Promoting Systems Thinking Through Arts-Based Science Activities

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Abstract: We present two interventions aimed at promoting learning about both art and science. We utilize arts-based assessments as well as traditional measures to examine learning and systems thinking. Taking place in rural communities in the Pacific Northwest, and focusing on students primarily in 3rd to 5th grade, our results indicate that arts-based assessments may compliment traditional measures of knowledge, while at the same time transcending language barriers and promoting positive emotions and interest.

Keywords: STEAM, arts-based assessment, art and science learning, systems thinking

Introduction

Various socio-scientific issues (e.g. energy crises, global climate change, food shortages) require an educated citizenry of voters, decision-makers, and consumers. Fully comprehending socio-scientific issues and their implication in today's society necessitates thinking that can bridge social, environmental, and economic systems. As science education shifts from educating few students with the intent to train them for careers in STEM, to educating all students to be able to respond to and communicate about these socio-scientific issues (Treagust & Tsui, 2014), systems thinking comes into the spotlight as one way to bolster 21st century competencies and STEM literacy for all students. Systems have long been recognized as a major conceptual theme running throughout all scientific disciplines. Unfortunately, systems-level thinking is not well-developed in schools, resulting in students having difficulty understanding complex and emergent systems. Yet, even elementary-level children are capable of understanding complex systems when given the opportunity).

The purpose of this study is to investigate how arts integration into STEM might support systems thinking about socio-scientific issues. Two interventions, "Buzzing for Blood", an after-school program focusing on zoonotic diseases and ecosystem dynamics, and "Zoom", a summer camp focusing on microbiomes, utilize an arts-based approach to developing systems-level understanding. Both curricula focus on serving upper elementary students in rural-agricultural communities, with an emphasis on hands-on activities centered in the community. What follows is a brief review of relevant literature regarding arts integration and systems thinking, a description of our investigation, and the presentation of initial findings and student art.

Theoretical framework

While the exact definition and precise goals of STEM (science, technology, engineering, and mathematics) education are still debated, descriptions of STEM education commonly include the integration of at least two STEM disciplines to encourage interdisciplinary thinking, cross-disciplinary recognition, and application of STEM concepts to real-world contexts (Bybee, 2010; Honey, Pearson, & Schweingruber, 2014; Vasquez, 2014). To achieve STEM literacy for all, some scholars suggest the integration of art into STEM education, creating STEAM education (Allina, 2018; Lima & Timm-Bottos, 2018). Art integrated into STEM disciplines allows students to interact with and create multiple models of complex ideas. In their discussion of drawing instruction in science, Ainsworth, Prain, and Tytler (2011) suggest five reasons for integrating art: 1) to enhance engagement, 2) to learn to represent in science, 3) to reason in science, 4) as a learning strategy, and 5) to communicate. The practice of drawing allows students to explore content differently as they engage through drawing. In the present study, we examine how students move through our co-designed curricula while learning about both art and science. We employ multiple measures to capture how students experience this project, as described below. Our goal is to both increase knowledge of arts and sciences, and at the same time increase interest and positive emotions associated with these constructs

Research design

A partnership among university researchers, community organizations, local artists, and experts in science and science communication, we attempt to build the capacity of educators and biomedical institutions to engage

rural, predominantly Latinx students in locally relevant science activities. This program is created and updated our team of interdisciplinary scholars (education, human development, public health communication, medicine, biology, informal science communicators, librarians, and volunteers) conducting iterative design-based research on STEAM programs related to health sciences. We engaged elementary students in scientific investigation and studio activities to blend scientific and artistic understanding. Utilizing scientific illustration, cartography, photography, sculpture, comic book narratives, and infographics, we investigate the research question: how did student thinking and feeling change as a result of participation in in these programs?

Results

Our preliminary results are promising. We can see that students engaged in both systems thinking and causal reasoning. Figures 1 and two are examples of student art that depicts how mosquitoes are supported and thrive in local communities. What is notable about this approach is that while Figure 1 illustrates more a more classic depiction of a food chain that supports mosquitos, Figure 2 extends this work with photographs from the students' community. To capture these images we supplied students with digital cameras and they walked us around their community. Here, we can see that the area right around students' homes are ideal breeding grounds for mosquitos, providing a source of food, water, and places to breed.

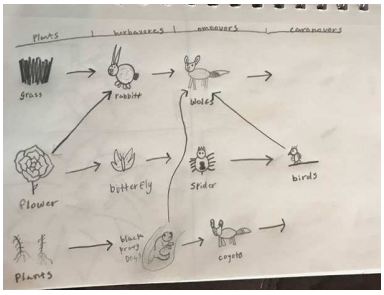

Figure 1. Student food chain.

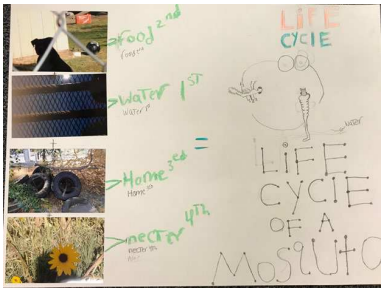

Figure 2. Student photos of community.

In addition to the student art, we created a number of quantitative measures for this project, and our initial results indicate that they are preforming reliably. Specifically, our 20-item true/false knowledge measure indicated that, on average, students learned a significant amount about the topics (from an average of 60% correct to 80% correct, $t(16) = 5.28$, $p < .05$). Additionally, our measures of interest (alphas = .912 and .891 for interest in science and art respectively) and emotions (alphas = .760 and .682 for emotions around science and art respectively) indicated that while we observed initial relationships between gender and age with engagement with science and art (girls were more interested in art, $r = .393$ and older students had stronger negative feelings about science $r = .403$ and art $r = .505$, these relationships disappeared by the end of the intervention.

Discussion

While still in the initial phases of data analysis, both the results of the arts-based assessments and more traditional quantitative assessments are promising. Students are making connections between different levels of perception, and providing evidence of emerging systems thinking grounded in their own communities. Additionally, students are reporting a reduction in negative emotions around science and art, which could be a precursor to future engagement.

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