TechTrends (2016) 60:598–605
DOI 10.1007/s11528-016-0109-5

ORIGINAL PAPER

Intended and Unintended Consequences of Educational Technology on Social Inequality

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Published online: 25 July 2016

Abstract While much has been written in the field of educational technology regarding educational excellence and efficiency, less attention has been paid to issues of equity. Along these lines, the field of educational technology often does not address key equity problems such as academic achievement and attainment gaps, and inequality of educational access and opportunity. In this paper, we survey research regarding persistent inequality issues related to (a) educational access and (b) educational opportunity in the U.S. education system. Furthermore, we discuss intended and unintended consequences of educational technology on social equality. We then conclude with a discussion of how educational technology researchers and practitioners should consider the broader social context in which their work is conducted and the intended and unintended consequences it might have on social inequality.

Keywords Educational technology · Social inequality · Achievement gaps · Educational access · Attainment gaps · Educational opportunity · MOOC

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One goal of educational technologies research is to systematically study and empirically validate tools that support educational excellence. Along these lines, empirical research has shown positive effects of technologies on students' problem-solving (Oh and Jonassen 2007), critical thinking (Jeong and Joung 2007), and collaboration (Weinberger, Stegmann, and Fischer 2007). Within this purview, education technologists have employed social media (Wang, Woo, Quek, Yang, and Liu 2012), games (Sun, Wang, and Chan 2011), multimedia (Mayer 2003; Moreno and Valdez 2005), and other digital resources to enhance student outcomes in K-12, higher education, and informal learning settings. Other work within educational technology has focused on the role of technologies in promoting the efficiency of educational processes, such as using classroom response systems or clickers to expedite formative assessment (Caldwell 2007).

Despite the favorable impacts of some technologies on educational excellence, these advances have taken place within a broader social context–one that is significantly unequal. To date, researchers have found that social inequality is linked to increases in the following: mental health problems, imprisonment rates, school-dropout, drug usage, and instances of teen births (Berliner 2013). As various solutions are sought, debates have often focused on the role of education to bridge inequality gaps and obviate the cycle of poverty (Campano, Ghiso, LeBlanc, and Sánchez 2016; Payne 2013). However, the U.S. education system has long been marked by inequality of educational outcomes among student sub-populations, as indexed by achievement and attainment gaps. Research has also shown that a student's socioeconomic background (determined by parental income, education, and occupation) is strongly linked to educational achievement (Coleman 1988). As intricately linked to one's socioeconomic background

within the U.S., race and ethnicity are also important considerations in examining achievement and attainment. Although there has been some closing of racial/ethnic achievement gaps (Lee 2002), the achievement gap between children from high- and low-income families has only widened over the past 50 years (Farkas 2011; National Center for Education Statistics 2016).

Student outcomes are also significantly unequal with respect to educational attainment (Jacob and Wilder 2010). Although we have seen significant improvements in rates of high school graduation for low-income and Black and Hispanic students over the past decade, these students still trail behind their socioeconomically advantaged, white peers (Grusky, Varner, Mattingly, Poulin, and Chou 2014). At the same time, despite increased rates of access to postsecondary institutions for these students, retention and completion rates remain low (Bailey and Dynarski 2011). Recent studies indicate that Black, Hispanic, and low-income students are much less likely to earn a four-year college degree (National Center for Education Statistics 2016), and are disproportionately represented in community colleges and lower-tier four-year institutions (Grusky et al. 2014). Crucially, these disparities in educational outcomes translate to disparities in individual labor market outcomes (Farkas 2011).

While education is one way to facilitate social mobility, Berliner (2013) argues that "family resources, or the lack of them, play an increasing role in the success and failure in the nations' youth" (p. 208). One might further argue that as the world becomes more dependent on technology, learning technology may inadvertently widen gaps over time. To further conversations about these issues in relation to educational technology, we survey prominent issues concerning inequality of educational access and opportunity in the U.S. education system. First, we discuss the role of technology as they relate to emerging "app gaps", access to college information, online learning, MOOCs and their role in access to educational access. The discussion of access to opportunities to learn will explore research focused on professional development and interface design. Collectively, this review provides examples of how technology has been used to successfully address issues of inequality, and briefly outlines examples of how educational technologies may function to worsen gaps. We then conclude our discussion with future design and development considerations for educational technology work that takes into account the larger social context.

Inequality of Access to Educational Institutions

We begin this section with a focus on issues of access to early education, arguably the most critical stage of cognitive development, before turning to issues of access to higher education, an area of unprecedented importance within our digital knowledge economy. Technological solutions to improving access for underserved students are also addressed, as well as the unintended consequences in which inequalities are reproduced or exacerbated.

Access to Early Education

Families living within low-income neighborhoods are faced with a number of challenges including access to high-quality childcare and early education. Head Start is one federally funded initiative that aims to close social inequality gaps by improving education starting at the pre-kindergarten level. Longitudinal studies have found this program to have positive long term effects in terms of high school completion rates and enrollment in college (Garces, Thomas, and Currie 2000; Jenkins, Farkas, Duncan, Burchinal, and Vandell 2016; Ludwig and Miller 2005). Other high quality pre-school programs have been found to reduce the probability of students being retained in grade, placed in special education, unemployed, incarcerated, and dropping out of school (Darling-Hammond 2013). Indeed, others find that "children in poverty can be 12 or 18 months behind the average child" (Barnett and Lamy 2013, p. 99). Further, these gaps do not seem to lessen or disappear as students advance through schooling. For these reasons, many have argued that access to early education is perhaps one of the most critical areas of inequality (Meyers, Rosenbaum, Ruhm, and Waldfogel 2004).

The television show Sesame Street is one widely accessed educational technology that targeted social inequality issues related to conceptual and social knowledge (Lamont and Small 2010). Notably, a recent meta-analysis found that Sesame Street programming had a positive impact on children's academic outcomes (e.g., reading, math, vocabulary) in 24 studies conducted across 15 countries, including studies conducted with students from low-income households (Mares and Pan 2013). However, relative to other, more interactive technological efforts to increase access to early education, surprisingly little research has been done to determine how best to reach children from underserved backgrounds in the early stages of development. Although there is evidence to support a rise in the use of computers and other devices in early childhood education, this rise parallels a rise in the digital divide, which includes growing inequality of access to broadband internet networks, an "app gap" and inequality of eligibility for e-rate discounts for internet service. For example, many pre-K public programs such as Head Start do not receive e-rate discounts (Guernsey 2012). This lack of scholarship on educational technology and early childhood education indicates an area in need of research on how technological innovation might help to overcome this early learning gap.

Access to Higher Education

Relative to higher education, low-income and minority secondary students have unequal access to institutions of higher education. Reasons for this include, but are not limited to, the rising cost of higher education and inequality of access to the kinds of high-level, college-preparatory coursework (e.g., advanced placement courses) and appropriate course sequencing (Weis et al. 2015). Even when underserved students do enroll, many experience difficulties that lead to decreased rates of retention and completion (Ishitani 2006). To date, initiatives such as academic advising, mentorship programs, financial aid advisement, and peer social programs have been shown to positively support first generation college students (Campbell and Campbell 1997, 2007; Dworsky and Pérez 2010/2; Y. K. Kim and Sax 2009; Nora and Crisp 2007; Unrau, Font, and Rawls 2012).

Differential access to "college-knowledge," which includes "information and skills that allow students to successfully navigate the complex college admissions and financial aid processes, as well as develop an understanding of college norms and culture" (Roderick, Nagaoka, and Coca 2009), is also a critical point of concern for underrepresented students and has become an increasingly important element in a digital age. In one study, Wohn and colleagues (2013) conducted research on high school students in the United States to determine the extent to which various types of social capital, including social media, related to students' confidence surrounding the college application process and their expectations relative to college success. The authors found that first-generation students (those whose parents did not graduate from college) who had access to and used social media to fill gaps in college knowledge increased their application efficacy and expectations for college success. Currently, many secondary schools block students' access to Facebook, where many participants were able to locate help and information. However, given evidence of the contemporary digital divide, these findings only underscore the need for educational technology to address issues of equal access to educational institutions. In a similar study, Brown, Wohn, and Ellison (2016) interviewed low-income and high-income prospective college students. Importantly, the authors found that low-income students were able to access a great deal of information about colleges online; however, the same students had difficulty interpreting and applying that knowledge. The authors discussed the need for educational technology to design resources that support informal learning about college access. Despite the availability of the information, the unanticipated results highlighted important differences in how learners from various background find and applied information in meaningful ways. Similarly, large scale correlation research by Zhang (2015) found that students employ internet access in different ways and cautioned that the "Internet may widen, rather than narrow, the achievement gaps between White and Black students, White and Hispanic students, and students with high and low socioeconomic status" (p. 221). Therefore, these gaps in access to college knowledge might increase as we continue to develop resources that are not designed for broad understanding or account for demographic backgrounds.

Online learning is another that area has been often discussed as a technology that would support educational access to educational institutions for underserved populations. Specifically, it was believed that limiting the constraints of space and time would open opportunities to a wider variety of students, such as those who are unable to travel to campus or those who work during traditional schooling hours (Bonk 2011). While research has shown benefits for collaborative learning in online settings, additional research shows that online learning is one technology that might engender inadvertent consequences on social inequality for marginalized populations. For instance, Ke and Kwak (2013) found that minority students perceived less social presence in online learning compared with their non-minority peers. Although students had opportunities for access, African American students cited feelings of timidity in online settings as the mode of communication shifted from oral to written communication, which may have contributed to the sense of limited social presence (Du, Ge, and Xu 2015). The authors further questioned "to what extent the previous findings [of online learning] is applicable to students from diverse cultural backgrounds, particularly African American female students" (p. 159). That is, they questioned how representative the effects of online learning are and their role in social inequality. Additional research suggests these online challenges may also exacerbate the gap of minority students in disciplines such as science, technology, engineering, and mathematics (Wladis, Hachey, and Conway 2015).

Amidst a great deal of hype, massive open online courses (MOOCs) have been advanced as a another mechanism to increase educational institutional access to some of the world's most selective and highly ranked universities, without the typical barriers associated with formal learning in higher education. However, recent studies show that the large majority of MOOC participants are already educated and employed (Christensen et al. 2014; Dillahunt, Wang, and Teasley 2014). In a review of the research, Spector (2014) suggested MOOCs fail to properly implement learning objectives and activities within the course. He thus argued that: "MOOCs should not be considered courses in the ordinary use of that term or according to the usage described in the hierarchy previously elaborated." (p. 389). Collectively, this suggests that those in need of access to quality higher education the most are not benefitting from the free and open nature of MOOCs. While Moe (2016) highlights how MOOCs have helped raise awareness about open resources, the empirical research suggests that MOOCs are not increasing access to postsecondary institutions and knowledge for underserved populations. As MOOCs continue to preserve preserve benefits for those

who are already educationally advantaged, they also present the unintended consequences of reproducing of the structure of inequality (Stich and Reeves, Massive open online courses and underserved students in the United States, under review).

Inequality of Access to Educational Opportunities

In this section, we focus specifically on inequality of access to educational opportunities, namely opportunities to learn. We address how educational technology has sought to address these inequities, both with positive and negative consequences.

Rigorous empirical work affirms that teachers are the most important in-school factor relative to student achievement (Darling-Hammond and Youngs 2002; Nye, Konstantopoulos, and Hedges 2004), and are thus crucial in the provision of high-quality learning opportunities to students. However, well-qualified teachers are also distributed inequitably throughout the U.S. education system. Evidence suggests that the least qualified (e.g., least experienced, field-uncertified) teachers are more likely to serve in schools with the largest shares of socioeconomically disadvantaged, minority students, and/or students in rural areas (Boyd et al. 2011; Lankford, Loeb, and Wyckoff 2002). Multiple studies have also shown that low-income and underperforming schools experience disproportionately higher rates of teacher attrition (Adamson and Darling-Hammond 2012; Borman and Dowling 2008; Boyd et al. 2011), which creates further equity problems. The consequences of these realities are great for students learning in schools with high percentages of inexperienced, undercredentialed, and ineffective teachers. These challenges collectively undermine the capacity of the education system to provide *all* students with sufficient and high-quality in-school opportunities to learn.

Many consider teacher professional development (PD) to be a key lever by which to tackle these problems (Polly and Hannafin 2011; Wei, Darling-Hammond, and Adamson 2010). While there has been some progress in delivering high-quality PD opportunities, the literature suggests that such opportunities are themselves distributed inequitably (Desimone, Smith, and Ueno 2006; Wei et al. 2010). For example, Wei et al. (2010) reported less PD opportunities among U.S. mathematics teachers in rural schools and schools with large shares of disadvantaged students. PD around working with growing populations of English language learners might be especially critical in new immigrant destinations (Lowenhaupt and Reeves 2015). Related research suggests that when PD is not present in underserved areas, teachers are less likely to integrate technology successfully or overcome initial problems (Anthony and Clark 2011; Clark and Gorski 2002; Mouza and Barrett-Greenly 2015). That is, despite having access to technology, an unintended variable of an integration is the lack of available training needed to make the implementation successful for teachers that need it the most. Without PD that introduces the technology and how to implement the requisite instructional strategies needed to be successful, implementations efforts of learning technologies may inadvertently widen gaps. While technology is often discussed as an empowering educational resource, unequal access to quality PD results in failed implementations and wasted resources in already struggling districts when not properly supported. Therefore, limited training, coupled with the rapid growth of technology, effectively only worsens the inequality problem.

There are several barriers to teachers' obtainment of high-quality PD of learning technologies that may factor into increasing socioeconomic gaps. Traditional PD necessitates the considerable investment of resources by school districts (Killeen, Monk, and Plecki 2002). In addition, the expertise required to provide efficacious in-service training might not even exist locally (Dede, Ketelhut, Whitehouse, Breit, and McCloskey 2008). Consequently, online professional development (OPD) has proliferated as an educational technology that can eliminate various barriers to high-quality PD. For example, using an online rather than face-to-face communication mode removes geographic barriers, making it a viable option to support improvement of teacher quality broadly, particularly for isolated teachers in rural or high-needs areas. Some further argue that using technology to foster teacher learning can help reduce turnover by providing teachers with the ongoing professional support they need (Zucker 2008). There is experimental evidence for the impact of OPD (O'Dwyer et al. 2010), in general, as well as some evidence for differential impact favoring uncertified teachers (To. Reeves and Pedulla 2013). Once again, further research has yet to show how this technology has targeted teachers in underserved areas and their unique needs.

An additional challenge is that students —those that serve a predominantly low-income, minority population—also lack access to high-quality curricular opportunities. Classic studies in the sociology of education have indicated significant curricular differences by social class and race, both between schools and within schools (Anyon 1981; Rist 1970). Concerns regarding access to differentiated knowledge within and between schools, independent of students' achievement or ability, remains a persistent issue for achievement and attainment gaps between minority and low-income students and their higher-income peers. For example,"richer districts typically provide extensive music and art programs, project-based science, and elaborate technology supports, while poor districts often have none of these and often offer stripped down drill-and-practice approaches to reading and math rather than teaching for higher-order applications" (Darling-Hammond 2013, p. 90).

To date, several studies have applied computer-based technologies to address underserved students' opportunities to learn and achievement. Suppes, Liang, Macken, and Flickinger (2014) implemented computer-based online Math and Language Arts courses with socioeconomically disadvantaged elementary and middle school students, and found that course participation was associated with performance on state test scores. Similarly, Freeman (2012) examined the impact of a digital mathematics intervention on Hispanic students in Colorado, concluding effects on users' mathematics ability and self-efficacy. These studies, in which technology-infused interventions were targeted at underserved students, indicate promise in using educational technologies to address educational achievement equity issues.

Other studies, however, provide evidence of possible differential effects of digital technologies on student subpopulations defined by socioeconomic status and race/ethnicity. Korat and Shamir (2008) investigated the use of an e-book with Israeli Kindergarten students and found that low-income students' emergent literacy improved more with e-book use than that of the middle socioeconomic-status group. On the other hand, Prinsen, Volman, Terwel, and van den Eeden (2009) examined the impact of a computer-supported collaborative learning intervention with primary school students on students' participation, and found that students from minority backgrounds benefitted less than their non-minority counterparts. Once again, these findings suggest that educational technologies can potentially serve to either close *or widen* extant gaps.

Even when students do have access to technology, the design of these tools may elicit unintended consequences due to differences in existing supports for technology use, prior knowledge, and how the technology is designed. While the reasons that educational technology may widen gaps are presumably various, studies suggest that one reason may be student differences in their level of access to knowledge or skills in using required technology (Kim et al. 2010; Ritzhaupt, Liu, Dawson, and Barron 2013). For instance, in a comparison of educational technology integration, Kim et al. (2010) found that students in the higher SES schools benefited more from mobile technology when compared with their lower SES counterparts. There may be various reasons for this, including proficiency in the language of the software, ability to interpret output, or understanding of how to apply the technology to increase learning. Similar studies by Claro and colleagues (2015) cautioned that problem-solving is more demanding within digital learning environment, which is problematic given that we know that those in lower SES students have less access to technology and potentially less proficient with digital tools (Volman, van Eck, Heemskerk, and Kuiper 2005). In terms of design, additional research has shown complicated results in technology integrations aimed at improving curricular opportunities for students. Gyabak and Godina (2011) explored the use of a digital storytelling tool to bridge the gap between various socioeconomic tiers. While the goal was to overcome the gap, an unintended consequence was that ELL students were less likely to benefit from the technology. Instead, students who were already more advanced in a second language (English) were more likely to be selected to lead student learning and thus garner benefits from the technology. They concluded that this phenomenon was problematic because it "marginalized and disempowered those students who spoke limited English (p. 2239)". They further argued the smaller group of advanced students were more likely to learn from these opportunities because of the confidence in their prior knowledge.

Concluding Thoughts

The field of educational technology has often focused on topics related to learning theory, development, and implementation. However, school systems are marked by important inequalities of access to institutions and opportunities to learn. To date, less attention has focused on the intersection of educational technology and equity, and the role of educational technology in mitigating existing educational inequalities. And while the discourse on the benefits of technology to curb inequality is laudable, technology-infused interventions may also have differential effects favoring already advantaged groups and serve to widen outcome gaps (Ceci and Papierno 2005). Further attention is needed to better understand the consequences of educational technology, both those intended and unintended, on equity among underserved students within the U.S.

As technology becomes more pervasive, it becomes more accessible to a wider audience, with varying degrees of impact to different demographics. Our review of the literature provides examples of research in which both gaps were addressed and compounded with technology. Specifically, we review prominent issues that focus on inequality of access and inequality of outcomes. In terms of the former, we discuss emerging unanticipated results of technology as they relate to the emerging app gap, access to college information, application of digital resources, and online learning. We also highlight the need for additional research which investigates the role of educational technology and early education. When discussing inequality of access, we highlight research that focuses on unequal access to professional development, technology supported instructional strategies, and how nuances in interface design might produce unanticipated consequences. Each represent areas where technology might widen rather than limit social inequality if not addressed.

While learning technologies may not be the root cause of some of the issues, nor are they a panacea, we argue the field should more explicitly consider the consequences of educational

technology on inequality during the design and development of these tools. In addition, advances in online formats (Reeves and Bonk 2015) and mobile technology (Mouza and Barrett-Greenly 2015) provide new mediums to a wider, more diverse set of learners (Bonk 2011). In addition, this may play especially important roles in countries where social mobility is heavily influenced by the realities of high stakes testing. Moreover, we suggest that researchers and practitioners consider that educational technologies should balance the broader importance of inequality of access and opportunity within the scope of research. If those at the forefront of learning technology innovation consider the broader social context during the design and development of future innovations, the field might be able to obviate potential negative consequences of educational technology and instead be part of the solution towards a more equitable model of education.

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