International Society of the Learning Sciences

Expanding Science Learning within Community-Based Hands-on Transdisciplinary STEAM Experiences

Areej Mawasi, Arizona State University, amwassi@asu.edu
Ruth Wylie, Arizona State University, ruth.wylie@asu.edu
Punya Mishra, Arizona State University, punya.mishra@asu.edu

Abstract: In this paper, we examine how a four-day out-of-school program planned and taught by a community-based organization allowed for a range of educational possibilities, specifically unlearning "school science" by participating in transdisciplinary STEAM activities, which in turn, offered generative ways to develop STEAM-related identities. These outcomes enabled learners to expand the ways they view science learning. Implications of this experience for designing and studying learning experiences for non-dominant learners are shared.

Transdisciplinarity: Thinking beyond disciplines to engage non-dominant learners in informal STEAM activities

Transdisciplinarity allows learners to creatively connect "different solutions, viewpoints, or perspectives" across disciplines (p. 24, Mishra et al., 2011). In the past decade, education research has stressed the importance of developing transdisciplinary STEAM curricula that encourage learners to view science, technology, engineering, and math as interconnected and to think critically and ethically about STEM disciplinary practices (e.g., Rosebery et al., 2010; Takeuchi et al., 2020; Mishra et al., 2011). In STEAM environments designed for non-dominant and historically marginalized learners, transdisciplinarity allows educators to leverage learners' assets (e.g., using culturally-relevant artifacts or linguistic resources) and diverse range of identities (Gee & Parekh, 2018; Nasir et al., 2006) to expand learning possibilities beyond the constraints of one specific discipline (Takeuchi et al., 2020). Such equity-oriented approaches allow for diverse forms of engagement and participation within learning environments. This allows learners to forge connections between learning environments that are both in and out of schools, connect knowledge across disciplines, and connect their learning activities to their identities, therefore linking these fields to their lived experiences (Sengupta-Irving & Vossoughi, 2019).

These opportunities are particularly relevant for the work that our collaborators, Al-Rowad for Science and Technology, do with Palestinian youth in Israel, a non-dominant population in STEAM and a historically marginalized population. While framing their work as "Science and Technology," the organization aims to increase individual and societal self-efficacy towards science by intentionally engaging learners with transdisciplinary hands-on activities that connect science, technology, engineering, art, and math.

Learning environment context at Al-Rowad for science and technology

We collected data from a four-day program for 10 fifth- and sixth-grade learners, led by two educators from the organization. Each day focused on a different concept and included didactic teaching, discussions, and hands-on activities. The instruction was often structured as a series of questions that prompted students to connect science concepts to everyday phenomena. The lead teacher would emphasize that "there is no right or wrong answer" to encourage students to share their thoughts. She respected learners' choice to not participate in the discussion, acknowledging that some students have different preferences about sharing in large groups. After these discussions, learners were given hands-on toolkits and instructions to build and complete the day's hands-on activity artifact. Students were then encouraged to take the completed activity home to share with family. In total students completed four activities: Super Absorbent Polymer, Newton's Disc, Illuminating Board, and Oil & Water.

Methodology for data collection and analysis

The data for this paper comes from a series of semi-structured interviews with participants (n=10) following the four-day (8 hour) workshop. The interviews were 40-60 minutes long (average time = 48.4 min, SD=8.9 min). An initial inductive coding was followed by a close reading of the interviews, first cycle coding of interviews, and writing summative memos about each student's experience (Saldaña, 2015).

Findings

Although the program was centered on scientific issues and promoted as focusing on science, participants engaged in activities that crossed disciplinary boundaries. This engagement and participation allowed learners to expand

their knowledge of STEAM possibilities (i.e., STEAM practices as interconnected and connected to varied disciplines). For instance, these activities included not just working and playing with colors and lights, but also processes of thinking, planning, drawing, and prototyping that unite the arts, science, and engineering. This transdisciplinary approach provides an alternative to traditional modes of school science and thereby expands what counts as authentic science, pushing participants to *unlearn school science* as reflected through the students' perceptions.

Since the hands-on activities incorporated *a transdisciplinary* connection between science, technology, and arts, this allowed learners to build multiple hands-on tools which serve as modeling for phenomena they discussed in class. On the other hand, not all learners described the activities as transdisciplinary. Examples in interviews indicate that STEAM learning is an emergent transdisciplinary process. While learners, in some cases, did not necessarily identify certain practices as tied with specific disciplines, they were attempting to think about STEAM through their own identities (e.g., I imagine, I draw) or activities they themselves do (e.g., drawing, playing with family). While at a surface level, it might read as if learners are not engaged in talking about STEAM disciplinary practices or discourses, it can be an opportunity for expanding ways in which non-dominant learners enact STEAM in relation to their everyday lives and self-identities. We expand on this idea of emergent identities below.

We identified varieties in how students perceive their STEAM activities, practices, and roles. These varieties reflect how each student's unique learning trajectory may be shaping their perceptions of engagement and participation within the program. The unique ways learners expressed their thinking enabled us to identify *emergent identities* in relation to the students experiences with activities. For instance, a student perceiving an artifact as an art, enabled them to see themselves as an artist and build connections between art and science.

Summary

The program activities that these learners participated in align with Dewey's (1956) fourfold areas of interest for learning: "the interest in conversation, or communication; in inquiry, or finding out things; in making things, or construction; and in artistic expression" (p. 48). Through these activities, learners engaged in (a) conversations and communication about STEAM practices both within and outside the program's in-person activities; (b) observation and inquiry; (c) making and constructing artifacts with scaffolds provided by instructors; and finally, (d) artistic expression through working with colors, drawing, and the aesthetics of the final artifact.

Looking beyond the specifics of this project, we suggest enabling a space for learners to expand agency towards the ways they see, engage, and perceive science activities, by viewing STEAM learning as an emergent process, rather than a process with science learning as its sole outcome. It is through the thoughtful design of pedagogy and activities that learners can go beyond seeing science as a disconnected array of facts taught in school, and instead approach it as an organic body of knowledge that is connected with other disciplines and with their personal lives and identities.

References

Dewey, J. (1956). The child and the curriculum; and The school and society (Combined ed., Phoenix books). Chicago: University of Chicago Press.

Gee, E., & Parekh, P. (2018). Gender in the Making: Literacies and Identities in Girls' Self-Initiated Making Activities. In Literacies, Sexualities, and Gender (pp. 54-65). Routledge.

Rosebery, A. S., Ogonowski, M., DiSchino, M., & Warren, B. (2010). "The coat traps all your body heat": Heterogeneity as fundamental to learning. The Journal of the Learning Sciences, 19(3), 322-357.

Saldaña, J. (2015). The Coding Manual for Qualitative Researchers. London, UK: Sage

Sengupta-Irving, T., & Vossoughi, S. (2019). Not in their name: re-interpreting discourses of STEM learning through the subjective experiences of minoritized girls. Race Ethnicity and Education, 22(4), 479-501.

Takeuchi, M. A., Sengupta, P., Shanahan, M. C., Adams, J. D., & Hachem, M. (2020). Transdisciplinarity in STEM education: a critical review. Studies in Science Education, 1-41.

Mishra, P., Koehler, M. J., & Henriksen, D. (2011). The seven trans-disciplinary habits of mind: Extending the TPACK framework towards 21st century learning. Educational Technology, 22-28.

Acknowledgments

The research work was partially supported by the Arizona State University GPSA Jumpstart and the Graduate Research and Support Program of ASU Graduate College. We also acknowledge and thank Al-Rowad for their participation in this project. Any opinions, findings, and conclusions are those of the authors and do not necessarily reflect the views of ASU or Al-Rowad.