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Maker Identity Development: What and How?

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Abstract: Focusing on developing maker-identities, especially for historically marginalized students in the computational field, can empower them to recognize and take ownership of their space in the field. Drawing from identity related literature in maker and computing related fields we identified seven factors of maker-identity - interest and motivation, competence and performance, confidence and self-efficacy, recognition, utility value and meaningfulness, perceptions of community, and external factors. Using this, we analyzed semi-structured interviews of students who participated in our summer makerspace camp to understand how these identity factors manifested in their reflections of the camp. We tie back our findings of positive impacts on maker-identity structures to the design structures of our makerspace such as co-design of the space, use-modify-create strategies, and open-ended design projects.

Introduction

Despite efforts to allow for participation and engagement of historically marginalized racial, ethnic and gender groups in STEM and computing fields, its demographic distribution is nowhere close to reflective of the general population. NACME's 2021 Research Brief showed that despite over 30% representation of underrepresented minorities in the United States, they only represent 18% of computer (CS) and information (IS) sciences and 15% of engineering bachelor's degrees. Hispanics or Latinos earned only 10% of CS and IS and 11% of engineering degrees, and Black or African Americans only earned 8% and 4% respectively.

Makerspaces are one approach that scholars, practitioners, and administrators recognize as having the potential to address this issue given their ability to provide students with access, resources, expertise, and a space to engage in hands-on computing and STEAM activities (Halverson & Sheridan, 2014; Blikstein, 2013; Presidential Proclamation - National Day of Making, 2014).

However, lack of access is only one of the innumerable barriers that minoritized youth must face when navigating the fields of STEM and computing. Despite their potential to bring more people into CS and engineering, makerspaces continue to be mostly dominated by White and Asian males. Thus, with systemic racism and traditional gender norms having impacted these fields over the years, access to makerspaces alone is not going to allow traditionally minoritized youth to recognize it as a space for them and to start engaging in these activities as their own. To make these spaces more inclusive and inviting to these young learners, we need to design these spaces and their curriculum in ways that are more culturally responsive and empower them to engage with the material on their own terms (Scott et al., 2015).

Various factors impact how students learn. As highlighted by Vermunt (1996) and Trujillo & Tanner (2014), cognition, metacognition, and affect play a role in learning; cognition being the mental process associated with learning, metacognition being the awareness of those processes, and affect dealing with the feelings arising when learning. In the case of historically marginalized students, who have received implicit and explicit messages about their participation in STEM and computational settings, affect is a very important factor to consider. As detailed by Trujillo & Tanner (2014), the affective domain consists of - but is not limited to - self-efficacy, sense of belonging, and science identity. Further, as discussed by Nasir & Hand (2008), identity, engagement, and learning are heavily intertwined such that when an individual feels that their identity is linked to a setting, they are more engaged and learn more. Additionally, while there has been research recognizing the importance of identity in CS and engineering (Mason & Rich, 2020; Godwin, 2016), there has been far less research on how this manifests itself in computational makerspaces specifically, and even less on what specific constructs define one's maker identity. In response, as part of a two-week long makerspace with students from Black/African American and Hispanic/Latinx communities, we aimed to understand the following two research questions:

1. Which factors of our participants' computational maker identity did our makerspace impact and how?
2. What particular design structures of our makerspace and curriculum resulted in these impacts?

In this paper, we refer to the development of computational maker identity as an expansion of computational identity (Tissenbaum et al., 2019), to include crafting, building and other non-computational skills.

Background

Identity as described by Gee (2000) is being recognized as a certain kind of person in a given context. A simple breakdown of this definition indicates that identity is contextual. Gee (2000) outlined four different ways to view identity, one of which is Affinity-identity, which he describes as a way of looking at who the person is. He suggests that those with a specific A-identity are a part of an affinity-group i.e., a group of people who share little besides their interest in something i.e.: the affinity. Along the same lines, Nasir & Hand (2008) define practice-linked identities as those that are linked to participation in particular social and cultural practice.

With makerspaces becoming a popular community of informal learning and tinkering over the last decade or so, scholars like Pinkard et al. (2017) are doing valuable work to incorporate identity, sense of belonging and computing empowerment into makerspaces like Digital Youth Divas. However, there is still work to be done to recognize what constitutes a "maker-identity."

Factors impacting identity development

In order to develop a framework for operationalizing identity in our computing makerspace we reviewed the research into science and engineering identity (Carlone & Johnson, 2007; Hazari et al., 2010; Godwin, 2016), computational identity and empowerment (Kong et al., 2018), coding attitudes and identity (Mason & Rich, 2020; Washington et al., 2016) and engagement and persistence of minority students in certain STEM fields (DuBow et al, 2017; Nasir & Hand; 2008). Students in our makerspace utilized a variety of these computing topics when engaging in making. Conducting a thematic analysis of prominent computational identity literature, we extracted and grouped the various identity factors under seven broad themes that would contribute to computational making identity development in our makerspace (see Table 1).

Table 1
Factors influencing computational making identity

Theme	Description
Interest & motivation	Defined as "A person's likes, preferences, favorites, affinity toward, or attraction to a subject, topic, or activity" (Godwin, 2016, p. 4). Interest is used by Godwin (2016) and Hazari et al. (2010) as a measure of engineering and physics identity respectively, and by Mason & Rich (2020) and Washington et al. (2016) as a construct to measure students' coding attitude, and CS attitude and identity respectively. Talley et al (2017) use motivation as a measure of self-efficacy when measuring the change in maker-identity in college students.
Confidence & self-efficacy	Confidence has been shown to impact coding attitudes (Mason & Rich, 2020) and identity (Washington et al., 2016). Talley et al. (2017) used self-efficacy as a measure of change in maker identity. Kong et al. (2018) measure creative and coding self-efficacy as factors of programming empowerment.
Competence & performance	Competence and performance are defined as "students' beliefs about their ability to perform the practices of their discipline and understand the content of their discipline" (Godwin, 2016, p. 4). Used by Godwin (2016), Hazari et al. (2010) and Carlone & Johnson (2007), as a measure of science/engineering identity development. Nasir & Hand (2008) suggest that becoming competent in a subset of activities is essential to the engagement and practice in the space.
Utility value & meaningfulness	Entails the students' ability to see the practice fit or apply into their current or future lives (Wigfield & Cambria, 2010). Used by Mason & Rich (2020) to measure student coding attitude and identity. Kong et al. (2018) use meaningfulness (Schiefele, 1998) and impact as factors of programming empowerment.
Recognition	A key measure in science and engineering identity framework (Carlone & Johnson, 2007; Hazari et al., 2010; Godwin, 2016), recognition has been defined as the feeling that others see you as a good science or engineering student.
Perception of the community	Mason & Rich (2020), Washington et al. (2016) and DuBow et al. (2017), show that how a student perceives the community (stereotypes about it, and what being a part of it means to outsiders) impacts a student's willingness to identify with the community.

External environmental factors	Factors such as access to domain, social support, preparation, family influence, structural barriers, social value, school attitude towards the practice play a significant role in whether a student engages and eventually identifies with the community and practice. (Mason & Rich, 2020; DuBow et al., 2017; Nasir & Hand, 2008)

Methods

Study Design

The Connected Spaces makerspace curriculum was conducted over two weeks in the summer of 2022. The participants were 18 middle school students, who were recruited from two local community organizations: DREAAM, working primarily with African American/Black and Latinx/Hispanic boys and The Well Experience with African American/Black and Latinx/Hispanic girls. The makerspace was set up on the campus of a large Midwest public university. The students participated in maker activities from 9am to 12pm for 10 weekdays, followed by lunch at a university dining court. Learning from a similar camp run the previous summer, we knew that significant support would be needed, particularly for students' final projects. To this end, 6 researchers and 3-4 mentors from the community organizations were present throughout to support the students.

The structure of the makerspace was intentional, but also flexible, with the researchers debriefing at the end of each day, to modify the next day's activity. For Week 1 of the camp, the students engaged in a modified use-modify-create structure (Lee et al., 2011), in which they started by making a simple mini project centered around the Circuit Playground Express microcontroller (with basic maker components such as LEDs, Neo pixels, sounds, touch sensors, and motors) by following instructions, that they would then modify and add onto. The choice of the microcontroller was driven by its compatibility with block-code, which we concluded would work best for middle-school students. On Day 6, students took part in mind-mapping activities to help them think about their own identities and values. On Day 7, the students were provided outline worksheets, on which they brainstormed their final individual project ideas and started thinking of the materials they might require. The last three days were spent building their final projects. On Day 10, community members, parents, and university staff were invited to an "open-house" of the students' projects, where the students demoed their projects. They also created display boards, to talk about their process and intention of creating these projects.

Data Collection

On the last two days of the camp, we interviewed five of the eighteen students. These students were chosen due to a variety of factors: consistent attendance (with some variation), prime demographic (age), and being relatively representative of the entire group (previous skill and experience). The semi-structured, one-on-one interviews were recorded and transcribed. Each interview lasted approximately 10 minutes and mainly consisted of questions regarding their makerspace experiences and final projects. We conducted a thematic analysis (Nowell et al., 2017) of the literature above to derive 36 initial factors (some repeating) indicating or influencing identity. After an initial inductive qualitative (Thomas, 2006) review of the transcripts, 18 of the factors were shortlisted as being present in the interviews. These 18 were then further grouped down into 7 categories (see Table 1). The interviews were then coded with these 7 categories each time a student indicated an impact on or due to a category. Iterative review of literature and analysis of coded data led to in vitro coding of the subcategories for each of the five students analyzed (see Table 2). Reflecting on the researcher debriefs after each camp day, as well as the planning documents and conversations, we were able to connect our findings to the curriculum design and decisions we made while creating the makerspace. Other data such as field notes, observations, photos, videos and audio recordings were also used to support these findings and connections to our makerspace design.

Findings and discussion

In this section, we will highlight some of the key instances in the interviews, where students indicated how certain factors of their identity were impacted, or in turn played a role in their makerspace experience. We will also further analyze the design decisions and structures of our makerspace that might have led to these impacts. Table 2 shows the maker identity factors each student mentioned in their respective interviews.

Table 2
Ways that each maker mentioned the structures of maker-identity

Makers:		Alexandra	Jasmin	Keith	Leo	Trinity
Interest and motivation	Interest was shown	*	*	*	*	

	Making was tied with previous interests	*	*	*	*	*
	Previously interested in some part of making	*	*	*	*	
	Showed continued interest in making	*	*		*	
	Making interest was developed	*	*	*	*	
Confidence and self-efficacy	Confidence was developed	*	*	*		
	Showed confidence to be a mentor		*	*	*	
	Self-efficacy was developed			*		*
Competence and Performance	Showed competence	*	*		*	*
	Competence was developed	*	*	*	*	
	Had previous competence				*	
Utility and Meaningfulness	Could see utility in making	*	*		*	
	Showed meaningfulness in making	*	*		*	*
Recognition	Showed recognition of self	*				
	Wanted to be recognized		*			
	Was recognized by mentor			*		
	Showed recognition of their friend					*
Perception of community	Showed change from previous perception of community	*	*			
External factors	Previous access to a part of making		*		*	
	Lack of previous access to a part of making	*		*	*	
	Mentioned social factors				*	*
	Making interfered with other interests			*		

Figure 1
Final Projects: Alexandra's dog collar project (a) and Leo's trash-pick-up robot project (b)

(a) (b)

Interest and motivation

All five participants were able to tie in their experience at the makerspace to some previous interest that they already had. Some talked about how their interests could be impacted through making, while others created final projects that integrated making into something they were passionate about. For instance, Alexandra decided to make a dog collar (Figure 1(a)) that would light up in different colors based on the dog's health conditions because she "[wants] to be a vet. [She wanted] to invent something for animals, especially dogs, because [she] has a dog." Leo created an automated trash-pick-up robot (Figure 1(b)), inspired by a video game he enjoyed. Four of the students came in with previous interest in either electronics, making, or inventing and the same students showed interest during the camp. When Jasmin was asked about her interest before the camp, she "thought [making] was boring," but at the end of the camp her view changed to it being fun and her stating "I want to come back!"

These experiences can be tied back to several of our early design decisions for the camp. For instance, based on earlier co-design sessions with other youth at these organizations, we creatively grounded the mini-project activities into pop-culture (like Marvel) to make them more relevant and build interest in the students about the tools being used. Secondly, the success of the open nature of the final projects seems to have stemmed from the two days of self-reflection of their identities, interests, and values. Examinations of the students' mind maps largely showed a tight connection between what they wrote during these sessions and their final projects.

Confidence and self-efficacy

We anticipated that having students engage in the use-modify-create in each mini project during Week 1, would enable them to develop their confidence by allowing them to progressively take on more personal and creative agency in their work. Students could build a simple basic project by following a step-by-step guide, and once they gained confidence in that skill, they could modify their projects in their own ways. This allowed for a low-floor-high-ceiling model where the students could slowly increase their confidence. The success of this approach was shown in students recognizing their growing confidence in making as they went through the camp. For example, Jasmin stated that the camp "changed me, 'cause like I didn't know [before the camp]… like… me? doing this?! It's hard. But now it's like, kind of easy for me to understand stuff and how it comes together and makes lights and movement." Some students also showed increased confidence in mentoring others, with Jasmin indicating excitement around being able to teach others how to do what she learned.

Competence and performance

Based on observations from the previous summer's camp, we recognized that students often failed to build their competence if their learning was not scaffolded first. This prompted us to have Week 1's curriculum expose the students to various maker components in low-stakes, scaffolded projects. This was also in response to the "keychain syndrome" which highlighted that students tended to fixate on basic projects they are first introduced to (Blikstein & Worsley, 2016). When interviewing students and examining their final projects, we found that they were able to extend the components and their making skills in exciting ways. All five of the students indicated that they were competent or developed competence through their projects and the maker activities. When Alexandra was asked what valuable skill she learnt, she said "coding is really easy when you just like pay attention." Alexandra also showed surprise at her own performance that she "actually just made a dog collar like this", which used several of the Week 1 components (light sensor, temperature sensor, LEDs) in ways that extended far beyond the originally scaffolded activities. Across all the students' projects, we observed similar outcomes where they extended the maker skills, they learned in Week 1 in new ways around personally relevant projects.

Utility value and meaningfulness

Researchers observed that many of the students were able to see the utility value and meaningfulness in their making through the intentionally open-ended final projects. Most students created projects that were driven by their previous interests and communities, which they identified during the two days of project brainstorming and self-reflective mind-mapping activities. For instance, Alexandra weighed in on her dog-collar's utility: "It will help vets, it'll help new or first-time dog owners … Or like people that don't understand dogs' body language. So, this will help them, like if your dog is overheating […] it will turn red for you so you will know." Three of the students indicated that they could see the utility of making in their future lives. Jasmin said the camp was valuable in helping her see how making could be useful in their lives in the future "Cause like when they [students] grow up and are like 'I don't know what I want to be' and they remember that they took this class, it's going to be easier."

Figure 2

Mind map of a student (a) and all the Mind maps displayed with feedback from peers (b)

(a) (b)

Recognition

To foster a sense of recognition, researchers provided opportunities for the students to recognize each other as makers, as well as allow them to show community members their work. After the mind-maps were created (Figures 2(a) & 2(b)), we stuck them up on a wall and encouraged them to walk around and give feedback and recognition to their peers. We also built in some peer feedback into the project brainstorming day, where students had to explain their idea to a partner. On the last day, we invited parents, community members and university staff to visit our makerspace and talk with our makers about the projects. This allowed the participants to receive a lot of feedback and recognition from the people they look up to. The interviews highlighted how this process resulted in recognition across students' experiences. As quoted above, Alexandra surprised herself with her ability to make a dog collar, stating she never believed she could do something like that. Jasmin wanted to feel recognized for her maker skills, saying she made her project "to show that I can actually make something." Trinity recognized the competencies of her peers, directly stating that Alexandra did not need help because "she got it so fast". Keith mentioned how he valued the recognition from the facilitators and how this impacted his self-perception noting that "Mr. C said that I did a really good job for my first time ever!"

Perception of the community

Two of the makers showed that they had preconceived notions of who could and could not work with electronics, neither believing themselves to be a part of the community to begin with. However, for both Alexandra and Jasmin, their perceptions changed and they felt like they could make on their own too, with Alexandra stating that "At first I thought I wasn't going to be able to get it, because you know, I thought I wasn't one of those kids that are like good at technology and stuff, but it's like really simple like when you get the hang of it. So that's something I changed. I feel like I can do coding more, outside of this". This highlights how participation in the camp changed their own perceptions of what a community of makers is and their inclusion in it.

External environmental factors

Keith had never coded before. Leo had never worked with electronics. Alexandra believed she had coded before, but never worked with electronics. Jasmin had worked with both before. Trinity indicated that she never liked working with electronics. Even though the participants had various levels of access to makerspace activities, they were all able to engage with the space and tools on their own terms. To this end, it was important that the makerspace feels like a place where the students can collaborate with their peers, while having fun. Alexandra indicated that access to the makerspace gave her the resources to build her ideas. She said that although "this [dog collar project] was something I'd thought about making before, I just didn't know quite what I wanted to make, but now […] I found what I wanted to make"; the makerspace gave her the resources to actually find out what she wanted to make: "'Cause when they said LED lights, I'm like what can I use for a dog or animal in general that I can use LED lights with? I can use a collar and stick the lights on it and make something out of that." Leo and Trinity stated that they enjoyed the social aspect of the makerspace, with Leo expressing joy that he "made a couple of friends."

Challenges

Despite showing positive impacts in creative self-efficacy and competence, and showing meaningfulness in her project, and recognition of one of her peers, Trinity indicated a strong dislike for making, saying: "I don't like coding and I don't like building stuff. I don't know why I don't like it, but I just don't like it. It's not my thing, that's why I don't like it." Whether we can attribute this to her lack of interest, preconceived notions of making, or some other factors, would require a deeper dive into her experience and mindset. Some other student hesitations included conflicts with previous commitments, for instance time at the makerspace for Keith was replacing time at his job. This goes to show the importance of situating making in a flexible environment, without hindering students' ability to participate in other parts of their identity. Lastly, brainstorming, mind mapping and peer-feedback were challenging for the students to grasp initially, suggesting that the work of maker-identity building, could have been incorporated into the curriculum and discussion from day one. This might have eased the students into it and allowed them to frame making as a reflection of their identities, instead of having it be separate from the identity construction parts of the camp.

Limitations and future work

While finding the general themes for the identity framework used in this paper, research focused on the technical side of making: i.e.: science, coding and computing were focused on. However, making is broader than that - it involves art and creativity along with collaboration and problem solving. Future work will focus on reviewing identity frameworks in those domains in addition to more identity frameworks in the STEM domain, to find commonalities and differences, to then investigate those structures of identity within our makerspace implementations. A large amount of data, including screen recordings, audio recordings and video recordings, along with photos of the makerspaces, projects, and mind-maps were collected during the two weeks of the makerspace. Due to space constraints, only the semi-structured interviews of five students were included, along with our review of photos and planning material to support our findings. More work could be done to triangulate additional data (e.g., whole camp video and audio recordings) with respect to this identity framework. Future work involves setting up another makerspace of a similar structure during the summer in 2023, with ongoing after-school makerspace activities during Fall 2022 and Spring 2023 semesters. With everything that we have learned about how our 2022 makerspace impacted their identity, we are working to incorporate structures that better allow for identity development. We will continue to investigate the impacts of our makerspace on identity, with more intentional and pointed observations and interviews, based on the realized framework.

Conclusion

Identity plays an important role in the learning process and engagement of students (Nasir & Hand, 2008). With the development of makerspaces, built to serve marginalized communities and youth, it is essential to engage their pre-existing identities with the practice-linked maker-identities that are being constructed in these makerspaces. Scholars such as Blikstein (2013), Halverson & Sheridan (2014), and Pinkard et al. (2017) are doing important work in constructing makerspaces that allow marginalized students not only access, but also agency to create in these spaces. The importance of considering affective factors that impact student engagement and learning in making for marginalized students is highlighted by these scholars. Our goal of tying identity with making is in line with such important work. Making personally relevant projects tied to one's identity allows for students' computational empowerment (Tissenbaum et al., 2019, Kong et al., 2018) empowering them to decide what they want to make and why, creating a more equitable approach to computing. Through this study, we attempted to find common factors that impact students' computational maker identity development, so that they are taken into consideration when building an equitable makerspace. We recognize that various factors of identity, including but not limited to - interest and motivation, competence and performance, confidence and self-efficacy, recognition, utility value and meaningfulness, perceptions of the maker community, external factors - can be impacted when the makers engage in the space. Keeping these factors in mind when designing makerspaces and their curricula can allow for computational identity development of students from all backgrounds, by grounding their maker identity in computational action (Tissenbaum et al., 2019).

Further, this study showed that structures such as co-designing the makerspace, open-ended projects, use-modify-create mini-projects, reflection and brainstorming activities can impact the utility value, interest, confidence and competence factors positively. Ensuring that the students receive feedback and are able to collaborate with each other, mentors, and community members, can provide additional opportunities for them to feel recognized. Creating a fun, open, and engaging atmosphere while allowing the students to build with access and agency, may allow them to discard preconceived notions of maker communities and build their identities as valued members of the making community. Structuring the design of makerspaces with the intentions of developing the students' maker identities across the factors highlighted in this paper, while they explore and tinker is key to ensuring that the students engage and learn in these spaces with agency as they begin developing their maker identities.

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