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## Equity in STEM-rich Making: Pedagogies and Designs

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### ABSTRACT



This brief essay offers an introduction to a special symposium on equity in STEM-rich making. The introduction provides context that frames current equity issues in the Maker Movement, as well as short descriptions of the four articles included in the symposium. Collectively the papers in this symposium examine how complex power dynamics shape youths' making experiences, and how carefully designed equity-oriented pedagogical and design approaches can support youth in challenging sociohistorical narratives and complex power dynamics around making. The four articles pay attention to how making, innovation, and community spaces are always under negotiation, resulting in potential in-between spaces where individuals reproduce and resist the narratives at play there.

### KEYWORDS

Making; Makerspace; Science, Technology, Engineering, and Math (STEM); Pedagogy; Designing Learning Environments

The birth of educational movements often carry with them the possibility of either improving educational experiences for all, or re-inscribing inequitable systems that allow only a few to flourish. The maker movement is no exception. Harkening back to educational efforts during the Industrial Revolution that returned to hand-based skills as a means of challenging typical school curricula (Rose, 2014), makerspaces across the country offer novel opportunities for inquiry-based, learner-driven playfulness with both traditional tools and new technology that can allow for rich learning, particularly in Science, Technology, Engineering, and Math (STEM). Making projects can take on a variety of forms—from building birdhouses out of wood, to designing light-up greeting cards made out of paper, gum-drop LEDs, copper tape, and a coin-cell battery, to programming an Arduino Lilypad microcomputer sewn into a sweatshirt that makes a tiny speaker play music based on one's arm movements. Across this range of making activities, youth engage in STEM investigations, sense-making, and critique that may not necessarily look like the typical school science lab experience (Bevan, Ryoo, & Shea, 2017). In this way, making can invite and engage youth (who may not normally consider themselves as “good at science”) into learning STEM concepts and practices while creating personally-meaningful and innovative designs.

Building on their potential role in breaking down barriers to STEM learning and attainment, especially among youth from non-dominant communities, such as youth of color, and youth from low-income communities, a large number of STEM-focused makerspaces have opened across both formal and informal sites of learning—schools, libraries, museums, and afterschool programs—all over the US. During a time when inequalities in STEM education and career pathways persist (National Science Foundation, 2018), the potential power of STEM-rich making and the maker movement is significant. STEM-rich making experiences can offer interest-driven openings where “learning is and for the making” (Sheridan et al., 2014, p. 528) for non-dominant communities who often do not “see” themselves in dominant STEM structures (Tan, Kang, O'Neill, & Calabrese Barton, 2013). This is especially important in the current era in which public education is under attack by the very governments charged with protecting it, and where youth of color, girls and women, and immigrant

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children are reminded on a regular basis that they do not have the same rights as their white male counterparts who dominate positions of power. Furthermore, the current war on science in the US has resulted in the government dismantling national structures that once ensured scientists were part of national discussions and decisions impacting the entire world. It is more crucial than ever that youth be empowered to push against the silencing of scientific reason and research, and to join the conversation as critical producers of new perspectives and knowledge that can improve lives and communities.

However, if the maker movement is not taken up with attention to equity, then it may cause more harm than good for the lives of our students, teachers, and communities. This is because the pedagogical approaches and designs of many makerspaces have not systematically taken up the educational needs and rights of students from non-dominant communities. And while many making programs now reach a demographic quite different from the white, middle-class male originally associated with the movement, the assumption continues to be that non-dominant communities have little to no previous knowledge or skills in making, nothing to offer the larger movement, and everything to gain from organized programmatic experiences (Vossoughi, Hooper, & Escudé, 2016). Challenging such an assumption, this special symposium seeks to contribute new knowledge and practice for transforming maker culture in ways that are *equitable* for all students, especially youth from non-dominant communities historically underrepresented in STEM. And while it is important to continue asking questions about *access* and *opportunity* in quality educational experiences in making, access and opportunity by themselves are inadequate. As a field, we must peel away the layers of access and opportunity that fundamentally shape young people's experiences. Little is known about how the design of making environments, including their programs and pedagogies, shape how opportunities to make unfold, and what this might mean for who participates, how, and why. Thus, it is important to also ask how complex power dynamics shape who has access to making/makerspaces, what forms of making are legitimized and by whom, and the narratives of what it means to be successful in making (e.g., Calabrese Barton, Tan, & Greenberg, 2017; Vossoughi et al., 2016).

This symposium examines how carefully designed equity-oriented pedagogical and design approaches can support youth in challenging sociohistorical narratives and complex power dynamics around making. Building on our various efforts both developing and researching STEM-rich making programs dedicated to valuing the culture, experiences, perspectives, and language youth bring to their learning, while interrogating the ways power is negotiated in such programs (e.g., Calabrese Barton & Tan, 2018; Calabrese Barton et al., 2017; Ryoo & Kekelis, 2016; Ryoo, Kali, & Bevan, 2016), we brought together this symposium to help add to the growing conversations about equity in making. This has been an evolving discussion, with a series of papers at conferences (e.g., AERA and FabLearn), which cross-cut makerspace design, programs, pedagogy, curriculum, learning opportunities, and so on. In this symposium, we sought to organize a dialogue that specifically addressed pedagogy and program design toward building more equitable making experiences for young people. The four articles in this symposium pay attention to how making, innovation, and community spaces are always under negotiation, resulting in potential in-between spaces where individuals reproduce and resist the narratives at play there.

Without defining equity in making education through a single perspective that could exclude the voices of people from varying sociohistorical contexts, the four symposium articles were purposefully chosen to examine practice, pedagogy, and design across different kinds of community/out-of-school *and* in-school settings. While all the articles critically take up the importance of challenging historical inequality in access to and forms of participation in making, each one presents a different way of framing equity in making, allowing the field to see more broadly the essential dimensions of a more complex equity agenda. Furthermore, while makerspaces support learning *beyond* what is valued in STEM fields, this symposium focuses on STEM-rich makerspaces toward thinking more expansively about how STEM is defined in the beliefs, practices, and perspectives that youth bring to the table.

Two articles examine making in schools: Fields, Kafai, Nakajima, Goode, and Margolis examine how an e-textiles unit can deepen access and diversify participation in making through interest-driven connections and sustained engagement. Their findings reveal the critical practices that high school teachers employ in promoting greater equity in making, including modeling in-progress artifacts,

valuing expertise from students, and promoting connections in personalized work. Martin, Dixon, and Betser examine how iteratively improving the design of their makerspace—through careful examination of the power dynamics between adults and youth in the space, as well as how better to embrace youth's repertoires of practice—could lead to a more equitable environment for learning and making. Both studies raise fundamental questions about what it could mean to include making as part of the standard curriculum in school settings, and how such opportunities shift epistemological power dynamics for youth of color and girls in STEM.

Two additional articles examine making in community settings. Tan and Calabrese Barton, drawing upon multi-year studies, examine how pedagogical practices purposefully co-designed among youth, community members, and researchers focused on supporting youth as they sought legitimacy through their STEM-rich making. Using a critical justice view of equity, the authors show how pedagogies of decolonization/reinhabitation may help to re-structure relations in making. Such restructured relationships may re-position youth makers legitimately with power and authority to leverage their community knowledge and wisdom towards identifying injustices in their lives and communities and in co-opting STEM-rich making practices towards responding to those injustice. Barajas-López and Bang examine how navigational pedagogies support the emergence of indigenous making practices in the context of an ArtScience Making Camp, raising questions about materiality in knowing/making, and how forms of materiality can re-structure the power hierarchies that privilege western forms of making over others. Both articles advance the knowledge base of equity in making by critically examining how systemic oppressions can be disrupted through local making; however, such making happens in concert with explicit dialog towards new visions of what constitutes STEM-rich making, for whom, and why.

Cutting across these studies are diverse methodological frames that allow for both teachers and youth voices to become more central to the discourse on making while opening up new questions that foreground the intersections of pedagogy and learning. For example, Martin, Dixon, and Betser use a method of iterative program design, while drawing on educator reflections on teaching and learning, to improve how their makerspaces supported youth repertoires of practice. Barajas-López and Bang leverage inter-generational and community participatory design-based research, opening up a dialog of multiple ways of knowing and being in making education research and practice.

Lastly, we note that each article keeps in focus the importance of and the ways in which makerspace designers, educators, and researchers critically reflect on their practice toward building more open and equitable learning environments for youth.

This symposium builds upon the momentum of a wide range of authors responding to ongoing conversations about what it means to create more equitable making experiences for youth, and serves as an invitation to keep the conversation both critical and continuous. We hope readers will gain a deeper understanding of: (1) the nuances of in/equity examined through these papers; (2) the rich variation across making spaces that require careful attention and care toward the unique sociocultural and historical contexts of our programs and the power hierarchies impacting interactions therein; (3) the ongoing nature of these conversations and how these four articles only begin to scratch at the surface, yet in ways we believe are hopeful and helpful; and (4) the importance of creating opportunities for our youth to deepen their STEM learning and experiences in ways that both validate their knowledge and perspectives while providing scaffolds that support their success across the range of STEM education, career, and interest pathways. We hope that this symposium is just the first in many around key issues of equity in making education, recognizing that not all makerspaces are, or should be, exactly alike and that the complexities of those spaces will continue to evolve with time.

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**Angela Calabrese Barton** is a professor in the Department of Teacher Education at Michigan State University. Her research is grounded in the intersections of teaching and learning science with an emphasis on equity and social justice. Her recent work takes place within three interrelated strands: 1) Working within the intersection of formal/informal education; 2) designing teaching learning tools and experiences that promote more expansive learning outcomes; and 3) methodologies for embracing authentic “research + practice” work. She is a fellow of the American Education Research Association.