# Promoting Diversity within the Maker Movement in Schools: New Assessments and Preliminary Results

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**Abstract:** In recent years, FabLabs and Makerspaces have opened all over the globe, including in schools. However, notwithstanding the popularity of this movement, its track record with diverse populations is still dismal. In this work, we discuss a pedagogical framework for a more inclusive "maker movement" and show results from the creation of new assessments for such environments.

## Introduction

In recent years, laser cutters and 3D printers have dramatically dropped in price, and open source hardware has popularized these technologies. FabLabs have opened all over the globe (Gershenfeld, 2007; Mikhak et al., 2002), the MAKE Magazine was created, and soon after the Maker Faire was established, and now several schools have their own labs (Blikstein, 2013): the Maker Movement is upon us. But despite its popularity, the maker movement and FabLabs carried with them the culture of its creators: high-end engineers (from the FabLab community) and publishers (from the MAKE Magazine). These professional cultures did not have a tradition of working in diverse schools. FabLabs were designed for expert hackers, and the "make" publications catered to a "teenage hacker" subculture overwhelmingly dominated by suburban white males with abundant resources (Buechley, 2013), characterized by a strong self-selection of elite students into autodidactic and relatively closed communities. Despite the fact that the "maker" movement went much beyond its origins, these roots influenced its modus operandi until these days: Buechley (2013) showed that since its inception, 90% of the covers of the MAKE Magazine have had white males on them, and 70% of the projects were cars or robots. When considering the expansion of this movement to public education there is an urgent need to consider diversity as a crucial component, as well as how the movement would fit into non-dominant cultures and context (Lee, Spencer, & Harpalani, 2003).

In previous work (Blikstein, 2008) we discussed how many of the projects proposed in maker workshops are irrelevant to the culture of diverse learners. In this paper, we will focus on the issue of diversity and cultural relevance, and comment on two studies that touch on these issues. Given the space limitations, we will only present a summary of the results. In a pilot study, we ran a survey instrument for approximately 400 students in two schools (one high SES, 10% minority, and one low SES, 99% minority). The survey's goal was to find differences in how students would engage in "maker" activities. The data showed that in both schools, students had a similar level of unfamiliarity with programming and robotics (both schools had 2.4 for programming and 1.7 for robotics on a 1-6 scale, "6" being "very familiar"). However, a significant difference appeared in the questions that were probing psychological constructs. Students in the high-SES school were more likely to say that they "had a good imagination" (5.1 vs. 4.7, $p < 0.001$), that intelligence is a malleable entity that can be changed (4.8 vs. 4.0, $p < 0.001$), and that they have had at least one idea for an invention (45% vs. 20%, $p < 0.01$). These and other survey results show that these two populations would engage very differently in activities characterized by autodidactism and in which self-efficacy play a significant role. Based on these data, we set out to develop a research-based curriculum for a maker workshop that would address—and potentially reduce—those differences. We started with ethnographic research in the schools, and realized that in the low-SES school, students would often report that they used to 'make' and build things with their parents and friends, and often had jobs in garages or carpentry shops: *these students were already makers, but were not aware of it.* Thus, we designed a curriculum to re-value familiar practices drawn from students' funds of knowledge, rather than replace existing ones (Freire, 1974; Moll, Amanti, Neff, & González, 1992). Students brought familiar practices to the lab (craft, carpentry), and they got augmented using socially-valued skills such as computation, fabrication, and mathematics.

To evaluate the results of this intervention, we developed many instruments for measuring the effectiveness of the curriculum, especially in terms of its reach to diverse populations. For example, we developed a test called "logic flow," in which students had to create a block diagram with computer pseudo-code describing the functioning of everyday objects. We administered this test before and after the workshop to a group of 15 students. Our coding scheme had eight dimensions of complexity and completeness of these logic flows. The results showed that while students from all expertise groups improved, the bottom third of the class improved almost twice as much as the top third, considering the medians, thus reducing the gap in computational knowledge between the students with high (typically white males) and low (typically minorities) previous knowledge about computer programming and making.

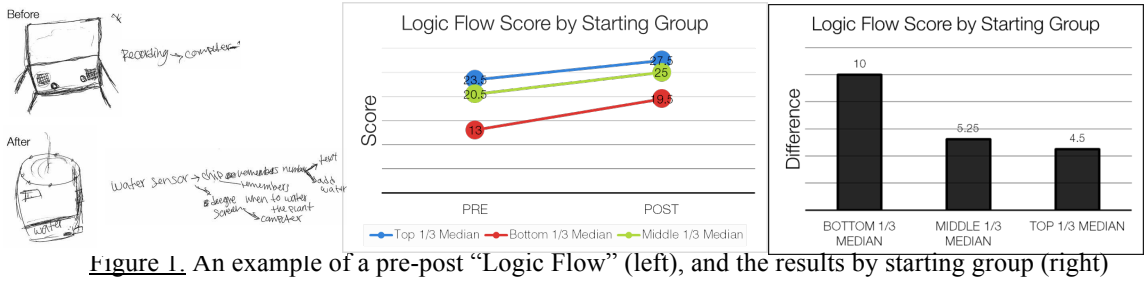


Figure 1. An example of a pre-post "Logic Flow" (left), and the results by starting group (right)

A second instrument that we developed was the "maker table:" students would write and draw all steps of a fabrication process, along with their confidence in their ability to perform each step. Again, we administered the test before and after the workshop, and the results were quite positive in terms of reducing inequality (see Figure 2). Not only did the scores improve equally for both boys and girls, but the gain as measured by the median of both groups overwhelmingly favored girls: while the improvement for boys was of one point, girls improves 3.4 median points from the beginning until the end of the workshop.

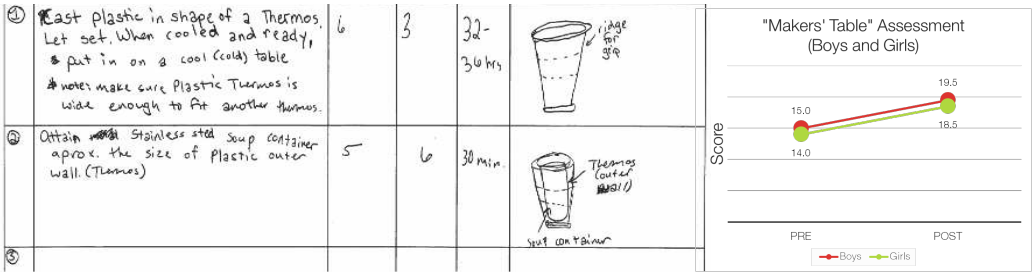


Figure 2. The "Maker's Table" (left) and the pre-post results (right)

These preliminary results point to (1) the great inequality in high- and low-SES schools in how students consume the "maker" movement, (2) the possibility and need of designing curricula to disproportionally benefit low-SES students, (3) the fact that improvement in these open-ended environments can be measured by customized instruments. Despite the potential of digital fabrication labs and 'making' in education, educators and scholars must remember that the real power of this movement is in its potential to reduce rather than amplify inequality, and that researchers have a crucial role in raising awareness to diversity, culturally-aware curricula, and new research methodologies for studying these environments.

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