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Tools Dictate the Divide: Entrenched Gendered Practices in the Making of Kinetic Sculptures

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Abstract: One of the promises of STEAM-based education is to ameliorate existing gender disparities regarding access to STEM fields. We analyze youth making kinetic sculptures as a novel STEAM-based approach to infusing historically gendered practices into the study of robotics. We found the distribution of labor was based on gender normative practices. This study highlights how STEAM-based education requires an examination of our tools and materials and how they reinscribe existing practices along traditional gendered lines.

Introduction

The potential of STEAM to transform education depends on how it tackles evident gender disparities regarding access to (and invitations to participate in) fields such as science, technology, engineering, and mathematics (STEM). In particular, activities related to electronics engineering and robotics have a particularly male-centered culture that needs to be changed in order to make learning spaces welcoming and nurturing to many gender identities, particularly female youth (Peppler, 2013). Prior work has explored the emergence of new ways of exploring STEM, starting at the tool level, where the introduction of the LilyPad Arduino in a classroom setting produced similar disruptions of gendered participation around electronics and coding as seen in the broader Maker Movement (Buechley & Mako-Hill, 2010). By examining children's use of a wider array of materials during the construction of kinetic sculptures (sculptures in which movement is a paramount element), we aim to identify tacitly accepted practices rooted in gendered stories of materials, examining children's use of artistic media and an Arduino-based robotic kit while learning coding, robotics, electronics, and sculpture making. The questions that guide our study are: (1) What are the practices in making a robotic kinetic sculpture? (2) How do gendered patterns affect the division of labor in a mixed-gender triad while designing and building a kinetic sculpture?

Methods

In the spring of 2022, data were collected during a workshop in a combined 5th and 6th grade class at a charter school in Orange County, California. From a total of over 15 hours for four student groups, we analyzed 75 minutes of video and audio recordings focused on one student trio, a sample composed of two girls and one boy, which served the purpose of identifying how youth divided labor with respect to gender in a group composed with majority girls. Our analysis focuses on the final hour of a kinetic sculpture workshop as students worked to piece their final sculptures together. The excerpt contains complex manipulation of materials with key moments of negotiation in the division of labor, while still being representative of the overall project labor division. We drew from Buchholz et al.'s (2014) methodology, coding *instances* in the video data, and determined the practices that took place. Each time one of the three youth exhibited a mediated action, it was coded and categorized as arts, electronics, or coding practice, using sub-codes within each of these categories. Two authors coded the video data to identify practices and count the frequency of these practices' appearances. We also registered duration (measured in seconds) for each category and subcategories of practices and coded 15 minutes of data; inter-rater reliability of the coding scheme was calculated by Cohen's kappa with k=.82. This coding process led us to determine the frequency and duration of each practice.

Findings

After coding the frequency and duration of each practice, three major groupings for the practices emerged: *Arts Practices, Electronic and Robotics Practices, and Computing Practices*. Our findings align with notions of art perceived as predominantly feminine, with girls engaging in art practices with more frequency and duration (70%) than their male counterparts (30%). Overall, the boy in the studied trio engaged 85% of the time spent with electronic and robotics practices, with girls collectively at 15%, reflecting a heavily male indexing of historically masculine-perceived practices (Buechley et al., 2010). Of the total time spent coding, the studied boy engaged 66% of the time in the coding activities, and the two girls altogether engaged in coding 33%. Nevertheless, girls held the computer (without coding) for more time (59%) than the boy (41%), which suggests that the computing activities themselves have a gendered division of labor that is worthy of further study. We observed that students from this trio had a very clear division of labor, which largely fell along gendered lines.

Table 1: *Percentages of labor division in key practices by gender*

Description of Practice	Percentage of Time Girls Engaged in Practices	Percentage of Time Boy Engaged in Practices
Arts (Including touching/hold art materials, balancing materials, drawing, planning the design, selecting and applying color/texture, building/manipulating/cutting materials)	**70%**	30%
Electronic and Robotics (Including touching/holding the Arduino Kit, connecting/disconnecting cables, manipulating/troubleshooting the potentiometer, manipulating/troubleshooting the servo motor)	15%	**85%**
Computing (Including coding/troubleshooting code; touching/holding the computer)	33%	**66%**
Totals	**47%**	**53%**

Figure 1.
Kinetic sculpture made by the studied trio: "A bowl that spins and has symbols."

Discussion

Our findings reinforce previous research on how STEAM activities and group practices that integrate the arts into STEM provide opportunities for broader participation in STEM education (Mejias et al., 2019; Peppler, 2013). This is evident in the way girls were engaged and spent more time in artistic practices during the kinetic sculpture project, as well as in the way the boy dominated electronics and robotics elements of the project. Interestingly, the arrangement of a trio of two girls and one boy did not favor girls' use of electronic and robotics, nor computing materials; gendered scripts of materials and practices seemed to have prevailed, with the two girls dominating artistic practices and the boy leading STEM practices. This study highlights how simply high-quality STEAM-based education alone is not enough to eradicate existing gender divides in STEM fields. To truly transform STEM education, it requires a closer examination of our tools and materials and how they implicitly reinscribe existing practices along traditional gendered lines.

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