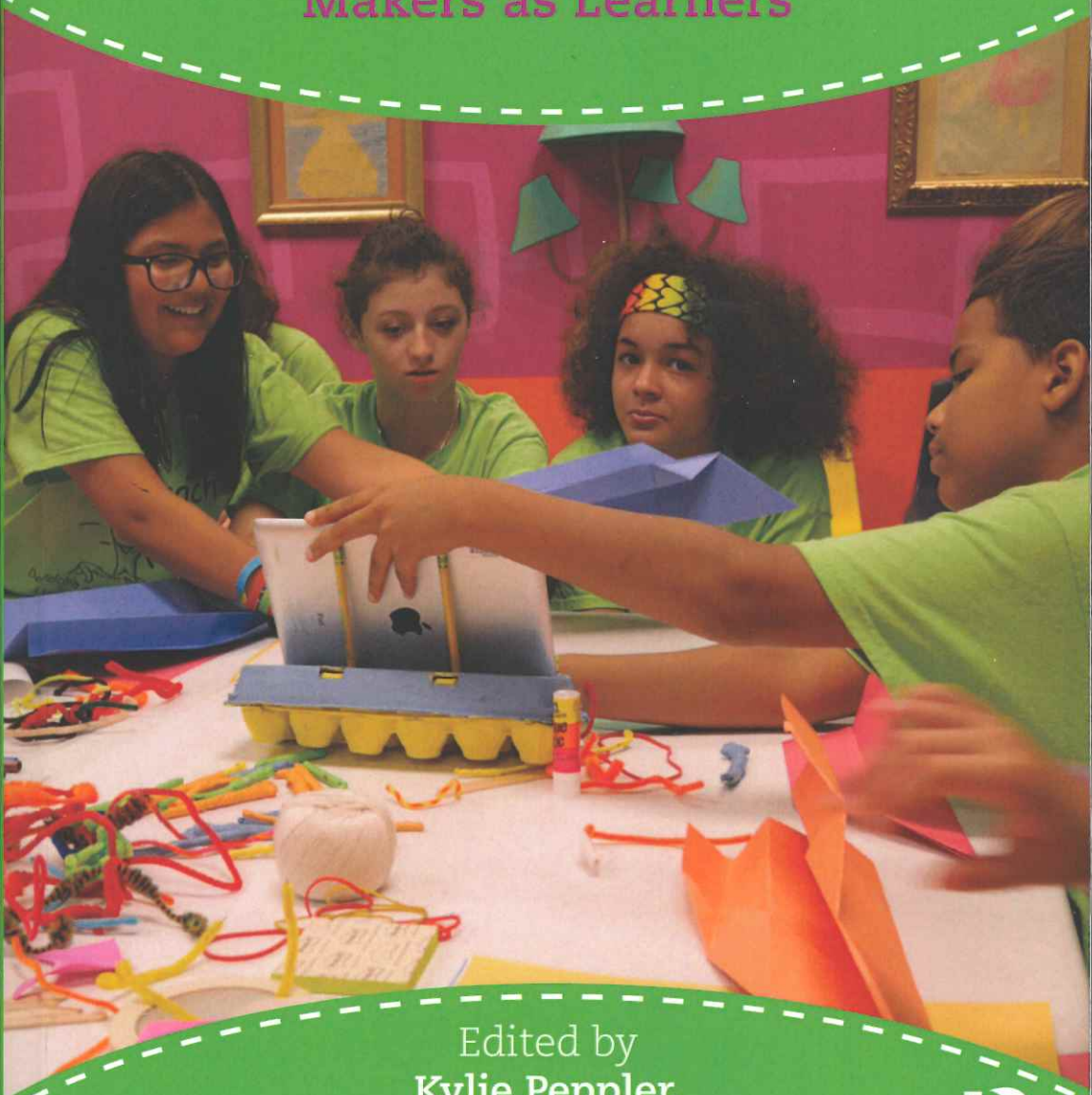
VOLUME 2

Makeology

Makers as Learners



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ROUTLEDGE

CHAPTER 1

Introduction to This Volume

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White House Maker Faire

In February 2012, the US White House hosted its first-ever science fair showcasing the talent and ingenuity of the next generation of scientists, engineers, and innovators. Students—many winners from local and national science fairs, competitions, and state fairs—had brought their posters and exhibits, among them the extreme marshmallow cannon designed by Joey Hudy, of Anthem, AZ. The picture of President Obama testing the contraption shooting marshmallows across the State Dining Room—surely a first in its history—went around the world. More importantly, Hudy's business card that read "Don't be bored, make something," inspired the President to encourage all students to become "makers of things, not just consumers of things." In July 2014, the White House announced that it would also be hosting its very own Maker Faire, joining hundreds of mini and large Maker Faires around the world.

Introducing the Maker Movement

To date, much of the interest in the Maker Movement concerns how excitement can be leveraged to fuel the next generation of STEM (science, technology, engineering, and mathematics) innovators (Honey & Kanter, 2013). Such interest has ranged from White House Maker Faires (Kalil, 2010) to President Obama's Educate to Innovate campaign (Obama, 2009). Though this potential holds promise, these volumes take a concerted effort to better understand making as a new domain unto itself, rather than in service of other learning outcomes. While connected to traditional disciplinary ways of understanding, we think making deserves to be understood and studied in its own right.

Open exploration, intrinsic interest, and creative ideas are but a few of the commitments at the core of today's Maker Movement—a grassroots culture dedicated to hands-on making and technological innovation. Popularized by *MAKE* magazine, Maker Faires, and online communities like Etsy, Ravelry, and Instructables, the Maker Movement embodies Do-It-Yourself (DIY) production across a host of domains, ranging from textile crafts to electronics, advanced robotics to traditional woodworking (Peppler & Bender, 2013). Across these applications, the Maker Movement is propelled by (a) the introduction of new technologies, like 3D printers, laser cutters, and Arduino robotics, that allow for faster prototyping and new forms of digital fabrication; and (b) the rise of the Internet, which allows for the sourcing of parts as well as the widespread sharing of ideas (Dougherty, 2013).

At the same time, there is a growing grassroots movement behind the technology that reclaims the deeply held cultural values arcing back to the DIY culture of mid-20th-century America. While these practices still have a distinct place among 21st-century makers, the influx of new technologies reinvigorates these ideas through a capacity for "long tail" production that allows makers to produce at the appropriate scale (Anderson, 2008) and pushes the limits of what's possible in traditional domains. This burgeoning and distributed community identifies making as an alternative to the consumer culture and seeks to hack, mod, tinker with, create, and reuse tools and materials.

Who, then, are makers? In practice, anyone who builds or adapts objects by hand, often with the simple pleasure of figuring out how things work, creating an aesthetic object, or seeking to solve an everyday problem, falls under this distinction. Makers frequently take pride in and desire to share projects and/or their creative processes with others, which is what fuels the larger communities of physical and online makerspaces, as well as pop-up events like world and regional Maker Faires. At the same time, the Maker Movement has begun to infiltrate the education enterprise. Schools are building makerspaces and FabLabs in their facilities and incorporating making into curricula. As with any instructional innovation, questions about the pedagogical value of making as a discipline are front and center, and researchers are beginning to wrap their heads around how people learn to make as well as how they make to learn.

Current research on the Maker Movement in education can be classified into three categories: understanding *making* as a set of designed learning activities, studying *makerspaces* as communities of practice, and exploring *makers* as identities of participation (Halverson & Sheridan, 2014). While there is clearly overlap among these three categories, it is useful to explore activities, communities, and identities independently, especially if

we want to avoid reductive policy questions like, "Is making good for kids?" or "Should we put a makerspace in our school?" Rather, we should be asking questions like, "In which ways can making connect to learning?" "Who gets into making and who does not?" and "What affordances do different materials have for learning through making?"

We have organized this growing movement of makerspaces, activities, and materials for learning in two volumes. In the first volume, *Makerspaces as Learning Environments*, we covered the wide range of makerspaces that provide multiple pathways to learning, with participants creating projects that vastly differ in terms of scope, function, production time, and support received. This introduction to making and makerspaces described making in a variety of educational ecosystems, spanning nursery schools, K–12 environments, higher education, hip-hop communities, museums, afterschool spaces, and online learning environments and offering practical takeaways for parents, educators, and researchers along the way.

In this volume, *Makers as Learners*, we highlight leading researchers and practitioners in the field as they discuss and share current perspectives on the Maker Movement and research on educational outcomes in makerspaces. We discuss a range of perspectives on learning through making, including the role of tinkering in the process of teaching and learning; how adaptive expertise and identity development are supported through making; and how new and playful tools can be used to assess informal learning. Throughout, we consider linkages among learning outcomes, equity issues, and the social and historical uses of materials within makerspaces. This volume also highlights a key set of transformative tools and materials that heightens possibilities for learning and create consequential invitations for a broader, and more diverse group of learners to participate. While not comprehensive of the range of making found in maker communities, this volume provides the reader with an innovative range of maker tools, materials, and processes that expand what it means to merge high and low technologies and to learn in and through making.

The Maker Movement and the Future of Learning

When it comes to promoting specific learning outcomes, the Maker Movement is a bit of a paradox. It simultaneously embodies a new and innovative grassroots approach to learning, yet it is well rooted in established theories and the time-honored truisms of high-quality education. Certainly, a central facet of the learning promoted by the Maker Movement is that it is *interest driven*; today's Maker Movement encourages the making and sharing of artifacts with high personal and social significance, ranging from robotics, 3D-printed objects, high-tech fashion, hydroponic

are a promising starting point, they are not always the most open to value everyone's and all forms of participation and content. Many youth DIY sites have millions of contributions, but most of the productions are connected to mainstream commercial content with only few examples of content related to the interests of underrepresented communities (Margolis, Estrella, Goode, Holme, & Nao, 2008; Warschauer, 2003). Why does this matter? If we want making to be a global activity, we need to make sure that who is making and what is being made is open and accessible to everyone. The artifacts and images of makers signal to others what is valued in this culture and what not, and ultimately they also signal who belongs to the maker culture and who does not. It is here where we see the greatest challenges in broadening participation in making.

Overview of Volume 2

Current research on understanding learning in making is far behind the growing enthusiasm for making in the educational world. The second volume of *Makeology* closes this gap by addressing three overarching themes: Section 1 approaches the Maker Movement from a cultural perspective, examining closely the complex relationship between gender, background, and accessibility with regard to the design and use of maker environments; Section 2 investigates how makers' tools and materials differentially shape their creative output and, consequently, their learning in the process; Section 3 then unpacks the promise of the Maker Movement as a vehicle for advancing disciplinary learning and closes with a comparative discussion between making, writing, and coding. Across the 14 chapters that constitute this volume, we seek to illustrate the impact of making on learning and development.

The first section, on the culture and identities of makers, presents a thorough investigation into the ways that learners' cultural and personal histories inform the way they engage in making. Here, Lisa Brahms and Kevin Crowley (Chapter 2) identify the core learning practices of making as revealed through analysis of the field's most seminal maker publication, *MAKE* magazine. Their findings suggest that educators seeking to harness the appeal of the Maker Movement should take a critical look at who is most visible in the community and what forms of participation emerge as most valued as a result. Next, Jennifer Oxman Ryan, Edward Clapp, Jessica Ross, and Shari Tishman (Chapter 3) examine how the learning that comes from maker experiences is affecting the way that learners see themselves as agents of change in the world. Such a view stands in contrast to the oft-presumed outcome of the Maker Movement as an avenue for advanced STEM or innovation mindsets. Such a dispositional view of the benefits of making is extended by Brigid Barron and Caitlin Martin's (Chapter 4) systematic

comparison of several 21st-century out-of-school pursuits, including video gaming, social media participation, and making. The evidence presented here provides yet another reason to consider making as more than just a potential improver of students' academic outcomes but an activity that can help develop the creative and mindful dispositions important to being an active participant in the 21st century. Kristin Searle, Deborah Fields, and Yasmin Kafai (Chapter 5) then address how a more considered view of the role of gender and tool choice can help educators design more inclusive making activities for youth from a variety of backgrounds. The authors use workshop data from students engaging in e-textile production to identify how youths' awareness of the gendered cultural histories of crafting, computer science, and engineering shape their participation and learning. Finally, Natalie Rusk (Chapter 6) investigates what motivates young people to take initiative, persist, and learn new skills in the process of making. By better understanding the motivation for making, Rusk seeks to help the field design and support maker experiences that help young people create, connect, share, and learn in physical as well as online communities.

In section two, we dive into how makers leverage the tools and materials on hand in the learning process. This section begins with Mike McGalliard's (Chapter 7) presentation of how cardboard used in the documentary *Caine's Arcade* transformed into one organization's global quest to support and extend youth creativity wherever it is found. In this discussion, key themes emerge about how creativity can be supported through activities using materials as basic as cardboard. On the other side of the technology spectrum, Sophia Bender (Chapter 8) presents a view of e-textile production as a fundamentally different way of relating to technology from what we are accustomed. Examining a range of tools and materials for e-textile creation, Bender illustrates a way of fostering powerful ideas using a softer, more intimate and transparent approach to technology that marries high and low tech, masculine and feminine, and technology with craft. Veena Vasudevan and Yasmin Kafai (Chapter 9) then illustrate how contemporary making can utilize tools and materials that further intertwine the concepts of arts & crafts and technology. The authors examine the bridge between everyday and craft materials and electronics in context of making games for learning, expanding ways into more technical topics for youth who are more comfortable with arts and crafts but also allowing those who might not have seen themselves as makers to engage in creative design. Finally, Karen Wilkinson, Luigi Anzivino, and Mike Petrich (Chapter 10) engage constructionist pedagogy to frame the learning experiences in the Tinkering Studio at the Exploratorium in San Francisco. Drawing on over two years of visitor observations, the authors present four dimensions and indicators of learning based on observable behaviors they recognized in

the tinkering activities in their studio. The findings suggest that learning in makerspaces is tightly tied not only to the spaces created for it, but also to the material context.

We close out the volume with an examination of the connections between making and disciplinary learning. Lee Martin and Colin Dixon (Chapter 11) investigate how aligning making endeavors with Next Generation Science Standards can help inform efforts to integrate making into K–12 engineering education. Matthew Berland (Chapter 12) turns our focus to the impact that a holistic view of play and tinkering can have on advancing computational literacy. Finally, Kylie Peppler (Chapter 13) presents how the "art of making" presents new opportunities for creativity and innovation in education. The volume concludes with Mitchel Resnick, Elyse Eidman-Aadahl and Dale Dougherty's (Chapter 14) conversation around the commonalities and compelling differences between writing, coding, and making. The authors provide us with thoughtful vignettes to consider as we move forward to envision the future of learning through making.

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"*Makeology* is the first broad and comprehensive examination of the Maker Movement as a catalytic force for young people's learning. Practitioners and scholars interested in implementing and studying making as a force for creative expression and student-centered learning will find in this two-volume collection a wealth of thoughtful and significant information."
—Margaret Honey, President & CEO, New York Hall of Science, USA

"This second volume offers a window into the biggest promise of the Maker Movement—to give children agency and meaning in their own learning. As a potentially transformative practice and field of scholarship, Makeology has the opportunity to catalyze the attention of researchers, teachers, school administrators, parents, curriculum developers, and policy makers because the authors offer insights into the ways one can begin to study, model, and understand these phenomena of learning."
—Dr. Sherry Hsi, Senior Research Scientist, the Concord Consortium, USA

"One thing we have in common is our commitment to putting more power in the hands of people from all backgrounds, enabling everyone to develop their voice and express themselves. There's a special opportunity right now. But that moment could also slip away, so it is all the more important to make connections and join forces with other communities with shared values, to make sure that all children have the opportunity to grow up as full and active participants in tomorrow's society."
—Mitchel Resnick, LEGO Papert Professor of Learning Research and head of the Lifelong Kindergarten group at the Media Laboratory at Massachusetts Institute of Technology, USA, from Volume 2

Makeology introduces the emerging landscape of the Maker Movement and its connection to interest-driven learning. While the movement is fueled in part by new tools, technologies, and online communities available to today's makers, its simultaneous emphasis on engaging the world through design and sharing with others harkens back to early educational predecessors including Froebel, Dewey, Montessori, and Papert. *Makers as Learners (Volume 2)* highlights leading researchers and practitioners as they discuss and share current perspectives on the Maker movement and research on educational outcomes in makerspaces. Each chapter closes with a set of practical takeaways for educators, researchers, and parents.

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