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# How Making and Maker Spaces have Contributed to Diversity & Inclusion in Engineering: A [non-traditional] Literature Review

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**How Making and Maker Spaces have Contributed to Diversity & Inclusion in Engineering: A [non-traditional] Literature Review**

*Abstract*

The Maker Movement, complete with the opening of maker spaces around the country, has been positioned as an 'equalizer,' a way to give more people access to the science, technology, engineering, and math (STEM) fields. The movement has emerged concurrent with the push to institute active learning in educational spaces; both making and active learning give learners hands-on experiences. In addition, the Maker Movement offers open-sourced technical instruction and creative, supportive spaces for people to apply and advance their understanding of practical STEM knowledge. Its goals were/are to increase access to STEM fields by engaging people from all backgrounds in making. This literature review investigates the promises that were made about making's potential as an 'equalizer' or force to help broaden participation and support diversity, and explores documentation of the actual impact the Maker Movement has had on diversity and inclusion of underrepresented and minority participants in engineering.

*Introduction*

This literature review explores the following questions: (1) Historically, what goals were set or promises made about the Maker Movement's ability to contribute to diversity and inclusion efforts in STEM? (2) In what ways are making communities addressing or attaining the goal of increasing access to the STEM fields?

The Maker Movement continues to advance today as making activities take place in communities, in K-12 schools and on college campuses. This literature review includes a summary of current practices and identification of areas in need of improvement. From this, mid-course correction suggestions are made.

*Background on Making, Maker Spaces and the Maker Movement*

The terms 'making,' 'maker space' and 'Maker Movement' came into public consciousness in the mid-2000s and are largely tied to the company, Make:, led by founder Dale Dougherty [1]. Dougherty started Make: with publisher-partner Tim O'Reilly in 2005; Make: publishes a magazine highlighting maker's projects and also hosts 'Maker Faire' events touted as the "Greatest Show and Tell on Earth" [2], [3]. Dougherty and his company did not invent these words – the first maker space was founded in Germany in 1995 [1] and it has always been "an inherent part of human nature to ideate, plan and create things with our hands and with tools" [4] – but his company gave makers a larger community to rally around and built the Maker Movement's momentum.

Dougherty says the term ‘making’ can refer to “creating, producing, crafting, shaping, tinkering, composing, and building” but that there is often overlap, and making “covers many areas of interest and many skills.” Elaborating, he says that “making sits at the intersection of art and science, and at the crossroads of technology and design” [5]. When asked who makers are, Dougherty often says, “we are all makers” [6], [7] meaning that everyone engages in some kind of making or has the potential to do so.

These creators, dubbed ‘makers,’ often gather in workshops that have been coined ‘maker spaces’ – again largely because of Make:’s use of the term ‘make’ [1]. Generally, a maker space is a place where like-minded folks can gather to learn skills, work on projects, use shared equipment and exchange ideas [8]. They are found in various locations such as communtity centers, libraries, colleges, K-12 schools, libraries and businesses.

*Research Questions*

In an effort to understand the Maker Movement’s contributions to diversity and inclusion, this literature review explores the following questions:

1. Historically, what goals were set or promises made about the Maker Movement’s ability to contribute to diversity and inclusion efforts in STEM?
2. In what ways are making communities addressing or attaining the goal of increasing access to the STEM fields?

*Methods*

In compiling literature for this review, I searched the archives of *the Journal of Engineering Education, Computer Aided Design Journal, ASME Journal of Mechanical Design,* and *Rapid Prototyping Journal* but did not find any relevant literature. While the sources of information for this paper do include conference proceedings, many of the other sources come from non-academic publications that are not as often cited in literature reviews. It is for this reason that I am referring to this as a non-traditional literature review.

Sources used include conference proceedings from the American Society of Engineering Education, Frontiers in Education (FIE), Association of American Colleges & Universities (AACU), International Conference on Interaction Design and Children, NCWIT Summit on Women and IT, and the Mudd Design Workshop IX: Design Thinking in Design Education; Make: magazine articles and reports published by Make:; statements by the Obama administration (which explicitly championed making); content about and critiques of the Maker Movement published by popular news media sources such as *The Atlantic* and the *Washington*

*Post*; articles published by educational news companies such as Scholastic and EdTech; recorded TED/TEDx talks; recorded MakerFaire presentations/speeches; and tweets by makers.

Using non-academic sources is appropriate in this context considering a large number of 'makers' are not academics. Conversations about what making is, what making stands for and who fits the mold of a maker are not happening in academic journals or even at most conferences; instead they are occurring in communities, in the news and on Twitter.

When reviewing archives, I used search terms such as "Maker Movement," "history of the Maker Movement," "maker," "maker space(s)," paired with terms such as "accessibility," "democratization," "race," "gender," "homeless," "diversity," and "inclusion." As I was reviewing relevant content, I utilized websites' 'tags' and 'recommendations' sections to find additional content related to the topic at hand.

*Hope for a Movement*

My first question looks to the past and specifically aims to understand what the Maker Movement's goals have been when it comes to diversity and inclusion.

Since the advent of Make:, the Maker Movement was largely been publicized as and promised to be the 'democratization' of technology, science, tools, and skills needed for innovation [1], [9]–[14]. Recent technological advancements paired with maker open-source culture have allowed for the realization of that ideal as the public can now get their hands on technology previously only accessible by experts [9]. Gui Cavalcanti, founder of Massachusetts workshop 'Artisan's Asylum,' has said that in his maker space, "anyone should be able to make anything at any time out of (almost) any material" [1]. But this newfound access does not come without limitations. Advanced technology, such as microprocessors, requires education and presents a barrier to entry, a hurdle that must be leaped if a maker wants to make.

In 2014, the Obama White House challenged U.S. mayors to support making in their communities; one of the important mayoral practices that the administration pointed to was the act of "supporting women and under-served communities in making" [15]. While the Obama Administration, who championed making with a number of events and initiatives [14], [16], explicitly addressed inclusion and support of underrepresented communities, similar mentions are not found from Dougherty or his associates. In fact, not until this year, when faced by a scandal detailed later in this paper, has Dougherty spoken on the role on inclusion in the maker community [17].

*Access to Making*

In exploring my second question, I aimed to identify the ways in which making communities are addressing or attaining the goal of increasing access to the STEM fields. In many instances, I found that the majority of maker spaces were not adequately addressing access goals and only a handful of one-off success stories exist where maker communities are aiding underrepresented individuals such as people of color, women, LGBTQ+ folks, disabled people, homeless people, veterans, etc.

*Inclusion Success Stories*

There is one instance where a homeless man named Marc Roth used his last fifty dollars to enroll in a maker space class on laser cutting. He picked up the skill quickly, then started using recycled materials to make saleable products. He became skilled enough to be hired as an instructor in the maker space and earned extra money by cutting parts for other makers. With some fundraised capital, he was able to buy his own laser cutter and start his own business. After experiencing success, he decided to give back, enabling people like him, who experience homelessness, to learn to make and build a career for themselves [18].

In Baltimore, Station North Tool Library is aiding low-income communities. Across the city, there are many long-time, low-income residents who are at risk of losing their homes as gentrification drives up costs. Station North Tool Library is a community space that lends out tool kits, similar to how a library would lend out books. These tools help residents in the area rehab their houses and build equity rather than being pushed out of the neighborhood by developers. Residents can become Tool Library members by paying a membership fee structured on a sliding scale; the membership fee totals $1 for every $1,000 you make annually [19].

Another instance of an inclusive maker initiative exists in Charlottesville, Virginia, where a school bus has been repurposed as a mobile maker space allowing supplies and maker equipment to be shared among a number of schools. The space's resources are used and integrated throughout the schools' curricula so that students regularly get access; for example, students in a history class used 3D printers to print various shelters historically used by Native Americans so they could visualize the peoples' community. The strength of this maker space is that it can go where the people are, as opposed to waiting for people to arrive [20].

Lastly, at the Pad (Prototyping and Design Lab) at University of Maryland, Baltimore County (UMBC), Assistant Professor Amy Hurst is working with communities of people with disabilities. She collaborates with folks to break down barriers to entry for making and STEM. For example, her team has made custom hand-grips for people who struggle to hold unadapted tools and has 3D printed graphs for visually-impaired people who can't see a math instructor's notes [10], [21].

*Women in Making*

With regards to women's involvement in making, Chris Anderson, maker and former editor-in-chief of *Wired Magazine*, has said that crafting and the DIY movement act as a "gateway" to making, bringing many girls and women into the making community [22]. So in order to engage women and girls in their community, some maker spaces have resorted to offering and advertising "feminine" maker projects such as weaving, sewing, knitting, humanitarian/service projects. Holbert points out that "maker communities, companies, and flagship projects tend to revolve around conventionally masculine projects." His research shows that "when making is framed as being a set of practices, skills, and technologies to give back to and support members of one's community," girls' motivation and persistence were both high throughout the making activity; the girls also indicated interest in future making that would help others [23].

Research does not indicate that simply including activities that are stereotypically feminine or specifically appeal to women in maker spaces has negative ramifications, but neglecting to acknowledge women's interest in non-helping or masculine activities can have unwanted consequences. Blosser argues that promoting engineering to girls using feminine stereotypes, including the idea that women are only interested in careers centered on helping others, "does more harm than good" [24]. She goes on to say it can negatively impact how supervisors/teachers assess women vs. men and that using stereotypes in promotional campaigns can influence a person's self-efficacy. Adding new programming for the purpose of broadening participation needs to be done with tact to avoid these unwanted results.

Some women, like Debbie Chachra of Olin College of Engineering, don't want to be called a maker. In a 2015 editorial written in *The Atlantic*, Chachra points out the sexism ingrained in making and maker's values. She said, "walk through a museum. Look around a city. Almost all the artifacts that we value as a society were made by or at the order of men" [25]. She compares coding, a maker's bread-and-butter, to education;

> You can also think about coding as eliciting a specific, desired set of behaviors from computing devices. It's the Searle's "Chinese room" take on the deeper, richer, messier, less reproducible, immeasurably more difficult version of this that we do with people—change their cognition, abilities, and behaviors. We call the latter "education," and it's mostly done by underpaid, undervalued women [25].

Most members of maker communities are in fact men, specifically white men. Chachra points to a pervasive value system within the maker community: those who make things are better than those who don't [25].

*Who Gets to Make*

A simple search of Make: Magazine's archives shows a severe gap in the maker community's work towards their mission. The movement aims to give people, who otherwise wouldn't have access, the ability to use tools, learn technology and invent. But searching Make:'s website uncovers that their conversations largely leave out some of the most underrepresented minority groups in STEM [26]–[28]. Figure 1 shows that "people with disabilities" are not mentioned as members of the maker community but rather as recipients of makers' charity. Figure 2 shows search results using the terms "african american" and "people of color" respectively. Combined there are only five results, one of which is simply an announcement of the *Hidden Figures* movie release. Dougherty calls everyone a maker [6], [7], but his company fails to involve those from underrepresented minority groups.

**Figure 1**: This image displays a screenshot showing the 18 results found on Make:'s website when using the search term, "people with disabilities." The boxes emphasize examples of places where the discourse reinforces the idea that people with disability are to be helped by making [28].

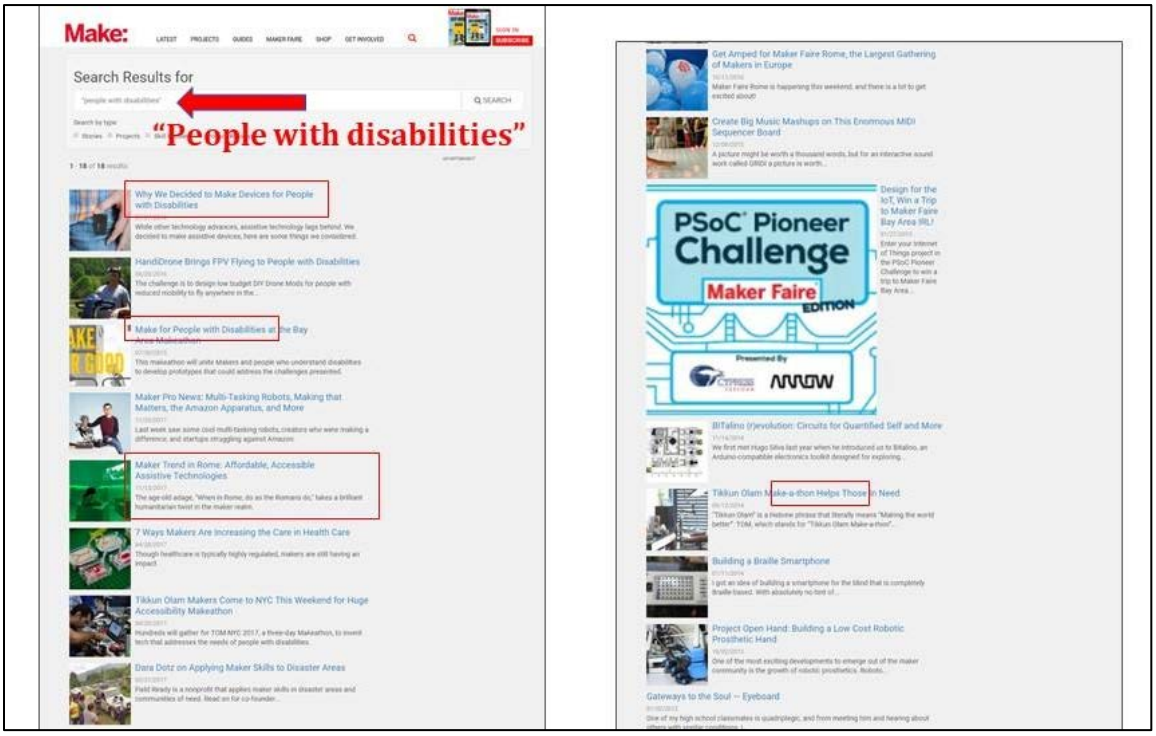
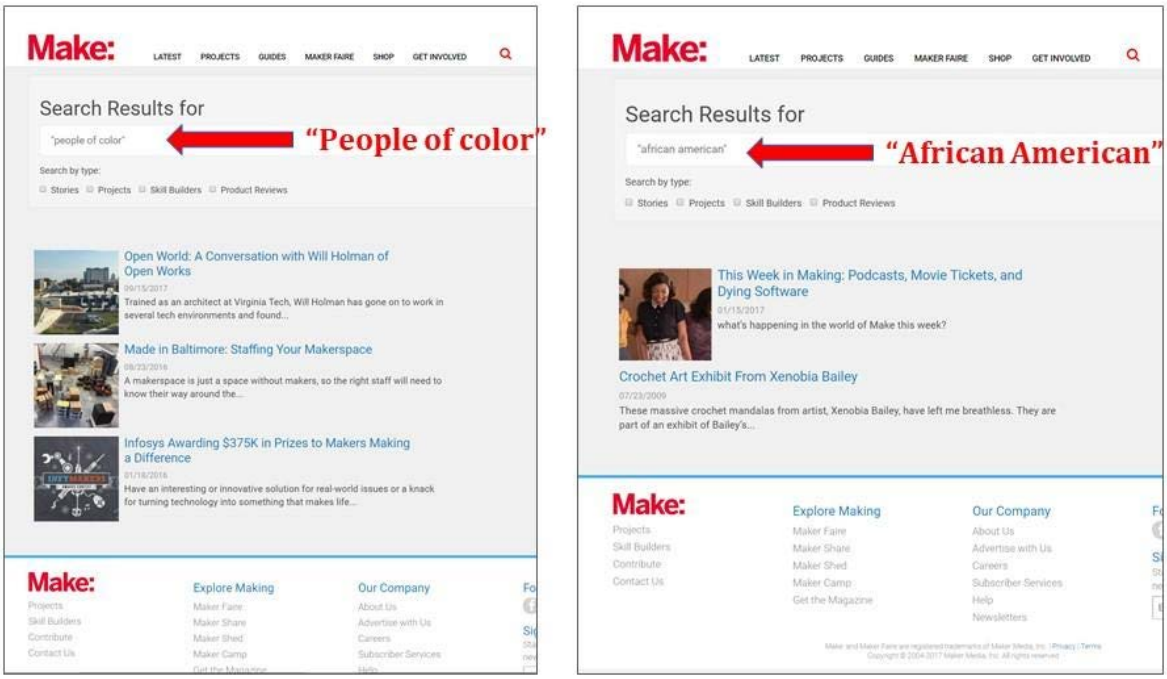



**Figure 2**: This image displays two screenshots. On the left are the three results found on Make:'s website when using the search term, "people of color"; on the right are the two results found on Make:'s website when using the search term, "African American" [26], [27].




Further evidence of Make:'s lack of inclusion of people of color and minority groups at large is seen in the attendance of Maker Faire. Table 1 shows attendees' demographics from the 2012, 2014 and 2015 World Maker Faire events [29]–[31]. They only began reporting attendee's race in 2015 in New York. Across the country that same year in California, 68% of attendees the Bay Area Maker Faire were white and 17% of attendees were reported to be Asian; the percentage of African American/Black attendees was not reported [32]. These statistics point to the fact that Make: and the Maker Movement are not reaching the people who have issues accessing STEM but instead are primarily engaging one population: affluent, white, well-educated males.

**Table 1**: This table merges data reported across three Maker Faire Attendee Studies. These studies were published about the World Maker Faire that takes place in New York City, NY, USA. Highlighted here are the demographics of World Maker Faire attendees in 2012, 2014 and 2015. [29]–[31]

| | 2012 | 2014 | 2015 |
|---|---|---|---|
| **Gender (reported as male/female)** | 61% male | 66% male | 62% male |
| **Average age** | 45.9 years old | 42 years old | 42 years old |
| **Median Household Income** | $108,000.00 | $124,500.00 | $124,500.00 |
| **Home Ownership Status** | 56% own their own home | 61% own their own home | 63% own their own home |
| **Education** | 97% attended college;<br>86% graduated college;<br>48% have postgraduate degrees | 96% attended college;<br>86% graduated college;<br>48% have postgraduate degrees | 96% attended college;<br>86% graduated college;<br>42% have postgraduate degrees |
| **Employment Status** | *Unreported* | 86% Employed | 89% Employed |
| **Marital Status** | 65% are married | 61% are married | 68% are married |
| **Race** | *Unreported* | *Unreported* | 67% White<br>12% Asian<br>7% Hispanic/Latino<br>3% Black/African American<br>14% Prefer not to answer |

Perhaps makers didn't consider who wasn't there year after year. Perhaps the exclusion of under-represented minority groups was subtle. Perhaps the demographic homogeneity was simply overlooked in these years. But there was nothing subtle about Dale Dougherty's attack of a young, Chinese, female maker in 2017, which has not been overlooked and has thrust the Maker Movement into the international spotlight.

On November 5, 2017, Dougherty tweeted to his large Twitter following that he questioned Naomi Wu's identity and her technical accomplishments [17], [33]–[35]. This came after weeks of Dougherty allegedly harassing Wu online directly through messages and tweets [33], [34]. In his online commentary, he pointed to a conspiracy theory on Reddit citing that Wu was fronting

for a white, male creator and wasn't responsible for the technology she displayed at events [17]. As Wu's reputation was shattered and her identity questioned, she claims to have lost contracts and work opportunities [34].

Wu believes the conspiracy was invented by 'Men's Rights Activists' (MRAs), men who are anti-feminism [29]. Dougherty, while not openly associated with MRAs, has published with a conservative lobbyist [36] and cross-posted their manufacturing policy goals on Make:'s website [37].

Dougherty's comments drew international attention and the power dynamic between Make:'s CEO and the young, uneducated maker was highlighted in the media [33].

Dougherty apologized in a short post shared on Make:'s website 32 hours after the tweets were posted. He said that the maker community is intended to be inclusive and he 'failed' by questioning this woman's identity [35]. But his statement was weak, and paired with the larger incident, it spoke to the non-inclusive nature of the making community.

Criticism of his actions continued and on November 19, 2017, he issued an "apology to Naomi Wu and the Make community." In his post, he acknowledged the role of his privilege stating, "my response reflected my unconscious biases; and the negative impact of my tweets was amplified by the fact that I, a white, Western, male CEO of a key company in the Maker community, publicly questioned a young, female, self-employed Chinese maker." Remarkably, Dougherty committed to work closely with Wu to 1) feature her work in Make: publications, 2) feature Wu at World Maker Faire 2018, 3) publish a diversity audit of the Make: company and set goals for advancing diversity and inclusion, and 4) develop a Maker Faire advisory board to oversee the events and ensure representation of full maker community [17].

*Closing – A Need for Mid-Course Correction*

Dougherty's most recent apology and commitment to change are promising, but as making becomes ubiquitous, touching the lives of more individuals, a commitment to inclusion and equity will become more and more important.

It's clear from Table 1 that inclusion doesn't happen naturally, it must be intentional. Going forward it is critical that Makers are intentional about inclusion when making products, creating maker communities, developing maker spaces, planning events, and communicating about makers and their activities. I have summarized research that identifies best practices of inclusion in diverse maker spaces in work previously presented at ASEE [38]. The results presented here provide evidence that more maker communities need to address barriers to entry and exclusionary practices that currently exist in making. Inclusive practices will be necessary in

order to engage a broader population – one that is representative of the world's population (all of whom are capable of being makers, according to Dougherty) – in making activities.

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