https://doi.org/10.36315/2025v2end090
Education and New Developments 2025

YOUNG WOMEN BELONG IN MAKERSPACES: DEVELOPING AND DETECTING YOUNG WOMEN'S AGENCY IN MAKING

Ken Rafanan[1], Elise Levin-Güracar[1], Nuria Jaumot-Pascual[1], Teresa Lara-Meloy[1], Harriette Stevens[2], & Jennifer Knudsen[1]
[1]TERC, Inc. (USA)
[2]Mathematics Education Group (USA)

Abstract

While many makerspaces are created by and cater to middle-aged males, our research has found that when supported, young women manifest their agency engaging in a multitude of making disciplines including those traditionally thought of as masculine fields such as woodworking and metalworking. Design principles, activities, findings and research tools from a program developed under an out-of-school maker project, AAMASE, are shared. The principles, activities and tools were developed to strengthen and support the agency of young African American women in a community-based makerspace in the mid-Atlantic region of the United States. The project focused on agency by co-designing making experiences with minoritized secondary-school youth and centering their experiences. Making projects ranged from one-day builds such as making resin art pieces, to longer entrepreneurship-focused projects such as designing a student locker organizer product. Principles for supporting and strengthening youth's agency in making are shared and expanded upon. The paper also briefly describes the researchers' use of the object-elicitation technique to investigate the makers' processes, identity, and development of agency. Finally, the paper presents data and analysis of young women's reflections on their experiences in the program.

Keywords: *Making, STEM, youth development, agency, design principles.*

1. Introduction

African American Young Women in Making to Engage in STEM and Entrepreneurship (AAMASE) was an NSF ITEST Developing and Testing Innovations project aimed at serving 13–18-year-old young women in Greensboro, North Carolina, USA. The project was a collaboration between TERC, a STEM education research and development organization, and the Forge Greensboro, a nonprofit community makerspace. Through participatory design research, we engaged youth in making and entrepreneurship activities emphasizing STEM disciplinary practices to amplify their agency while building their engagement and skills in STEM and their awareness of STEM career pathways. Participants learned how to design, build, and pitch a product with guidance from designers, makers, and entrepreneurs.

The research included interviews with partners, mentors, and facilitators, activity recordings, and interviews with the youth. The research insights shared below are based on data from four groups that participated in the program for 8-10 weeks each. Each group had about 10 middle and high school age young women who were mostly African American, but also included white, Hawaiian Native, and Latina young women. Three participant cohorts were recruited through out-of-school learning organizations that had existing youth-serving programs and one cohort was recruited from a private school. This paper focuses on youth agency and experience throughout the program, integrating data from object elicitation interviews and observations.

2. Theoretical framework and literature review

This work is framed by a values-based theory of change centered around agency. Theory of change (Weiss, 1995) is a theory of how and why an initiative works. It makes clear what assumptions are being made in an intervention, and the desired outcomes. A values-based theory of change starts with a value or values for learning and engagement (Wardrip, Evancho, & McNamara, 2018).

For this project, we propose a definition of agency as follows: a person's or group's ability, inclination, and sensitivity to conceptualize and pursue the making of an object (physical, psychological, and/or social) to address a need or desire given a set of appropriate physical and/or social resources. This working definition allows the scaling of our unit of analysis between individual and group as appropriate as well as recognizing the salient resource features of an environment. In their review of the agency literature, Cavazzoni et al. (2022) defined agency loosely as "people's ability to exert control over one's life and [to] pursue goals" (p. 1126) and found that studies used agency along two main conceptual pathways: 1) how an individual engages in agentic actions across their social environments; and 2) how an individual engages in agentic action in a more constrained realm of action. Our working definition of agency is aligned with the more constrained perspective as we aim to support and develop agency in participants in making and STEAM-focused learning environments.

Due to structural racism, women, women of color, and African American women in particular have been kept at the margins of STEM for far too long. African American women tend to be marginalized in school STEM (Brickhouse, 2001), and their experiences of micro-aggressions and other racist practices affect their proclivity to engage in STEM (Grossman & Porche 2014). Too often, their agency is diminished. Contrastingly, when their science experiences can match their aspirations—either in or out of school—they engage and blossom in STEM (Tan, et al., 2013; King & Pringle, 2019). This marginalization has impacted our STEM workforce. An NSF report found that less than 5 percent of science and engineering occupations are occupied by African Americans, while they made up 12 percent of the total workforce (NSF, 2017).

The AAMASE program aimed to better support young women's agency in a STEM learning environment. Makerspaces' fusion of craft and high tech holds great promise for enabling makers to see the need for STEM and to engage in STEM-related work. Often, though, white, cis-gendered males (Bang, 2015) are over-represented in makerspaces and can perpetuate barriers to improved agency. In response, researchers and practitioners have sought ways to center non-dominant youth in the community of makers to support learning. Further, entrepreneurship, an area where marginalized groups have faced systemic barriers, provides motivation for making and a pathway to STEM careers (Howard, Smith, & Nwaigwe, 2020). AAMASE offered a combination of engagement in making and entrepreneurship, focused on the strengths of young women of color (from middle grades to early high-school) to draw them towards the center of a making/entrepreneurial community, the Forge: a makerspace with both low- and high-tech tools focused on the process of making, community, and incubation of businesses.

2.1. Makerspaces as STEM learning environments

AAMASE situates its approach to making as a community-centered, culturally embedded practice. Making and design projects bring together tools and communities to provide both motivation and a context for developing STEM practices (Gravel et al., 2018; Martin, 2015) that are aligned with the Next Generation Science Standards (NGSS) (NGSS, 2013). In fact, programs like AAMASE can support improved agency that results in new visions of STEM that invite broader participation (Calabrese-Barton, Tan, & Greenberg, 2017).

2.2. Young African American women as makers and entrepreneurs

Creating more equitable environments for making and learning requires "learning designers to consider who a maker is (and who can be a maker); what a maker does; for whom a maker makes … [and] who a maker can become in, and through, the act of making" (Castek et al., 2019). Importantly, design principles for fostering more agentic making environments call for incorporating STEM practices as a meaningful part of the making activity (Vossoughi, Escudé, Kong, & Hooper, 2014). AAMASE centered young women's making interests and experiences to subvert the inequities often found in making culture and actualized culturally sustaining pedagogy by amplifying participants' voices (Champion et al., 2020).

2.3. Engaging Young African American women through participatory design research

Too often, minoritized youth are the objects of STEM programs, without having much influence on their design. For example, the design principles in Kennedy and Odell's (2014) overview of high-quality STEM programs leave youth out of the stakeholders included in the design of such programs. Ignoring youth results in missed opportunities for helping minoritized youth learn STEM practices in a way that influences their views of their STEM futures (Tan et al., 2013). *Participatory design research* (PDR) offers an alternative: "Participatory design [PD] is an essential design strategy for creating artifacts and experiences that reflect the voices of the population being designed for and with" (Coenraad et al., 2019). Three main factors contributed to the program reflecting the youths' STEM and making-related interests: 1) youth were told at the beginning of the program that it was a research project and that their voices were essential for the field to learn from their experiences; 2) the AAMASE program staff and design researchers asked the participants (a majority of whom were young women of color) what they wanted to create and

learn and then observed participants' engagement throughout up through reflections on completed build cycles; and 3) perhaps most critically, when youth asked for different resources or learnings, program facilitators worked diligently to provide the experience that the youth were seeking.

3. Research design and methods

A major element of data collection was object elicitation (Levin-Güracar et al., 2024), wherein the interviewee brings an object that they made in the program with them into the interview to spark a conversation about their experiences and what they learned. Since the objects were created by the youth, they embody their knowledge, skills, and attitudes and make interviews easier by shifting the focus 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). For this project, a protocol was developed to contribute to the understanding of participants' development in the project's three foci (i.e., STEM, making, entrepreneurship). The protocol started the conversation around how they approached the design and making process, with follow-up prompts about process, design, idea gathering, and prototyping.

4. Elements of agency

Cavazzoni and colleagues write, "There is still little agreement on how this construct [of agency] should be understood and defined. ... Indeed, no current consensus or standardized methodology exists to assess agency" (2022). Given the lack of consensus, we propose for AAMASE the following five criteria for assessing agency: 1) Self-efficacy - is there evidence that participants perceive that their effort influences their success; 2) Personalization - do the products/processes that participants create/articulate show attempts to make them more relevant or useful to specific people in participants' lives; 3) Connection - do the products/processes that participants create/articulate show connections to notions of self or others; 4) Planfulness - do the products/processes that participants create/articulate show evidence that they were pursued based on some plan or design; and 5) Iteration - do the products/processes that participants create/articulate show evidence that they were improved upon.

5. Supporting agency through AAMASE

Each session of AAMASE, youth were introduced to a different making discipline such as resin, pottery, laser cutting, plasma cutting, 3D printing, sewing, and electronics. These disciplines were chosen in community with the participants. For the final three sessions, youth were presented with a selection of 12 design challenges to solve a problem for a facilitator-created youth persona. Youth had full agency in selecting which challenge they wanted to take on, as well as choice in how they wanted to address the design challenge with access to multiple making disciplines, materials and making mentors around the Forge. Entrepreneurship was integrated throughout; participants developed their brand concept; they learned about business concepts (e.g., costs, labor, and marketing); and some youth showcased their project and their business ideas in a Shark Tank-style final project presentation.

Given our working definition of agency, in addition to organizing the project to support an agency-supportive environment more generally, the specific learning activities and pedagogy in AAMASE aimed to support the five criteria of self-efficacy, personalization, connection, planfulness, and iteration. A single making activity might incorporate support for all five of the criteria or just a subset, but no activity should fail to support multiple.

For example, one of the projects engaged participants in a resin art project. Youth worked with a mentor to experience the fundamentals of resin art as well as some of its chemistry. Youth were provided with coaster molds and various materials that could be used inside of the resin (flowers, glitter, etc.).

One youth, Ciera, decided to use a photocard of a K-pop star, a non-standard decoration that she happened to have with her, into her resin coaster pour. In her object elicitation interview with a researcher, Ciera explained that using the photocard brought herself into the project:

> *It kind of gave it a little bit more meaning because, even though it's like a piece of cardboard, you know, with two random people who probably will never know me, it makes brings me joy, ... making this whole piece that I know that no one else in the world could basically remake because of how different epoxy is, it kind of makes it all a little bit more, ... gives a little bit more worth to me.*

Ciera clearly connects the resin project to personalization, adding her favorite artist's photo directly into her resin pour. The nature of the project made this possible. While the product (coaster) was the same for all students, it was open as to how they decorated and made the final product their own. Ciera also commented on the project's opportunity for creativity and making something unique:

> *It's awesome ... I like this project a lot because it has a lot of like creativity and uniqueness with it. You know, you could all be given the exact same materials and everyone could create something completely different. I like [it] because you can express your individuality, and you can basically bring yourself into your piece. And then your piece is an extension of you*.

Ciera's project further demonstrates the connection aspect of agency, connecting her project to an interest that she shares with peers. Ciera also demonstrates self-efficacy; she is proud of what she created and was able to use the materials to make something personal. Other youth shared similar experiences about AAMASE providing space to explore their creativity. One said:

> *While I'm here at the Forge, I want to dive into my own creativity. I haven't been able to connect as well to my creative side, and I feel like if I can, then I can get to know myself better, plus the more you create the more creative you are then the more pieces of yourself that you get to make, and that can make others happy; it can make you happy.*

To support youth in experiencing their "creative side", projects must support youth's agency and support them in engaging in ways that connect to themselves. This youth is talking about making pieces of herself, clearly understanding the importance of personalization in the making process.

6. Conclusion

To better support young women's agency in makerspaces, programs should be organized to center around the participants' learning interests and focusing the learning activities on their experience instead of on a set curriculum with specified goal products. The structure of AAMASE making activities supported Ciera's and other participants' agency most frequently through the support of *self-efficacy*, *personalization*, and *connection*. Due to time constraints, *planfulness* and *iteration* were supported less often. The AAMASE participants reported and displayed high engagement and enjoyment. Experiences like Ciera's and those of her peers are key to engaging young women in STEM-rich learning experiences and ultimately broadening STEM opportunities for all.

Acknowledgments

The authors extend our gratitude to the participants of the AAMASE program for their enthusiasm for the program and their willingness to participate in our research. The authors also thank The Forge for being such patient partners in this endeavor. This material is based upon work supported by the National Science Foundation ITEST Program (award #2148543). 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.

References

Bang, M. (2015). Culture, learning, and development and the natural world: The influences of situative perspectives. *Educational Psychologist, 50*(3), 220-233.

Brickhouse, N. W. (2001). Embodying Science: A Feminist Perspective on Learning. *Journal of Research in Science Teaching, 38*(3), 282-295.

Calabrese Barton, A., Tan, E., & Greenberg, D. (2017). The makerspace movement: Sites of possibilities for equitable opportunities to engage underrepresented youth in STEM. *Teachers College Record, 119*(7), 1-44.

Castek, J., Schira Hagerman, M., & Woodard, R. (2019). *Principles for equity-centered design of STEAM learning-through-making*. University of Arizona, Tucson, AZ.

Cavazzoni, F., Fiorini, A., & Veronese, G. (2022). How Do We Assess How Agentic We Are? A Literature Review of Existing Instruments to Evaluate and Measure Individuals' Agency. *Social Indicators Research, 159*, 1125-1153. https://doi.org/10.1007/s11205-021-02791-8

Champion, D. N., Tucker-Raymond, E., Millner, A., Gravel, B., Wright, C. G., Likely, R., ... & Dandridge, T. M. (2020). (Designing for) learning computational STEM and arts integration in culturally sustaining learning ecologies. *Information and Learning Sciences*, *121*(9/10), 785-804.

Coenraad, M., Palmer, J., Franklin, D., & Weintrop, D. (2019, June). Enacting identities: Participatory design as a context for youth to reflect, project, and apply their emerging identities. *Proceedings of the 18th ACM International Conference on Interaction Design and Children* (pp. 185-196).

Gravel, B., Tucker-Raymond, E., Kohberger, K., & Browne, K. (2018) Navigating worlds of information: Literacy practices of experienced makers. *International Journal of Technology and Design Education, 28*(4), 921-938.

Grossman, J. M., & Porche, M. V. (2014). Perceived Gender and Racial/Ethnic Barriers to STEM Success. *Urban Education*, *49*(6), 698-727.

Harper, D. (2002). Talking about pictures: A case for photo elicitation. *Visual studies*, *17*(1), 13-26.

Howard, T., Smith, N., & Nwaigwe, U. (2020). *Banks and the Black Community: What Can Major Commercial and Retail Banking Institutions Do to Better Support Black Entrepreneurs and Businesses in the U.S.?* Center for Policy Analysis and Research.

Kennedy, T. J., & Odell, M. R. L. (2014). Engaging students in STEM education. *Science Education International*, *25*(3), 246-258.

King, N. S., & Pringle, R. M. (2019). Black girls speak STEM: Counterstories of informal and formal learning experiences. *Journal of Research in Science Teaching*, *56*, 539-569.

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, L. (2015). The Promise of the Maker Movement for Education. *Journal of Pre-College Engineering Education Research (J-PEER)*, *5*(1), Article 4.

National Science Foundation, National Center for Science and Engineering Statistics. (2017). Women, Minorities, and Persons with Disabilities in Science and Engineering: 2017 (*Special Report NSF 17-310*). Arlington, VA.

NGSS Lead States. (2013). *Next generation science standards: For states, by states*. Washington, DC: The National Academy Press.

Tan, E., Calabrese Barton, A., Kang, H., & O'Neill, T. (2013). Desiring a career in STEM-related fields: How middle school girls articulate and negotiate identities-in-practice in science. *Journal of Research in Science Teaching*, *50*(10), 1143-1179.

Vossoughi, S., Escudé, M., Kong, F., & Hooper, P. (2013, October). Tinkering, learning & equity in the after-school setting. In *Annual FabLearn conference*. Palo Alto, CA: Stanford University.

Wardrip, P., Evancho, J., & McNamara, A. (2018). Identifying what matters. *Phi Delta Kappan*, *99*(6), 60-63.

Weiss, C. (1995). Nothing as Practical as Good Theory: Exploring Theory-Based Evaluation for Comprehensive Community Initiatives for Children and Families. In J. Connell, A. Kubisch, L. Schorr, & C. Weiss (Eds.), *New Approaches to Evaluating Community Initiatives*. Washington, DC: Aspen Institute.