FROM GOOD INTENTIONS TO REAL OUTCOMES

EQUITY BY DESIGN IN LEARNING TECHNOLOGIES

The Digital Media + Learning Research Hub
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EXECUTIVE SUMMARY

The growth of online communication, media, and gaming is driving dramatic changes in how we learn. Responding to these shifts, new forms of technology-enhanced learning and instruction, such as personalized learning, open online courses, educational games and apps, and tools for learning analytics, are garnering significant public attention and private investment. These technologies hold tremendous promise for improving learning experiences and outcomes. Despite this promise, however, evidence is mounting that these new technologies tend to be used and accessed in unequal ways, and they may even exacerbate inequality.

In February and May 2017, leading researchers, educators, and technologists convened for in-depth working sessions to share challenges and solutions for how learning technologies can provide the greatest benefits for our most vulnerable learners. The group identified the following challenges:

- **Same Technology, Unequal Schools:** The push for educational technology has meant that more young people across the socioeconomic spectrum in the United States have access to learning technologies through their schools. Even when the playing field is leveled for technology access, however, inequities persist. *Schools serving privileged students tend to use the same technologies in more progressive ways than schools serving less privileged students.*

- **Open ≠ Equitable:** Ubiquitous digital devices and online networks have radically reduced costs for accessing online and digital learning. As intuitive as the idea sounds, however, free and open technologies do not democratize education. In fact, evidence is mounting that *free online learning materials disproportionately benefit the affluent and highly educated.*

- **Social and Cultural Forces Derail Good Intentions:** New technologies are taken up in varied and unexpected ways by diverse learners and in diverse settings. *Once technological and economic barriers are removed, broader social and cultural forces determine outcomes.* Efforts to democratize education through technology have often faltered because technologists failed to anticipate broader social and cultural forces. Unintended outcomes commonly grow out of two underlying social and cultural forces: *institutionalized and unconscious bias and social distance between developers and those they seek to serve.*

The following promising strategies were identified in addressing equity in learning technologies:

- **Unite Around Shared Purpose:** Equity-oriented efforts can bring developers, reformers, and learners together with common purpose, thus reducing social distance between these groups. When initiatives are co-developed and co-facilitated with stakeholders, they are more likely to be better attuned to important elements of social and cultural contexts, and learners are more likely to take ownership of these initiatives.

- **Align Home, School, and Community:** While affluent students often have tech-savvy parents and the latest technology at home, less resourced students cannot count on these supports. This disconnect can be exacerbated when developers and reformers build technology literacy and capacity in school. One fruitful strategy for reducing this gap

is building the capacity of parents and mentors alongside that of children. Intergenerational learning experiences can strengthen family ties while giving parents and children new skills to explore new domains.

- **Connect to the Interest and Identities of Minority Children and Youth:** Peer learning communities are exclusionary when they reflect a dominant culture in ways that create a hostile environment for outsiders, but they can also be harnessed to create safe affinity spaces for minority children and youth. Powerful learning experiences result when students have the opportunity to connect their interests from outside of school to learning opportunities in more academic contexts.

- **Target the Needs of Subgroups:** When developers and reformers understand the specific needs of the communities they serve, they can deploy targeted programs that give the greatest advantage to the neediest groups. These can include addressing stereotype threat, addressing specific costs that matter more to low-income groups, and targeting high-risk moments in the learning trajectory.

We stand at the cusp of widespread adoption of new technologies that have the potential to both radically reduce or exacerbate existing forms of educational inequity. A concerted push for research, innovation, and joint action around a common purpose of deploying learning technologies in the service of equity could dramatically enhance our understanding of how new technologies can truly democratize education. The time is ripe for a coalition that unites research, practice, and design, and that cuts across the public-private divide in the service of a more equitable future for learning technologies.

INTRODUCTION

The growth of online communication, media, and gaming is driving dramatic changes in how we learn. Responding to these shifts, new forms of technology-enhanced learning and instruction, such as personalized learning, open online courses, educational games and apps, and tools for learning analytics, are garnering significant public attention and private investment. These technologies hold tremendous promise for improving learning experiences and outcomes. Despite this promise, however, evidence is mounting that these new technologies tend to be used and accessed in unequal ways, and they may even exacerbate inequity.

In February and May 2017, leading researchers, educators, and technologists convened for in-depth working sessions to share challenges and solutions for how learning technologies can provide the greatest benefits for our most vulnerable learners.The aim was to develop guiding principles and a shared agenda for how educational platforms and funders can best serve diverse and disadvantaged learners. These principles include inclusive design processes, ways of addressing barriers, and methods to effectively measure impact.

This report synthesizes the research, learnings, and recommendations that participants offered at the two workshops. After framing the nature of the challenge, the report then describes promising strategies and examples, and it ends with recommendations for next steps in research and coalition building.

WHY DO LEARNING TECHNOLOGIES LEAD TO INEQUITABLE OUTCOMES?

Developers of new learning technologies are often motivated by the hope of democratizing access to educational opportunity. Low-cost computing devices and the open internet offer unprecedented new avenues for expanding access to knowledge and learning. These contemporary efforts continue a long lineage of technologists who have sought to mobilize emerging technology to expand access to learning. The potential of massive open online courses (MOOCs) to democratize higher education was a rallying cry of 2013, which echoed the belief a century earlier that "with radio the underprivileged school becomes the privileged."[1]

While students in remote corners of the world and in all walks of life have benefited from these efforts, the path to technology-driven reform is full of obstacles. Larry Cuban has argued persuasively that computers are "oversold and underused" despite the persistent belief that their presence in classrooms will transform education.[2] Promising new technologies such as "edutainment" CD-ROMs eventually became dominated by fairly conventional forms of content.[3] When new educational technologies spread beyond progressive developer and early adopter communities, the weight of existing institutions and norms can squash their disruptive and transformative potential. Unlike entertainment and consumer markets, educational institutions exert a uniquely conservative influence.

These conservative tendencies extend to entrenched forms of inequality as well. Despite the best intentions of technology developers, learning technologies more often than not fail to close achievement and opportunity gaps and can even widen them. The sociologist Paul Attewell argues that these inequalities operate at two levels: the first and second digital divides.[4] The first digital divide is of access: who can get devices, software, connectivity, and other technology resources. Even when these gaps are closed, however, a second digital divide often persists: Affluent students use the same technologies to support richer forms of learning with greater adult mentorship. This first section of the report offers evidence of how inequity persists despite removing technical and economic barriers, and what we know about the social and cultural forces that determine these inequitable outcomes.

Same Technology, Unequal Schools

The push for educational technology has meant that more young people across the socioeconomic spectrum in the United States have access to learning technologies through their schools. Even when the playing field is leveled for technology access, however, inequities persist. *Schools serving privileged students tend to use the same technologies in more progressive ways than schools serving less privileged students.*

- In the 1990s, Harold Wenglinsky at the Educational Testing Service looked at the 1996 National Assessment of Educational Progress scores and found that low-income, nonwhite children more often used technology in math class for drill and practice, while affluent, white children were

1 Cuban, Larry. 1986. *Teachers and Machines: The Classroom Use of Technology Since 1920*. New York: Teachers College Press.
2 Cuban, Larry. 2001. *Oversold and Underused: Computers in the Classroom*. Cambridge, MA: Harvard University Press.
3 Ito, Mizuko. 2009. *Engineering Play: A Cultural History of Children's Software*. Cambridge, MA: MIT Press.
4 Attewell, Paul. 2001. "Comment: The First and Second Digital Divides." *Sociology of Education* 74(3): 252–259.

more likely to use technology for graphing, problem-solving, and other higher-order exercises.[5] These findings were repeated in the 2010 NAEP scores and surveys in a short study by Ulrich Boser.[6]

- In 2016, Matt Rafalow studied three high schools in Southern California, which all had the same levels of technology access, but served different populations of students. He found that schools serving elite students saw creative and playful uses of technology as essential. By contrast, schools serving middle- and lower-income students found these more empowered uses of technology threatening or irrelevant, and focused on more basic skills.[7]

Open ≠ Equitable

Ubiquitous digital devices and online networks have radically reduced costs for accessing online and digital learning. As intuitive as the idea sounds, however, free and open technologies do not democratize education. In fact, evidence is mounting that *free online learning materials disproportionately benefit the affluent and highly educated.*

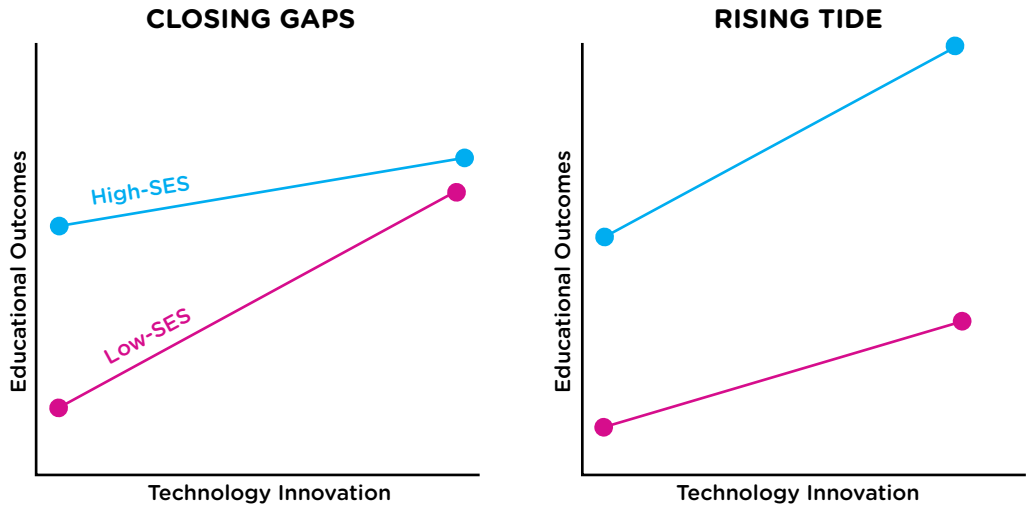

Figure 1: From Hansen and Reich 2015.

- John Hansen and Justin Reich connected data from free online courses at Harvard and MIT with data from U.S. census block tracts and found that individuals who register for edX courses are more affluent than typical Americans. Higher median neighborhood income and

5 Wenglinsky, Harold. 1998. *Does It Compute? The Relationship between Educational Technology and Student Achievement in Mathematics*. Princeton, NJ: Educational Testing Service.

6 Boser, Ulrich. 2013. "Are Schools Getting a Big Enough Bang for Their Education Technology Buck?" Washington, DC: Center for American Progress. Retrieved August 20, 2017 (https://www.americanprogress.org/issues/education/reports/2013/06/14/66485/are-schools-getting-a-big-enough-bang-for-their-education-technology-buck/).

7 Rafalow, Matthew H. Forthcoming. "Disciplining Play: Digital Youth Culture as Capital at School." *American Journal of Sociology*.

parental education were also predictors of student success in MOOCs, especially among the youngest learners.[8]

- At a global scale, René Kizilcec, Andrew Saltarelli, Justin Reich, and Geoffrey Cohen looked at the relationships between country-level affluence and MOOC participation. They found that those in wealthier countries are much more likely to complete MOOCs and receive certificates.[9]

- Scratch is a block-based programming language that children (and adults) can use to make programs, games, animations, and other digital media. The Scratch online community serves millions of young people from all backgrounds who access from home, school, and other community-based organizations. Early active participants in the online community who were accessing from home likely skewed toward youth in more privileged families. Preliminary analysis of 2016 data indicates, however, that this dynamic has shifted. The demographics of Scratch users today largely mirror the demographics of the country overall due to the high levels of uptake of Scratch in diverse schools, offsetting the bias inherent in home-based access.

- Looking at how open peer-production tools such as wikis are used in schools, Justin Reich, Richard Murnane, and John Willett found that in more affluent schools, wikis were more likely to be created, more likely to be used for longer periods, and to have more opportunities for student involvement.[10]

Social and Cultural Forces Derail Good Intentions

New technologies are taken up in varied and unexpected ways by diverse learners and in diverse settings. Once technological and economic barriers are removed, broader social and cultural forces determine outcomes. Efforts to democratize education through technology have often faltered because technologists failed to anticipate broader social and cultural forces.

- Vikki Katz and Carmen Gonzales found low uptake of Connect2Compete, a broadband subsidy program, because it was not tailored to needs of the low-income families it was meant to serve. Local variation mattered. For example, many immigrant families in Arizona were concerned about using school-issued laptops because of fears of state surveillance. In addition, the program assumed that families were completely disconnected and would welcome even a single ethernet connection. In reality, most families were already online and needed to reliably connect multiple devices via Wi-Fi in order to meet the needs of the entire family.[11]

8 Hansen, John D. and Justin Reich. 2015. "Democratizing Education? Examining Access and Usage Patterns in Massive Open Online Courses." *Science* 350(6265): 1245–48.

9 Kizilcec, René F., Andrew J. Saltarelli, Justin Reich, and Geoffrey L. Cohen. 2017. "Closing Global Achievement Gaps in MOOCs." *Science* 355(6322): 251–52.

10 Reich, Justin, Richard Murnane, and John Willett. 2012. "The State of Wiki Usage in U.S. K-12 Schools: Leveraging Web 2.0 Data Warehouses to Assess Quality and Equity in Online Learning Environments." *Educational Researcher* 41(1): 7–15.

11 Katz, Vikki S. and Carmen Gonzalez. 2016. "Community Variations in Low-Income Latino Families' Technology Adoption and Integration." *American Behavioral Scientist* 60(1): 59–80. See also http://digitalequityforlearning.org/.

- Juliet Schor and colleagues analyze exclusionary status negotiations in open sharing platforms, including a time bank, a food swap, a makerspace, and an open learning group for entrepreneurs. In all these peer-to-peer networks, participants subtly marked higher socioeconomic and educational status, and used taste, style, and microlevel interactions to exclude those who did not fit in. Lindsey Carfagna, who led the open learning case, found that those who exhibited confidence and economic security fared best in the social scene and were overwhelmingly white and male.[12]

- Monica Bulger, Patrick McCormick, and Mikaela Pitcan chronicle the public backlash against inBloom, an effort to develop a centralized platform for sharing student records and learning resources. Technologists and reformers did not anticipate the high levels of public concern about data security and privacy and the corporatization of education, and parent-led opposition to inBloom snowballed.[13]

- Varied One Laptop Per Child (OLPC) startup efforts are also instructive, though the jury is still out on the longer term impacts of these efforts. Mark Warschauer and Morgan Ames note how in Birmingham, Alabama an OLPC effort was rolled out with little support for teacher training, and few resources for upkeep, and equipment quickly faded into a state of disrepair.[14] Paraguay offered stronger supports for training and local adaptation, but even in this case, Daniela Rosner and Morgan Ames describe how the program did not fully anticipate the needs and costs for repair. Rural settings, in particular, suffered from lack of local expertise and financial resources to purchase replacement parts. Overall, 40 percent of the laptops were broken and unused after a year and four months.[15] By contrast, the effort in Uruguay is a well-supported national effort that provides multiple layers of support, including local capacity building, and is still going strong.

These varied examples of unintended outcomes grow out of two underlying social and cultural forces: *institutionalized and unconscious bias and social distance between developers and those they seek to serve*.

Bias

Bias operates even when participants believe they are being neutral or nondiscriminatory because it is institutionalized and sometimes unconscious. Even when efforts are deployed with the explicit intention of serving disadvantaged youth, learners who are part of more entitled, tech-savvy, and highly educated families take advantage of new programs and opportunities more aggressively, and at higher rates.

12 Schor, Juliet B., Connor Fitzmaurice, Lindsey B. Carfagna, Will Attwood-Charles, Emilie Dubois Poteat. 2016. "Paradoxes of Openness and Distinction in the Sharing Economy." *Poetics* 54: 66–81. See also Carfagna, Lindsey. 2014. *Beyond Learning-as-Usual: Connected Learning among Open Learners*. Irvine, CA: Digital Media and Learning Research Hub.

13 Bulger, Monica, Patrick McCormick, and Mikaela Pitcan. 2017. *The Legacy of InBloom*. New York: Data and Society Research Institute.

14 Warschauer, Mark and Morgan Ames. 2010. *Journal of International Affairs* 64(1), 33-51.

15 Rosner, Daniela K. and Morgan G. Ames. 2014. "Design for Repair? Infrastructures and Materialities of Breakdown." Presented at the 17th ACM conference on Computer Supported Cooperative Work and Social Computing, February 15-19, Baltimore, MD.

This dynamic is particularly evident in opt-in programs and enrichment. This is why even free and open online learning resources deployed with the hope of closing gaps by reducing costs have actually widened them.

In other cases, people in positions of influence engage in behaviors that may not be intentionally prejudiced but that have the effect of excluding certain learners. Rafalow's study of three different schools in Southern California documents how teachers hold shared assumptions about the students they serve that are perpetuated through well-defined and resilient school cultures and practices. Carfagna's open learning communities embrace an ethic of inclusion but send subtle signals to participants about who does and who does not belong.

When learners encounter these biases, exclusion occurs in unintended but powerful ways. Researchers have uncovered how learning environments can make minority groups feel like outsiders, and how those feelings can directly affect student performance.[16] The negative impact of this "stereotype threat" is a recursive process,[17] in which subtle cues make minority learners feel like outsiders, those feelings lead to negative performance, and learners become more attuned to the cues that make them feel like outsiders. In the case of open online communities, learners who experience these threats to their identity simply choose not to participate or drop out, amplifying the influence of this social and psychological dynamic.

Social Distance

In addition to problems of bias, efforts to deploy new technologies in equitable ways fall short because those developing and deploying new technology more often than not inhabit contexts quite different from the low-income and minority groups they are seeking to serve. The social and cultural distance between these groups has led to blind spots and lack of visibility of the contexts and needs of the target subgroups. Sociologist Tressie McMillan Cottom argues that technologists often imagine their students as "roaming autodidacts," described as

"a self-motivated, able learner that is simultaneously embedded in technocratic futures and disembedded from place, culture, history, and markets" (214).[18] Lack of awareness of learners' specific social and cultural contexts can lead to unanticipated outcomes.

The cases of Connect2Compete, OLPC, and InBloom provide a varied set of examples of the unfortunate consequences of these blind spots and assumptions. Problems can arise because of lack of visibility across settings, such as when school-based personnel do not know what is happening at home and with families. At other times, the lack of visibility is because of the distance between the culture and experience of developers, learners, and their families. Social distance, and the unexpected

16 Steele, Claude M. 2011. *Whistling Vivaldi: How Stereotypes Affect Us and What We Can Do*. New York: W.W. Norton.

17 Cohen, Geoffrey L., Julio Garcia, Valerie Purdie-Vaughns, Nancy Apfel, and Patricia Brzustoski. 2009. "Recursive Processes in Self-Affirmation: Intervening to Close the Minority Achievement Gap." *Science* 324(5925): 400–403.

18 McMillan Cottom, Tressie. 2017. "Black Cyberfeminism: Ways Forward for Intersectionality and Digital Sociology." Pp. 211–232 in *Digital Sociologies*, edited by J. Daniels, K. Gregory, and T. M. Cottom. Bristol, England: Policy Press.

uptake of new technology is particularly pronounced when crossing national boundaries, as well as boundaries of culture and class.[19]

The obvious barriers to democratizing education through technology are related to cost and technology access, but social and cultural barriers are just as real and challenging. These social and cultural barriers are harder to discern, require more nuance to address, and vary substantially across different communities and contexts. While researchers have become adept at identifying bias and blind spots, the struggle is to convert these critiques into productive designs and actions. In the remainder of this report, we describe projects and efforts that have made progress on these dimensions, the strategies that guide their work, and next steps that can amplify these approaches.

19 Maurer, Bill, Smoki Musaray and Ivan Small, eds. Forthcoming. *Money at the Margins: Global Perspectives on Technology, Financial Inclusion and Design*. New York: Berghahn.

STRATEGIES AND BRIGHT SPOTS

The remainder of this report focuses on strategies and efforts that have tackled some of these underlying and poorly understood social and cultural barriers. We see great promise in improving the outcomes of equity-oriented investments by stronger connections and shared purpose between developers and the communities being served. Other efforts are successful because they target the specific needs of subgroups, fill in gaps in their ecosystem, and connect to their culture and identity. As connected learning advocates have argued over the past decade,[20] powerful learning experiences result when students have the opportunity to connect their interests, identities, and home experiences to school and other learning settings. Many successful efforts also draw on interdisciplinary and cross-sector relationships that bring together expertise from social science, technology, and education.

Even with the right stakeholders at the table, efforts need to be monitored closely to ensure that the expected equity outcomes are achieved. The tendency for more privileged learners to gain extra advantage with new designs is persistent and difficult to mitigate. It is only by reflecting, synthesizing, sharing, and iterating across a range of approaches that we can hope to truly address the challenges of deploying new technology in equitable ways.

Unite around Shared Purpose

Equity-oriented efforts can bring developers, reformers, and learners together with common purpose, thus reducing social distance between these groups. When initiatives are co-developed and co-facilitated with stakeholders, they are more likely to be better attuned to important elements of social and cultural contexts, and learners are more likely to take ownership of these initiatives.

- For her doctoral thesis, Betsy DiSalvo created a program called the Glitch Game Testers to develop new pathways for African American boys into computer science.[21] High school students worked on quality-assurance projects for computer game companies and were deeply involved in shaping the trajectory of the initiative — choosing the name and logo, developing practices, and instigating more formal computer science education.

- The Verizon Innovative Learning Schools program is in the midst of an eight-year initiative to provide tablet computers and three years of free 4G wireless access to more than 100 Title I middle schools across the United States. One of the requirements of the program is that schools create a Student Tech Team to co-design technology policy, help lead the program roll-out, and serve as advisors and troubleshooters throughout the program. Giving students co-ownership of the program increases engagement and reduces disciplinary issues.[22]

20 Ito, Mizuko, Kris Gutiérrez, Sonia Livingstone, Bill Penuel, Jean Rhodes, Katie Salen, Juliet Schor, Julian Sefton-Green, and S. Craig Watkins. 2013. *Connected Learning: An Agenda for Research and Design*. Irvine, CA: Digital Media and Learning Research Hub. Retrieved August 26, 2016 (http://dmlhub.net/publications/connected-learning-agenda-research-and-design).

21 DiSalvo, Betsy and Amy Bruckman. 2011. "From Interests to Values." *Communications of the ACM* 54(8): 27–29.

22 Digital Promise. "Two Students Take the Lead with Technology," Retrieved August 29, 2017 (http://digitalpromise.org/2016/02/17/two-students-take-the-lead-with-technology/).

Align Home, School, and Community

While affluent students often have tech-savvy parents and the latest technology at home, less resourced students cannot count on these supports. This disconnect can be exacerbated when developers and reformers build technology literacy and capacity in school. One fruitful strategy for reducing this gap is building the capacity of parents and mentors alongside that of children. Intergenerational learning experiences can strengthen family ties while giving parents and children new skills to explore new domains.

- In the Family Creative Learning project, Ricarose Roque engaged parents and children in creative technology–focused workshops held at community-based organizations.[23] Unlike in more traditional crafts, parents and children have fewer intergenerational touch points when it comes to new technology, particularly among less tech-savvy parents. By hosting meals and activities using Scratch and the Makey Makey invention kit within safe and welcoming spaces, the project built capacity within families to support children's becoming digital creators.

- TechGoesHome is a project in the Boston Public Schools in which families can get access to a $50 laptop and discounted internet options. Parents of BPS children take a 15-hour computer literacy course taught by a teacher in the child's school, and at the end of the course they can buy their computer. Parents develop new technology skills while they improve their home access, and they develop a new relationship with a teacher inside their child's school. The program simultaneously improves computer access, parent and child technology literacy, home-school connections, and teacher relationships with communities, all by situating a program about technology access in a broader social context.[24]

Connect to the Interests and Identities of Minority Children and Youth

Peer learning communities are exclusionary when they reflect a dominant culture in ways that create a hostile environment for outsiders, but they can also be harnessed to create safe affinity spaces for minority children and youth.

In the Coding for All project,[25] Scratch developers and designers are building new entry points into the Scratch community that target common interests of girls and students of color. The Scratch team is creating Microworlds that include a subset of programming blocks and prepopulated graphics and images to support a diverse set of hobbies and interests, such as clothing and fashion or hip-hop dance. In addition, partnerships with libraries and community-based organizations ensure that lower-income youth are engaging with these new resources and are offered new pathways into the online Scratch community.

23 Roque, Ricarose Vallarta. 2016. "Family Creative Learning : Designing Structures to Engage Kids and Parents as Computational Creators." PhD dissertation, Department of Media Arts and Sciences, Massachusetts Institute of Technology, Cambridge, MA.
24 Tech Goes Home. N.d. "Impact and Results." Retrieved August 28, 2017 (http://www.techgoeshome.org/impact).
25 Scratch. N.d. "Coding for All Project." Retrieved August 18, 2017 (https://scratch.mit.edu/codingforall/).

- The Digital Youth Network's Digital Divas project creates culturally relevant STEM learning activities for middle school girls offered in after-school programs. Girls learn programming and engineering through e-textiles and other girl-friendly design projects.[26]

- In both of these cases, designers are not only creating engaging new programs, but they are working with community partners to ensure that they serve lower-income and minority students.

Target the Needs of Subgroups

When developers and reformers understand the specific needs of the communities they serve, they can deploy targeted programs that give the greatest advantage to the neediest groups. These can include addressing stereotype threat, addressing specific costs that matter more to low-income groups, and targeting high-risk moments in the learning trajectory.

Mitigating Stereotype Threats

Interventions that "inoculate" students from the negative effects of stereotype threat can be paired with efforts to remove stigmatizing materials and negative stimuli from learning environments. Targeted interventions of this kind can have outsized effects.

- Starting from research showing a "global achievement gap" in MOOCs between learners from the world's most and least affluent countries, researchers at Stanford and MIT deployed interventions in two MOOCs to test whether psychological barriers may be one cause of this gap.[27] Both interventions were simply writing exercises in a pre-course survey, randomly assigned to students. One exercise was a belonging intervention, in which students wrote about what it felt like to belong in an online community, and the other was a value-affirmation intervention, in which students wrote about how taking a course reflected values they held dear. In a control condition, a typical global achievement gap was identified, but in the two intervention conditions, students from the least developed countries persisted and earned certificates at the same rates as those from more developed countries, closing the gap. These interventions reached thousands of learners at essentially zero marginal cost.

Costs that Matter for Low-Income Groups

In the case of most MOOCs, an educational product with a price of $0 provides more benefits to the affluent, but other products with a price of $0 may be successfully closing opportunity gaps. In particular, when an educational product comes at a substantial cost to low-income families, but would be a trivial cost to affluent families, free goods may be particularly effective at closing gaps.

26 Digital Youth Network. N.d. "Digital Youth Divas." Retrieved August 18, 2017 (http://digitalyouthnetwork.org/project/digital-divas/).

27 Kizilcec, René F., Andrew J. Saltarelli, Justin Reich, and Geoffrey L. Cohen. 2017. "Closing Global Achievement Gaps in MOOCs." *Science* 355(6322): 251–52.

- OpenStax develops free, peer-reviewed, openly licensed textbooks for introductory college courses.[28] A substantial portion of all college enrollments in any given semester are in a relatively small number of introductory courses: Algebra, Biology, Calculus, Economics, Psychology, Government, and so forth. The textbooks for these survey courses can cost more than $100, a substantial burden on students in community colleges and other settings who may be paying only a few hundred dollars per credit hour. Since 2012, OpenStax has saved students more than $155 million in textbook costs. While certainly students from all backgrounds may be benefiting from these resources, the families benefiting most are those for whom a $175 textbook represents a major financial hurdle.

- Desmos has developed a free, browser-based graphing calculator as a direct competitor to the Texas Instruments lines of calculators, such as the TI-84+ that retails for $150. The Desmos graphing calculator has substantially more functionality than a handheld calculator and represents a major improvement in terms of accessibility through integration with screen readers and other accessibility software. As in the case of OpenStax, the TI $150 price tag is trivial for affluent families but a substantial burden for low-income schools and families — especially when many families already sacrifice to make more fully functional laptops, phones, and tablets available to their children.

Target High-Risk Moments

Learners from less resourced backgrounds face unique challenges at key points in their educational trajectories. Transition points — starting at new schools, starting new courses, changes in semesters — are fruitful places to explore how technology might support student success or keep students from falling off track.

- "Summer melt" is a phenomenon described by Ben Castleman of the University of Virginia and Lindsay Page of University of Pittsburgh.[29] They found, in studies of three large urban districts, that between 10 percent and 40 percent of "college-intending" students with acceptances to college failed to enroll in the fall after their senior year of high school. Schools that had successfully improved graduation rates and college acceptance rates were losing students in the transition to college. A series of interventions, based on text messaging that reminded students of key dates and actions related to enrollment, registration, financial aid, and orientation, successfully raised college entry by several percentage points at very low cost.

28 Pitt, Rebecca. 2015. "Mainstreaming Open Textbooks: Educator Perspectives on the Impact of OpenStax College Open Textbooks." *The International Review of Research in Open and Distributed Learning* 16(4): 133–155.

29 Castleman, Benjamin L. and Lindsay C. Page. 2014. *Summer Melt : Supporting Low-Income Students through the Transition to College*. Cambridge, MA: Harvard Education Press.

NEXT STEPS

In the decades ahead, digital media will become increasingly central to learning experiences in K-12 schools, higher education, informal, and lifelong learning for professionals and hobbyists. In many respects, with the wealth of information and learning communities available online, it is the best of times to be a learner. Making the benefits of this transformation available to all students will require industry-wide efforts among developers, educators, researchers, and funders. Much progress has been made in making learning experiences that are low cost and universally accessible, but the next wave of efforts at democratizing education through technology need to pay greater attention to the social and cultural barriers that are faced by the students furthest from opportunity.

A surge of effort is needed from all stakeholders to investigate and address these barriers to creating more equitable learning through learning technology. Through a richer understanding of complex barriers to equity, the principles underlying exemplar projects, and a concerted period of innovation and experimentation on improving educational equality, we can make substantial progress in a short period. In turn, these efforts can undergird longer term efforts at reform that locate technology within a broader ecosystem of organizations and change efforts. [30]

Research Agenda

This report takes some initial steps in gathering case studies and surfacing equity-promoting strategies, but we need more extensive and granular studies to effectively translate empirical research into action and design. We suggest three areas of investment for future research — case studies, targeted research on subgroups, and translational research.

Case Studies

We have described a handful of projects that are closing gaps between more and less advantaged learners, but many more such efforts exist. Chronicling a wide variety of efforts to reduce inequality through learning technologies, with all their successes and failures, would provide the data and cases needed to attempt to draw generalizable conclusions about principles that could be applied to work for equity in diverse settings.

A range of cases will be important for understanding how related ideas operate in different contexts and for understanding nuanced differences and factors. For instance, the effects of pricing on education technology and equality remain poorly understood. Free MOOCs seem to expand opportunity gaps, while providing free textbooks seems to close them. The $50 cost for a laptop in the Tech-GoesHome program might create more buy-in and ownership, and ultimately more long-term good, than a completely free laptop. One consistent theme in the research on behavioral nudges, from efforts to address stereotype threat to summer melt, is that similar messages can have highly variable effectiveness in different contexts. Creating interest-driven pathways is a promising strategy for

30 See, for example, the international New Pedagogies for Deep Learning effort which integrates new technology into a multi-level ecological approach to reform: Cobo, Cristobal, Claudia Brovetto, and Fiorella Gago. 2016. "A Global Network for Deep Learning: The Case of Uruguay." Paper presented at the LINC Conference, May 23 - 25, 2016, Cambridge, MA.

engaging diverse youth, but it is also one of the primary tools that affluent families use to secure access to scarce elite education. Understanding these nuances will be essential to providing actionable advice to developers and educators.

Targeted Research on Subgroups

One crucial component of ongoing work in education technology will be continued efforts to measure differences in how various subgroups experience and benefit from education technology. Our deepening understanding of education technology and equity depends upon data collection and research that captures relevant demographic backgrounds of students. If we do not measure the effects of education technology on different subgroups, we cannot address the inequalities that emerge. There are substantial barriers to this kind of data collection: federal privacy-protection laws that protect young Internet users, potentially deleterious effects on enrollment and usage from asking people personal questions, and other challenges. But the benefits may be particularly pronounced at this moment in edtech history. Combining demographic data with new forms of learner behavior data collected by online learning environments promises to open important new frontiers in research into education technology and equity. Nearly all of the background research from the first part of this report, and the interventions described in the second, depend on measuring and understanding how different learners access and use learning technology in different ways. If we can more richly understand how learners from different backgrounds and contexts engage with education technology, we are better equipped to ensure that innovations target the students who are furthest from opportunity.

Synthesis and Translational Research

From a rich set of cases, we can begin to synthesize a set of strategies and principles to inform stakeholders across education technology. This report begins this effort, but it is only a first step. In order to arrive at actionable insights and concrete tools, we need a richer base of empirical work and iterative and collaborative development of guidelines, instruments, and other tools for funders, developers, practitioners, and researchers.

For funders, these insights might provide a new set of questions for vetting new grantees or entrepreneurs or for encouraging existing funding recipients. For developers, a new set of design principles for digital equity could help inform technologies that can be adapted to diverse contexts, and new development approaches that continually examine how tools are used differently in different communities. For educators, translational research would inform the development of concrete guides and materials for how to select and use technologies to support all students, as well as training materials for how to evaluate equity dimensions of classroom materials. For researchers, a synthesis of research on education technology and equity would open new frontiers for theory building and design research. We also expect that the process of synthesizing and translating insights across research, development, and practice will build relationships across these communities of practice.

Coalition Building

Ultimately, a synthesis of what is known in education technology could lead to a new set of design principles for digital equity, guidelines that could help stakeholders across sectors jointly approach the development and use of new learning technologies with an eye toward ensuring that innovations are targeted at serving the learners who need the most support.

Research + Practice + Development Partnerships

Developing a rich set of cases will also mean cultivating collaborative relationships between developers, practitioners, and researchers. With the exception of Scratch, edX, and a handful of other efforts, most large-scale learning-technology deployments are being led by independent nonprofits and corporations, not academic institutions. Conducting research and learning from these efforts will require reducing social distance between these sectors and organizational cultures, and uniting around the common purpose of promoting equity. This means creating trust and building relationships, as well as the nitty-gritty of data-sharing agreements and agreed-upon practices for sharing and disseminating results.

Experimentation and Innovation

Working across silos to advance an agenda of equity through education technology would fuel innovation and experimentation. Informed by fresh thinking and inspired by a shared commitment across the sector, new efforts to deploy design principles for digital equity would create new proof points, exemplars, and lessons learned. Just as waves of innovation can follow successful new ventures, a shared social commitment can also inspire innovation. We stand at the cusp of widespread adoption of new technologies that have the potential to both radically reduce or exacerbate existing forms of educational inequity. The time is ripe for a coalition that unites research, practice, and design and that cuts across the public-private divide to address pressing problems in learning technologies and equity.

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