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Building Detectors, Building Identities: Engaging Refugee Background Youth in a STEM Summer Camp (RTP)

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Abstract

This research to practice study examines how a group of diverse refugee background youth participated in cosmic ray research during a one-week STEM summer camp. Refugee background youth are often marginalized in STEM education due to the cultural, linguistic, socioeconomic, and structural barriers that limit their access to enriching science learning opportunities. These barriers can result in exclusion from science pathways and limited development of science identity during formative educational years. Pre-college STEM enrichment programs, particularly those offering hands-on experiential STEM learning, can provide a critical context for expanding refugee youths' access to STEM. Grounded in identity work, which conceptualizes learning and identity as processes shaped through participation in social practice, we explored how students' reflections reveal interests, emerging identities, and aspirations in science. Data sources include semi-structured interviews with eleven multilingual youth (identified as Iraqi, Congolese, Nepali, Ethiopian, and Latinx), field notes from participant observation, and photographs of camp activities. Reflective thematic analysis revealed that students actively developed and expressed both disciplinary (Physics) and non-disciplinary competencies. The summer camp experience supported their existing interest in STEM careers, strengthened their STEM confidence, and enhanced their experience via staff and peer interactions. These findings offer insight into how pre-college programs can create inclusive, STEM identity-affirming spaces for refugee and immigrant youth. This research contributes to the growing body of work on equity-focused K–12 STEM education for refugee-background youth. It offers practical implications for designing STEM enrichment programs that promote access and engagement among refugee and immigrant youth in STEM.

Keywords: STEM identity, refugees, experiential STEM learning, informal science program

Introduction

Despite the physical presence of minority youth in science, technology, engineering and mathematics (STEM) classrooms, minoritized youth experience difficulty in developing identities in science or recognizing themselves as scientists due to poor experiences with science at school, marginalization due to race and ethnicity, lack of a sense of belonging, cultural and linguistic barriers, feelings of being a misfit in science spaces and living in underserved communities [1], [2]. Among these groups, refugee background youth occupy a unique position of layered marginalization due to their disrupted formal schooling and constrained access to equitable science learning opportunities. These barriers continue to position refugee youth as learners in need rather than as capable contributors to STEM communities.

Research has shown that access to meaningful and engaging science experiences is important for building and sustaining student STEM interest and motivation, while supporting the development of science identity [3], [4]. However, refugee youth may have fewer opportunities to access these kinds of science engagement. Informal science learning environments, such as after-school programs and summer camps, address inequities in STEM participation by providing flexible, hands-on science learning activities and supportive relationships with mentors and staff. These settings may offer context for greater engagement with science and, importantly, empower refugee youth to disrupt dominant hierarchies and deficit narratives about refugee status and STEM competencies [5], [6]. When these programs are designed with equity in mind, they can support learners in developing confidence and a sense of belonging in STEM [7].

We ground our study in the framework of identity work [8], which defines identity work as “the actions that individuals take and the relationships they form (and the resources they leverage to do so) at any given moment and as constrained by the historically, culturally, and socially legitimized norms, rules, and expectations that operate within the spaces in which such work takes place”[8, p. 38]. From this framing, we view STEM identity as an evolving process demonstrated through students' actions, relationships, and engagement with the resources the science space affords them. Our study examines student engagement during a one-week summer camp and its resources to provide insights into how interest, expertise, and aspirations in science are developed and expressed. Specifically, we ask: How did participation in the RESET summer camp shape refugee-background youths’ experiences and interest in science, and emerging science identities?

Background

Refugees and Immigrant Youth in K-12 STEM Education

Roughly 6% of K-12 students in the U.S. are refugee background youth [9] who face significant educational and societal challenges [10], [11] like marginalization in schools [12], academic gaps due to interrupted schooling [13], as well as discriminatory language ideologies and racial stereotypes in the host country [14]. Youth who have been classified as refugees institutionally, systemically, and collectively may develop deficiency perspectives that restrict their access to learning opportunities [15]. Within science, technology, engineering, and mathematics (STEM) learning contexts, refugee background youth may face several challenges, including stereotypes and bias [16] related to their language proficiency [17] as well as the lack of role models and mentors, unequal access to resources, and a less supportive or inclusive academic environment [18], [19]. These challenges limit their access to meaningful science learning opportunities, often resulting in exclusion from science pathways and limited development of science identity during formative educational years due to lower confidence and insufficient support [20]. However, research from the last two decades has started to challenge the deficit-based view of refugee identities, instead highlighting the strengths and rich lived experiences of refugee-background youth [21], [22]. More studies emphasize how refugee youth transform negative experiences into aspiration, pride, strength, hope, and opportunity [23], [24], possess unique strengths like adaptability and multilingualism [25], and demonstrate agency, critical awareness, and a desire to contribute positively to society and pursue diverse career paths [26].

Developing STEM Identity in Informal STEM Learning Contexts for Refugee Learners.

An expanding body of research demonstrates the imperative of developing refugee background students' science identity [27], [28], [29] as a means of supporting their participation and meaningful engagement in STEM disciplines. Some studies suggest re-thinking ways to work with these youth [30] by utilizing critical instructional practices, such as linguistically responsive pedagogy, translanguaging, and socio-politically responsive pedagogy [31], [32]. More importantly, recent studies show that students develop more robust STEM identities through socially mediated, culturally responsive, and participatory learning environments [6]

Particularly, studies on informal science programs or out-of-school STEM programs demonstrate that science camp environments can support science identity by enabling social interaction, collaboration, and experiential learning, which allow youth to negotiate and construct STEM-based identities [33], [34], [35]. For example, a study examining racially minoritized girls found that a supportive, collaborative, and culturally responsive summer camp with encouraging instructors and peers played a significant role in fostering the girls' positive STEM identities,

particularly when they engaged in hands-on, inquiry-based activities that emphasized creativity, problem-solving, and real-world relevance [33]. Similarly, [1] review of informal STEM learning for underserved populations further underscores that supportive relationships, hands-on projects, and belonging are central to identity development, indicating that such program features are likely to benefit refugee learners as well.

In brief, this literature suggests that out-of-school STEM programs and camps can play a critical role in supporting refugee students' STEM engagement by emphasizing hands-on experiential learning, community recognition, belonging, relevance, and identity affirmation as outcomes that are often difficult to achieve within traditional classrooms. These science enrichment programs can provide a context for expanding refugee youths' access to science and supporting a stronger sense of identity within it. Engineering is not typically the sole focus in STEM-based informal learning opportunities for K-12 learners. Often, such programs create interdisciplinary programming with the aim of increasing students' STEM-based identities without a clear focus on one sub-discipline. Yet few studies explore how students' disciplinary identities (physics, computer science, engineering, etc.) are constructed within and as part of their STEM identities. Thus, this paper sheds light on how students might experience engineering practices and identity-work within a larger physics-focused informal STEM learning program.

Methods

RESET Afterschool Program

The RESET program was a physics-focused afterschool program embedded in a larger afterschool program. It was designed to support refugee youth in developing a positive identity in science, and it was held at a University in the United States. The project was a three-year ethnography funded by the National Science Foundation. The program served 28 youths who identified as Iraqi, Congolese, Nepali, South Sudanese, Ethiopian, Burmese, and Ugandan. The program was designed to be culturally and linguistically sustaining [36] by affirming and sustaining refugee youth's cultural and linguistic resources while they worked collaboratively with scientists and peers in the program. The RESET program offered (1) cosmic ray research, a physics project in which refugee youth worked collaboratively with physics professors, instructors and peers to build cosmic ray detectors and calibrate data; (2) digital storytelling, where students created science films and videos of their science learning; and (3) family and community science events, where students periodically presented their science projects to their families.

During the first two years of the afterschool program, students were introduced to physics and computing, learned filming techniques, began making the components of their detectors, and began assembling detectors. They also held two family and community science events. We note here that the first semester of the program was disrupted by the pandemic. While the original plan for the program involved building detectors as the first activity, the COVID pandemic shifted the timeline and activities of the project. Thus, it wasn't until the end of the 2nd year of programming that we were able to support the youth in completing their construction of four cosmic ray detectors, working in groups. To ensure that all students had the chance to fully participate in detector building, we created a one-week summer camp experience focused on detector building, with other enrichment activities held on the university campus.

Figure 1: Detector Taping and Gluing

(L) Group gluing the photomultiplier tube to the detector (R) Group taping the plastic cardboard to the scintillator.

RESET Summer Camp Program

Early in the program's second year, youth were asked to form groups of four to work collaboratively on four detectors throughout the year. Groups were self-selected and remained roughly intact until project completion. However, during the summer, students frequently helped out different groups and socialized across groups. During the camp, the youth focused on assembling their detectors by consolidating the scintillator and photomultiplier tube, wrapping the detector with reflective foil and black plastic to seal in light, and attaching the HiSPARC box to the detector to read its output and begin calibration. Calibration is the stage at which the cosmic ray detectors are confirmed to be functional and capable of collecting atmospheric data that can be analyzed to make predictions about particle activity. By the end of the academic year, only one group had assembled their detector and begun to learn about calibration testing, while others were still troubleshooting issues with their photomultiplier tubes or hadn't had the chance to build yet. This was in part due to the small area we had dedicated to detector building, which

did not at first allow all groups to work at the same time. One of the primary goals of the summer camp was for the youth to complete and test their detectors in preparation for calibration. Students who had completed the one detector then worked with other groups to help them complete their detectors as well. Although the core project activities remained the same during the summer, the youth were able to dedicate significantly more time to their work, engaging in longer hours rather than during the school year. The summer camp format also increased youth collaboration and allowed for additional science-related activities that could not be accommodated during regular afterschool sessions.

Camp Schedule

The program schedule was structured to balance cosmic ray research (detector building), creative exploration, and collaboration across the week. Each day began with an activity, and the youth also had a lunch break. Early in the week, youth were introduced to the program through reflective and creative activities such as self-portraits and unpacking the research theme, which helped establish context and group cohesion. The science instructor led a conversation on detector building in the only lecture-style session in the program; other sessions were hands-on experiential learning. As the week progressed, the schedule emphasized extended blocks of detector work, providing youth with sustained time to assemble, troubleshoot, and complete their cosmic ray detectors. Scheduled breaks supported focus and smooth transitions between activities, while a midweek off-site activity provided an opportunity for social connection. The week concluded with continued detector work and a group debrief led by the filming instructors, reinforcing reflection, communication, and shared understanding of the work. Throughout the week, photography, interviews, and filming were integrated to document youth engagement and the learning process.

Participants

We had a total of eleven students who participated in the summer program (see details in the table below). The participants come from diverse ethnic backgrounds, including Iraqi, Ethiopian, Nepali, Mexican, Congolese, and Ugandan. Nine of the participants moved to the United States as children with their families, except for Habte, whose parents are refugees, but he was born in the United States, and Raphael, who had an unrecognized refugee status. We had five male and six female refugee youth, ranging from 7th to 12th grade. Youth career interests varied widely, including fields such as medicine, technology, computer science, data science, banking, nursing, interior design, and travel, with a few youth, like Raphael, still undecided. All participants were reimbursed for their week-long participation with a $200 gift card.

Table 1: Student Participants

Participants	Ethnicities	Gender	Grade in Y2	Career Interest
Leya	Iraqi	Female	9th	Family physician/Pediatrician
Habte	Ethiopia	Male	12th	Biology/Filming/Technology
Raj	Nepali	Male	11th	Computer science
Raphael	Mexican	Male	10th	Not sure
Ali	Iraqi	Male	11th	Software engineering
Naila	Iraqi	Female	7th	Data scientist
Fabien	Congolese	Male	10th	Not sure, likes travelling
Dorcas	Ugandan	Female	9th	Bank Manager
Charise	Congolese	Female	9th	Nursing
Jeanny	Congolese	Female	7th	Interior designer
Otesha	Congolese	Female	12th	Dentist

Staff Participants

The summer program was supported by a diverse team of multilingual staff members with a range of educational backgrounds and roles. Ray, a physics graduate, served as a STEM instructor, while the second author, who is a co-PI on the RESET project, served as the program director of the camp. The team also included undergraduate research assistants and STEM undergraduates who served as tutors. The program also included coordinators who oversaw the program's operations and supported both staff and students throughout the summer. English served as the primary language of communication among both staff and students; however, the program also encouraged and welcomed the use of other languages.

Table 2: Adult Participants

Staff	Ethnicity	Gender	Educational level/role in the summer program
Ray	Puerto Rican	Male	Physics graduate/STEM Instructor
Sarah	White	Female	Research Professor/Program Director
Rachel	Mexican American	Female	Education Undergraduate/Research Assistant
Megan	Peruvian	Female	Education Undergraduate/Research Assistant
Sam	White	Male	STEM undergraduate/Tutor
Leo	White	Male	STEM undergraduate/Tutor
Abdul	African	Male	STEM undergraduate/Tutor
Jesse	Black	Male	Program Coordinator
Stephen	White	Male	Program Coordinator

Data Sources and Analysis

We collected semi-structured interviews, photographs, and wrote field notes throughout the summer camp. Students were asked questions about their experiences building the detectors,

their perspectives on STEM careers, and their refugee status. We also asked about their participation in the program and how it may have contributed to new understandings of themselves and science. All data collected from the field were de-identified to ensure anonymity. The interviews were transcribed using an automated transcription service as the first step of analysis, and the transcripts were further cleaned by members of the research team. The cleaned transcripts were then openly coded by the lead author, with the research questions and our theoretical framings guiding the development of codes (See table 3 for codes and example quotes). The team held meetings to discuss these codes, which were further refined, categorized, and recategorized into themes through multiple readings and revisiting of the interview transcripts and field notes. We later finalized the themes that best address our research questions, which are discussed in the next section.

Table 3: Examples of selected codes and themes

Themes	**Codes**	**Example Quotes**
Competence and Expertise	like hands-on working on the detector	I like it because we're working with our hands, not just sitting there and listening to them talk about the detectors, cuz I know that was boring in the beginning, talking about it and not doing, trying to build the detectors. So yeah.
Supporting existing interest in Future STEM Career	STEM (Software engineering) is in my future	I think I want to become a software engineer, something like that. Mm-hmm <affirmative>, but if that never works out, then, you know, I'll have my eyes open for anything with programming or maybe something with engineering, anything like that. I,
Solidifying Confidence in STEM	Confident in knowledge of science	Like confidence in myself knowing science than before. Like, I feel like I'm more confident in my knowledge of science
Interactions supporting STEM Experience	Tutors in RESET are important relationships	It's um, tutors and, um, the kids. And like they talk to each other, you know, they're not awkward around each other

Results

Our analysis revealed four themes: (1) the program supported youth's competence and expertise in STEM, (2) the program supported existing interests in future STEM careers, (3) the program solidified youths' confidence in STEM, and (4) Interactions with staff and peers enhanced STEM experience. We provide more details on these themes in the sections below.

Theme 1: Competence and Expertise in STEM

Participating in the RESET camp supported youth in developing competence in STEM practices. Activities such as building detectors, making cables, taping the detectors, and testing them to prepare for calibration required students to engage in procedural and problem-solving work and provided opportunities for youth to take up roles that allowed their competence to be visible. Through repeated participation in these tasks, youth developed expertise in the process of detector building. For example, Habte described in his interview how hands-on engagement and repetition of tasks supported him in developing competence. He shared, "I like to learn how it works and the process. I think I did it about four or three times. I got to learn how to build it, and I would know, I would expect what comes next." Habte, though, recounted how he had to repeat the process of building his group's detector a couple of times; repetition was a process through which familiarity with scientific procedures developed. Habte demonstrated a growing procedural knowledge and increased competence in navigating complex tasks. Participating in the program also supported youth being able to see themselves as people who can participate in a scientific practice, as Ali commented, "I feel like I saw a problem that I could solve."

Our analysis also suggested that students demonstrated cross-disciplinary skills, such as art and engineering skills. For example, by assembling the scintillator, light guide, PMT, and soldering wire, Naila described her experience as gaining engineering skills, "I feel like I'm doing more like engineering". In addition, other students considered drawing, filming, and editing as activities they engaged in during the program. Habte shared how he loved the editing and filming that complemented his science learning. Because students had the opportunity to film some portions of their science activities, Habte mentioned, "I really enjoyed filming and editing". We also saw that some of the students enjoyed demonstrating their competence in arts and drawing by bringing their artistic skills into the detector building, drawing objects of interest to them on the assembled detector. Here, Charise expressed how she enjoyed taping the detectors and drawing on them. "I like how we did the taping. Actually, I like how we put out names on it, cuz it's just, it is great".

These excerpts revealed that the youth's participation in the summer program involved more than just building the detector. The process of building detectors also developed in them cross-disciplinary related identities, such as engineering and arts in physics, also blurring the boundaries between these disciplines. The youth demonstrated knowledge and competence by reflecting on their most memorable experiences and articulating both the disciplinary and soft skills they had gained from engaging in cosmic ray physics.

Theme 2: Supporting existing interest in future STEM Careers

Another theme that emerged from our analysis is the inclination of the youth towards a STEM career. In our interview, and in line with our guiding question, we were interested in knowing what the youth thought about their future and perhaps what kinds of things they would love to explore after high school, majority of the students commented that they saw STEM in their future careers, although there were youth such as Fabien who was not sure what he would do after high school, and others like Raphael and Dorcas who were most certain that they would not be exploring STEM in their future. However, eight of the youth in the camp were positive about their direction towards STEM. For example, Ali shared how he intends to pursue his dream of being a software engineer. When asked if any STEM could be in his future, he responded, "I think I want to become a software engineer, something like that. <Interviewer: Mm-hmm >, but if that never works out, then, you know, I'll have my eyes open for anything with programming or maybe something with engineering, anything like that". Similarly, Naila mentioned being "for sure a hundred percent" on data science as her future, and Otesha shared her excitement about being a dentist and "just working on teeth and stuff like that," And Leya also shared how science and technology are very much in her future as she works towards being a family physician.

Most importantly, we observed that the youth who were most certain about their future involvement in STEM were particularly drawn to the aspects of cosmic ray physics that aligned with their career interests. For example, Ali, who aspired to be a software engineer, found the calibration portion of the program most engaging, followed closely by the first-year introduction to Python, which directly connected to his future STEM goals. He shared here

> I mean mostly all of it, but the most was when you showed me the Excel sheet with the calibration, I felt like that's very sciency cuz you're collecting data and you're calibrating the machine. The sciency-est part about it was like solving the problem of what, like how you can detect the most cosmic rays with the least amount of voltage.

Ali described the calibration process as the most "sciency" part of the program for him because this aligns with his interests. Similarly, Habte, who mentioned loving filming and editing, found the filming and editing part of the program the most interesting, for which he had received much validation and recognition for creating one of the best vlogs and science videos in the program. Leya, who wanted to be a family physician, in her description of participating in the program, continually used the word *help.* She mentioned how she was most proud of helping the other team work on their gluing. She shared, "We didn't do much other than help the other team, like glue, I guess. I'm proud of that". When we showed her one of her pictures working on the detector, she also mentioned feeling sciency because she was helping out. In her words, "That felt sciency to me because I'm like helping out, you know, and I look focused". We also found

this to be true of Charise, who wants to be a nurse and a dancer, “I liked the arts. I like the detector, but just, I don't, I don't like the beginning [lecture conversation]. I just like the part where we draw.” In this case she is referring to drawing on the detector which all groups did once they completed them.

These excerpts demonstrate that refugee youth are capable of imagining a future for themselves in STEM, and science programs are not simply about teaching youth how to pursue STEM careers. Rather, programs should be approached as opportunities to nurture and expand students’ existing interests. Youth tended to find the aspects of the program that aligned with their personal interests the most engaging, suggesting that these existing interests can be further developed and cultivated through diverse and well-designed science programs.

Theme 3: Solidifying Confidence in STEM

Participating in the afterschool program, and by extension the one-week summer camp, supported refugee youth’s confidence in science. Our analysis revealed that refugee youth developed a stronger affinity for science, and helped some of the youth who previously disliked science and math in school to see these disciplines from a fresh perspective. Importantly, participation increased their confidence in STEM. Youth like Naila expressed that participating in the program contributed to her love for science, in her words, “I actually do think that the science that we do here really contributes to my love of science.” Similarly, Ali commented that he never saw himself as a scientist until he was immersed in such a hands-on experiential learning program like RESET, he shared here

> I feel like it solidified that I wanna go into STEM and wanna go into technology. And I feel like before I never saw myself as a scientist, but I guess now I could see myself as, you know, it’s possible that I can go that route. That's a door that's open for me if I ever want to go there.

In addition, Ali also suggested that participating in the afterschool program was helpful in his school science. He shared how physics got easier to learn because of the level of attention he was given in the program, compared to his physics classroom “I feel like it's a lot easier too, I feel like coming here, physics is a lot easier to learn here because when like in a big class and the teacher's teaching like 30 students, it's hard to get you know, one-on-one help”.

Participating in the program also increased the youth's level of confidence in science and physics topics. Naila shared

> I feel like it made me way more confident about science. Cause we were talking about solar, and we were also talking about cosmic rays a little, and I feel like it boosted my confidence

Leya also shared how participating in the program made her more confident in her knowledge of science, in her words, “I feel like I'm more confident in my knowledge of science.” Student conversations revealed that the afterschool program not only engaged students in experiential learning of science but also provided an opportunity for students who were having a poor sense of competence and belonging in science and math to gain a new perspective, helping them see, as Leya said, that “science isn’t that bad at all.”

Theme 4: Interactions with Staff and Peers

Refugee youth shared about how the staff, program tutors, instructors, coordinators, and their peers contributed to their overall experience in the program. Specifically, the youth mentioned the importance of the interaction they had with the tutors and instructors as very influential and supportive of their journeys into science.

Supportive Staff: Students expressed that the staff, particularly the instructors, served as mentors and that made their experiences more interesting. Naila shared that she really enjoyed communicating with the staff. She shared, “I really liked talking to all the staff, like you [Interviewer] too, that was really fun”. Importantly, Leya suggested that they developed stronger relationship with the tutors compared to physicists because they “interact more often.” We note here that while we organized trainings on culturally and linguistically sustaining pedagogies for all the staff and researchers in the program, the expertise of some of the staff may have come from years of experience beyond the scope of the program, and also may be due to their international and immigrant backgrounds, which were in some way similar to the kids. Similarly, Ali described how the supportive environment created by tutors and instructors made it easier for him to ask questions without feeling like a burden.

> I don't know anybody else that I could ask about the physics questions at school, or anything like that. Yeah. I feel like it's more of a bother, I'm talking to ask my teachers, things like that. But when I come here, and I ask, you know, ask you[Interviewer] or ask somebody else, it doesn't feel like you guys are hating it or you know, something like that.

Ali described tutors as approachable and helpful, particularly in how they engaged with him and shared real-life experiences. Despite having had an academic setback when he was stuck in Iraq during COVID, he did not experience any sense of judgment in the program. Instead, he

described the program as a space where tutors were consistently supportive and responsive to his needs, allowing him to seek help without feeling behind.

Peers: Some of the youth also recounted how their peers made them have a positive experience in the afterschool program. Charise felt supported in the program when working alongside her friends, Otesha and Dorcas, while Raphael similarly identified his friends as an important support system. Otesha elaborated on how both peers and tutors contributed to this sense of comfort and belonging.

> It's the tutors and the kids, and as they talk to each other, they're not awkward around each other..But here, you're comfortable with anybody…You feel like you have known them for a long time.

Otesha's comment explained that the ease of interaction among participants and staff in this program fostered a sense of familiarity and comfort. These findings reiterate the importance of a supportive community, shaped by both peers and tutors, in strengthening refugee-background youths' experiences and engagement in science.

Discussion and Implications

Studies [4], [37] have generously highlighted the important work STEM summer camps play in deepening youth's interest in science. Findings from this study contribute to the growing body of work, particularly for refugee background youth (e.g., [38], [39], [6]) developing identities in STEM. By examining how student experiences in the summer camp shape their interest and emerging identities, we demonstrate that refugee youth are not passive recipients of science education, but are able to demonstrate curiosity, existing science interests, and the capacity to demonstrate expertise when engaged experientially with programs such as RESET. This work challenges deficit-oriented narratives about refugee youth as learners "in need" instead supports youth agency and positions them as co-contributors to the STEM learning community.

Importantly, our findings demonstrate that supporting student interest is critical for student participation and identity development. As revealed in our study, students gravitated towards program activities that connected to their existing interests, suggesting that designing for student choice and interest within science programs is important for sustaining their STEM engagement and, in the long run, an enduring science identity [8]. This understanding can help us advance how to design informal science programs to be a site for empowering students' science interest and choices rather than transmitting science content or skills only.

In addition to this, our study underscores the potential of informal science programs to sidestep or break down the barriers refugee youth often face in formal education. Many of the youth, who had hated science or didn't imagine themselves as capable in science and math in their formal STEM classroom, expressed a renewed confidence in STEM abilities and reimagined themselves as capable participants in science by participating in the informal science program (e.g., Ali in the physics classroom vs. the RESET program). Our study suggests that informal science programs play an important role in addressing inequities in science [29]. Inclusive STEM programs need to consider both cognitive and critical dimensions of learning when designing learning experiences, to be able to validate students' competencies while promoting their engagement in scientific practices.

Our findings also reveal the possibility of informal program design building an integrated STEM experience for science learners and thereby developing students' STEM-related identity. While the RESET program was not engineering-focused, students developed cross-disciplinary STEM-related identities that included engineering, arts, and technology. Our study suggested that cross-disciplinary science programs can broaden pathways into STEM by providing multiple ways of engagement with science for students.

Our work has implications for designing and implementing STEM programs for refugee and immigrant youth. We suggest that programs that intentionally center youths' interests and immigration or cultural backgrounds can support their engagement, confidence, and sense of belonging, which are critical for sustaining identities in STEM. Future research can explore long-term science programs developed for refugee and immigrant youth to provide insights into equity-oriented approaches for promoting access and engagement for this specific group of minoritized youth in STEM.

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