Analysis of the Impact of Educational Technology on Social Inequity in the United States

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Abstract. The desire to improve and modernize education through educational technology is met with a daunting wall, as educational technologies oftentimes reflect and exacerbate social inequities. This work explores the growth in United States' educational inequity stemming from the interdependent relationships between education, the digital divide, and social inequities. Diving into three case studies, this paper addresses the privatization consequences that result from the disproportionate funding barriers that schools in marginalized communities face in purchasing Smart Boards, as well as the dangerous impacts of SMART Technologies' techno-solutionist marketing in worsening educational inequities. In comparison, massive open online courses (MOOCs), which are designed with the goal of improving education equity, appear to circumvent the funding barriers that Smart Boards provide, but fail to address the more tailored educational needs of marginalized communities – ultimately landing at the same fate as that of Smart Boards in worsening educational inequities. Lastly, this paper investigates reading software related to improving education for students with reading issues and blind students. Massively popular and effective in helping these students be more engaged and independent in reading, reading software is overall successful in creating a positive push toward educational equity. However, individual reading software can easily fall to the same failures of Smart Boards and MOOCs in contributing to educational inequity.

Although improving educational equity requires a holistic approach, from a technology design standpoint, the following recommendations are made: (a) develop educational technology with the goals of improving education quality and equity, (b) circumvent as many barriers as possible to technology access through technology design, (c) work with marginalized communities to truly understand their needs and create a technology they will use, and (d) continue work toward equitable educational technology.

Keywords: Access to education and learning · Evaluation of accessibility · Usability, and user experience · Educational technology · Educational inequity · Digital divide · Educational technology integration

1 Introduction

Access to quality education is fundamental to bridging inequity gaps and raising socioeconomic mobility but is typically limited to students in privileged neighborhoods and/or

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those without disabilities [1]. In response, the era of smartphones and laptops has touted the rise of educational technology as a critical player in closing these gaps in education quality and access. However, the desire to improve and modernize education through technological solutions is met with challenges as new educational technologies oftentimes worsen the inequities they aim to resolve. Although educational technology has a role in improving education quality and improving socioeconomic mobility, it tends to fall flat in these goals and often exacerbates social inequities due to the following failures: (i) Failure to circumvent structural barriers to technology access through technology design, as demonstrated with the Smart Board; and (ii) Failure to consider why individuals may choose against utilizing technology, as demonstrated with MOOCs.

1.1 Education, Inequity, and the Digital Divide

The uneven distribution of quality education is built by design in the United States education system. Although school funding varies by state, in general, about half of school funding comes from property taxes, meaning that schools in lower income areas receive significantly less funds than those in higher income neighborhoods [2]. Furthermore, most states do not provide any additional funding to school districts that serve student populations of high poverty or color. When considering how equal funding doesn't result in equitable funding–as schools with many students in poverty or of color will require additional funds to provide specialized training for teachers and resources for students, such as free lunch, school supplies, ESL courses, etc.–the funding discrepancies in schools are especially extreme, as schools that are most in need receive severely inadequate funds [3]. (It should be noted that the root cause of these inequities historically stem from systemic racism, and although this paper does not go into the issue of racism, the divides in race, class, and education are heavily linked and complex [2–7]).

These funding discrepancies have huge ramifications, as underfunded schools struggle to receive extra funding and consider providing quality education as less of a priority. Since schools in the United States can receive additional funding off highly-ranked test scores on standardized exams and higher enrollment rates, these schools tend to emphasize test scores and "competitive" appearances against other schools, while cutting corners wherever possible due to lack of funding [8]. Additionally, highly qualified and experienced teachers appear to be one of the leading factors in improving academic achievement in students [2]. Unfortunately, unable to hire enough quality teachers, underfunded schools hire the highest number of unqualified teachers, who also contribute to the disproportionately high rate of attrition that these schools often face [1]. Furthermore, teacher professional development is distributed unevenly [1], worsening the inability of the education system to provide quality education for all. Students with disabilities, who already tend to experience a subpar education experience across the board, are even more so at a disservice in underfunded schools [4, 6, 7].

These inequities are then reflected into the population, as a student's socioeconomic status is strongly related to their educational achievement, school-dropout rate, mental health problems, drug usage, imprisonment rates, and teen birth rates [1]. Students of low income have disproportionately low representation in colleges/4-yr institutions, which results in labor market disparities [1]. Furthermore, the growing omnipresence of technology necessitates the development of digital skills for basic survival. This not only

demands for the integration of technology in education, but also magnifies the widening gaps in education quality, achievement, and attainment [1], as the disparities in education become increasingly impacted by the disparities in technology access and usage.

The digital divide can be defined as the rankings and gaps in technology access and engagement [9]. This divide can stem from unequal opportunities to access and use various technology, as well as unequal engagement with technology [9]. Additionally, access to quality education, especially early education that incorporates educational technology, contributes to the digital divide [1], which again contributes to the cycle of inequity.

The digital divide is heavily expressed in education, as well-funded schools integrate technology into their curriculum to enhance learning, while underfunded schools, if they have the technology, tend to utilize it more as a form of babysitting [10]. Due to lack of funding, underfunded schools do not have the means to adequately train and provide sufficient technology support for their teachers, leading to situations like the one mentioned above [10]. Additionally, since teachers are one of the primary catalysts for adopting technology in their classrooms [11], the tendency for underfunded schools to hire teachers who lack experience and confidence with technology compounds the ineffectiveness of digital skills education in schools serving disadvantaged communities. Furthermore, high quality technology support is a major contributor of successful educational technology integration [11–13]. However, K12 technology support teams are typically grossly understaffed, overworked, and extremely lacking [14–16]–with only 34–48% of teachers deeming them adequate in 2018 [17]. Overall, teachers employed in underfunded schools, which tend to focus on exam score optimization and appearances, have higher dissatisfaction rates with educational technology than teachers in schools that emphasize students, inclusion, and quality instruction for all [8, 12].

A speculation for this is that the differences in school priority determines whether the school leadership will truly address the needs of their teachers and students, or whether they will cut corners on education quality, as it is not their focus. With the explosion in technology usage, schools that focus on quality instruction, which are typically well-funded, will be more prone to support, to the best of their ability, successful technology integration to enhance education, and vice versa–furthering discrepancies in education quality. Additionally, so many other factors–such as internet access and student support at home–disproportionately impact students of low income and of color [1]. Ultimately, these additional factors significantly impact the success of educational technology integration in classrooms, widening the digital divide and contributing to inequity [1].

Interestingly, technology access itself does not drive technology usage, as about 20% of those with internet access rarely, if ever, use it [10]. Race, income, and educational attainment are strongly correlated with internet usage–with white, high income, and high educational attainment each positively correlating with high internet use rates [10]. As a result, if, at the expense of other media outlets, the internet took on an even greater role in the distribution of information, the digital divide would significantly widen [10]. Although the incorporation of technology in education is critically important, the tendency for a significant portion of the population to avoid using technology highlights the need to holistically improve the United States' education system. The

goals of improving education and reducing the digital divide can easily fall into the trap of techno-solutionism, as technology companies market their products as the simple solution to solving these complex issues. While technology can be part of the solution, its potential is often over-exaggerated, as in the case of the Smart Board.

2 Smart Boards and Educational Inequity

Developed by SMART Technologies, Smart Boards were regarded as the next transformative technology in the education environment, painting visions of students and teachers collaborating and connecting on multiple devices through a whiteboard of the future. Numerous research studies have been published indicating that Smart Boards do live up to their fanfare in helping students be more engaged and learn better [18–23]. However, their integration into the classroom has had mixed results, as some schools found great success with them, but others continue to phase them out [24–27].

Smart Board marketing, filled with techno-solutionist buzzwords such as "transformative, interactive, fun, efficient," [28] pressures schools into purchasing SMART's products, lest they be seen by parents as outdated [25]–adding to the compulsion underfunded schools have in placing a top priority on maintaining their competitive appearances. Parents want the best for their children, and when school funding cannot support the $300,000–$1,000,00 burden [25–27, 29] of Smart Boards–their updates, constant maintenance, continuous rotation of new and improved add-ons–parents step in with open wallets [25]. Consequently, when parent donations do not cover expenses, private businesses find opportunities to extend generous partnerships [25].

Consequently, parents with the means to donate find themselves more appreciated and heard, especially at school events involving fundraising, curriculum, and administration policies [25]. Inevitably, students with higher socioeconomic backgrounds begin to have more of their educational needs met by their school, while the needs of students in marginalized communities remain unheard. Moreover, these schools–in which parents of higher socioeconomic status comprises a significant portion of their parent population–are typically already well-funded and more able to utilize Smart Boards to enhance learning, due to the presence of experienced and qualified teachers, dedicated resources toward technology support and professional development, and utmost priority on quality instruction. The same, however, cannot be said for low-income underfunded schools.

Due to lack of funding, many schools simply cannot afford to purchase Smart Boards [1, 8, 12] or cannot afford to keep up with the continuous costs and are stuck with broken or outdated Smart Boards [26, 27, 29]. As a result, these schools may be deemed as less competitive and find their enrollment rates, and subsequently, their funding amounts dropping–in turn, potentially causing their teacher attrition rates to further increase. Ultimately, the students who remain in these schools are harmed, as their quality of education lowers. Due to their tendency to hire less qualified teachers and inability to provide beyond any basic, generic technology training and professional development [12, 25], low-income schools that are able to purchase Smart Boards are likely to be extra prone to using their Smart Boards as glorified projectors, a practice that is fairly common across all schools [25]. In this case, the purchase of Smart Boards becomes a waste of money as it provides no additional benefit to students, and instead, exhausts

resources that could have been put toward beneficial items. Although, between the two situations mentioned above, perhaps the latter, in which schools ineffectively use their Smart Boards, is more attractive than the prior, in which schools lose funding. However, because most schools rely on business partnerships to purchase Smart Boards, underfunded schools that especially rely on these partnerships are likely to experience an exaggerated impact of these private businesses over school climate in comparison to well-funded schools.

Following these partnerships, private businesses may begin to gift students with logo-ridden stickers and pencils, while teachers find themselves in sponsorships with business partners and SMART Technologies, exchanging sale promotions for additional funds toward SMART product purchases [25]. These school-wide marketing tactics pit schools in a competition where they must continue purchasing technology and building relations with private business, as if it proves their dedication to quality instruction [25]. As mentioned earlier, well-funded schools may be better equipped to balance this competition with holistic dedication to quality education; but underfunded schools may find this pressure of privatization further compounds their tendency to maintain appearances at the expense of quality education.

Ultimately, the failure of the Smart Board in diminishing gaps in education quality stems from its inability to circumvent structural barriers to technology access, such as funding and the digital divide, through its design. It is likely that SMART Technologies did not have educational inequity in mind when developing the Smart Board. Nevertheless, the exorbitant costs of the Smart Board have contributed to the growing privatization of public schools and the widening gaps in education quality, the digital divide, and social inequity.

3 MOOCs and Educational Inequity

Massive open online courses (MOOCs) were, and still are, heralded as the new form of education that serves the public good and breaks down education barriers, providing the entire world with university-quality education [30, 31]. MOOCs are typically developed with university partnerships, and offer online education for free to anyone, regardless of previous academic achievement and university enrollment status [30, 31]. Since they are free, online, and are absent of typical university pre-selection requirements, MOOCs enable less privileged groups to potentially improve their career trajectory at a much lower cost in comparison to traditional higher education [32]. However, students in marginalized communities are vastly underrepresented in MOOCs, as most MOOC students are already educated and employed [32, 33]. In fact, minority students who participated in MOOCs often reported feelings of intimidation and reduced social presence [1]. Ironically, those who need the benefits of higher education–those who MOOCs were designed to specifically serve–are not benefitting from them. Instead, the benefits of MOOCs are provided toward those who are already educationally advantaged [32, 33]. While this situation may seem puzzling as there are much fewer barriers to MOOCs than traditional forms of higher education, the remaining barriers to MOOC access are significantly impactful.

Pollack Ichou noticed that the barriers marginalized students face in accessing MOOCs can be considered as a lack of access in four categories: material, mental, skills,

and usage access, based on van Dijk's and Hacker's concept of four types of technology access [33, 34]. A lack of material access refers to an individual's lack of information and communications technology, such as computers and affordable and stable internet access–a lack that is commonly seen among low-income communities and globally in lesser developed countries [1, 8, 32–34]. Indisputably, compared to individuals of higher socioeconomic backgrounds, individuals of lower socioeconomic backgrounds are less likely to have material access. Although the choice for MOOCs to operate online seems to overlook the lack of material access that many people have, the majority of individuals in the United States have and use the internet, and the rate of internet usage and access continues to grow [35]. Accordingly, while the online aspect of MOOCs is imperfect in meeting the material access needs of everyone, it meets those needs for more people compared to traditional forms of higher education. Additionally, this highlights the limits of technology design in circumventing all structural barriers to technology and emphasizes the need for a holistic approach in tackling these complex issues. However, even with sufficient material access, individuals in marginalized communities may still refrain from participating in MOOCs for various reasons.

A lack of mental access refers to an individual's lack of elementary digital experience, which may be due to factors such as disinterest, technology anxiety, or hesitancy [34]. This lack of mental access can be seen among individuals in marginalized communities who avoid internet use, preferring to seek out alternative sources for information [10]. Consequently, these individuals are likely unaware of MOOCs, and even if they were aware, would be highly unlikely to participate. Unfortunately, even if an individual has sufficient material and mental access, they may still be unable to participate in MOOCs due to a lack of skills and usage access.

A lack of skills access refers to an individual's lack of digital skills [34], but can also be extended to include a lack of literary skills in the context of MOOCs [33]. Due to discrepancies in education quality, home technology access, and parent attitude, experience, and skills, digital literacy skills are developed unevenly, with individuals in marginalized communities typically lacking in digital skills when compared to their peers [33]. Furthermore, because nearly all MOOCs are taught in English and require college-level reading and writing, literary skills and English fluency are critical in the successful completion of MOOCs [33]. Similar to the case of digital skill development, literary skills and English fluency tend to be less developed for individuals in marginalized communities, further preventing them from participating in MOOCs. Perhaps most detrimental of all for individuals participating in MOOCs is a lack of usage access.

Many individuals in marginalized communities will have sufficient material, mental and skills access to participate in MOOCs, but they often lack usage access, or a lack of usage opportunities [33, 34]. In regard to MOOCs, this is demonstrated by the prevalence of abstract and high-level courses, such as artificial intelligence, which tend to be engaging for many already-educated students, but are simply not practical nor relevant to many students of marginalized groups [33]. Undoubtedly, if these courses are not applicable to marginalized students, they will be unlikely to participate in them.

Beyond these four access categories, MOOCs also fail to consider the varied education backgrounds of individuals in differing socioeconomic backgrounds. MOOCs tend

to present the same material to all students in order to provide content equality. However, when considering how MOOCs will accept students regardless of prior academic achievement, the "equality" of MOOCs makes them arbitrarily too advanced or basic for any student. When reviewing the tendency of MOOCs to consist of mostly highly educated students [32, 33], MOOC instructors are then more likely to adjust their course materials to match the more advanced level of their students, rendering MOOCs to likely be too advanced for students with less educational attainment and possibly contributing to the feelings of intimidation and reduced social presence that minority MOOC students face [1].

Ultimately, the failure of MOOCs in diminishing gaps in education quality stem from their oversight in addressing the digital divide due to not fully understanding the tailored needs of marginalized communities. Although MOOCs were designed to circumvent as many barriers to higher education as possible, their failure to better uniquely tailor MOOCs toward marginalized communities has resulted in a lack of marginalized student representation–ultimately, furthering the digital divide, education gaps, and social inequity.

4 Reading Software and Educational Inequity

Unlike Smart Boards and MOOCs, reading software can arguably be seen as one of the few educational technologies that have truly made a positive push toward improving educational quality and equity. For purposes of this research, reading software can represent any software program that has reading aid functions, such as text-to-speech or optical character recognition (OCR, which is the capability to visually distinguish text in various formats, such as physical paper, images, or PDFs), regardless of whether the software's primary purpose is to aid in reading. For example, Apple and Microsoft products typically have built in text-to-speech screen reading technology [36, 37]; Google Drive has some OCR capabilities in transcribing files, such as PDFs or images that screen readers typically cannot read, into files that are compatible with screen readers [38]; and many reading software will contain text-to-speech and OCR capabilities that include highlighting individual words to match users' reading pace or as the words are read aloud [39–41]. For blind students, text-to-speech is vital for accessing information encountered in both school and daily life; for these individuals, text-to-speech enables reading, learning, and navigating digital media independently [42]. For students with reading issues, such as those stemming from dyslexia or ADHD, text-to-speech and/or OCR highlighting features can drastically improve their education, as these technologies help students be more engaged and independent in reading [39–41]. The massive popularity and commonplace adoption of reading software [39–41] indicates an overall ability in meeting both general access needs and the tailored needs of marginalized students.

As a category, reading software has demonstrated some positive impacts in educational equity, but individual reading software products can tend to replicate the failures of Smart Board and MOOCs in contributing toward educational inequity. Reading software can vary wildly in price with some being free or low cost to others costing in the range of thousands of dollars [42, 43]. Furthermore, not all reading software are built

to the same standards, with the more affordable software often providing less or subpar features, such as poorer voice quality in text-to-speech or lacking strong OCR capabilities, in comparison to their more expensive counterparts [43]. The combination of pricing and quality differences between individual reading software products can prevent students with specialized needs and lower socioeconomic backgrounds from accessing the software they need due to cost, material access, and usage access barriers. While students who can afford these products may find their education quality improving, those unable to afford the expense may be left behind, widening the education quality gaps within marginalized communities and between marginalized and privileged communities. For individual technology businesses, striking a balance between improving equity and maintaining financial security can be challenging, but this balance tends to be a main factor in determining, from an organizational standpoint, whether an educational technology will positively or negatively impact educational equity.

5 Conclusion

Fundamentally, improving the education system with regards to social inequity requires a holistic approach that includes political and funding change; shifting views on school culture, administration, instructional practices, and privatization; and suitable educational technology [8]. Although educational technology is contributing to social inequity, for educational technology developers, there are several design factors to consider in creating positively impactful educational technology. The first of which is prioritizing education quality and equity. A developer that prioritizes positive impact first and profit second may be less likely to repeat some of the failures described in this work. By pushing back against techno-solutionism, perhaps future educational technology and their marketing can work to shift public mindset and school culture toward one where quality education is prioritized through meeting the needs of students, teachers, and staff, instead of through technology purchases.

Awareness of structural barriers to technology access is key for researchers and developers to circumvent these barriers as much as possible through technology design. As exemplified between Smart Boards and MOOCs, where MOOCs are much more accessible than Smart Boards, circumventing a significant portion of barriers is possible. To circumvent these barriers, we should develop technology that is free or low-cost, compatible with commonly used devices and the internet, and can be accessed by anyone regardless of educational standing. Since running a nonprofit educational technology business may not be financially feasible to most, potential options to maintain financial stability and low product cost may include setting up scholarship or donation systems, in which generous individuals can donate money toward school technology purchases, and well-funded schools can purchase educational technology at a suitable profit margin for business while underfunded schools are offered the technology for free or at a reduced cost.

Another potential option is to create partnerships with states, so that states can purchase educational technology to provide for everyone at no cost. For example, Arizona provides educational lab licenses of SketchUp Pro for free to schools that are involved with the state's licensing grant program [44]. Portland's Smart City PDX's Digital Divide

project is another example, in which the state partners with community and nonprofit organization to reduce the digital divide–in an especially urgent manner due to the COVID-19 pandemic's impact in increasing technology dependence–by distributing technology devices, internet access, and digital skills training at no cost to those who are typically excluded from technology access [45]. By partnering with local government while keeping equity in mind, future educational technology may be able to shift public mindset and political policies toward focusing more on educational equity.

By working with marginalized communities, educational technology developers can better understand the tailored needs of these communities and why certain populations may choose against utilizing an educational technology. By providing a platform for marginalized communities to actively participate in developing technology for themselves, educational technology developers and community members can better create technology that will actually be used by these communities. As demonstrated by MOOCs, the oversight in understanding specific digital divide barriers for marginalized groups rendered MOOCs ineffective in their goal of equitably improving education.

Lastly, the continued work toward developing equitable educational technology is crucial. Although currently developed educational technology will likely cause some social harm because they cannot be truly equitable on their own–since technology alone is immensely limited in its ability to solve complex problems, as demonstrated by the limits in MOOCs of addressing material access–educational technology is incredibly important from a digital skill building standpoint, but also for those who cannot have a quality education without it, as demonstrated through reading software. These are significant positive impacts that, while overshadowed by the many significant negative impacts of educational technology, compel the continued development of educational technology.

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