

“I FINALLY FIGURED OUT HOW TO DO IT!” MATH AND MAKER IDENTITY DEVELOPMENT

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Abstract

AMPED 4 Making is a collaboration between TERC and the Cesar Chavez Foundation to develop and pilot a two-year afterschool program that integrates math and making in semester-long units. For each semester, mini-maker projects lead to a larger project focused on making something for youths' own communities and implementing the community-focused values of labor organizer Cesar Chavez. One of the program's goals is to engage youth in a blend of design and making in and for the community—consequential making—to enhance and develop youth's agency and positive identity as makers, mathematical doers and users, and community members. From this goal follows this research question: How do youth's agency and identity as makers, mathematics doers and users, and community members change with participation in the program? To answer this question, we used a combination of methods that included object elicitation interviews, facilitator feedback, and facilitator interviews. Object elicitation interviewing is a data collection method where an object made by the children centers the conversation. Since they are participant-made objects, they embody children's knowledge, skills, and attitudes and make interviews easier by shifting the focus of attention from the interviewer-interviewee dyad to the object. In this paper, we examine the program's findings related to children's math and making identity development. We define math identity as a person's self-understanding as math doers that can flow between being competent and incompetent and that includes interests, aspirations, and engagement. We found that children valued the fact that they were able to express different dimensions of their identities, such as their cultural background, through the projects that they made. Children were proud of what they accomplished in the program, including completing projects, trying new things, and persevering when they encountered adversity. The research identified growth in children's math identity through their increased comfort in using math in the program and their self-perception of their competence as math doers. Youth also increased their awareness of how they are makers. This study shows that integrating math and making into a community-oriented afterschool program supports positive youth math and making identity development.

Keywords: *Math identity, maker identity, object elicitation, afterschool, STEM.*

1. Introduction

A collaboration of the Cesar Chavez Foundation and TERC, and funded by the National Science Foundation, AMPED 4 Making is a middle school afterschool program of mathematics-oriented design and making infused with the core values of civil rights leader Cesar Chavez. Thus, there is a strong focus on caring for community. Among AMPED 4 Making's goals are to engage youth in a blend of design and making in and for the community—consequential making (Barton & Tan, 2018)—to enhance and develop youth's agency and positive identity, as makers, mathematical doers and users, and community members.

AMPED 4 Making is a two-year program composed of four semester-long units. For each semester, mini-maker projects lead up to a larger project focused on making something for youths' own communities—an afterschool program, family, and school levels. For example, youth begin the program's first semester by making a clay figurine that represents something important about themselves. They go on to build skills with 3D modeling and printing and cardboard construction, culminating in making a storage system for program participants to store projects in progress, which they can use in following semesters. Sessions integrate selected Cesar Chavez values by focusing on different aspects of community, such as the case of the storage system that benefits the afterschool program community.

2. Literature review and theoretical framework

We frame the AMPED 4 Making program using Barton and Tan's (2019) concept of *consequential learning*, which they described as learning that "examines what matters to people and how associated values and practices, when coordinated through social activity, can allow for imagining new social futures" (p. 5). This framework seamlessly connects with the Cesar Chavez community values that emphasize individual development in the context of the progress and prosperity of the community (Chavez, 1991). From this perspective, consequential learning provides a context for both individual and community development, which is this program focus on youths' development of positive identities as makers and math does through community-oriented making activities.

Over the past two decades, the mathematics education community has shown particular interest in the development of youth's mathematical identities, as evidenced by Aguirre et al.'s book (2024) and a multitude of other publications (summarized in Darragh, 2016). Researchers and practitioners see a strong link between mathematical identity and mathematics learning (Boaler & Greeno, 2000). Some out-of-school programming aims at aiding students' positive mathematics identity development (e.g., Gholson & Robinson 2019). This paper describes our recent efforts in this arena.

We define math identity through a quote from Danny Martin (2006): "a person's self-understanding ... in the context of doing mathematics (i.e., usually a choice between a competent performer ... or an incompetent ... but often flowing back and forth)" (pp. 206–207). More recently, Goff et al. (2020) unpacked identity as a cluster of "aspirations, interest, engagement, and perceived competence" (p. 276) and we find these characteristics useful in our analysis of AMPED 4 Making's effect on youth identity.

In the making literature's exploration of identity (e.g., Li, Gao & Yun, 2024; Culpepper & Gauntlett, 2020), maker mindset is commonly discussed. A useful definition is that "the thing being made and its utility becomes a pragmatic goal that sustains motivation, interest and engagement" (Chu et al., 2015). AMPED 4 Making uses maker identity and maker mindset to support students' interest and motivation in mathematics.

3. Design and methods

We used a combination of methods that included object elicitation interviews, facilitator feedback, and facilitator interviews. Object elicitation is a data collection method where an object made by the children centers the conversation (Levin-Güracar et al., 2024). Since they are participant-made objects, they embody children's knowledge, skills, and attitudes and make interviews easier by shifting the focus of attention from the interviewer-interviewee dyad to the object. This type of interview elicits richer information than regular interviews because images and objects facilitate recalling processes and memories in more detail (Harper, 2002). We conducted object elicitation interviews and focus groups with the youth at the end of each semester, so we were able to see how youths' descriptions of the steps they took to make their projects, how they used math, and how they solved problems changed through their participation in the program.

We analyzed facilitators' feedback and the transcripts of object elicitation interviews and facilitator interviews using deductive coding by starting with the main ideas in the research question that we address in this paper as the main codes (Fereday & Muir-Cochrane, 2006). Then, we consolidated the codes into broader themes.

Seven middle school pilot sites were recruited by the Cesar Chavez Foundation to run the AMPED 4 Making afterschool club. The sites were in middle schools in California, where a majority of the over 200 enrolled youth are Latinx (about 80%), ages 10–14 years, multilingual, and receive free or reduced-priced lunch. In some sites, the AMPED 4 Making club was part of the school's existing afterschool offerings, so the youth were already part of an ongoing program and either chose or were voluntold to participate in the club. In other sites, there was no ongoing afterschool program, so CCF recruited youth to participate. The program ran for three years (one pilot year, and two implementation years).

In this paper, we address the project's research question about youths' development in regard to math and making: *How do youth's agency and identity as makers, mathematics doers and users, and community members change with participation in AMPD4Making?*

4. Findings

This paper shows that youths' participation in the AMPED 4 Making program positively contributed to youth's positive development, particularly in their development of their identities as math doers and makers, through consequential making that centered community values. The findings are divided

into three intimately linked main themes: the connection between identity and community, participants' development of their identity as makers, and connection between math learning and math identity.

4.1. Identity and community

In the second semester, youth focused on making for the family level of community. Youth made stuffies that represented their family and luminaries with symbols to represent their family. Luminaries are lanterns that are part of a tradition in the Southwest that dates back to XVI century Mexico. During object elicitation interviews, youth highlighted different dimensions of their identities through the projects they had made. When asked about the Mexican flag stuffie he created, one youth, Carlos, responded that,

"Well, because it reminds me of my family heritage and culture and it's a really important thing for me."

Being able to do projects that reminded Carlos of his family heritage and culture was "very unique" and he reported that it's a "very good thing that we do here." He further explained the importance of being proud of their heritage:

"We also did many things that also represent us, which I feel is a very important thing in [AMPED 4 Making] because it lets us understand ourselves, but also in a way, be proud of who we are and getting to know who we are and sharing that with everyone."

In another project, youth talked about how they used the decorations on their luminaries to represent their families, such as using a square to represent the four members of their family.

In the fourth semester, the focus was on the school community. One of the sites made raised garden beds for their school. When youth were asked in an object elicitation focus group what they would plant, they talked about planting flowers as something nice for the school. Later, they talked about wanting to grow useful plants, such as aloe vera, because as Rose explained, "*it could be used if a student has a burn or something.*" The youth were thinking in depth about what they could plant that would benefit the greater school community.

4.2. Identity as makers

In facilitator interviews and focus groups, and in object elicitation interviews with the youth we saw that the youth grew in their identities as makers. Facilitators repeatedly stated that the youth were proud of what they accomplished in the program, such as completing projects like the raised garden beds, trying new things like using a saw to cut the materials for the luminaries, and persevering when they encountered adversity. When talking about a hands-on assessment building a card stock box that fit 12 dice, Walter was proud of what he completed.

"I'm proud [of the box I made] and I'm pretty happy that I finally figured out how to do it."

Later in the semester, Walter showcased two projects that, though they were unfinished, he was happy about. When asked by a researcher if he was proud of his projects, he stated,

"Yes, definitely; especially for the measuring and trying and failing to do stuff"

It is noteworthy that he mentioned the fact that he understood that trying and failing were part of the process, while earlier he was proud of what he accomplished because he was able to make sense of the steps to make the box. Notice also that his mathematical activity was also mentioned as a source of pride, suggesting overlap between these two aspects of identity—mathematics and making.

In the object elicitation interviews, we also observed changes in how youth talked about the making process. Youth became more comfortable explaining the steps involved in making and their decision-making along the process. For example, initially Walter mostly held up his project to show it to the researcher and point out the different elements, without explaining the process or the decisions he made as he built it. In a later interview, the same youth was clearer in his explanation of how he created a cardboard photo frame. Instead of pointing at the different elements of his project, he explained the specific steps he took and the difficulties he ran into, clearly taking pride in his increased expertise as a maker.

4.3. Math learning and math identity

We saw the development of math skills, knowledge, and understanding and positive mathematical identities both in youth interviews and in what facilitators reported about youth. Facilitators noted the youth's growth over the course of the program, such as by referencing growth in the youth's use of measurement and overall comfort in math: the perceived competence that Goff identified as a component of math identity. They also clearly showed increased engagement in mathematics, another of Goff's categories. One of the facilitators explained the changes she observed in the following way:

“I could tell math wasn’t so intimidating to them. At the beginning, I asked them about including measurements, they wouldn’t know how, or didn’t want to discuss it; by the end, they were open to talking about these things, or the 3D objects.”

The comparison between youths’ first and second semester object elicitation showed that, in the earlier interviews, youth tended to have a harder time expressing their ideas in math. However, in later interviews they were able to talk about the application of specific math ideas with more sophistication. They expressed confidence in their abilities and in their control over the mathematics ideas and practices, signs of growing math identities as the competent performers of which Martin wrote. For example, Walter showed awareness about when it was appropriate to use one measurement unit or another, indicating he understood this aspect of competent performance. He stated,

“I had to measure a lot of things. And sometimes I’d use things in inches, sometimes centimeters. I mean, for the bigger projects, feet because one was better to use for the thing.”

Walter showed that he understood which units were more appropriate to use in different situations according to the dimensions of the project at hand. Similarly, youth pointed out that millimeters were the most appropriate units for 3D printing because the size of the small size of projects and being off by an inch or a centimeter would radically change the result.

Youth also showed that they were aware of their own growth as math doers and users through their participation in the program. Carlos, for instance, appreciated learning how to be organized in his work. He stated,

“I learned [that] it’s very important to have things written on paper, actually, because it keeps us organized and it’s very good. Honestly.”

Being organized is a math problem solving skill and his recognizing its importance shows that he added this skill to his “toolkit” of a competent performer. He was also keenly aware about the difference between learning in school and learning in the program, and how the hands-on approach of the program could help some youth who may have a harder time with paper and pencil math activities. He shared,

“[In school] we would always measure things, but we will never do it hands on, because we just measured things on paper. But here we have it hands on. And I feel like this helps a lot of kids because I’m fine with paper. But I feel like it helps a lot of kids get a grasp of understanding the way measurements work, how math works, but really hands on, which is, I guess the way they learn.”

Carlos expressed an aspect of his mathematics identity as well—“I’m fine with paper” [for learning math]—while recognizing the value of hands-on experiences for others.

In all object elicitation interviews, youth were asked if they used or learned any math while making. The way youth talked about math showed a change in their awareness of the role of math in the making processes. It also showed growth in math identity as, in their minds, the importance of the math they were doing grew as did their perceptions of competence. They initially answered that they did not do math in the program or dismissed measuring as not being math. However, in later interviews, they showed that they understood the importance of measurement as math for making projects and were quite specific in how they talked about the math that they used.

5. Conclusion

This paper shows that youth in the AMPED 4 Making program valued having the opportunity to express different dimensions of their identities, such as their cultural background and being part of a family, through the projects that they made. Youth were proud of what they accomplished in the program, including completing projects, trying new things, and persevering when they encountered adversity. The research identified growth in youths’ math identity through their increased comfort in using math in the program and their self-perception of their competence as math doers. They also increased their awareness of how they were makers and that the growth in their identities as makers and as math doers went hand in hand. This study shows that integrating math and making into a community-oriented afterschool program supports positive youth math and making identity development.

We found that by setting a maker task based in the community, opportunities to develop positive community, maker, and math identities naturally arise. This is important because there is an emphasis in literature and in practice on the deep connections between learning mathematics and mathematics identity (e.g., Aguirre, J., Mayfield-Ingram, K., & Martin, D. B. (2024). Based on these findings, we recommend broader adoption of math curriculum in making that integrate youth’s identities and cultures.

Acknowledgments

This material is based upon work partially supported by the National Science Foundation. AMPED 4 Making is funded through the AISL Program (award #2215382). Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

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