Assessing EdTech's Viability and Impact on Educational Equity

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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I. Introduction: The State of Education Now

The U.S. consistently ranks number 1 in GDP by country and is reported as the 5th highest spending per enrolled elementary to secondary student in the world (National Center for Education Statistics, 2022). Yet, large disparities in relation to socioeconomic circumstances continue to widen educational gaps in the country. Jonathan Kozol, an educator and prominent progressive activist for public education pushed for attention on this issue, "Unless we have the wealth to pay for private education, we are compelled by law to go to public school—and to the public school in our district. Thus the state, by requiring attendance but refusing to require equity, effectively requires inequality. Compulsory inequity, perpetuated by state law, too frequently condemns our children to unequal lives" (Kozol, 1991). Although this statement was uttered nearly four decades ago, the legacy legislation that determines distribution of federal education funds continues to remain unchanged, further exacerbated by current President Trump's call to cut funding through an executive order 14242 (Exec. Order No. 14242, 2025) by dismantling the Department of Education. Approximately 45% of schools have been affected by teacher shortages largely due to reduced funding of school programs in recent years (Delarosa, 2023). Limitations of funding can have a large impact on the quality, personalization, and efficacy of lesson plans designed to enable those who are struggling academically, or gifted students.

Beyond regulatory and funding decisions, deeply rooted issues exist in the current educational sector. For example, the issue of teacher shortages that have been prevalent. In the most recent Census Report, 95% of households reported having computers and 90% reported having broadband internet connection in their homes. However, the educational gap was

exacerbated during the COVID-19 pandemic of 2020 when learning was moved online (Census Bureau, 2024). This implies that digital learning issues lie beyond surface level connectivity issues, but deeper in the design and content of the lessons shared.

The Nation's Report Card shows a concerning lack of improvement in the academic achievement gaps of students over the course of 10 years, as shown below in Figure 1.

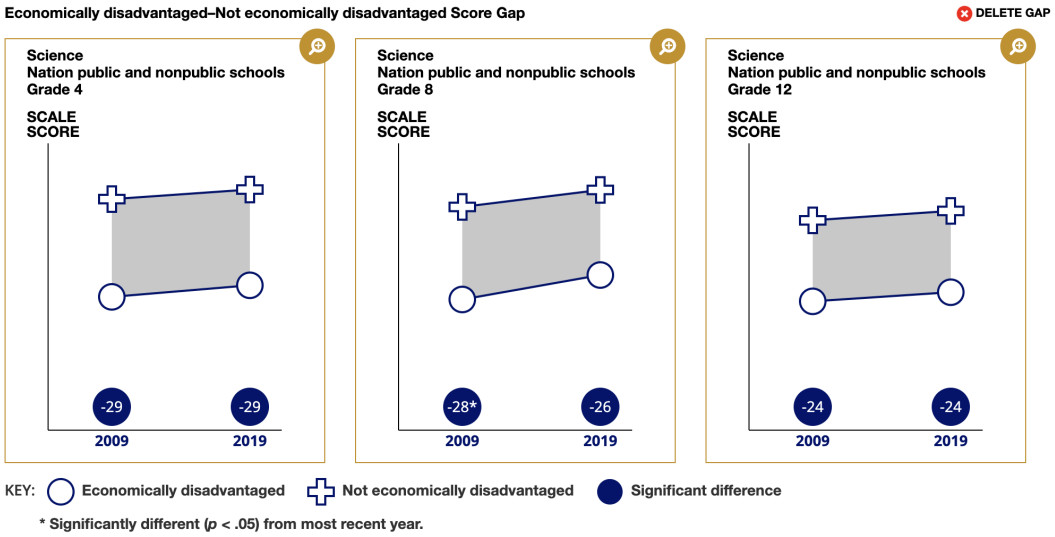

Figure 1: Achievement Gap based on economic disadvantages from 2009 to 2019 from The Nation's Report Card (NAEP, 2019)

The Covid-19 pandemic forced education systems online, bringing an influx of innovation in educational technology (edtech) to comply with distance learning requirements (Gopika, 2023). Broadly defined, edtech encompasses any technological tool to support learning. This may involve the analysis of student data to generate reports or a method of instruction delivery such as publically accessible educational videos. Although this greatly increased the number of edtech products available for educators to use, evidence of these tools' ability to solve

engrained issues in education should be analyzed. This paper reviews historical and popular edtech tools to determine whether the introduction of edtech tools has alleviated persistent issues or simply delivered them through a new medium.

II. Problem Definition

Education Funding

Roughly 40% of funding for public education is derived from local government property taxes, resulting in staggering differences in education spending by district. For example, within Virginia, there was a $10,848 difference in spending on instruction per student between districts Arlington and Radford (VPAP, 2024). Such disparities can become more pronounced in light of recent legislative changes. Namely, the recent signing of executive order 14242 (Exec. Order No. 14242, 2025) possibility widening this gap by calling for the dismantling of the Department of Education.

Rizvi, an education researcher at the University of Melbourne, observes growing federal support of minimizing financial support for education that these choices were inevitable, “Given the rapid rise in demand for education around the world, […] an educational system that is funded exclusively through the public purse is no longer a realistic option”. He cites neoliberal ideology beliefs as the reason to support these legislative decisions: “Privatization will inevitably improve the productivity of government agencies through the power of private property rights, market pressures and competition, and by giving back to people ‘more for their own money’”. Neoliberal ideology views educators and students as investors and consumers, using their local property evaluation as a metric of probable success in return. Educational resources are also viewed as finite materials reserved for increasing production of capital (Rizvi, 2016).

While trends to reduce government support and oversight of education are often motivated by a desire to encourage internal competition and increase district-level freedom, Hryhorash (2022) finds diminishing financial support harms not just education quality, but also the very competitiveness suh policies aim to promote. In their analysis, Hryhorash (2022) grouped countries based on social wellness, economic context, and levels of education funding, using indicators such as the Human Development Index (HDI) and the Global Competitiveness Index (GCI) and data on higher education expenditures and the quality from Universitas 21 (U21), an international network of research-focused universities. Through correlation-regression analysis, a common statistical analysis method used to measure the strength and direction between variables, Hryhorash (2022) found a "significant direct correlation between the amount of higher education expenditures per student and the competitiveness of higher education in OECD countries… and the human development index, as well as the global competitiveness index". The correlation between education spending and human development index supports the argument that education is a tool for social mobility. Students enrolled in higher quality classrooms earn about $320,000 more in their lifetimes (Friedman, 2022). Therefore poorer districts are financially handicapped, preventing opportunities to improve their academic infrastructures and offer opportunities for students to achieve upwards mobility. Furthermore, inadequate funding has negatively affected staffing within the education sector. While the pandemic has certainly exacerbated staffing issues and teacher morale, trends in understaffing have existed prior to the pandemic as shown in the graph of teaching job openings and hiring rates over 20 years (NCES, 2023).

Persistent funding issues have resulted in traditionally low teaching salaries, only increasing $29 in the last 28 years consequently, the educational sector suffers from many long

standing internal issues including staff shortage. A 2023 USA Today survey found that 86% of public schools were struggling to adequately fill teaching positions, with high-poverty districts continuing to have 57% of schools report understaffing (Schermele, 2023). This issue is further exacerbated when more than a third of current educators express plans to leave the education sector in the next two years (Kurtz, 2024).

During the pandemic, when distance learning was enforced, national reading and math score averages saw the largest performance drop in 30 years (NCES, 2022).

Programs like The Metropolitan Council for Education Opportunity (METCO) in Massachusetts aim to overcome education segregation with physical relocation through a lottery program that shuttles students from poorer neighborhoods to more affluent school systems. Since its start in 1966, it has been shown to successfully alleviate the issues tied to school segregation related academic gaps. Life changing differences, like a 75% drop in drop out rate, 21% 4-year college enrollment increase, and most importantly a $16,250 average earning increase, shows how students can and have utilized desegregation programs to use education as a tool for class mobility (Setren, 2024). As for a nation wide solution, scaling a lottery shuttle solution is not feasible, especially in more rural locations. Moreover, shuttle systems divert funding and efforts to improve educational equality towards private, wealthy school systems rather than low income district schools.

Technology: Personalized Instruction and Connectivity

Though many students and teachers struggled to adapt to distance learning teaching styles, there were two main factors that set the lowest and highest quartiles apart. The National Center for Education Statistics found that the best performing students had reliable access to a

device with high speed internet and individual academic assistance from an educator (NCES, 2022). The benefit of integrating technology for educational uses has been recognized early on by the early 2000s rapid development of education technology (edtech). MOOCs (Massive Open Online Courses) like Coursera opened access to complete, high quality courses, with cases like Khan Academy and independent youtubers offering course lessons completely free of charge. Alternatively, edtech products designed to help educators manage large classes or learning management systems (LMS) were developed as a supplemental tool rather than one to replace interpersonal instruction.

The digitization of the education sector has gained elevated attention with new surges of innovations due to integration with AI and growing demands from worsening teacher-to-student ratio. One notable innovation of OERs from the increases in computing power are the rising of diagnostic educational tools. For example, IXL, an open source program designed to aid young students in learning basic and advanced mathematics skills, facilitates in class lectures with the real time diagnostics of every student's weak areas in assigned math exercises (IXL, 2021). This allows instructors to adjust lesson plans and assignments to pinpoint skills that students need the most help with. This can be especially helpful in classes with a disproportionate ratio of teachers to students. Dancsa asserts that online tools can help extend access to course content available at any time with an internet connection and a compatible end device. This can provide data to give educators further insight into a student's performance with extra practice through LMS, or students the opportunity to correct or deepen their understanding with course material though Youtube and/or digital libraries (Dancsa et al., 2023).

Thanks to a series of federal grants, the vast majority of public schools – 94 percent – have reported in a 2022 survey that they were able to supply laptops or tablets to students who

needed a device. Though internet connectivity, especially in rural areas continues to be an issue with roughly half of students reporting to have reliable internet access either at home or a public space outside of school (Kuykendall, 2022).

III. Research Approach

To identify what qualities make OERs an effective tool for students, historical analyses of popular OERs will be completed. In order to examine the educational sector holistically through the lens of education equality, Latour's (1996) Actor Network Theory (ANT) will be used to analyze the interactions between educators, students, guardians, and legislative stakeholders.

Within the Actor Network Theory, the social world is viewed as a dynamic network of "actants" or human and non-human entities connected through the relationships between them. Non-human actors such as AI algorithms and public opinion hold equal value within the network. As a semiotic method, each entity or actor gains meaning and importance through interactions with other actors. For example, edtech products are defined by how educators, students and its impact on internet connectivity standards. Latour claims that nothing exists outside of these interactions, therefore as relationships between actants change, the network and its associated social dynamics consequently change along with it.

The Frankfurt School of Critical Theory will be used to analyze the interactions of technology and education in the scope of class mobility. The Frankfurt Critical Theory is a framework that aims to criticize ideologies and objects of power, namely technology, in a capitalistic economy with the goal of social emancipation. Critical theory asserts that educational content and implementation must be challenged to ensure that it does not comply with oppressive system, "By embracing the power of student, educator, and researcher agency within an

oppressive American school system, critical pedagogy grounds social justice education using tools of critique that question how knowledge is produced, controlled, and disseminated". Technological rationality, an idea also postulated by the Frankfurt school, is a concept that views technology as a dominant forebringer of efficiency, standardization, and the loss of critical thinking. To examine the integration of technology into education, both Frankfurt School theories will be applied to assess edtech's ability to be used as a tool for social mobility or an extension of an oppressive system (Ryoo & Crawford, 2023).

Viewing the issue of segregation in education centered around the introduction of educational technology in public education systems, an additional step of categorization must be made when identifying actors. The additional categories consist of the public school sector, political sector, tech sector and social dynamics. To accurately assess edtech as an instrument for improving social mobility, interactions between the education, political and tech sphere are required as a part of the discussion as illustrated in Figure 2.

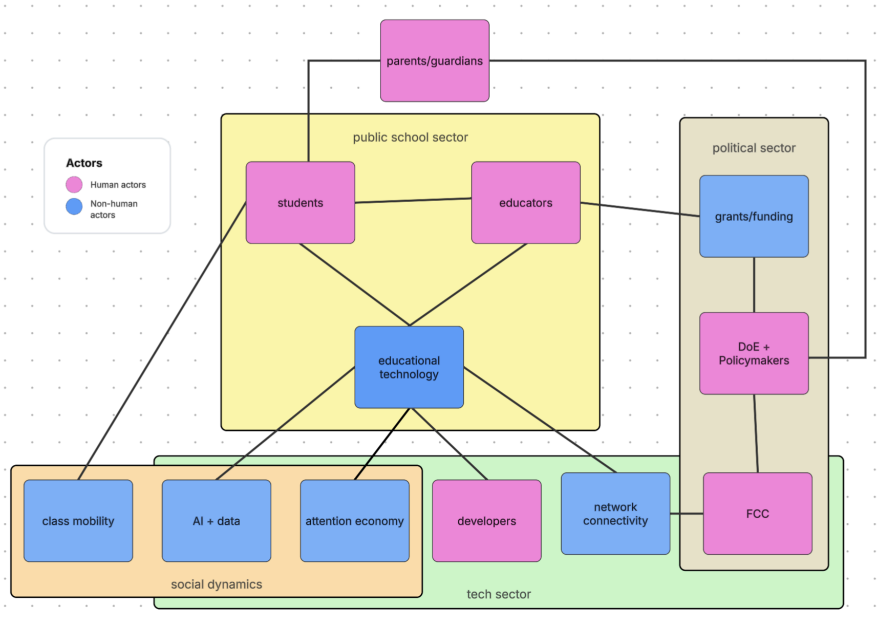

Figure 2: Diagram of the Actor Network Theory on Educational Technology created by the author

IV. Results

Building on the identification of key actors through the Actor Network Theory, it is revealed the issue of designing truly effective edtech tools for equalizing education stretches far beyond educators. Following a Frankfurtian critical analysis of the current educational system reveals the need for a deep reconstruction for how education content is developed. In order to subvert existing oppressive systems that seek to remove critical thinking among students, the following section outlines essential steps required to create a system that fosters the development of edtech aimed at equalizing academic opportunities.

Actors and Money Flow

Although the added computing power behind edtech tools implies that simply having access to online educational technology improves academic performance through personalized education, the issue is not as simple as expanding broadband network coverage. In addition to allocating efforts to improve infrastructure, proper training on the usage of the provided devices are necessary to fully leverage the benefits of digital educational tools. Specifically in a study on high school students in Cape Coast Metropolis, Ghana, Amponsah found that educators could best leverage internet usage to improve student's academic performance through search engine training and social media usage supervision (Amponsah et al., 2022).

Frankfurtian critical theory also raises concerns related to the recent development of attention economics, where human attention is a scarce and profitable resource, often most heavily applied in social media where algorithms are developed solely to vye for the users

attention. In edtech, it can be seen where hyper attention is being substituted for deep attention (a requirement for in-depth understanding). This can be seen in Duolingo, a gamified language learning app where lessons can be completed within a few minutes anywhere on a mobile device. Users can easily take on as many of Duolingo's selection of forty different languages and the ability to switch between languages instantly. While studies have shown Duolingo can help users with no prior foundational knowledge improve to express simple ideas, it is often achieved through longer duration interactions through a language forum that is not as visually accessible (Shortt, 2021). Furthermore, Duolingo's scope of user data collection was exposed in data leak to include the most number of data points compared to other language learning apps. A total of nineteen data points were identified, namely photos/videos, advertising data, name, phone number, search history, contacts, and payment info revealing the added security risks and user surveillance when using edtech apps (SurfShark, 2023). Current legislation on data collection and development usage is severely lagging, calling into question whether edtech tools should fulfill standardized security rules before being officially integrated into public school curriculum. Through the Frankfurtian critical theory, no digital application exists without participation in the attention economy (Lewin, 2016). To ensure both the effectiveness and safe use of edtech products, the introduction of devices into schools and homes will require the combined efforts of both educators and parents to teach students informed, responsible use of edtech products.

The Department of Education and its parent entities are relevant for securing funding and enforcing regulation for how school systems integrate their technologies into the existing curriculum. Currently, the Schools and Libraries Program of the Universal Service Fund, or the E-Rate Program established under the 1999 Telecommunications Act provides funding for internet access and any telecommunications services used by public academic infrastructures.

Through this, 95% of public schools were able to provide digital devices for their students (Delarosa, 2023). This ensures that any technological solutions available through broadband connection are accessible for students. More recently the general responsibility to provide reliable internet connection, especially to rural areas falls under the Federal Communications Commission. Through the Connect America Fund, the FCC has provided, "23 million Americans who lack access to infrastructure capable of providing 10/1 Mbps fixed broadband" (FCC, 2013).

Key Challenges with Online Educational Resources

Along with the introduction of supplemental online educational tools came emerging concerns in relation to the effectiveness and socialization in students. Following distance learning during the Covid-19 era, prolonged exposure to digital instruction, behavioral issues such as difficulty in integrating in new social situations deteriorated long after returning to brick and mortar instruction . Students continued to feel disconnected from their community including "extensive decreases in social well-being, and a significant portion of the students failed to rebound to their pre-COVID level by 2022: In 2019, 45% of survey respondents said that they contributed to society daily or more often, compared to 31% who reported this sentiment in 2022" (Furlong et al, 2024). This highlights the interpersonal relationship within the school sector (with both student peers and educators) as vital to the welfare and development of social skills in students. The integration of online open source educational tools should therefore never replace human educators, nor be considered as a stand alone option for students in low educational spending areas.

Corey Boone, the founder of Just Math Tutoring Company, experiencing both teaching in a fully virtual and in-person environment highlights the complexity of education equality beyond

technical resources, “The problem with underfunded schools is not just the access to top notch tools, it is the mindset and the experience of the teachers and environment. If you can take a good passionate teacher and place her in a classroom of mediocre students, they will thrive, online tools can't replicate that. I think that is equity in education”. Boone asserts that the creation of an equal education system can never be complete without the presence of a high quality educator. Edtech in the public school sector in the lens of equality can only be viewed as an extension of a teacher’s lesson. The impact of edtech products is contingent on the ability of educators to motivate students and an environment that fosters open discussion and collaboration between students.

Due to the nature of online educational tools largely individualized to offer personalized learning opportunities, the depth of students' understanding can easily be overlooked. Under a critical theory lens, educational technology tends to prioritize efficiency and standardization through its usage of numerical scoring to track student performance. For example, IXL’s SmartScore automatically adjusts scoring to a students’ answer pattern and the problem’s difficulty rating as a part of their custom 4-part framework consisting of curriculum content, diagnostics, analytics, and guidance. With three of the four parts tailored towards helping educators personalize their lesson plans based on diagnostic reports on what areas students struggled with most (IXL, 2022). While this may assist educators by managing larger class sizes in high student to teacher ratio settings, this also reduces students to agents of memorization rather than creation and critique (Yudi, 2023). Placing false prioritization of standardized scoring can create a false sense of learning or academic performance improvement, removing an educator's close connection to students to ensure they have an in-depth understanding of the material and the students from asking further questions.

MIND Research, the research facility behind the ST Math, a pioneering gamified educational tool has defined the balance of in-person and digital instruction. Blended learning, a combination of online and face-to-face lessons, can maximize the benefits of interpersonal feedback from educators and aggregated diagnostics from software solutions. Using a blended learning framework when designing OERs, open source educational tools, is most beneficial for balancing the computational analysis power of AI to provide feedback to a large class with the social needs of students. Using Bloom's taxonomy to evaluate the effectiveness of educational technology tools, proof of highest-order thinking skills can be exemplified through creating new and original work from understanding of course content as shown in Figure 3.

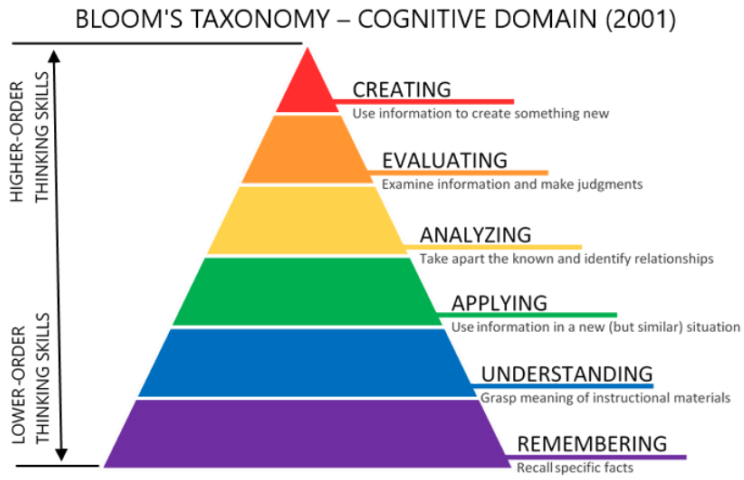

Figure 3: Bloom's Taxonomy from the University of Florida's Center for Instructional Technology and Training. (University of Florida, 2023)

The ECPA learning path was also developed to promote creational level understanding within a blended learning environment. Included is a four part lesson plan in chronological order: Experience, Connect, Practice, Apply. The first phase of experience is entirely dedicated to a

student's individual exploration of a new math topic through a math game lesson, devoid of textual instructions to encourage self-directed conceptual learning through trial and error. In-person classroom interactions resume in the connection phase for students to receive verbal explanations of the topic along with repetitive practice, before applying them to new general problems (Nisbet et al., 2014). As students experiment with different solutions in ST Math's instructionless math games introduces the concept of formulating new hypotheses and implementation of a solution, which satisfies Bloom's taxonomy's highest-order thinking skill.

Although students are the most direct users of edtech products, ultimately parents hold greater legislative influence in education funding policy decisions. In order to enact changes that will result in significant change for students in under-resourced school districts, public consensus on the importance of edtech must change.

V. Conclusion

Bridging the socioeconomic gap in education is highly complex, rooted in federal funding issues and connectivity related limitations. Introducing digital solutions into the classroom can mitigate learning latency by improving personalization of lessons, but it also raises concerns among parents. These concerns are primarily related to social connection retention and data storage privacy. To design an open source online educational tool to be an accessible means for all educators and students to benefit from high quality personalized education requires a push from students and parents to improve federal funding allocation policies. Considering the results from a critical theory analysis of popular edtech products, the most effective features of positively received tools are in blended learning themed designs with a focus on creationary understanding of course material. This ensures a balance on both the

educator and student's needs to ensure that the student's social needs are not ignored and that the teacher shortage can not be favorably argued in support of replacive OERs. A network consisting of students, educators, federal entities, developers and parents was constructed to accurately analyze the impact of edtech with the goal of equalizing education. Through the historical discourse of segregative legislation in education to a system analysis of successful modern tools, a solution to equalize education requires the cooperation of all actors within the network.

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