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Girls' Reluctance and Intersectional Identities in STEM-Rich Makerspaces

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Abstract: Craft and e-textile circuits are technologies that bridge the gender gap in Science, Technology, Engineering, and Mathematics (STEM) learning. Acknowledging the need to study girls' underrepresentation in STEM, this article delves into the identity negotiations of four girls aged eleven to fourteen as they construct craft and e-textiles at a library makerspace. Qualitative analysis of their talk at the workshop found that several factors shaped the girls' identity work, such as their awareness of their abilities and fellow participants' projects, their understanding of parents' expectations, and their strengths in other STEM domains. While all four girls reluctantly participated in making circuits, the reason for their reluctance varied from an interest in craft and the messiness of working with conductive thread to the preference for familiarity and complexity within other STEM domains such as programming and engineering. Further, as the girls questioned their need to engage in circuit-making, their preference for a particular identity became apparent. Overall, this study's findings underscore the tensions in learning in technology-rich environments such as makerspaces, highlighting maker technologies' affordances and limitations and emphasizing the need for a deeper understanding of what shapes learners' participation and identities.

Keywords: identity; intersectionality; STEM; craft and e-textile circuits; makerspaces

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1. Introduction

The recent Maker Movement within education has renewed interest in hands-on creation, incorporating playful inquiry methods, fostering conducive learning environments, and utilizing a variety of technologies for independent and collaborative learning spaces [1–3]. As students in K-12 engage in making, they adopt roles as problem-solvers, scientists, and engineers [4], participating in STEM-rich [5] maker practices [6]. While research shows promising outcomes in learning through making, it is essential to recognize making as a multifaceted social and creative endeavor [7]. Therefore, understanding learning through making should consider the roles of technologies and innovations as well as that of the individuals involved. Based on sociocultural learning theories emphasizing continuous adaptation to activities shaping one's identity, this study explores four girls' learning and identity formation in a public library makerspace.

1.1. Learning While Making

Research on making and learning is still emerging. While there is an acknowledgment of various maker practices [8], STEM-rich making [5], and their relation to design thinking [9] and engineering problem-solving [10,11], an exploration into how makers engage with these practices is ongoing. Maker education, rooted in constructionist pedagogies, emphasizes the active integration of STEM concepts and practices, blending technology education and design-based learning with a focus on creative ideation [12]. Recent studies suggest that making fosters twenty-first-century skills [13,14], engages diverse learners [15,16], and promotes inclusivity in STEM fields [17,18]. However, researchers note that facilitator support is crucial for STEM learning through making [19], and there are limitations to a solely constructionist understanding of learning in makerspaces [20]. Balancing generous pedagogies, STEM-inclusive tools, and contextual factors are essential. This article investigates learning through making as an individual and collaborative endeavor shaped by various conditions [21]. Drawing on cultural learning models emphasizing collaboration, exploration, and innovation [22,23], it examines different forms of participation in makerspaces and their implications for STEM learning outcomes for all learners. Gendered stereotypes in STEM learning, perpetuated by beliefs about innate abilities and interests, pose challenges to inclusivity and diversity [24–26]. Such stereotypes reinforce power dynamics, hinder access to STEM for marginalized groups [27,28], and challenge maker education as well [25,29].

1.2. Making Circuits

Technologies such as paper computing, soft circuits, and e-textiles promise to bridge the gender divide in making and STEM. Fusing domains such as craft and sewing with electronics, circuitry, and computation, these technologies disrupt the notions of gender and technology use by making circuitry, electronics, and computing—traditionally masculine practices—accessible to girls and women through the use of materials and tools [30,31]. Research using craft and e-textile circuitry [32–35] suggests that the combination of traditionally feminine materials challenges gender scripts and promotes participation, particularly among girls, increasing leadership and technical engagement and challenging the perception of gender disparities in STEM fields as solely an issue of interest or ability. A study [33] involving 12- to 14-year-old Native American boys' participation in e-textile-based making showed that boys are interested in sewing and related practices but express difficulties in handling needles and conductive thread. While the boys readily related to the computational component, they also appreciated the possibility of self-expression and cultural connections. Native American girls of the same age felt empowered to explore computing and engineering concepts within their cultural contexts, bridging home and school contexts [34]. While making with e-textile components fostered a sense of agency among the girls, culturally responsive making engaged youth of all genders and backgrounds in scientific identities. Another study [36] examined how historically ingrained gender roles influence engagement with e-textiles and found that girls, more frequently than boys, assumed leadership and project ownership, perhaps owing to the materials utilized in e-textiles, such as needles, fabric, and conductive thread, which traditionally align with feminine activities like sewing and crafting. These findings suggest that e-textile components imply tacitly accepted gendered practices and can promote the re-envisioning of traditionally male-dominated areas of education. Rather than requiring learners to accommodate and fit in, craft and e-textile components reinvent STEM norms and values for learners, paving the way for equitable STEM education.

2. Theoretical Framework

2.1. Girls' STEM Identities

Identity is relevant to this article's articulation of four girls' learning while making with e-textile materials in a library makerspace and serves the goal of understanding the factors that drive and shape girls' experiences in out-of-school STEM workshops. This inquiry is necessitated by recent findings demonstrating that some STEM fields see a gender ratio of one-to-one, while others, such as physics, engineering, and computer science, are persistent at four-to-one [37]. Girls, especially girls of color, are less likely to pursue careers in STEM [38–41], and a high percentage of girls lose interest in STEM in middle school around adolescence [42–45]. Additionally, with the knowledge that adolescent girls are more likely to identify outside of STEM disciplines, this article draws attention to the intersectional [46–48] experiences of girls in STEM, intersecting social categorization that contributes to unequal experiences. Girls' recognition of such categorization and its effects shape their identity.

2.2. Negotiating Identity in Social and Historical Contexts

Identity is about being a certain kind of person in a particular context [49]. Studying individuals' identities requires attention to the complex process of becoming and one's recognition by others within a community of practice [50,51]. Who one is and who one desires to be at any given moment is constantly under negotiation and contingent upon access to resources, as well as the social, cultural, and historical context in which one seeks to author oneself with and against the expectations of others [52,53]. "History in person" [54,55] emphasizes how individuals actively negotiate their identity within the context of historical narratives and social structures that categorize them by race, class, and academic achievement. These narratives and structures are "double binds" [56] that force individuals to choose between conflicting expectations [e.g., among women, being assertive vs. being nurturing], thereby shaping identities. Envisioning futures, individuals constantly struggle against or within these larger social and institutional discourses. Despite these challenges, learning STEM is often presented as culturally and socially neutral, focusing on success measured through grades [57], reinforcing notions of an exclusive field, and shaping students' perceptions of who belongs and contributing to the marginalization of learners.

Young women of color, in particular, must contend with intersecting social markers like gender, social class, and race [58] that often clash with stereotypical images of scientists and engineers. For most women, social norms, such as expectations of femininity, conflict with the desire to be seen as someone who excels in STEM fields [45,59,60]. Validation of learners' self-perception as capable significantly impacts their views of themselves in these fields [45,51], as does recognition from teachers, peers, and family. By extension, conflicting with the norm, not having access to mentors, or not being seen as a successful learner by others present uphill challenges. Navigating the challenges inherent in the structure of STEM education requires considerable identity work, as well as the active, agentic actions and decision-making by individuals as culturally and historically shaped beings [59,60]. Through such navigation [61,62], individuals shape their participation in contexts, shaping them in a process of dialectic tension.

Intersectionality is a powerful lens for understanding the effects of race and gender but has evolved to encompass attributes such as socioeconomic class, nationality, sexuality, religion, and other dimensions within the framework of a 'matrix of domination' [46]. Further, scholars [61–66] highlight the challenge of integrating these factors without treating them as separate entities, emphasizing the need to examine the interconnected and reinforcing processes that shape experiences in everyday life [67]. Therefore, an intersectional perspective goes beyond acknowledging differences based on categories to viewing differences additively. For example, intersectional lenses illuminate how learning and becoming in STEM are entangled with identity [68] and how learners' intersectional identity networks affect perceptions [69]. Leveraging counter-narratives of resilience is crucial for learners, especially women of color in STEM [70]. Learning contexts are instrumental in shaping identities, too. For example, STEM projects serve as counterspaces for marginalized young women based on their intersectional identities [71]. Informal technology programs support the intersectional sociopolitical development of girls of color, shaping their personal and academic trajectories [72]. Attention to personal relationships, role models, authentic settings, hands-on activities, and non-stereotypical structures is essential in fostering agency, particularly in STEM contexts [73].

This article contributes to this body of research by promoting a deep understanding of STEM learning and participation by investigating the complexities relative to entangled identities and larger social systems to support youth in STEM learning as they engage in established norms and practices but are also informed by their agency, wisdom, and self-realization. Building on the above theoretical framework and body of research, this article responds to two research questions set in the context of an e-textile and craft circuit-focused maker workshop:

How do girls negotiate identity as they engage in circuit-making at the workshop?

What factors shape their identity negotiations, and what are the outcomes of this process?

3. Methods

This article's methodology is grounded in an interpretive perspective in which socially constructed and negotiated experiences [74] are instrumental to understanding.

3.1. Setting

The author collected data for this study at a Southwest American public library makerspace frequented by families with school-age children and adults. This makerspace supported free-form participation and after-school STEM enrichment through making for its patrons. The maker workshop reported in this article was semi-structured and designed to enrich STEM learning for K-12-age children by teaching participants to construct series and parallel circuits using the materials available and then supporting their use of circuits in projects of their own to take home. Over two summers, eighteen participants (aged between nine and fourteen years) attended the workshop; each participant created at least one project using each type of circuitry material. Each workshop lasted four consecutive days a week, and each session was two hours long.

The first three sessions began with a brief tutorial (connecting circuit components and instructions for series and parallel circuits using either craft or e-textile components). All participants were introduced to both craft and e-textile components. Following the tutorial, all participants worked individually or in teams on at least one project that included the circuit type for the day, including studying and repairing a circuit in a toy (Table 1). At the end of each session, the participants shared their projects and discussed possible improvements. The participants could create a big project on the workshop's final day, including any circuit component and design. At the end of each workshop series, the author, who was also the workshop facilitator, informally interviewed the workshop participants, asking them questions about their experiences at the workshop, whether they considered their project work a learning and STEM learning opportunity, their hobbies and interests, and their future project and STEM learning plans.

Table 1. Workshop modules and goals in alignment with principles of STEM-rich making.

Principles of Making	Principles of Making in the Context of Circuit-Making	Alignment of Principles with Workshop Goals
Exploration of materials, tools, designs, and ideas	Explore materials and circuit designs to express ideas.	Create a project that needs a circuit (series or parallel, using materials of choice), or add a circuit to an existing artifact to add to its functionality.
Application of knowledge	Consider circuit designs in the context of maker projects. Consider suitable circuit designs are suitable for maker projects.	
Persevering in understanding and developing ideas	Identify problems, understand them in context, and consider potential solutions. Consider changes that can be made in the context of the maker project.	Identify attributes of projects that need to be modified. Understand how these can be modified.
Communicating ideas to others and collaborating with others to innovate and ideate	Talk about project ideas with others in the space, seek other perspectives on ideas, and remix ideas, projects, and circuit designs.	Engage with and learn from others' ideas.

Each participant was allocated a workstation but was free to move around and collaborate. Recording devices (a laptop with the screen facing the participants) were placed at either end of the table to record workshop activities. Two small digital cameras and two cell phones were available for participants to record their projects and other projects that they found interesting. Even though the data analyzed in this study were collected in 2016 and 2017, the topic of this article, which focuses on the complexities of learning in STEM-rich makerspaces, remains an area of interest for educators, researchers, and community members. A university ethics review board approved the study design, and all study participants and their accompanying adults provided informed consent. All names used here are pseudonyms.

3.2. Participants

This article reports findings based on the analysis of four girls' participation in the workshop: Ava (fourteen, Caucasian), Jazmine (eleven, African American), Amy (thirteen, Caucasian), and Valentina (thirteen, Latiné). These girls were reluctant to fully engage in the workshop despite demonstrating the ability to independently construct circuits. While other participants took on ambitious projects and proudly demonstrated these to their peers, these girls created the circuits but did not develop them fully into ideas, demonstrating a lack of personal connection and input. This article is motivated both by their reluctance and the need to understand some learners' lack of engagement in technologically rich learning environments.

3.3. Data Analysis

Overall, the data analysis procedure was guided by the assumption that individuals traverse through numerous contexts, each carrying diverse meanings and interpretations. Individuals' access to and positioning within these contexts, as well as their figuring of the structure, dictates their agentic identity negotiation within them. In addition to the above, the analytical approach also considers learning as the process of becoming a particular kind of learner within the context of the makerspace. It is important to note that this analysis does elaborate on the learners' racial and ethnic identities despite the attention paid to these in the STEM identity literature. This is because the girls themselves did not mention or indicate their racial and ethnic identities as instrumental to their participation. Their gender identities reflect their description of themselves.

The analysis began by creating detailed profiles for each participant, including background details gathered from workshop recordings and field notes (e.g., current school grade, hobbies and interests, how they felt about participating in the workshop, their plans for pursuing circuitry and making after the workshop ended, and if they considered the workshop activities to be STEM), and post-workshop informal interview transcripts. These profiles were narratives capturing learners' experiences as situated actions [75]. Codes were identified in response to the following broad questions to highlight intersectional influences and the identity negotiation of the four girls at the workshop. First, at the intersection of which factors (interest or lack thereof, influence, specific STEM domain, craft) does this individual's participation exist? Second, how do these factors shape this individual's figuring of self in activity (support, detract, overlap, excite, question)? How are these factors related to each other (positive, negative, neutral)? How do combinations of different factors shape the individual's figuring of self (toward STEM, away from STEM, questioning)? This constituted the first step of the analysis and resulted in discerning patterns in the girls' identities, such as the resources they employed and their roles in socio-cultural contexts.

The following deductive step constituted understanding how identities and resources interacted in different contexts and varied among the girls, especially regarding their participation at the workshop, their interests, others' perception of them, and their inclination towards making and circuitry. This understanding supported the development of themes (preferences for a certain kind of STEM because of identity implications, preference for certain kinds of engagements shaped by parental expectations, a lack of interest in craft and making because of identity implications, preference for craft and STEM as a result of imagining possibilities in these domains, recognition of a number of factors shaping participation, and deciding not to persevere in recognition of learning and identity challenges). With attention to the interplay between the above elements, identity outcomes, and the girls' involvement in the tasks, as well as the resulting interpretations of the girls' identities, syntheses of the findings were created for Ava, Jazmine, Amy, and Valentina. Condensed syntheses are shared below, along with details of the participants' maker projects.

4. Findings

4.1. Ava

> "It's quite difficult. . .Sewing circuits is not even just sewing; I don't make the rules, like in cross stitch. . .Craft's difficult too, but it is pretty, which is rewarding for me. . .My Dad's an engineer, so he keeps telling me that STEM is full of possibilities, jobs and a career. . .It gets a bit too much. . .I just don't see why I need to do this, be here. . .Everyone around me was younger and so energetic. . .Just like that, their project was done and it was amazing. . .I'll just keep doing what I love."

Ava, the oldest participant in the workshop, was an enthusiastic crafter who found it difficult to engage with circuitry components. Despite the similarities between circuitry and traditional sewing and craft elements, Ava struggled to adapt to the workshop environment, where energetic, collaborative ideation was the norm. She felt out of place among the younger, more adaptable participants who quickly grasped the use of circuit components. Ava worked on a craft project and embellished it with two LEDs and a battery unit sewn into a piece of felt. She covered the circuit with another piece of felt and placed an origami swan on top. Ava considered her project to be unimpressive. Although her parents had taken her to several workshops and local STEM events in an effort to encourage her interest in STEM, Ava found it difficult to relate to STEM topics and open-ended learning environments. She described herself as "okay" at school science and math but felt that she had let her parents down by failing to engage meaningfully in the workshop. Ava's experience at the workshop underscored a gap in our understanding of learners' difficulties in learning STEM in makerspaces.

"If it interested me, I could learn, but I just don't see why I need to do this, be here". As Ava distanced herself from the workshop activities, she hoped to explore and blend technologies into crafts in her own way. While e-textile components did not afford Ava a pathway into circuitry, she used her project to reinstate her identity as a crafter, a daughter of STEM enthusiast parents, and a learner who preferred school-like direct instruction. Overall, Ava's experience embodied her parents' aspirations and efforts, her difficulties in relating to STEM topics, and her discomfort with certain ways of learning. Despite her lack of interest and need to pursue circuitry in the workshop setting, Ava's experience provides valuable insight into the importance of creating more inclusive and diverse learning environments in makerspaces.

4.2. Jazmine

> "I like this as a craft, but craft got difficult. . .I've always liked making stuff. . .Some kids were making bug robots that could move around and stuff, and mine was just 'meh'. . .I think I could ask for help. . .This was Dad's idea, so he needs to help me. . .I'm just going to try harder and see what happens. Dad got me into this, so he'll have to help me, you know what I mean?"

The workshop was Jazmine's first foray into informal STEM workshops. Like Ava, her father encouraged her to be a STEM professional, specifically, an engineer. At eleven years old, Jazmine was more optimistic than Ava, but she also felt she lacked the skills to construct circuits successfully. Like Ava, Jazmine compared her projects to others' and concluded she was not good enough. Although Jazmine heard from her father that engineering was fun and engaging, she was unsure of her prospects in the field. She made a felt tie with two LEDs sewn together in a series circuit and marveled at the other participants' projects. At least one other participant admired Jazmine's skills with felt and scissors, "It's difficult to cut out tiny patterns, you know?" Despite feeling only marginally successful, Jazmine planned to keep trying, hoping she would feel more confident as a learner. She used her project to inquire into the kind of learner she was and wondered if she could align her views of STEM with her father's.

At the same time, Jazmine also questioned her father's aspirations for her and beliefs in her abilities but was optimistic that she would feel better with her father's support. Her father's inspiration and encouragement offered her hope. Like Ava, Jazmine did not find felt swatches and craft resources inviting enough to confidently explore circuitry, despite independently sewing a series circuit into her project. She considered circuitry to be an extension of her father's interest in STEM. Jazmine negotiated her identity at the intersection of a crafter, a loving daughter, an optimistic learner at school, and a learner whose skills and success need to be affirmed externally. "I felt way out of my league, like, maybe I'd made a huge mistake trying to get into something I am bad at, but maybe I could ask for some help". Feeling a sense of failure, Jazmine cautiously identified as a STEM learner.

4.3. Amy

> "I would say that I am like an eight, programming-wise, but a two, craft-wise. . .I have not crafted since first grade, but I thought it would be good to try something new. . .These two things (programming and circuitry) are very different. . .The editing is different. . .There's a way to be careful, but if you can't fix it, why try circuitry at all?. . .I don't think I want to try circuitry; I like programming better. . .Maybe I will get someone to work with me, and then craft can be their expertise, and programming can be my expertise."

Amy considered tinkering with circuitry materials to be a craft, something she had not liked since first grade. She was a self-taught programmer and an adventurous and independent learner. Deciding that she only wanted to dabble in circuitry, she sewed the simplest series circuit on a piece of felt. Amy did not work on any projects; however, unlike Ava and Jazmine, she felt more competent than the others at the workshop. Amy expressed a preference for complexity in programming. "Just like writing a program, (in circuitry) you never know what will go wrong until you try it out". She compared learning through trial and error in programming to sewing, highlighting the importance of encountering challenges. Amy demonstrated an interest in e-textile circuitry but did not want to sew or craft. Rather, she hoped to collaborate with someone who had these skills.

> "I like complexity, but like the floss in tangles, you can't fix in any way other than cutting the floss to reconnect the circuit. So, like, try more complex designs using the microcontrollers; what can I connect to it rather than sewing the circuit? I would say that's my strength."

Despite feeling frustrated by the conductive thread tangles, Amy envisioned possibilities for circuitry projects. Through her mention of the differences in editing code (as opposed to repairing a tangled e-circuit) and the need for care, she demonstrated a good understanding of what programming entailed and that it took special skills to be a good programmer. However, Amy did not want to commit to anything that felt like crafting or needed to be fixed differently, indicating a preference for familiarity. The conductive thread, needle, and felt swatches deterred Amy, while the LEDs, batteries, and microcontrollers helped her reiterate her preference for programming. Having gained some expertise in programming, Amy was reluctant to start as a novice in the domain of circuitry; her identity as a programmer conflicted with her identity as a maker. At the same time, perhaps Amy's skills as a programmer helped her envision prospects in STEM. Amy clarified her priorities, "I think the most valuable thing was learning that it's okay to try something totally new. I learned that I could do it if I tried hard enough, but I don't want to". Clearly, Amy understood where and with which tools she wanted to be an adventurous learner.

4.4. Valentina

> "I take pre-engineering, so I can relate to this very well. . .No one can avoid problem-solving altogether, just different kinds of problems. . .I like that there's a STEM learning side of it and a crafting and fun side of it. . .I have always thought of engineering as building things to solve problems. . .I will try this for my science fair project, just don't know exactly how."

Valentina attended a K-12 STEM program and was enrolled in pre-engineering classes. She was confident of her ability in STEM. Like Amy, Valentina put together a simple series circuit on a small felt swatch, placing two heart-shaped felt cutouts underneath and above it. Valentina felt positive and confident about her participation in the workshop and future STEM endeavors. She demonstrated an understanding of the importance of problem-solving in engineering.

> "I liked stepping out of my comfort zone and trying this; I will have to get better at sewing and then sewing circuits because they are both important. Learning to sew is difficult enough, but with this, you have to sew in a particular way. Regular thread forgives you, but not this one."

Unlike Amy, Valentina valued craft as much as engineering and expressed an interest in pursuing a circuitry project for her school's annual science fair. However, Valentina's lack of a specific plan for the science fair project did not make her feel poorly, nor did she feel the need to compare her circuit to that of others at the workshop, as Ava and Jazmine did. Valentina was secure in her understanding of her abilities. Her affiliation with the STEM school likely helped her develop a strong STEM identity, which became relevant at the workshop. In addition to identifying strongly with the field of engineering, Valentina found the craft-like quality of e-textiles fascinating. Never having explored circuits before, Valentina was committed to learning to use e-textile components for a science fair project. Clearly, the components served as Valentina's entry point into circuitry, but Valentina expressed a preference for math. "It was fun, but it's not really my thing. I like solving math problems more. I'm glad I tried it, but I think I'll stick with math". Valentina expressed her experience positively and identified as a crafter and a future engineer at the intersection of STEM and learning in school and out-of-school settings. Like Amy, Valentina expressed her frustration about conductive thread and preferred familiarity. Circuitry was not meant for her in the long term.

4.5. Summary of Findings

The above findings indicate that some identities, such as that of an independent learner, a learner comfortable with uncertainty, and learners who are good at using technology, are more likely to be affirmed and become relevant in the context of a makerspace (Figure 1). All four girls were aware of the prevailing stereotypes about craft, STEM domains, and materials [36]. Further, in the context of the makerspace, the negotiation of some identities, for example, that of a crafter or a learner with interests other than STEM, led to tension and challenged the learners. Other identities, such as that of a programmer or a learner attending a STEM school, supported STEM identity negotiation. Learners like Amy and Valentina had established a strong STEM identity prior to attending the workshop and were confident in their ability to perform the identity to be recognized by others and feel competent overall [76]. It is also likely that disciplinary STEM identities in relation to computer science and engineering are relevant in makerspaces just as they are in schools, which is why Amy and Valentina felt comfortable enough to express their lack of interest and ideas without supporting them with innovative artifacts. These observations are particularly relevant to our understanding of STEM identities and identity work in the context of makerspaces and based on the knowledge of the robust and pervasive nature of disciplinary identities and stereotypes about craft and making. Neither of the four participants demonstrated a strong interest in making circuits and constructing artifacts with circuitry materials, which was the workshop's primary goal. Yet, they demonstrated distinct identity work, highlighting gaps in our understanding of learning and identities supported in makerspaces. Some other tensions, such as the ones below, deserve mention, too.

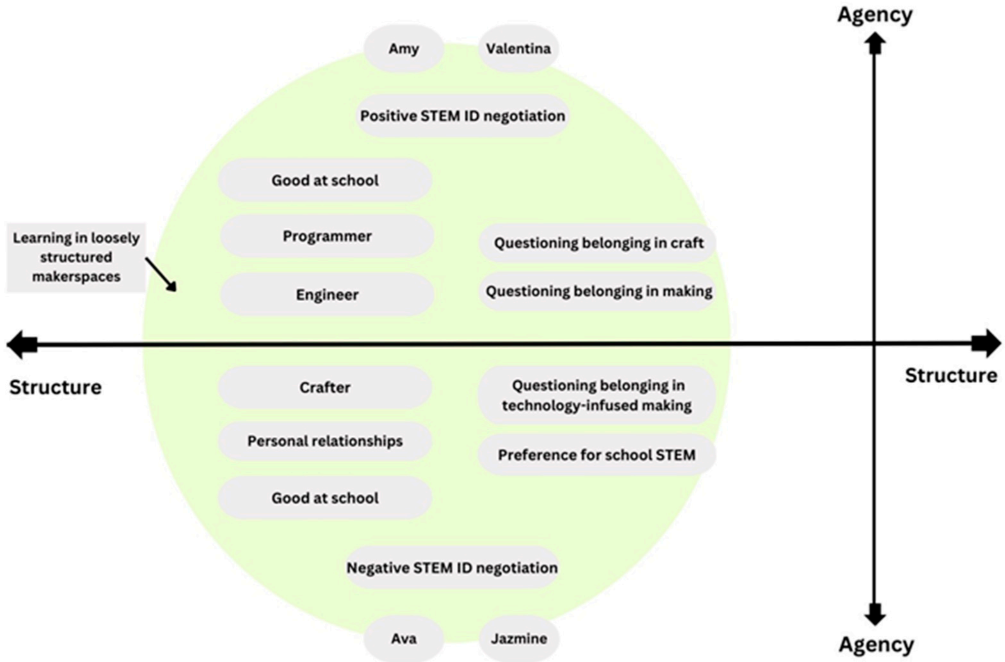

Figure 1. An illustration of maker identities as a function of structures informing STEM learning and learners' agentic identity work in recognition of the structure.

The above analysis demonstrated that we must avoid viewing STEM identities as monolithic. Further, these observations of interactions between identity attributes (for example, a robust disciplinary identity and its interaction with a general STEM identity) that intersect need to be further researched. Ava, Jazmine, Amy, and Valentina felt differently about their participation in the workshop. While Ava considered herself the most unsuccessful, Jazmine felt moderately successful. Both girls felt that their projects were less ingenious than their peers'. Each girl was introduced to this and other STEM workshops by a parent who wanted them to pursue a STEM career. On the other hand, Amy and Valentina felt successful at the workshop and did not feel the need to compare their work against that of other participants. Neither girl mentioned the role of a parent in motivating their participation in the workshop, pointing to the importance of early, learner-initiated interests and how these, when compared to interests nurtured by others, lead to different trajectories and outcomes. Family, friends, and community support must align with learners' interests [77,78] to positively impact learners; missing the personal connection with STEM disciplines, it is perhaps difficult for learners like Ava and Jazmine to feel successful. Valentina's experience suggests that exposure to STEM experiences across many domains may contribute to a multifaceted STEM identity. Jazmine and Ava's preference for direct instruction highlights the impact of learning environments on STEM engagement, suggesting that an individual's preferred style of learning can shape their identification with specific STEM activities. Makerspaces that emphasize independent, unstructured, and self-initiated collaborative learning might contribute to intense identity work to identify out of some domains of learning, in this case, circuitry.

The above findings add to a well-established research base supporting the importance of disciplinary identities within communities. As learners integrate into a community, one aspect of their disciplinary identity, such as a STEM identity, may become stable while another aspect may become fluid and even less certain [79]. The degree to which learners envision their future selves in STEM disciplines influences the stability of their existing identities within STEM fields, suggesting that learners connect their aspirations, engagement in STEM practices, and STEM identities, reinforcing a loop. Practice-linked identities, a connection between oneself, and the practices associated with a particular field [29] are relevant here, too. Individuals are more likely to actively participate in disciplines when they feel this connection between their personal identity, their aspirations, and the practices involved. Therefore, the findings of this study suggest that a strong sense of connection to STEM practices can enhance engagement and participation in STEM-related activities, while the lack of a connection can lead to unproductive tensions for learners.

5. Discussion

This article highlighted the intersectional identity work of four girls at a circuit-making workshop in a library makerspace. The girls' identity negotiations were multidimensional because they were affected by factors such as interest in a related domain, an inclination for independent work, willingness to seek help, a pre-existing robust learner identity affirmed by people close to them, and an overall approach to learning. Further work in this context merits attention in the following areas.

First, although social and parental support in learning is greatly desirable, in some cases, parental encouragement for STEM participation can be troubling. Although the girls described their parents' encouragement differently, it is clear that they needed empathy from their parents, an understanding of *their* interests (Ava), and learning support (Jazmine). Amy and Valentina, on the other hand, never mentioned how they developed an interest in STEM, making, and related domains. Although parents often shape school choices and hobbies [80–84], we see here the impacts of parents' and learners' unquestioned and overly positive perceptions of STEM learning and careers that complicate learners' experiences [69,80,85]. The interplay between such perceptions and learners' experiences and identities needs to be studied across learning contexts, beyond first-generation and underrepresented learners.

Second, we have frequently assumed that crafting, storytelling, etc., can serve as segues into STEM learning. These four girls' experiences demonstrate that we must delve deeper into understanding the nature of these segues and whom they serve. For example, craft and engineering both require considerable problem-solving, but as Valentina articulated, engineering is more solution and outcome-driven than craft. This focus on solutions and functionality might take away the joy of crafting and bricolage for learners like Ava. Hence, for learners like Ava, craft would not serve as an entry to STEM. Amy, too, preferred construction and problem-solving in programming over circuitry because complications with e-textile circuitry troubled her, suggesting that some learners prefer to engage and solve problems only within preferred domains and for reasons that we do not immediately recognize. Hence, in the context of a STEM-focused makerspace, magnifying the worth of one domain (e.g., the circuitry aspect of craft circuits) diminished the value of some skills (e.g., craft) and identities [68,85]. The rise of interdisciplinary learning compels us to examine how identities and practices intersect and interact, influencing learners' experiences, and we must consider how these shape learners' experiences. Acknowledging and addressing these intersections can create more inclusive and meaningful learning experiences that recognize learners' diverse interests and perspectives. At the same time, such recognition of overlaps between domains of practice can help learners develop a deeper understanding of STEM disciplines and what these disciplines mean in relation to the world and their lives [86–89].

Third, girls who were already accustomed to learning independently and unraveling a particular kind of material and process-related complexity felt more successful at making. Others, despite attempting to surmount significant challenges, felt less accomplished and found little appreciation for who they were [68,90,91]. All four girls' reluctance and unique identity work provide the context for understanding reluctant participants as learners who prefer learning in another domain, likely feel challenged in technology-rich learning environments, or refrain from participating because they are already good at something equally complex and do not feel the need to challenge themselves further. However, identity work varies greatly, even among learners who demonstrate similar learning outcomes.

Further, the four girls described in this paper negotiated and enacted their identities based on their understanding of themselves, their aspirations, and what participating at the workshop entailed, implying that they (and those around them) had interpreted our encouragement for girls in STEM in a certain way. While their interpretation of STEM and what it entails is positive, it is simultaneously underdeveloped and yet solidified. We must untangle these interpretations in the context of learners' current and future trajectories through increasingly interdisciplinary STEM practice. A well-rounded understanding of what learners interpret as meaningful STEM learning, what it affords them, and their response to our gaze on them as STEM learners is crucial for us to understand what these identity negotiations mean for them. Since productive learning experiences involve multiple means of participation and collaboration, Ava, Jazmine, Amy, Valentina, and many others must understand that how they see themselves in relation to STEM will continue to evolve.

Finally, while maker and technology-infused and mediated learning environments are generally known to be beneficial for learners, this paper shows that many tensions and complexities arise when learning with technologies and in relation to the domains of technology use. Clearly, the draw of craft materials worked only to a certain extent before the need to consider these materials as circuitry components became more critical, indicating that to oversimplify learners' experiences by viewing learning while making solely as fun and inviting learning experiences with friends is inaccurate. Hence, interpreting maker education and learning while making at large and complex intersections such as the ones described in this paper benefits scholarship in this area.

6. Conclusions

In conclusion, this article was attentive to four girls' intersectional identities in the context of a makerspace. In thinking about learning as culturally organized and learners' participation as advancing or hindering their social recognition 91], the article highlighted the resources available to the four girls across contexts and their relationships with other learners, materials, and disciplines. Their identities at the makerspace were at the intersection of several factors shaping their lives, and some intersections proved to be more relevant and powerful. In considering how learning technologies such as circuitry components shape access for different types of learning and learners, this article articulated that identities are intertwined with relational, emotional, and material elements, consisting of practices and routines constructed and accumulated over time and encompassing experiences of success and failure.

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