Making Public Schools Places of Innovation in the 21st Century

Summary
Amidst the COVID-19 crisis, over 40% of underserved students in public schools continue to experience a digital divide, limiting their ability to complete schoolwork, and significantly increasing the achievement gap[1]. With limited access to the rapidly developing technologies of today's economy and the education, civic participation, and employment opportunities afforded by them, critical and significant segments of the US population are being systematically excluded. *When provided to all students, maker education and digital fabrication provides equitable access to the tools, ways of thinking, and skills that are important for social mobility; at the same time teaching the critical digital literacies that are necessary for equal access to opportunity and democratic participation, creating a more educated, innovative, entrepreneurial and ready workforce, and harnessing the full potential of America's future.*

We propose that the new administration implement a multi-pronged approach to bring maker-centered learning environments to K-12 students throughout the United States, that builds on existing infrastructure and focuses on: (1) spearheading and promoting a *national campaign* on the role of making in our daily lives and the workforce, (2) increasing access to *maker and digital fabrication professional development* training for K-12 educators, and (3) *incentivizing public-private partnerships* to expand access to the tools and resources for maker-centered learning curricula and spaces.

Challenge and Opportunity

Research has shown that maker, constructionist learning experiences are incredibly powerful. But they are not being offered to all students. The set-up, accessibility, and nature of dominant maker activities do not offer a financial or cultural entry point to all students, particularly those underrepresented in STEM; girls and Black, Indigenous, and other people of color (BIPOC). This is a serious obstacle to a more diverse and inclusive teaching of STEM disciplines, and a roadblock to social justice, democratic civic participation, and a globally competitive workforce.

Hands-on, constructionist making and digital fabrication activities provide new ways for students to learn and carry out the Science and Engineering Practices identified by the Next Generation Science Standards not found in typical formal science classes (Simpson, Burris, & Maltese, 2017). They also can provide more diverse opportunities to engage with the core practices and foundational elements of becoming scientists, engineers, mathematicians and STEM professionals. The skill sets and digital literacies developed through maker-centered learning are the skills and literacies of the 21st Century economy[2], an economy of rapidly developing, interconnected technologies that will drive our work, and civic participation, and will require citizens to understand the black box of technology in order to make critical, and informed decisions.

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[1] "53% of Americans Say the Internet Has Been Essential During the COVID-19 Outbreak," Pew Research Center - Internet and Technology, accessed December 22, 2020, https://www.pewresearch.org/internet/2020/04/30/53-of-americans-say-the-internet-has-been-essential-during-the-covid-19-outbreak/

[2] "State Guide for Preparing the Future Workforce Now," National Governors Association, accessed December 22, 2020, https://www.nga.org/futureworkforce/

Providing maker-centered learning opportunities must focus first on student populations that have not had access to hands-on approaches and digital skills development, such as BIPOC students across the country with fewer resources and social inroads to STEM learning. We need the collective mindshare of our entire diverse population to solve the world's greatest challenges. In the 2016 White House guide on workplace diversity, equity and inclusion, President Barack Obama noted *"Research has shown that diverse groups are more effective at problem solving than homogeneous groups, and policies that promote diversity and inclusion will enhance our ability to draw from the broadest possible pool of talent, solve our toughest challenges, maximize employee engagement and innovation, and lead by example by setting a high standard for providing access to opportunity to all segments of our society."*[3] (Smith & Powers, 2016.)

The demand for maker-centered education is growing across the USA in K-12 education. As schools continue to seek opportunities for improving STEM education through hands-on, relevant learning opportunities for all types of learners, makerspaces, Fab Labs, and innovation spaces are surfacing as a resource. However, to implement these resources at scale, community stakeholders must understand what their potential is, educators must be provided appropriate professional development opportunities and training, and deep community partnerships must be fostered to nurture the local support ecosystem necessary for these spaces to thrive. As an example, in 2008, MC2STEM High School in Cleveland, Ohio became the first school to host a makerspace/Fab Lab, serving a few hundred students. This was a public-private partnership between the Gates Foundation, the State of Ohio, the Cleveland Metropolitan School District and a vibrant community of local public and private funders and partners. Since this proto-lab was created, the network of educational makerspaces and Fab Labs has grown. Similar to the way that the Computer Science For All (CSforALL) project grew out of the New York City Foundation for Computer Science, in partnership with the New York City Department of Education and a number of public and private funders and partners, in Chattanooga, TN the Hamilton County school district has partnered with the Public Education Foundation and local industry, Volkswagen, to build Fab Lab infrastructure, teacher professional development and maker-centered curriculum in 16 middle and high schools across the district serving 9,000+students. In the state of Wisconsin, the Wisconsin Economic Development Corporation has partnered with school districts to develop a statewide network of Fab Labs for K-12. Through a grant-making program, 2.8M has been invested in these makerspaces for schools. To date, 77 Wisconsin school districts have received funding to support their students, and build a pipeline for economic growth and the workforce for the state through maker-centered education and infrastructure. The concept of maker-centered learning environments in formal education is growing, but needs coherent scaling and support to reach all students across the nation.

National support for maker-centered learning could rapidly accelerate this opportunity for thousands of public schools across the country. This can be a driver for eradicating the digital divide and bringing new student populations into STEM pathways by right-sizing access to and

[3] Smith, Megan and Laura Weidman Powers. "Raising the Floor: Sharing What Works in Workplace Diversity, Equity, and Inclusion," *The White House*. (blog 29 November 2016.) accessed 17 December 2020. https://obamawhitehouse.archives.gov/blog/2016/11/28/raising-floor-sharing-what-works-workplace-diversity-equity-and-inclusion.

equipping teachers with the pedagogical knowledge for taking on new technologies in the classroom as we enter a new century of rapid and transformative technological change. Building on similar national calls, such as CSforALL, a national call for maker-centered learning can provide the additional software and hardware needed for our students to be prepared with crucial 21st century skills as well as prepare educators and guides to implementation and deeper learning opportunities. By increasing the number of students in public schools with access to technological infrastructure and equipping teachers with the pedagogy to deliver the full capabilities of maker-centered learning, we can help to eliminate the STEM digital deserts predominantly found in our countries rural and urban communities where 37% of adults are dependent on smartphones[4]. This strategy will address the digital divide for the country's most vulnerable populations of people, and increase access to real world learning and innovation opportunities through a comprehensive strategy that starts with our school-age children.

Recognizing the strategic role of maker education, the Chinese government is funding a huge number of makerspaces in urban and rural schools throughout China, and making digital fabrication, computer science, and maker/engineering content part of the lives of millions of students. There is a rapidly growing number of national competitions, awards, and grant programs in maker education in the country. Together with the national strategic project of "mass entrepreneurship," China might be poised to have, in a decade, a generation of inventors, problem solvers, and entrepreneurs. A similar project is taking place in India, where the government is funding or incentivizing the creation of the "ATAL Labs" (India's version of a makerspace) in thousands of schools nationwide.

Plan of Action

We propose establishing and supporting hands-on making and digital fabrication as a part of formal education curriculum for every student across the USA, with a primary focus on underrepresented BIPOC student populations through our public schools. To ensure maker-centered learning for all students, there are three aspects that must be considered:

1) a general awareness and understanding of the benefit of access to maker-centered learning;

2) increased widespread access to and prioritization of digital fabrication professional development training for all K-12 educators, and

3) increased resources from public and private stakeholders to provide needed funding, infrastructure, tools and resources for maker-centered learning curricula and spaces.

Action Plan Implementation

To achieve this vision, we propose the creation of a Center for Excellence in K-12 Maker-Centered Learning at every Educational Service Agency (ESA) across the United States. Each Center for Excellence should be charged with: (1) providing education and training for educators in the background, pedagogy, and practices of hands-on maker-centered education (2) working with public-private partnerships to incentivize every school in the country to provide time, resources and facilities to integrate these activities in formal school programs, and (3) shepherding the creation of the local infrastructure of curricula, broadband, and low-cost technologies to universalize these practices.

[4] "Internet/Broadband Fact Sheet," Pew Research Center - Internet and Technology, accessed December 22, 2020, https://www.pewresearch.org/internet/fact-sheet/internet-broadband/

Working in partnership with ESAs would allow deeper support for school districts that have little to no maker-centered learning knowledge or activities, while providing specific support to those schools and districts that already have activity underway. Hosting the overall center at the ESA level builds a local comprehensive support and strategy that can meet specific needs while growing the work effort collectively, and making a collective impact on local and regional levels.

Coordination and Partnership
Although ESAs operate at a state and local level, given the focus is both the physical infrastructure and human resources for delivering maker-centered learning to children in all communities, there is an opportunity to activate several federal agencies all in service to deliver this learning to all students. In support of the broadband infrastructure, both the Federal Communications Commission (FCC) and Office of the Comptroller of the Currency OCC would be key government partners along with the Department of Education (Dept of Ed), Department of Labor (DoL), National Science Foundation (NSF), and the White House Office of Science and Technology Policy (OSTP), to support teacher education and professional development for this pedagogical approach. The Office of the First Lady would additionally be a support for building a grassroots and grasstops community campaign for the benefits of maker-centered learning.

Additional private sector partners would include The National Digital Inclusion Alliance, The Field Building Collaborative for K-12 maker education members; Digital Promise, Citizen Schools, Fab Foundation, FabLearn, Maker Ed, Nation of Makers, and the Association of Education Service Agencies. Existing funding streams could include Perkins V funding with a pilot in 2021 using the Innovation and Modernization dollars. Additionally, leveraging other Federal funding opportunities such as Title I, and Workforce Innovation Opportunity Act dollars, could provide and scale technological infrastructure and support teacher training for new professional standards nationwide to bring maker-centered education to every student in the country.

Legislation
Use some pre-existing legislation to ensure there is focus on maker-centered learning. Specifically, The U.S. Congress can reauthorize Title II-B of the Higher Education Act, and ensure educator preparation programs are equipped to train pre-service educators on the use of maker and digital fabrication technology and teaching methods.

Allow the use of the FY21 Budget Reconciliation Section by Section Subtitle A: Education Matters Section 2001 for Elementary and Secondary School Emergency Relief Fund (ESSERF) funding allocation for learning loss to support equitable services by providing infrastructure, tools and resources for maker-centered learning curricula and spaces.

Grant the use of funds from H.R. 447, the National Apprenticeship Act of 2021to support makerspaces and professional development associated with apprenticeship programming.

Lastly, pass the National Fab Lab Network Act (HR 3837) to set a public vision for maker-centered learning and investing necessary financial resources to sustain the effort. Introduced by Representative Bill Foster, the National Fab Lab Network Act could create new funding sources for states and districts in supporting maker-centered learning.

About the Authors

Paulo Blikstein is an Associate Professor of Education and an Affiliate Associate Professor of Computer Science at Columbia University. His research focuses on how new technologies can deeply transform the learning of science, computer science, and engineering. Blikstein created some of the world's first educational FabLabs and Makerspaces in the world, and founded the FabLearn project. A recipient of the National Science Foundation Early Career Award and the AERA Jan Hawkins Early Career Award, Blikstein holds a PhD. in Learning Sciences from Northwestern University and an MSc. from the MIT Media Lab, and was on the faculty of the Graduate School of Education at Stanford University from 2008 to 2018.

Kyle Cornforth

Kyle has two decades of experience working at the intersection of education, organizational development, social justice, and advocacy. Currently she is the Executive Director of Maker Ed, and oversees major initiatives, programs, and partnerships. Over the last 20 years, Kyle has trained teachers from all over the world on how non-traditional education experiences are essential to truly prepare students for their lives on this planet, with the belief that teachers, administrators, and schools have the opportunity to adapt their practices to the shifting world. To this end, she worked within a nascent field to build shared practice and professionalism to ensure equity and cultural relevance are foundational to program delivery at the Edible Schoolyard Project. With her incredible team, Kyle built ESYP's internationally renowned training programs and communities of practice. Kyle holds clear communication, accountability, and feedback in all directions of an organization as vital to ensuring an organization can fulfill its mission. She loves to dance, cook, and hang out with her family.

Dorothy Jones-Davis is the Executive Director of Nation of Makers. Dorothy previously worked at the Foundation for the National Institutes of Health (FNIH) where she created and managed public-private partnerships in Neuroscience between the NIH, FDA academia, non-profit, advocacy organizations, and industry partners. Prior to that role, she served as an AAAS Science and Technology Policy Fellow in the National Science Foundation's (NSF) Directorate for Engineering, was a co-founder and co-producer of the National Maker Faire and the DC Mini Maker Faire, a researcher at the University of California, San Francisco and a lecturer at San Francisco State University.

Sherry Lassiter, Ed.M., is the President and CEO of the Fab Foundation, a non-profit committed to building technical capacity, improving individuals' abilities to develop themselves and their communities and bringing access to tools and knowledge that cultivate and support innovative practices. She additionally serves as Director of the International Fab Lab Outreach Program at MIT, is on the board of the Airbus Foundation and the Fab City Foundation and serves as advisor to the Museum of Science and Industry Chicago Innovation Committee and Maker's Asylum Mumbai Executive Steering Committee for STEAM School.

Sonya Pryor-Jones is an educator and non-profit leader currently serving as the Chief Implementation Officer for the Fab Foundation. Previously she worked as the Executive Director of the STEM Hub at Case Western Reserve University where she created a public-private partnership for regional STEM high schools and K-12 STEM programming. She was honored as a Champion of Change for Making by the Obama Administration in 2016. Sonya is a member of the 2021 cohort of the Aspen Tech Hub Tech Executive Leadership program. She is a board of trustee for Kenyon College, and strategic advisory board member for 100Kin10. Sonya founded Fab House, a neighborhood based makerspace and maker in residence program located in a Cleveland, Ohio neighborhood revitalization zone.

The authors of this document are members of the Field Building Collaborative. The Field Building Collaborative was formed in 2019 to elevate maker-centered, constructionist learning through building a field of knowledge and shared practices to support the integration of K-12 maker and digital fabrication learning in formal and informal education. The founding members of the Field Building Collaborative include Digital Promise, Citizen Schools (Make for All), Fab Foundation, FabLearn, MakerEd, and Nation of Makers. The collaborative's work is currently funded by a NSF INCLUDES grant with the Fab Foundation serving as the PI.

Frequently Asked Questions

1. Education reform and implementation happens on the state level and varies from state to state. Why pursue policy change on the federal level?

While states govern the implementation of educational reform, the federal government plays a key role in convening stakeholders that are necessary for implementation, providing guidance as to a cohesive national alignment of educational policies and priorities, and providing support and funding structures to allow for state-by-state implementation. An example of this top-down approach can be seen with the implementation of CSforAll - the initiative that aims "to make high-quality computer science an integral part of the educational experience of all K-12 students and teachers."[5] While CSforAll built upon "efforts already being led by parents, teachers, school districts, states, and private sector leaders from across the country," it was guided by a Presidential initiative that called for expanded funding, professional development opportunities, and engagement from local government and private sector stakeholders.[6]

2. Is there additional historical precedent or context that exists that this proposal builds on or refutes that one should be aware of?

The system for the National School Lunch Program is analogous to this effort. The National Maker Centered Learning initiative includes a communications strategy, infrastructure, and training. This comprehensive approach provides links to key components of the system and positions the initiative for sustainability.

3. How much does the government spend on the particular policy issue currently? Are the historical precedents to demonstrate spending on the issue directly? If it is new, what other adjacent issues or policies could indirectly demonstrate spending?

To date the federal government has spent limited resources on maker focused education. The National Science Foundation (NSF) founded maker education projects at approximately 6.4M from.

4. Why should it be the federal government taking action on this issue vs. a state or local government? Or (if applicable) why not incentivize the private sector to address it directly?

The role of the U.S. The Department of Education is to promote student achievement and preparation for global competitiveness by fostering educational excellence and ensuring equal access. Maker-centered learning is key to both student achievement and global competitiveness. Elsewhere in countries like China and Finland, national level efforts have been put in place around maker centered learning to ensure that their students are achieving at a 21st Century standard and ready to compete with other students around the world.

[5] "CSforALL," CSforALL, accessed December 22, 2020, https://www.csforall.org/
[6] "Computer Science For All," The Obama White House Archives, accessed December 22, 2020, https://obamawhitehouse.archives.gov/blog/2016/01/30/computer-science-all

5. What would a less ambitious version look like to start gaining traction and interest?

A less ambitious version would be a fragmented approach focusing on only one of the focus areas: (1) spearheading and promoting a *national campaign* on the role of making in our daily lives and the workforce, (2) increasing access to *maker and digital fabrication professional development* training for K-12 educators, and (3) *incentivizing public-private partnerships* to expand access to the tools and resources for maker-centered learning curricula and spaces.

Some additional levers for traction might include 1) the Department of Education issuing a "Dear Colleague" letter affirming that the maker centered learning approach is needed in every school to meet the needs of all our children, and ensure their place as STEM citizens and on the career path of their choice 2) Saff and fund The Office of Science and Technology Policy to continue the early non funded efforted of the maker movement with a focus on K-12 maker centered learning 3) Mobilizing a public-private partnership with cross agency and non government organizational leaders to set a national vision for maker centered learning.

6. What is maker and digital fabrication education? What are the benefits of it?

Maker and digital fabrication education are part of a learning approach and continuum that is anchored in constructionism and provide people with learning opportunities that allow them to investigate ideas, problems, and phenomenom through the use of manual and digital tools. The benefits of this hands-on, constructionist learning provide new ways for students to learn and carry out the Science and Engineering Practices identified by the Next Generation Science Standards not found in typical formal science classes (Simpson, Burris, & Maltese, 2017). And provide more diverse opportunities to engage with the core practices and foundational elements for STEM careers. The skill sets and digital literacies developed through maker-centered learning are the skills and literacies of the 21st Century economy.

7. Why is the current level of maker education insufficient?

Currently maker education is afforded to the most wealthy and connected school and out of school time learning environments. While the growth trend of these spaces are on a rise, they are predominantly in white, wealthy communities across the country. This further widens racial inequities, achievement gaps, and access to postsecondary opportunities for BIPOC students and women and girls.

8. How does maker education tie in with NGSS and Common Core Standards?

Maker-centered learning offers a new medium for carrying out the Science and Engineering Practices identified by the Next Generation Science Standards, and Common Core Standards. They also allow for the use of relevant project based learning where students can drive their own learning outcomes. Some examples can be found on this repository dedicated to integrating digital fabrication to K-12 while addressing learning standards: https://www.scopesdf.org/

9. How does this differ from traditional Career and Technical Education (CTE) programs?

Traditionally CTE is organized in schools for a segment of the student population, and in some cases the pedagogy used is linear with a focus on tools. Maker centered learning is proposed for all students across subject areas. Additionally the constructionist approach centers student interests and ideas as the driver not the tools.

10. Where is there current success?

Success for this approach is scattered across the United States in schools. Most recently there are some district and statewide examples. With a national push, this could be scaled and compete with successful national efforts in countries like China and Finland.

11. Who are target audiences?

The target audiences are K-12 students, and K-12 teachers, starting with under-resourced BIPOC communities.

12. How could this address the crises of this moment (COVID, race, unemployment)?

By developing skills in digital design and manufacturing in students and communities, as well as providing the infrastructure to prototype and manufacture, we build the local ability to respond to crises like COVID-19, for designing and small-scale manufacturing of Personal Protective Equipment (PPE) for local community needs, and we build resilience to a changing economy. These spaces provide the environment to support local entrepreneurship and the ability to design solutions for local challenges, providing opportunities for new business, new employment and new participants (BIPOC) in economic development and growth.