM Identity	12	ISME	I think STEM subjects (math, science, technology, engineering) are interesting.
Overall Efficacy	3	MSSES	If people tell me I can't do something, it makes me try harder.
STEM Ability	12	MSSES	Figure out how long it will take to travel from Milwaukee to Madison, driving at 55 mph (math).
Math–Science Efficacy	12	MSSES	I am determined to use my science knowledge in my future career (science).
Belonging in STEM	5	MSSES	It is important that my role model(s) or mentor(s) are of the same race or ethnicity as I am.

Note. Middle School Self-Efficacy Scale (MSSES; Fouad et al., 1997 [35]); Is Science Me? (ISME; Ascherbacher et al., 2010 [68]).

4.2.1. Is Science Me?

To measure *STEM identity*, we used the survey instrument, Is Science Me? (ISME; [74]), which has widely been used and has been empirically validated in different school settings (20 items; α = 0.84) as a form of science identity [35]. The instrument was developed to measure secondary school students' identities and is frequently used in informal science learning because it considers students' social norms and interactions [81]. Item responses are on a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree).

4.2.2. Middle School Self-Efficacy Scale

We used selected items from the Middle School Self-Efficacy Scale (MSSES; [35]) to measure math–science efficacy (12 items; α = 0.84), overall efficacy (3 items; α = 0.79), belongingness in STEM (5 items; α = 0.70), and STEM ability (12 items; α = 0.74). The original validity and reliability evidence was conducted with Hispanic and Latino/a/x students, with particularly adequate validity for women and minority students [35]. All item responses on this instrument are on a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree).

4.3. Data Collection

Upon arrival at the camp, all participants completed the survey to establish a baseline score before the start of the camp. Upon conclusion of the camp, participants retook the survey to determine if any changes in their perceptions occurred. A select number of participants (n = 4, see Table 5) participated in virtual post-camp interviews related to their experiences at the camp. These four students were the only ones who responded to participate in a post-camp virtual interview. Sample questions from the interview included: (a) How have your feelings changed due to participating in the program, if at all?; (b) How do you think about yourself as a STEM learner as you participate in the summer camp?; and (c) How do you feel about this being single-gender (girls only) instead of including boys? All interviews were manually transcribed.

Table 5. Interviewed URM camp participants.

Name (Pseudonym)	Grade	Race/Ethnicity	Type of School
Bella	8th	Latina	Single Gender
Ivy	8th	Black	Single Gender
Jada	7th	Black	Co-Ed
Kiara	7th	Black	Co-Ed

4.4. Data Analysis

For our data analysis, we initially conducted paired *t*-tests on the pre- and post-test data for each construct represented in the survey. Subsequently, we collectively analyzed the transcribed interview data using a deductive coding method, as outlined by Creswell and Guetterman ([91]; refer to Table 6 for our codebook). Our coding scheme was informed by a thorough review of the literature, constructs from the instruments we employed, and our theoretical frameworks of STEM identity and intersectionality. All three authors applied a collaborative approach to coding as an instrumental way to mitigate bias. In coding disagreements, we refined the definitions in our codebook until a consensus was reached [92] For example, we originally had one code for gendered experiences; however, the first author noticed that gender stereotypes were occurring frequently enough to have their code, so the three authors determined an appropriate definition for both of our codes of Gendered Experiences: Stereotypes and Gendered Experiences. Upon completing collaboratively deductively coding the transcripts, we computed the frequency of each code [93] to understand the significance of specific factors in our research focus. We present the results from the girls' data in the following section.

Table 6. Codebook for interviews.

Code	Definition	Example Quote
Race	Discussions around racial identity as it relates to STEM learning.	I thought it would be a good experience to meet more girls like me, that are Black and Latina.
STEM Ability	Students discuss their perceived ability in science, technology, engineering, or mathematics.	I wanted to be able to feel more confident within myself and be able to do projects and feel better about myself when I'm starting a new school year.
STEM Efficacy	Student's belief in their capacity to execute behaviors necessary to produce specific performance attributes related to STEM.	We did a lot of mathematical skills. I'm really glad about that. Because that's an area I want to really work on.
STEM Identity	It encompasses the dispositions and deeply held beliefs that individuals develop about their ability to participate and perform effectively in STEM contexts and to use STEM to change the conditions of their lives.	I got to really learn what STEM is really about for myself.
Belonging in STEM	Student's personal belief that one is an accepted member of the STEM community whose presence and contributions are valued.	I thought that I pretty much belonged in the camp; I didn't really have any problems.
Interest in STEM	Discussions or observations that portray or elicit affective changes like increased engagement, which is characterized by persistence and focused attention.	I think it gave us ideas on what to do in the future for those interested in STEM career fields or topics to study.
Gendered Experiences: Stereotypes	Perceptions of a particular gender group being stereotyped.	I was used to just seeing, basically, almost all males in STEM. And that was just what I was used to seeing.
Gendered Experiences	Other discussions related to the role that gender plays concerning their STEM identity or activities surrounding the informal learning environment.	I felt more comfortable, and I felt as if I were able to express my feelings easier than with guys being in the camp.
Challenges	Moments when the girls discuss any barriers or challenges related to the STEM activities during the camp.	I think the only challenge was specifically with my group. And it was only because we didn't really communicate as much.

4.5. Positionality

Regarding positionality, the first author is a Black woman and a STEM education Ph.D. student with an established relationship with the STEM summer camp featured in this study. Her belief in the importance of such informal learning opportunities is rooted in her personal experiences. She participated in similar programs as a girl and later worked in various capacities in STEM as a professional woman. Her background includes experience in middle school STEM education in formal and informal STEM learning environments and educational technologies.

The second author, a White male and STEM education Ph.D. candidate, served as the co-researcher during the STEM summer camp. He collaborated closely with the first author to develop a research and data management plan. He was deeply embedded throughout the process of the camp, such as attending education training prior to the start of the camp, attending the parent–student meeting, and following the lead and supporting the first author throughout the week-long camp. His experiences span agricultural sciences, informal STEM learning, and secondary education teaching.

The third author, a White woman and a professor of mathematics education, mentored and guided the first two authors in their research and data analysis. Her guidance and insights, rooted in her unique background, further enriched our study by offering valuable perspectives that complemented the contributions of the first two authors.

Each author's individual experiences, cultural backgrounds, and professional expertise inevitably shape their perspectives and, by extension, influence the interpretation and conclusions of this study. Recognizing this, we sought to maintain reflexivity and openness throughout the research process to mitigate potential biases in our findings and implications. This involved regular team discussions and reflective journaling to scrutinize our perspectives and possible impacts on the interpretation of data. By engaging in regular debriefing sessions and consultations with external experts, we aimed to expose our work to critical scrutiny and challenge, thereby enhancing the credibility and robustness of our findings. This acknowledgment underscores the importance of a nuanced and comprehensive analysis to accommodate the multifaceted aspects of the subject matter and ensure the integrity of our research findings.

5. Findings

This section, organized by measured constructs, details our critical quantitative and qualitative findings related to the research questions. To triangulate our findings, we first present our quantitative results, followed by supporting qualitative results taken from the interview data. Table 7 presents the pre- and post-program survey construct means and standard deviations on each measure and summarizes the results of the paired *t*-tests, including the effect sizes (Cohen's *d*; [94]), reported as standardized differences between the means (pre- and post-). Figure 2 displays frequency counts for all codes derived from student interviews. All names used are pseudonyms for student anonymity.

Table 7. Paired *t*-test results.

Variable	Pre-Group Mean (SE)	Post-Group Mean (SE)	Standardized Mean Difference	*t*-Value	*df*	Bonferroni-Adjusted *p*-Value
Identity	3.43 (0.04)	3.61 (0.04)	0.631	−3.4586	115.89	0.001
Overall Efficacy	3.63 (0.08)	3.90 (0.07)	0.465	−2.4886	115.84	0.014
Ability	3.64 (0.04)	3.86 (0.04)	0.746	−3.9086	115.95	0.0002
Math–Science Efficacy	3.63 (0.04)	3.75 (0.05)	0.338	−1.8371	115.06	0.067
Belonging	3.37 (0.06)	3.53 (0.07)	0.328	−1.7471	112.35	0.080

Note. $n = 59$ respondents. We used the Bonferroni-adjusted *p*-value for multiple comparisons across the items.

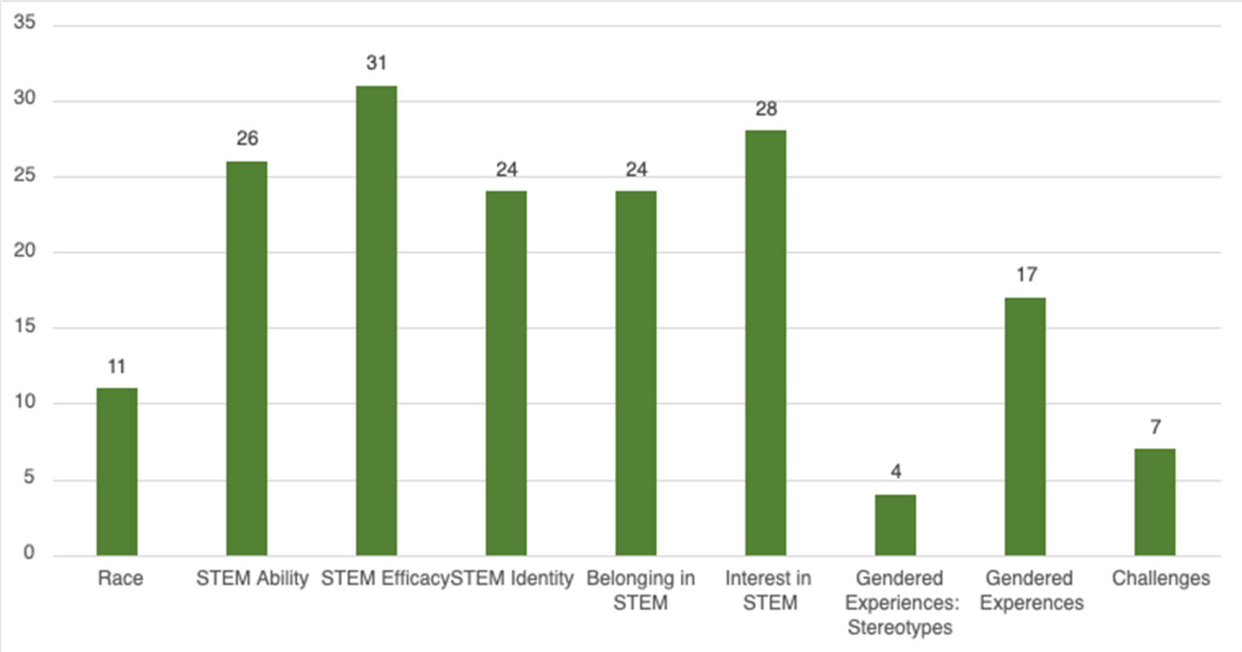

Figure 2. Frequency of codes from post-camp interviews (n = 4 girls).

5.1. STEM Identity

Our definition of STEM identity refers to girls' engagement in STEM activities and their narration of experiences and self-perceptions within these activities [27,29,30]. Paired t-tests revealed a statistically significant increase in STEM identity scores, with an effect size of $d = 0.631$ (3.43 to 3.61, $p = 0.001$). This quantitative finding is complemented by qualitative insights from interviews, where the theme of STEM identity emerged explicitly 24 times.

Some URM girls' interviews provided rich illustrations of their STEM identity as they engaged in camp learning activities. For instance, Kiara's self-reflection aligns with our definition of STEM identity, emphasizing her positive experience in creating a podcast with local STEM women role models. Kiara stated, "I found it really helpful. . . to have something that our camp had, like emerging technologies or science, and learning [about] things around us". These sentiments underscore the value she attributes to STEM learning experiences and their positive contribution to her understanding of STEM concepts. In accordance with Kang et al. [14], Kiara envisions her current self and a reflection of her future self through positive relationships with STEM career women of similar racial and gender backgrounds. Next, we see how such activities also play a crucial role in fostering an inclusive and empowering environment where URM girls feel a sense of belonging.

5.2. Belonging in STEM

Belonging in STEM is defined as a girl's personal belief that she is an accepted member of the STEM community and that her presence and contributions are valued [95]. Our paired t-test results show that on a five-point Likert scale, girls' sense of belonging in STEM gains was not statistically significant at the 0.05 level (3.37 to 3.53, $d = 0.328$, $p = 0.08$). In our post-interviews with girls, a sense of belonging in STEM was conveyed 24 times.

In her interview, Kiara, a Black seventh-grade girl, explicitly used the word "belong" while describing her camp experiences. She shared how her perception of her sense of belonging in STEM improved as a direct result of her participation:

"Some parts of me that felt like I didn't belong, because I didn't think that I was really all that smart or that I could do things like this. And before participating in this camp, I was a little bit nervous because I thought I wasn't going to be able to actually achieve or succeed in anything that we were going to be learning there. I thought there was going to be like other smarter girls than me or, [that] they would be even better at the things that I could do. *But participating in this camp it definitely made me feel like I belong there,* (emphasis added) and that everyone's learning everything, and everyone makes mistakes."

Here, Kiara articulates a transformative shift in her self-perception. Initially burdened with fear of failure, anxiety, and imposter syndrome symptoms, her camp experiences challenged these self-limiting beliefs. Observing her peers make mistakes during shared activities reassured her, bolstering her persistence throughout the camp. Consequently, Kiara affirmed her sense of belonging within this informal STEM environment, strengthening her STEM identity. After extensively reviewing interview data, we observed a similar pattern among several other girls. Participating in the all-girls STEM summer camp enhanced their comfort levels within STEM fields, emphasizing the importance of such experiences in fostering a sense of belonging in STEM.

5.3. Efficacy in STEM

STEM efficacy refers to a student's belief in their ability to execute behaviors requisite for attaining specific performance outcomes in STEM-related tasks [79,80]. We scrutinized two indicators of efficacy in our study: overall efficacy and math–science efficacy. Quantitative results demonstrated a significant increase in overall efficacy from the pre- to post-test, as indicated by an effect size of $d = 0.465$ (3.63 to 3.90, $p = 0.01$). Contrarily, changes in participants' math–science efficacy, as measured by the t-test, did not prove statistically significant (3.63 to 3.75, $d = 0.338$, $p = 0.067$). Throughout the interviews, the theme of efficacy was addressed 31 times.

After reviewing the quantitative findings, our qualitative data illuminated how the girls enacted different behaviors to achieve specific STEM-related outcomes. For instance, Ivy (a Black eighth-grade girl) conveyed her perceived confidence in STEM by explaining in her interview that she had the opportunity to "really learn what STEM is. . . for myself." She further expressed her belief that she "got smarter [and] understands how to use" STEM daily. Such self-reflective statements reveal the impact of the camp on fostering her belief in her efficacy in STEM, contributing to her STEM identity.

5.4. STEM Ability Beliefs

Students' perceived ability to engage or participate in STEM disciplines is called *STEM ability beliefs* [32,35]. Our t-test revealed a statistically significant increase in STEM ability beliefs from pre- to post-test, with an effect size of Cohen's $d = 0.746$ (3.64 to 3.86, $p = 0.0002$). From the interviews, STEM ability belief was coded 26 times.

In the qualitative data, we discovered instances of the girls demonstrating and discussing their self-perceived engagement in STEM activities. For instance, Bella (Latina, eighth grade) expressed increased confidence in her science ability and her intention to "switch to honors science", seeking "more of a challenge." This shift in her perceived science ability is one instance of how the camp fostered growth in this aspect of her STEM identity. Similarly, Jada (Black, seventh grade) affirmed her self-perceived ability, suggesting that her experiences would assist with her future career goals and academic progress. An additional review of the qualitative data revealed instances where the girls envisioned themselves as future STEM participants. For example, Jada recounted her persistence during a math activity despite initial difficulties using an advanced graphing calculator. She said she "kept trying and trying" until she could complete the math activity successfully.

5.5. Race and Gender Intersectionality with STEM Identity

Emerging from the literature, it is clear that URM middle school girls' racial and gender intersectionality cannot be dissociated when analyzing STEM identity. Coupled with this understanding is the influence of ecological systems-level factors. While the survey instruments provided insights into specific facets of STEM identity, interviews broadened our intersectionality lens.

5.5.1. Race (and Ethnicity) and STEM Identity

The majority of the camp participants were URM girls (n = 48), namely Black and Hispanic, with a substantial presence of volunteers, guest STEM professionals, and instructional staff from racially minoritized groups. In this environment, participants could connect with peers, sharing their racial and ethnic backgrounds and lived experiences. A recurring theme in our interview data, emphasized by 11 instances, was the significance of racial representation. Bella reflected on her experience as "inspiring and encouraging" and further elaborated:

"I think having more examples of Black and Latina women in STEM, I think that really helped me because they don't really show that as much in the world. And as much as I would like it to say, because knowing that there are more women that you can do, and knowing that they do make a difference, and it's not just like males or non-colored it."

This sentiment echoes in Kiara's feedback, underscoring the crucial role of racial and ethnic representation in STEM identity formation. She said the camp was "really helpful for Black and Latina girls in STEM." Both girls underscore the vital role that racial and ethnic representation in STEM role models play in STEM identity (specifically "belonging") at both microsystem and mesosystem levels in informal STEM learning environments.

5.5.2. Gender and STEM Identity

The camp's "girls only" format emerged as another focal point at the lower ecological systems level. During the interviews, participants openly discussed gender perspectives. In our analysis, we identified four instances of gender stereotypes, as defined in our codebook, and seventeen instances of other gendered experiences. A group activity where the girls interviewed local professional STEM women was particularly enlightening. Ivy's recounting of her interaction with one such woman sheds light on gender dynamics in the STEM workforce:

> What is it like being in a workplace with mainly men? And she [the woman] explained to me how hard it was and how difficult it was to work with men because of the way they treated her [the woman], the way they [men] took her work, and the way that they [men] did things, and she said that she [the woman] couldn't do it. She [the woman] elaborated to me [Ivy] about how we're totally different and how they [men] didn't treat her [the woman] the same.

Ivy's reflections are profound, acknowledging the pervasive gender dynamics at play and underscoring the importance of gender representation in STEM, "Black and Latina women coming from different companies, and speaking to us, so we can really see what it's like". Relevant to gender in informal STEM learning environments, Ivy initially said that being in an all-girls camp was "okay" but quickly shifted to "the concept of that because girls and boys have a different way of learning." Kiara said she felt "kind of relieved that this is only a girls only camp because I find boys really weird". Bella said that being an all-girls camp meant that she "wouldn't have to worry about any drama" and felt "more comfortable . . . knowing that it would be girls". These intimate statements are just some of the many instances that underline the URM middle school girls' perspectives based on their histories of gender stereotypes and experiences of women (and boys) while conducting STEM activities.

Going further, even though Ivy's podcasting encounter happened at the mesosystem level, her interactions with peers and women in STEM at the camp also touched upon the broader macrosystem. Ivy speaks to her embracing an understanding of societal norms regarding women in the STEM workforce: ". . . they [men] have a different way of opportunities when it comes to careers." Such reflections underscore the depth of gender dynamics and emphasize the importance of gender representation in STEM.

5.6. Intersectionality of Race and Gender and STEM Identity

The confluence of race and gender was palpably present in the narratives of our interviewees, especially Bella, who provided a deeply descriptive understanding of her experiences:

> Um. . .this was my first year participating. And I applied to it because I thought it would be a good experience to meet more girls like me, that are like Black and Latina. And so there'll be a difference because, at my school, I didn't really have a good connection with girls that were my ethnicity. . .There aren't many Latina girls in my school. And I'm the only one that is in orchestra and in honors. So I thought that it would be a good idea to meet other girls.

On her feelings about the camp being all girls, she does not separate gender from race in her response, even articulating her understanding of statistics regarding gendered realities of the STEM workforce:

> . . .It's like kind of proven that when it comes to middle school, girls' confidence lowers, while the boys' confidence, in the majority of cases it, rises. So, I think having a club or a camp for especially girls and especially colored girls. . .all together and coming in as a group of one, I think that that's a good idea.

Bella also stressed, ". . .having more examples of Black and Latina women in STEM. . . really helped me because, like, they don't really show that as much in the world. . .I think it's very, like inspiring and encouraging."

In the three instances, Bella articulates how her intersectional identity as a Latina girl influenced her decision to participate, underscoring her aspiration for a sense of belonging. The composition of the all-girls camp, predominantly featuring URM girls, was notably significant to her. Furthermore, Bella's reflections suggest that her perspectives as a "middle school" Latina girl were shaped not only by personal experiences but also by broader societal perceptions of girls and women of color in STEM domains. Her insights provide a window into how intersectionality encompasses both immediate influences from the microsystem and mesosystem and broader, potentially distal factors such as media portrayals or historical narratives, touching upon the elements of the macrosystem and chronosystem.

In sum, our findings highlight the indelible mark of racial and gender intersectionality on the STEM identities of URM middle school girls. Through their narratives, the informal learning environment provided more than just a backdrop; it was a crucible for enriched interactions, allowing URM middle school girls to connect with peers and mentors of similar backgrounds. Informal STEM learning settings, like residential university camps, emerged not merely as a medium for engagement but as robust pillars of support and inspiration for URM girls during their transformative middle school years.

6. Discussion

National interest in diversity in the STEM workforce has heightened, which disproportionately shows that women of color are the least represented group amongst STEM professionals [7]. However, critical scholars have shifted away from earlier conceptions that pinpoint reasons why URM girls and women leak out of the STEM pipeline [43] to today's contemporary discourse, which challenges us to consider why we want girls to pursue STEM and how systemic racism and sexism factor into URM girls' and women's pursuit of STEM careers [4,27,29,44–46].

To do so, we sought to understand how URM middle school girls narrate their STEM identity as a set of affective factors related to their intersectionality (race and gender). We studied URM middle school girls' participation in a week-long informal STEM learning camp influenced by those factors [81]. In the transformative middle school years, STEM identity is complex and layered as students shape their math and science identities, and many begin to experience declining interest in STEM subjects [11,20,32,68].

Thus, understanding STEM identity has increasingly become a topic of research interest over the past few decades [14,29,32,66,68]. In particular, understanding STEM identity in informal STEM environments has been noted for increased investigation [6,47].

Our research adds to the existing body of work on gender equity in STEM by giving more clarity to URM middle school girls' STEM identities and their sense of belonging in STEM [16,27,30,31,46,67] in informal STEM learning environments [52,54].

Our study suggests that students' micro-level interactions during a single-gendered STEM summer camp can reveal how URM middle school girls' sense of belonging in STEM can contribute to the development of their STEM identities [32]. Further, we found that participation in the camp enhanced some girls' STEM identities as they engaged in STEM activities [47]. Additionally, we reported quantitatively and through the micro-interactions that participation in the camp increased the girls' self-efficacy in STEM [36,96] to better understand the girls' confidence in their ability to perform different STEM-related tasks [79,80,90]. Moreover, our findings support an increase in girls' STEM ability beliefs [32,35].

In our study, although the instruments we employed examined various facets of STEM identity, our interview data compelled us to explore supplementary contextual factors that shape STEM identity, mainly related to the intersectionality of race and gender [78]. Applying ecological theories [25] to designing informal learning environments for URM middle school girls in STEM provides a comprehensive framework for understanding the multifaceted influences on their identity development. By examining the microsystem, mesosystem, exosystem, and macrosystem, the approach addresses the specific challenges and opportunities these girls face. This integrated approach facilitates the creation of an empowering and inclusive environment that encourages the participation and success of URM middle school girls in STEM fields.

Our findings support the idea that it is essential to see yourself as capable of achieving goals and having URM role models that pursue and push boundaries within STEM [68,77,90,97]. The macrosystem level attributed societal distal factors (the COVID-19 pandemic and social movements, such as "Black Lives Matter"), which could have indirectly menaced girls' full engagement. For example, the camp was closed early due to a COVID-19 breakout among staff and students; further, the interviews were completed virtually after the conclusion of the camp, which could have influenced girls' perceptions.

Our study stands apart from prior literature in informal STEM learning because we look at both the URM girls' STEM identities using affective measures, as well as how the intersection of race and gender contributes to their STEM identity formation during their middle school years. For example, Bella's reflections highlight her perceived importance of providing spaces for Black and Latina women engaged in STEM to increase their sense of belonging in STEM altogether.

7. Limitations and Implications

It is essential to acknowledge that research work cannot fully prepare emerging or seasoned scholars for natural disasters. While this aspect was not initially a part of the study, the results highlight how natural disasters or disruptions, such as COVID-19, can potentially impact student survey responses before and after the study. When planning and conducting studies involving students as participants, researchers must consider the possibility that unforeseen circumstances beyond their control may derail their project designs. Therefore, the question arises, "What structures, systems, activities, or support can be strategically incorporated into project designs to mitigate closure, disruptions in data collection, and subsequent data analysis"?

As the world continues to learn from the effects of COVID-19 on education, informal learning researchers must situate their studies during this time within the context of the pandemic. In this study, due to a COVID-19 outbreak, the ability of individuals to fully participate in informal STEM learning activities was disrupted. This disruption could have influenced the responses to the post-survey instruments. The second major limitation of our study is that, due to the sudden closure of the camp, we could only conduct four interviews (remotely) with the camp participants, which was different from our original intention. However, to reinforce our findings, we utilized interactional and discourse sequences from our data corpus to highlight examples that support the quantitative findings and findings from the interviews.

Additionally, our study reveals two implications regarding the STEM identity of middle school URM girls in informal learning environments. Firstly, single-gender camps, where URM girls constitute the racial and ethnic majority, provide safe spaces for these girls to discuss challenges related to race and gender in STEM authentically. Furthermore, when middle school URM girls have role models who reflect their racial, ethnic, and gender backgrounds, it offers them valuable opportunities for identity development. Single-gender STEM camps should explore ways to provide such unique opportunities to foster the development of girls' STEM identities.

Lastly, informal STEM facilitators should anticipate challenges URM girls may encounter in these settings. These challenges may include issues with collaboration among girls and how to address racial and gender-related topics within the STEM workplace. One advantage of this camp was that it facilitated interactions between URM girls and professionals in various STEM fields, allowing them to learn, interview, and reflect on the experiences of being URM girls and women in STEM careers. The URM girls could identify real issues these professionals faced and how they overcame them.

8. Conclusions

This research addresses a critical gap in the literature by assisting STEM educational practitioners in addressing the factors contributing to the attrition of girls who have initially shown an interest in STEM and elucidating the underrepresentation of women of color in STEM careers. Although most girls demonstrated an overall positive advancement in their STEM identity development, the persistence of racial and gender-related challenges remained a subject of discussion and concern. Further investigation is necessary to comprehend the influence of single-gender STEM camps on URM girls' formation of STEM identity, thereby contributing to the existing body of literature on gendered STEM identity formation and fostering communities of practice. Subsequent research endeavors will continue to explore the girls' STEM identity development process and its sustenance over time.

We conclude this manuscript by offering three recommendations from a research, policy, and practitioner perspective. First and foremost, there is a compelling need for more qualitative and quantitative research studies that specifically concentrate on URM girls in middle grades within the context of informal science learning and STEM education. This research should examine not only the achievement outcomes of URM girls but also interrogate the design of those informal STEM environments as they facilitate influential factors in STEM identity formation (belonging, efficacy, and ability belief). Not examined in this paper, this could include instructor quality and professional development for working with URM girls in these settings. In addition, increasing the number of studies that specifically report the experiences of middle school URM girls participating in STEM informal learning is crucial. Last, it is an imperative step towards addressing the intersectionality of race and gender in STEM, particularly considering the limitations in current research that fail to adequately represent the experiences of girls from historically marginalized backgrounds in American public education. Understanding STEM identities using ecological systems theory can help researchers gather and interpret identity data as multiple contextual variables and experiences influence it.

The primary goal of informal STEM learning research is to alleviate the equity disparities in STEM education that persist in public education by providing all learners opportunities to engage with STEM in ways that are meaningful to them. The global pandemic has highlighted the critical need for community-based learning opportunities, including virtual ones, for vulnerable public-school students. In response, federal, state, and district education policymakers have an opportunity to prioritize initiatives that not only address pandemic-related concerns but also advance STEM education. Earmarking federal funds for informal STEM learning interventions can mitigate the effects of the pandemic on URM middle school girls' perceptions of how they identify with STEM.

The field must focus on bridging the gap between theory and practice. Moreover, increased funding for informal science education providers to conduct research-based projects can advance the field. In order to better understand the complexities of girls' STEM identity formation, it is essential to support ecological systems surrounding girls as they engage in informal science activities. The rise of STEM learning ecosystems, which expose girls to a diverse range of female STEM role models, is a promising development. These role models can be encountered not only through career talks but also through social media campaigns. This approach is particularly potent for URM girls who may have limited access to role models from their racial and ethnic group in person, promoting a more inclusive and diverse STEM community. These recommendations collectively aim to address the intersectionality of race and gender in STEM education and promote equitable opportunities for girls in informal science learning contexts, paving the way for a more diverse and inclusive STEM landscape.

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