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Learning by Making: Investigating Students' Identity Exploration Using Environmental Science and Art

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Abstract

The United States is currently projecting a shortage in the number of qualified STEM professionals. These projections have led to renewed calls for a focus on varied instructional practices to reinvigorate interest and proficiency in STEM subjects. One such practice, learning by making, has been suggested as a potential approach to STEM education. This study reports the results of 18 high school students' identity exploration towards STEM careers in a four-week maker course based in environmental science and art. Epistemic Network Analysis was utilized for data analysis and visualization. Research outcomes and implications are discussed.

Aim

Educational researchers have argued that learning by making by utilizing specific technology (e.g. 3Doodler, LittleBits, and Makey Makey), can facilitate new ways of understanding concepts, supporting identities and dispositions, and triggering future trajectories in academic domains and careers (Bevan, 2017). The purpose of this research study was to examine the identity exploration trajectories that resulted from participation in a four-week learning by making course centered around environmental science.

Problem and Research Question

The problem addressed by this research study is as follows: Experts project that the United States will continue to experience a shortage in the number of experienced STEM professionals (Kitchen, Sonnert, & Sadler, 2018). To mitigate this shortfall, there has been an emerging interest in the development of a variety of instructional practices to reinvigorate student interest and proficiency in STEM subjects. One such practice, learning by making, focuses on the design and creation of both physical and digital artifacts (Halverson & Sheridan, 2014).

Despite the potential of learning by making to foster proficiency in STEM education, there is relatively little literature on the efficacy of learning by making programs, specifically on, a) which theoretical and pedagogical approaches may best complement making activities in supporting the acquisition of knowledge and skills in domains that are valued in schools, and b) the interactions between self and learning and the related changes in learner interest and valuing of STEM content (Halverson & Sheridan, 2014). To address this gap in the literature, this study was guided by the following research question: In what ways did students in a

maker-centered course engage in the exploration of identities related to environmental science and art?

Theoretical Framework

This study focused on investigating STEM learning as a longitudinal process of change over time defined here as identity exploration. Projective Reflection was utilized as a theoretical framework for this study. Projective Reflection operationalizes identity exploration as the intersection of a learner's knowledge, interest and valuing, perceptions and definitions of self, as well as self-organization and self-control (Shah, Foster, & Barany, 2017). Though learners were measured along individual constructs, the goal of Projective Reflection was to understand an integrated process of identity exploration throughout a learner's starting self, exploration of possible selves, and new self. Projective Reflection was utilized to guide the design of the curriculum experience throughout the four-week course, in addition to its use as an assessment of student progress to track change over time.

Participants and Context

This study was conducted at a large environmental education center in the Northeastern United States. The center is one of the first urban environmental education centers in the country and offers programming across four core program areas: environmental education, environmental art, land stewardship, and wildlife rehabilitation. These programs are offered to school-aged children (K-12) year-round through partnerships with local schools, some of which focus broadly on STEM, some of which focus specifically on environmental science.

Participants were invited from local after-school centers and programs. A total of 18 high school students agreed to participate in a four-week long course on environmental science and art. In addressing learning by making, students were introduced to the LittleBits Electronics Kit. LittleBits are color-coded, modular pieces that magnetically snap together to create many opportunities to build innovative projects.

Data Collection and Analysis

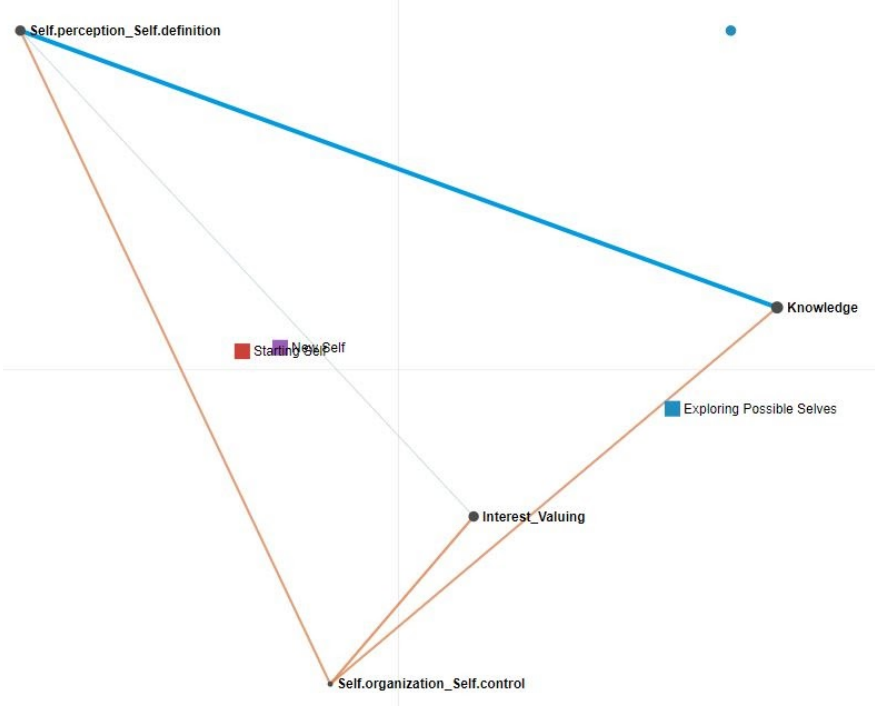
Student background surveys, pre-post Projective Reflection surveys, journals, and exit surveys were organized and preliminarily coded for usage with Epistemic Network Analysis (ENA). ENA is a technique for modeling the structure of connections in data. It models the connections between codes by quantifying the co-occurrence of codes within conversations, producing a weighted network of co-occurrences, along with associated visualization for each unit of analysis in the data (Shaffer & Ruis, 2017). Specifically, ENA was used to analyze all the networks simultaneously, resulting in a set of networks that can be compared both visually and statistically.

Research Findings

In examining the ENA visualizations, three key factors are of note: (1) The orientation of the diagram does not matter; (2) The placement of the constructs on the axes does not matter; and (3) The thickness of the lines (connections) between constructs as well as the position of the mean in relation to the constructs are important. Figure 1 illustrates an epistemic network comparing all 18 participants' starting self compared to their exploration of possible selves. The difference model illustrates that the students had stronger connections between their knowledge and self-perception/self-definitions during the exploration of possible selves phase of identity exploration. Though connections were similar in strength between students' interests/valuing and self-perceptions/self-definitions across both identity phases, the remaining connections between constructs were viewed as slightly stronger in the starting self phase. A paired-samples t-test was conducted to compare the identity phases of starting self to the exploration of possible selves. The t-test revealed (t(-8.05)=8.17, p=0.00) a statistically significant difference in cumulative identity exploration score between students' starting selves and their exploration of possible selves.

Figure 1

Epistemic Network Comparing Students' Starting Selves and Exploring Possible Selves



Conclusion/Discussion

In addressing the research question, there are several takeaways based on the ENA visualizations. While there were clear outcomes in terms of students' knowledge and self-

perception/self-definition as it relates to their exploration of possible selves, it cannot be stated outright that identity was supported in an integrated capacity. The difference model illustrated that a majority of the strongest identity connections already existed in terms of students' starting selves. As such, there was little support for the kind of integrated identity as described by Projective Reflection. Given the preliminary nature of this work, further visualizations highlighting the difference models of starting self/new self and exploring possible selves/new self may reveal the type of integration of these identity constructs expected in Projective Reflection.

Implications

The results of this study highlighted the outcomes of a four-week maker course focused on environmental science and art. Based on data analysis through ENA, students made the strongest connections between their knowledge and self-perceptions/self-definitions in their exploration of possible selves. While there was not enough evidence to claim an integrated process of identity exploration as defined by Projective Reflection, potential limitations were identified through these outcomes. The design of the four-week course may not have provided enough time for identity exploration as Projective Reflection theorizes this change to occur longitudinally. An extended course structure may reveal varied results by comparison. By providing more varied opportunities within the course, such as allowing students to utilize outdoor resources offered by the environmental center, students may have been able to view themselves in the position of environmental scientists more easily. The emphasis on experiencing these role possible selves could impact the integration of identity exploration constructs.

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Author Biography

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