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Steaming Up After-School Science: Promoting Girls' Science Identity Development

Mark Enfield[1]

Abstract

This paper describes three girls' development during a year-long, after-school science program. The program was designed to integrate engineering and design experiences, employ technology to support multimedia authoring, and apply a STEAM instructional framework. The "STEAM" framework invited the use of artistic creativity when completing science and engineering tasks. This research investigated the role of STEM/STEAM in supporting girls' identity development in science. This case-study design examines the girls' products, video recordings of sessions, and quick interviews. Analyses imply conclusions about these girls' identity trajectories in science as a result of participation in this after-school science program. Participation was important; only two of the three girls remained throughout the year. The two girls who remained in the program demonstrated identity development in science. By the end of the year, both girls positioned themselves as scientific thinkers through their actions and final products. However, artistic creativity did not seem to significantly impact the girls' engagement with STEM. While nearly all activities included opportunities to engage creativity either to present knowledge, there was no evidence that artistic creativity effected the girls' engagement. These findings challenge science education researchers and practitioners to consider the arguments for and against the STEAM framework, as well as how informal STEM experiences engage and support girls' science identity development.

Keywords: Informal education, girls' science identities, STEM/STEAM

Subject/Problem

This study focuses on three girls' science identity development in the context of a year-long, after-school program. The study is rooted in theoretical perspectives on identity [1, 2] to consider how public attention to STEM, and the recent construction STEAM, serve as organizing frameworks that facilitate inclusion of marginalized science learners, in this case girls. The study raises questions about how STEAM affords opportunities to support development of girls' science identities.

Limited time in school devoted to science learning [3] and a need to reframe science learning and literacy [4] has led to a growth in efforts to enrich science learning through after-school programming [e.g. 5, 6-9]. After-school programs do more than enrich school science learning; they serve to reframe science and knowing science—in short, the meaning of science literacy [9]—and give voice to disenfranchised science learners [6]. This study focuses on dimensions of gender and race for disenfranchisement. In terms of gender, research is clear that school science is problematic for girls [10, 11]. In particular, schools and teachers often negatively influence girls' confidence and affiliation with science [12-16].

STEM—Science, Technology, Engineering, and Mathematics—is familiar in contemporary science instruction. Recently, some have argued that integrating Art, making STEAM, engages marginalized students' strengths [17]. STEAM proponents claim art integration complements educational reforms [18] and promotes science literacy [17]. Others argue that increasing creativity can support positive science-identity development, particularly for girls [15, 19]. These perspectives encourage STEM educators to consider artistic creativity in STEM learning. However, the STEAM framework and artistic creativity have yet to be thoroughly investigated as an approach to improve girls' science-identity development. This study investigates the STEAM framework's role in developing girls' science identities.

[1] Elon University (United States)

Design

This case-study [20] of three girls' participation in a year-long, voluntary, after-school science program observes and analyzes the girls' identity development using participant observation [21]. At the beginning and end of the year, participants completed a modified Draw-A-Scientist Task [22]. Additional data sources include researcher annotations, video recordings of sessions, written work, and participant-generated multi-media recordings. Using a naturalistic inquiry, there were no formal interviews, but video-recorded mini-interviews occurred throughout the year in the form of single-question verbal responses given as children left for the day.

The context was a local high-poverty elementary school. The neighborhood school was in a historically middle-class neighborhood, but after desegregation and job losses, the residential makeup changed, leaving primarily children from minority, immigrant, and low-income families to attend the school. Many of the children lived in federally-subsidized housing. The after-school program teachers included the author/researcher (a university professor), an undergraduate preservice teacher, and a classroom teacher.

Findings

These findings consider cases of three girl's experiences across the year and how those experiences developed the girls' identities. The three girls represented different races and abilities. Pseudonyms were selected by the author.

Sue was of Asian descent. Her immigrant parents had limited English proficiency, but Sue had was a fluent speaker and was identified by teachers as a successful, high performing student. Sue was naturally curious and interested in learning science. At the beginning of the year, Sue revealed a complex view of science as more than simple experiments and explosions. In particular, she chose to draw a scientist's lifespan in her draw-a-scientist task. Sue's creativity focused on problem solving, but not artistic representation. When asked about creativity, her response focused on using creativity in engineering design. Throughout the year, Sue's use of creativity in representation seemed to be after-thoughts. However, Sue was engaged and even completed an independent investigation during a school break. She was enthusiastic and usually was a small group leader. At the end of the year, Sue's representation of a scientist was more simplified than her initial drawing, but she continued to challenge the stereotypical views of science. Concurrently, her identity as a science student seemed unchanged.Beth was a low-income Caucasian girl who struggled academically and socially. Her classroom teacher reported that she was behind academically, while other teachers in the school commented on Beth's behavioral struggles. Initially, Beth demonstrated fairly typical ideas about science. However, she was an eager participant and often led in small group activities and was more inclined to be artistically creative when completing science and engineering tasks. In a mini-interview, she revealed an understanding of the interrelationship between creativity, design, and engineering. However, in many activities, this kind of creativity and design were also after-thoughts. Beth was a good observer and described things well. Beth improved her ability to explain: growth in her scientific proficiency. At the end of the year, her representation of science included more positive female gender perspectives and more complex ideas about science.Narissa was African American and low-income; she begged for food from the author/researcher. The assistant principal explained that Narissa received take-home food supplements, but she was not surprised she begged for food. While Narissa was an effective participant in the after-school program, she was frequently in trouble in school. Initially, her drawing presented interesting and complex ideas about science, including women and girls engaged in a variety of science activities. During the year, Narissa's leadership focsed on being a communicator of group work. Narissa did not complete the program because she was removed as a consequence of behavior in school. Therefore, her case was incomplete.

Implications

One implication from these cases was that for these three girls, the inclusion of artistic creativity—the "A" of STEAM—did not seem influence their science identities. All three girls participated in the activities, seemed to learn science concepts, and demonstrated confidence in their ability to make sense of and explain science. They all demonstrated leadership as regular contributors, leaders in small groups, and being willing to share ideas. However, there is no evidence to support a claim that emphasis on creativity

in science and engineering impacted these girls. In mini-interviews about creativity, none clearly indicated that creativity was influential. Videos of the girls during sessions and also their written work suggest that the arts and creativity were added on at the end rather than integral in their work. Particularly when working on design problems, their focus was first on function and problem solving. This raises questions about frameworks like STEAM; does STEAM affect girls' engagement, motivation, and affinity with STEM? One challenge in the program was maintaining participation. As a voluntary after-school program at an elementary school, the school established expectations for students. This was problematic for the Narissa, since, due to her behavior in school, she was not allowed to participate in the program after spring break. However, she benefitted from the program and may have developed a stronger science identity. She was a very bright girl who struggled to conform to the norms of school. Building on the issues around affiliation and support that Carlone and Johnson [23] describe, science educators committed to social justice and equity must also consider the various limits to participation that affect girls' opportunities to develop affiliation with science. One limit in this study could be the role of the teacher. The program was initially co-led by the author/researcher and an undergraduate student, with support from a classroom teacher. Beginning in January, the undergraduate student was no longer involved in the program. The author/research did not provide the same modeling and scaffolding of artistic creativity as the undergraduate student. This may be a limitation for this study. However, the girls' participation did not seem to vary significantly, and therefore we assume the nature of creativity did not have a profound impact on building the girls affiliation with STEM. Finally, it is important to note that one of the girls chose to complete extra investigations during a school break. Sue not only completed the activities, she wrote a two-page description of her findings that she brought to share in the after-school program. This implies that she developed a public identity and affinity with science: she presented her work to the after-school program participants, engaged in scientific practices, and wrote up her results. Thus, the program seems to be building general affiliation with science and, in the case of this girl, also built individual affinity and identity with science.

References

[1] Wortham, S., *The interdependence of social identificaiton and learning.* American Educational Research Journal, 2004. **41**(3): p. 715-750.

[2] Gee, J.P., *Identity as an analytic lens for research in education.* Review of Research in Education, 2000. **25**(1): p. 99-125.

[3] Blank, R., *Science instructional time is declining in elementary schools: What are the implications for student achievement and closing the gap?* Science Education, 2013. **97**(6): p. 830-847.

[4] Barton, A.C. and M.D. Osbourne, *Marginalized discourses and pedagogies: Constructively confronting science for all.* Jouranl of Research in Science Teaching, 1998. **39**(4): p. 339-340.

[5] Rahm, J., *Collaborative imaginaries and multi-sited ethnography: space-time dimensions of engagement in an afterschool science programme for girls.* Ethnography and Education, 2012. **7**(2): p. 247-264.

[6] Rahm, J. and D. Ash, *Learning environments at the margin: Case studies of disenfranchised youth doing science in an aquarium and an after-school program.* Learning Envinronment Reserch, 2008. **11**: p. 49-62.

[7] Barton, A.C. and C. Berchini, *Becoming an insider: Teaching science in urban settings.* Theory into Practice, 2013. **51**: p. 21-27.

[8] Barton, A.C. and E. Tan, *Funds of knowledge and discourses and hybrid space.* Journal of Research in Science Teaching, 2009. **46**(1): p. 50-73.

[9] Barton, A.C. and E. Tan, *We be burnin': Agency, identity, and learning in a green energy program.* Journal of the Learning Sciences, 2010. **19**(2): p. 187-229.

[10] Zimmerman, H.T., *Particpating in science at home: Recognition work and learning in biology.* Journal of Research in Science Teaching, 2012. **49**(5): p. 597-630.

[11] Brickhouse, N.W. and J.T. Potter, *Young women's scientific idenitity formation in an urban context.* Jouranl of Research in Science Teaching, 2001. **39**(8): p. 965-980.

[12] Baker, D., *What Works: Using Curriculum and Pedagogy to Increase Girls' Interest and Participation in Science.* Theory Into Practice, 2013. **52**(1): p. 14-20.

[13] Carlone, H.B., *The culturel production of science in reform-based physics: Girls access, participation, and resistance.* Journal of Research in Science Teaching, 2004. **41**(4): p. 392-414.
[14] Carlone, H.B., A.C. Johnson, and C.M. Scott, *Agency amidst formidable structures: How girls perform gender in science class.* Jouranl of Research in Science Teaching, 2015. **52**(4): p. 474-488.
[15] Cooper, R. and C. Heaverlo, *Problem solving and creativity and design: What influence do they have on girls' interest in STEM subject areas?* American Journal of Engineering Education, 2013. **4**(1): p. 27-38.
[16] Thompson, J., *Engaging Girls' Sociohistorical Identities in Science.* Journal of the Learning Sciences, 2014. **23**(3): p. 392-446.
[17] Jolly, A. *STEM vs. STEAM: Do the arts belong?* Education Week Teacher, 2014.
[18] NGSS Lead States, *Next generation science standards: For states, by states*. 2013, National Academy Press.
[19] Yoon, S.Y., et al., *The effects of integrated science, technology, and engineering education on elementary students' knowledge and identity development.* School Science & Mathematics, 2014. **114**(380-391).
[20] Yin, R.K., *Case Study Research : Design and Methods*. 3rd ed. 2002, Thousand Oaks: Sage Publications.
[21] Atkinson, P. and M. Hammersly, *Ethnography and participant observation*, in *Handbook of Qualitative Research*, N.K. Denzin and Y. Lincoln, Editors. 1994, Sage Publications: Thousand Oaks. p. 248-261.
[22] Schibeci, R.A.S., Irene, *Elementary School Children's Perceptions of Scientists.* School Science and Mathematics (v83 n1 p14-20 Jan 1983), 1983. **83**(1): p. 14-20.
[23] Carlone, H.B. and A.C. Johnson, *Unpacking 'culture' in cultural studies of science education: cultural difference versus cultural production.* Ethnography and Education, 2014. **7**(2): p. 151-173.