

## MATH AND MAKING FOR MIDDLE SCHOOL YOUTH: A LONGITUDINAL SINGLE-CASE STUDY

Elise Levin-Güracar<sup>1</sup>, Nuria Jaumot-Pascual<sup>1</sup>, Teresa Lara-Meloy<sup>1</sup>, & Jad Eways<sup>2</sup>

<sup>1</sup>TERC, Inc. (USA)

<sup>2</sup>Cesar Chavez Foundation (USA)

### Abstract

In AMPED 4 Making, middle school youth engaged in design-and-making projects that address community goals aiming for changes in youth's relationship with mathematics and making. In each project, youth used mathematics to design, prototype, or build meaningful and useful artifacts. Part of AMPED 4 relies on the life and values of Cesar Chavez as a touchstone for Latinx youth's positive identity. AMPED 4 Making sought to understand how the program supported the development of positive math and making identities among participating youth. This longitudinal single-case study uses object elicitation data to show the changes in math and making identities that Rose experienced over the course of her participation in AMPED 4 Making over two school years. Object elicitation is a data collection method that centers the youth interview around an object that youth made in the program. Since the objects were created by the youth, the objects embody the youth's knowledge, skills, and attitudes. The findings in this longitudinal single-case study show that AMPED 4 Making provided Rose with opportunities to engage in consequential math and making for communities, supporting her development of a positive identity as a maker and math user.

**Keywords:** *Longitudinal single-case study, object elicitation, out-of-school learning, hands-on learning, STEM.*

---

### 1. Introduction

In AMPED 4 Making, middle school youth engaged in design-and-making projects that addressed community goals aiming to strengthen and improve youth's relationship with mathematics. Guided by an afterschool facilitator, in each project, youth used mathematics to design, prototype, or build meaningful and useful artifacts.

AMPED 4 Making was a research and curriculum design program designed by TERC and the Cesar Chavez Foundation (CCF) to serve Latinx youth across agricultural areas in the Southwest and California, USA. TERC is a nonprofit organization located in Cambridge, Massachusetts, U.S., that focuses on STEM education research, evaluation, and curriculum design. CCF's mission is to uplift the lives of Latinos through social enterprises. The curriculum design component included designing four semester units of making activities with pre and post assessments. The purpose of the research component was to understand the math content and practices youth learned through the program, and how youth agency and identity developed through participation. The program provided training to facilitators around math and making through hands-on making and modeling of math conversations. AMPED 4 Making ran at seven sites that served majority Latinx youth, including many multilingual learners and youth on free and reduced-price lunch programs. Generally, the program met once per week at each site.

Each semester of AMPED 4 Making focused on a different level of community: family, after-school club, school, and the larger community. This case study centers on Rose, a middle school student during her participation as a 7<sup>th</sup> and 8<sup>th</sup> grader. In the first year of Rose's participation, the program was focused on making related to family and classroom community and in the second year it was focused on making for the school community. In the first year, Rose made a muffin stuffie that represented her family and cubbies for the classroom for program materials. In the second year, Rose worked with peers to make a large planter for the school community.

## 2. Theoretical framework and literature review

This work is framed by the life and work of Cesar Chavez, using his values as a touchstone for rural Latinx youth's positive identity and agency, which is in line with research on programs that successfully meet goals of encouraging cultural knowledge while addressing academic content (Riggs et al., 2010). Cesar Chavez viewed education as a pathway to freedom; he believed, "*Students must have initiative; they should not be mere imitators. They must learn to think and act for themselves—and be free*" (United Farm Workers, n.d.). Freedom through this lens would be attained through youth agency (Zavala, 2014). Further, AMPED 4 Making's focus on community action aligns with Chavez's vision of community development: "*It is not enough to progress as individuals while our friends and neighbors are left behind*" (Chavez, 1991). Through this lens, AMPED 4 Making strove 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. Further, AMPED 4 Making was structured to engage students in grade-appropriate mathematics, such as the volume and surface area of geometric shapes, within the context of informal learning projects.

AMPED 4 Making addressed youth's development of **agency and identity in mathematics, making, and community membership**. Martin defined mathematical identity as encompassing "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*)" (2006, p. 206–207). More recently, Goff et al. (2020) unpacked identity as a cluster of "aspirations, interest, engagement, and perceived competence" (p. 276). Maker identity parallels mathematical identity. Maker identity consists of initiative and intentionality, conceptual understanding, problem solving and critical thinking, creativity and self-expression, social and emotional engagement (Bevan et al., 2020). While little has been written about the influence of maker identity specifically on *mathematics* identity, we take guidance from research addressing equity focused on STEM identity (Carlone & Johnson, 2007; Tan et al., 2013) and making (Tucker-Raymond, 2019) to study the relationship between the two. Our project engages Goff et al.'s definition of math identity and aims to develop it through deep mathematical understanding and hands-on learning through making. AMPED 4 Making is premised on the idea that everyday and community mathematics support learning school math with conceptual understanding.

## 3. Research design and methods

This longitudinal single-case study (Yin, 2003) explains the changes experienced by Rose over the course of her participation in AMPED 4 Making over two school years (2022-2023 and 2023-2024). We detail the changes in how Rose expressed her ideas and learning in two areas: maker identity and connections between making and math through two end-of-year object elicitation interviews (May 2023 and May 2024). In the first interview, Rose showcased a stuffie and connectors for the cardboard cubbies she was making. Later, in the second interview, Rose showcased a planter box.

### 3.1. Data collection and data analysis methods

AMPED 4 Making's data collection methods included a youth survey, a math learning assessment, interviews with facilitators, weekly facilitator feedback, and object elicitation interviews or focus groups with the youth. This longitudinal single-case study is exclusively based on the data and analysis of Rose's object elicitation 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).

The team used deductive coding to analyze the object elicitation data (Saldaña, 2003). Deductive coding is a top-down approach where the team develops codes from pre-existing knowledge, such as theory or a program's research questions, and uses those codes to identify excerpts in the data that fit those codes. In this study, we developed deductive codes based on the study's research questions.

### 3.2. Description of participants

Rose was one of over 200 middle school youth across California participating in AMPED 4 Making. She participated in the program for two semesters, in 2023 when she was in 7<sup>th</sup> grade and in 2024 when she was in 8<sup>th</sup> grade at a public middle school in the Central Valley of California, U.S. Rose was a female student who identified as Mexican, Native, and white and was part of object elicitation focus groups at the end of each year of her participation.

This longitudinal single-case study responds to two of the project's research questions that focus on Rose's development both in terms of her math learning and her identity as a maker:

- What math content and practices did Rose learn through participation in AMPED 4 Making?
- How did Rose's agency and identity as a maker, mathematics doer and user, and community member change with participation in AMPED 4 Making?

#### 4. Findings

Based on the object elicitation focus groups that Rose participated in, the team identified growth in her ability to describe the math she used related to the projects, and an ability to discuss her making process more in depth.

##### 4.1. Maker identity

As described earlier, maker identity includes initiative and intentionality, conceptual understanding, problem solving and critical thinking, creativity and self-expression, social and emotional engagement (Bevan et al., 2020). The comparison of Rose's two object elicitation interviews showed that she experienced changes in her maker identity from one year to the next thanks to her participation in the program.

In the first year, she shared that she went into the program knowing how to sew but didn't help anyone because no one asked. Rose did not demonstrate initiative or collaboration with peers related to sewing. In the second year, Rose explained how she worked with others in the program and how each of them took on their own roles, demonstrating increased social engagement.

In both object elicitations, Rose connected what she made to the community themes of the program, particularly family, school, and the larger community. She was able to describe the purpose of the item that she made and how it related to the community level she was making it for. Additionally, by the second interview Rose was more articulate when discussing the steps of her making process, going into detail about the prototype they created, showing increased conceptual understanding and problem solving. In both years, Rose was able to connect her making to the level of community intended by the project.

In the first year, Rose talked about how her muffin stuffie reflected her family as a community. She created this stuffie because baking is an activity that her family enjoyed engaging in together:

*"[I made a muffin] because me and my family like to bake. One of the things we bake a lot is mostly cupcakes and cake ... I showed this to my mom."*

Rose used her creativity and self-expression to respond to the making prompt, creating an object that embodied something meaningful about herself and her family. In addition, baking itself was a making skill that Rose already had, a fact she shared with her peers.

In the second round of data collection, Rose participated in a focus group with two youth who worked with her throughout the semester to create a raised garden box for the school. When talking about what she wanted to plant in these raised garden boxes, Rose said that she would like to put in flowers to make the school prettier:

*"I'm pretty sure we're going to put flowers in these ones ... Just to make the school more nice."*

Rose was thinking of her community in terms of providing a pleasurable environment for those in the school. Later in the interview, she also suggested that aloe vera would be useful to plant because of its medicinal properties:

*"I was thinking we could put aloe vera because aloe vera can be used if a student has a burned sun or something."*

Here, Rose was thinking about helping her community, both in terms of beautifying the school, and more deeply about providing a solution for those at the school who might get hurt. Rose was thinking about how to use her newly developed skills to give back to her school community through beautification and providing a plant that can be useful. This shows that her maker identity developed to engage deeper social and emotional engagement.

##### 4.2. Connections between making and math identity

As explained earlier, Goff et al. (2020) defined identity as a cluster of "aspirations, interest, engagement, and perceived competence" (p. 276). This section shows the dramatic changes that Rose experienced in her math identity through her engagement in making through AMPED 4 Making.

In her first object elicitation, Rose was not able to explicitly describe the math she used in her making of projects such the stuffie and the connectors for the cubbies, and did not conceptualize

measurement as being math. However, the second-year interview revealed a very different understanding of math. Rose articulated how she used measurement and other math concepts in her making of the planters. This difference demonstrates a change in Rose's understanding of what math is, and how it relates to making.

As a part of the object elicitation focus groups in both years, Rose was asked what math she used while in the program. The first year, Rose shook her head in disagreement when asked about math. Although math was intentionally woven into the AMPED 4 Making projects, Rose may not have been aware of it because it was not always made explicit and was not presented in the same way she typically experienced it in school (i.e., in worksheets). In the first interview, Rose did not express high interest or engagement when asked about the math related to the program, hinting that she had yet to make connections between her making and math.

In the second-year interview when the interviewer asked about her use of math, Rose said “*Oh, yeah!*” and went on to explain in detail math concepts that she used to measure wood beams while making the raised planter box.

*“So, the full board was 72 inches, then we divided by 4 so we could use the tape measure. So, if you lay the tape measure all the way out you could make the 4 marks.”*

Rose demonstrated her interest in and engagement with math by fluently describing her math use in her making. Further, she demonstrated confidence through her clear description of measurement and a creative way to measure the pieces of wood for the planter at once.

In addition to explaining the measurement used in the raised planter, Rose also explained that they were learning about volume both with the project and in school math. In this second interview she clearly and fluently discussed the math that was present in the making activity and connected it to math she was engaged in outside of the program. By the end of her second year in the program, Rose demonstrated a stronger math identity and was able to connect it with her maker identity through the project she created.

## 5. Conclusion

The findings in this single-case study show that AMPED 4 Making provided Rose with opportunities to engage in consequential math and making for communities (Barton & Tan, 2018). Through these opportunities, Rose was able to make connections and develop positive identities in math and making (Bevan et al., 2020; Goff et al., 2020; Martin, 2006). The growth Rose experienced in AMPED 4 Making shows that bringing together math and making in informal learning environments supports math skills development and an understanding of the relevance of making skills.

## Acknowledgments

The current article and presentation are based upon work partially supported by the National Science Foundation (NSF-AISL #2215382). Any opinions, findings, and conclusions or recommendations expressed here are those of the author(s) and do not necessarily reflect the views of the National Science Foundation. We would like to thank Rose for her participation in the program and data collection, and for sharing her insights with the team. Additionally, we would like to thank Vanessa Galeana, who as a summer intern at TERC through the REU program (NSF #2150364) began data analysis for this longitudinal single-case study.

## References

- Barton, A. C., & Tan, E. (2018). *STEM-rich maker learning: Designing for equity with youth of color*. Teachers College Press.
- Bevan, B., Ryoo, J. J., Vanderwerff, A., & Wilkinson, K. (2020). “I see students differently”: Following the lead of maker educators in defining what counts as learning. *Frontiers in Education*, 5, 121.
- Carlone, H., & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, 44(8), 1187-1218.
- Chavez, C. (1991). *Remarks from Dedication Ceremony of Cesar Chavez Elementary School in Coachella, CA*.

- Goff, E. E., Mulvey, K. L., Irvin, M. J., & Hartstone-Rose, A. (2020). The effects of prior informal science and math experiences on undergraduate STEM identity, *Research in Science & Technological Education*, 38(3), 272-288.
- Harper, D. (2002). Talking about pictures: A case for photo elicitation. *Visual studies*, 17(1), 13-26.
- Levin-Güracar, E., Jaumot-Pascual, N., Rafanan, K., Lara-Meloy, T., Eways, J., & Mitchell, I. (2024, September 28–October 1). Object elicitation interviews: Engaging youth in conversations about their STEM learning through making [Conference presentation]. *ASTC Annual Conference*, Chicago, IL, United States.
- Martin, D. B. (2006). Mathematics learning and participation as racialized forms of experience: African American parents speak on the struggle for mathematics literacy. *Mathematical Thinking and Learning*, 8(3), 197-229.
- Riggs, N. R., Bohnert, A. M., Guzman, M. D., & Davidson, D. (2010). Examining the potential of community-based after-school programs for Latino youth. *American Journal of Community Psychology*, 45(3), 417-429.
- Saldaña, J. (2003). *Longitudinal qualitative research: Analyzing change through time*. AltaMira Press.
- Tucker-Raymond, E. (2019). *Principles for equity-centered design of STEAM learning-through-making*. <https://circlcenter.org/wp-content/uploads/2019/10/Castek-STEAM-Learning-Making-Whitepaper.pdf>
- United Farm Workers. (n.d.). *Education of the heart. Cesar Chavez in his own words*. <https://ufw.org/research/history/education-heart-cesar-chavez-words>
- Yin, R. K. (2003). *Case study research: Design and methods* (3rd ed.). Sage Publications.
- Zavala, M. (2014). Latina/o youth's perspectives on race, language, and learning mathematics. *Journal of Urban Mathematics Education*, 7(1).