

MATH AND MAKING IN AFTERSCHOOL - A PEDAGOGIC INNOVATION WITH LATINX MIDDLE SCHOOL YOUTH

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Abstract

Amped 4 Making (A4M) is an afterschool program co-developed by TERC and the Cesar Chavez Foundation (CCF) that integrates mathematics-oriented design and making with the community values of civil rights leader Cesar Chavez. The program engaged Latinx middle school youth across the U.S. Southwest in community-focused maker projects, aiming to broaden participation in STEM through culturally responsive practices. A4M consists of four semester-long modules designed to support rural Latinx youth's mathematical identity and agency. Materials include student and facilitator resources in multiple media and accompanying training. Youth aged 10–14 engaged in co-designed, locally adaptable making projects that connected mathematics learning, community, and cultural strengths. A4M's design/making framework integrates the mindset of design thinking with hands-on making through an iterative cycle. This structure supported both youth and facilitators in recognizing and leveraging embedded mathematics. Through this approach, A4M provides a model for transforming how Latinx youth engage with informal math learning, and how they see themselves as mathematical thinkers—solving problems rooted in their communities through making.

Keywords: *Math and making, pedagogic innovation, giving back, design cycle, Latinx youth.*

1. Literature review

AMPED 4 Making (A4M) developed and piloted an afterschool program of mathematics-oriented design and making that was infused with the community-oriented core values of civil rights leader Cesar Chavez. The making focus was animated through activities that align with a broader view of making espoused by Leah Buechley as well as Clapp, Ross, Ryan, and Tishman in their book, *Maker-Centered Learning* (2016). In this exclusivity-eschewing view, a maker is a person who makes things. Our participants (and the facilitators) are makers by engaging in the making activity and their maker identities are developed through their engagement in making. Clapp and colleagues provide a useful “symptoms-based” framing for considering whether a learning experience is maker-centered by considering characteristics touching on aspects of community, process, and the environment. In its development, the co-designers of A4M considered multiple community, process and environmental aspects to ensure that the learning experience centered around the participants' making experiences.

Existing research has found that giving back—which encompasses “behaviors associated with improving an individual's community and helping others” (Page, 2010, p. 10)—are important for underrepresented groups among whom communal values are important. Furthermore, the literature shows that even though STEM disciplines are seen as individualistic and competitive (Diekman et al., 2017), engaging in giving back, community-oriented activities support students' persistence in STEM (Jaumot-Pascual et al., 2023; Silva et al., 2021). Jaumot-Pascual et al. (2023) found that Native students in computer science did not have difficulty in finding ways to use their technology skills give back to their communities on and off campus through activities such as teaching, mentoring, conducting outreach, and using technology to preserve cultural artifacts and Tribal documentation.

2. Context of the program

2.1. Description of the program

A collaboration of the Cesar Chavez Foundation (CCF) and TERC, (funded by the National Science Foundation (award #2215382) before being prematurely terminated), A4M is a middle school afterschool program of mathematics-oriented design and making infused with the core values of civil rights leader Cesar Chavez. Thus, the program has a strong focus on caring for community, as exemplified by this quote.

“We cannot seek achievement for ourselves and forget about progress and prosperity for our community ... Our ambitions must be broad enough to include the aspirations and needs of others, for their sakes and for our own.”—Cesar Chavez, 1991

A4M’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,
- understanding of mathematics, such as geometric principles or linear measurements, within the context of informal learning projects, and
- perceptions of how they can use mathematics, design, and making in their future lives and work.

As a two-year after school program, youth sign up at their schools each semester. Semesters are composed of mini-maker projects which lead up to a larger project focused on making something for youths’ own communities—the afterschool program, their family and the school. For example, in Semester 1 youth 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 also integrate select Cesar Chavez values.

2.2. Participants

CCF recruited seven middle school sites in California to run the A4M afterschool club. A majority of the over 200 enrolled youth participants are Latinx (about 80%), ages 10–14 years, multilingual, and receive free or reduced-priced lunch. At some sites, A4M was part of the school’s existing afterschool offerings, so only youth already in an ongoing program either chose or were guided to participate in A4M. At other sites, there was no ongoing afterschool program, so any youth in the school could join.

2.3. Facilitators

This kind of complex project with many “moving parts” requires special skills and awareness on the part of the afterschool facilitators who facilitate it (NRC, 2015). We take inspiration from Vossoughi, et al. (2013), studying how afterschool maker programs can foster equity. Centrally, facilitators must be able to recognize the mathematics in its many forms: the mathematics that youth use in making, school mathematics, and community mathematical know-how. Just as important, staff must attend to youth’s identity development. This is no small feat. Both topics, (and how they fit together) were addressed in professional development (PD) workshops. Research suggests that facilitators need at least three kinds of skills: in making, in pedagogy, and in youth development (Vossoughi & Bevan, 2014). In A4M PD, facilitators wore two hats: as learners (participating in mathematics and making), and as facilitators (e.g., learning how to make norms or mathematics explicit). During the academic year, facilitators had opportunities to reflect on their own practice, anchored in artifacts or videos from afterschool sessions.

3. Curriculum design

Middle school youth in AMPED 4 Making engaged in design-and-making projects that addressed community goals based on Cesar Chavez’s values. These values were integrated across the curriculum in several ways, such as through the integration of the distinctive “Sí se puede” cheer at the beginning of sessions, the use of community-centered topics emphasized in the making projects, and the emphasis on peer support. This project aimed for changes in youth’s relationship with mathematics. Youth had opportunities to engage with important mathematics while drawing on community and cultural strengths, particularly in community mathematical know-how.

The project used a co-design framework to develop an equity-focused making program. The A4M team co-designed lesson plans for four semesters that introduce a series of mini-making projects, such as an LED lantern, a 3D-printed bookmark, an LED patch, stuffies, and cubbies. During the first year and before each session, the team would meet to review the lesson plan and practice the relevant making skills.

After each session, the team would meet to review feedback from youth and facilitators on how the session went and propose any changes to be applied to the past lesson and future ones, as relevant. These piloted sessions formed the cornerstones of projects in future years.

The focus of A4M projects progressively moved from the smallest circles of community, most proximal to youth (e.g., family and the afterschool program) to the largest circles of community (e.g., school, neighborhood). For example, in the program's first semester, youth reflected on their families through making a luminary that integrated elements that represented something important about them. Youth used images that represented their families in different ways, such as showing activities that their families enjoyed doing together (e.g., making arepas; riding horses, caring for pets), or using an abstract square to represent four members of their family. In later semesters, the program focused on making projects that represented or that were designed to either represent or be helpful for the larger community, such as designing and 3D printing a wall mosaic representing their neighborhood community or building wooden planters for the school. Each of the projects also required that the youth engage in foundational mathematics for a successful build. The most mathematical topics were measurement, volume, rigid transformations, and proportionality. By focusing projects on making for the community, the A4M curriculum engaged youth not only in consequential making but also consequential use of mathematics.

4. Research design and methods

This project's research followed a mixed methods convergent parallel design (Creswell, 2021), where quantitative and qualitative data collection and analysis occurred simultaneously. The research took place in two stages (co-design and implementation).

The project implemented a multi-method approach to collect data to ensure triangulation, including pre/post surveys, pre/post math assessments, facilitator reflection forms, facilitator interviews, and youth object elicitation interviews. The methods were chosen for their appropriateness to the informal education setting, their participatory nature, and their precision. Research activities were integrated into the co-design process for a more naturalistic understanding of the phenomena. TERC and CCF staff were co-researchers and collaborated in the development and implementation of the data collection instruments, the analysis of the data, and the development of findings.

This description of the pedagogical innovation of A4M is mainly based on the data and analysis of object elicitation and facilitator interviews and focus groups. Object elicitation is a data collection method that centers the youth interview around an object that youth made in the program (Levin-Güracar et al., 2024). Since the objects were created by the youth, the objects embody the youth'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 analyzed the transcripts of object elicitation interviews and focus groups using deductive coding by starting with the main ideas in the research questions as the main codes (Fereday & Muir-Cochrane, 2006). Then, codes were consolidated into broader themes, which we present in the findings.

5. Implementation results

This paper shows that the integration of consequential making and the Cesar Chavez values in the A4M program is a pedagogical innovation that supported participating youths' community orientation. We divided the concept of community orientation into two main themes: youth's community orientation by encouraging their interest in giving back and their engagement in teamwork.

5.1. Giving back

Participants kept family, friends, and their school community in mind when considering how they were going to use their new making skills. Participants talked about using their new making skills to engage in reciprocity and gifting with people in their lives, making things that they would find useful or would enjoy and to show them gratitude and love. In the first year, when the youth were asked to make a stuffy representing their families, four youth made their stuffies to give to their siblings (horses, football, frog), four made stuffies related to activities that they do with their families, such as cooking and baking, one made an item that connects with their family business (arcade machine), and one made a religious symbol because their family is religious. Additionally, three participants made stuffies that represented an activity that they personally enjoyed (riding horses and motorcycles, playing PacMan). The quote below shows how Leo thought about the development of his stuffy, from the original idea to the making process and the math involved to the motivation for making it.

Leo: I made a stuffy, it felt pretty good because it didn't come out that bad and it was my first time making one, it's a horse. I really like riding horses. I've been having horses since I was four.

Interviewer: How did you make it?

Leo: I just turned it from a 2D to a 3D. I just folded it, and I cut it, and I did the same with the hair with the body shape, and then I sewed the shape together, and I left a little hole right here so I could stuff it in, and I didn't get to finish. I will finish at home. It is for my little brother. He is 5 and likes horses too.

In year 2, youth built wooden planters for their school community. 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 to make it prettier. They also talked about having useful plants such that they can be used for medicinal purposes, like mint or aloe vera. Rose explained, “[aloe vera] could be used if a student has a burn or something”. The youth were thinking about using their new making skills for the benefit of their greater school community by considering what to plant that would be beneficial.

5.2. Supporting teamwork

Facilitators worked to develop positive relationships with the youth and create supportive environments where youth were able to come together as a group. They used the program's routines, such as starting sessions with the “Sí se puede” cheer, as a way to bring the group together and create a sense of belonging in the program. During interviews and in weekly feedback forms, facilitators explained that they encouraged the youth to work together and help each other, particularly when one of them finished early or if another had difficulty figuring out how to do something. A facilitator commented,

At first, they weren't really talking to each other ... If they didn't know how to do something, I'd encourage them to team up with someone and they would be like ‘Oh, OK! I get this now!’”

In the weekly feedback forms, facilitators talked about students working together and learning from each other with more frequency as the weeks went on to the extent that “some students would become teachers to other students,” as one of the facilitators shared. They reported that youth interacted with each other in positive terms, using language that described motivation, enjoyment, collaboration, leadership, teaching each other, mutual encouragement, and even safety, as shown in this example:

The students were using tools safely, which is an important skill, and it was great to see the students helping each other out. I kept encouraging them to work collaboratively and develop their skills, and they'll no doubt continue to thrive.

Youth also shared how supporting each other became part of how the program run. In the following quote, Stephen shared how he received help from a peer when he ran into difficulties while working on his stuffie, which included a circuit with an LED light:

My friend helped me out with the [LED] light because I didn't really remember how to do it. So, they helped me out with the light, and they also help me out with cutting the shapes.

6. Conclusions and recommendations

A4M integration of the community goals based on Cesar Chavez's values created a supportive environment that promoted teamwork and collaboration. These values also opened up opportunities for relational making, which was taken up by learners, who found ways to engage in consequential making that integrated math and giving back. We recommend the implementation of programs that engage youth in solving problems in the communities they care about, drawing on their connections to the people living near them to promote consequential making, giving back, and the development of a positive math identity.

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