The University of Chicago

Education Technology in Chicago

Highlighting the Values of Access and Implementation as Crucial to Technological Efficacy Within Chicago High School Education

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Introduction & Background

In the past decades, education has advanced significantly in not only its scope of resources to teach, but also in its ability to leverage and distribute those resources. The days of immediately entering a trade out of high-school are largely gone; and with the increasing availability of higher education brought in from various economic channels, college attendance following high-school graduation has risen from 47% in 1965[1] to almost 70% in 2018[2]. In modern high school education this funnel has necessitated a certain level of standardisation: the SAT in the U.S., the GCSE in the UK, the CBSE in India, and the International Baccalaureate internationally are just some of many examples. Although this may not be the ideal measurement of a student's abilities, it is the result of decades of refinement. It is also the most accurate quantitative measure of the combination of a student's natural abilities, interest in a subject, and work ethic – something very important, yet made much more difficult through abstract or qualitative measures.

As Western economies have advanced and transitioned, postsecondary education has become a pre-requisite for a large number of jobs – the Georgetown public Policy Institute projected 65% of jobs created by 2020 would require postsecondary qualifications[3], which has proven roughly accurate. As this system has been established, so has the standardisation through which students embark on their academic journeys. In the U.K., students take generally between five and twelve GCSE exams at the age of sixteen following a two-year period of study – this number can go higher or lower depending on the proficiency of each student. Following this, a majority of students will spend another two years studying between two and four A-Levels, and use their predicted final grades halfway through to send off their university applications. Usually, some number of these universities hand out offers conditional on achievement of final A-Level grades.

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[1] Current Population Reports, Factors Related to High School Graduation and College Attendance, 1967, Census Bureau. Accessed 2 Nov 2021.
[2] Hanson, Melanie. "College Enrollment & Student Demographic Statistics" EducationData.org, August 7, 2021, https://educationdata.org/college-enrollment-statistics
[3] Carnevale, A., Smith, N., Strohl, J., Recovery: Job Growth and Education Requirements Through 2020, 2020, Georgetown Public Policy Institute.

The COVID-19 pandemic has redirected the field of education in many ways, serving not only as a catalyst for innovation in methods to integrate technology into education, but also to provide bolstering for what already exists. Lalilo, a learning platform that uses AI to provide reading training for children, multiplied its users by six between June 2020 and January 2020. Open Digital Education, a French schooling social network recorded an all-time high of six million daily active users in April. And Labster, a virtual-reality science platform nearly doubled its clients between January and June[4]. This crisis has precipitated real change, and although the above examples are only a fraction of the bigger picture, there is little doubt that this trend will carry – especially as remote and flipped learning have been important components of this educational paradigm shift.

This has catalysed the attention brought towards education technology and the use of mobile phones and laptops which – within the technological space – are increasingly common accessories for an increasingly young demographic; and students who own phones and laptops bring them to school. Furthermore, these technologies almost all have smart capabilities: in-school learning is connected through apps and email messaging is almost always necessary in the modern classroom. These apps have a range of functions such as monitoring homework, tracking grades, organising data, providing extra- curricular support and providing a student-teacher medium. These new technologies, which have advanced so rapidly over the past decade (and half-decade) bring to light to an important question: *How can students use their technology, with increasingly advanced technological capabilities, to enhance their in-lesson learning and ultimately improve their grades?*

For my research, this is the question I will explore, aiming to fill a gap in the current research on education technology. As the world becomes increasingly enveloped by technology, mobile learning methods (including mobile phones and mobile laptops) are first to crack open this education-technology integration. I will attempt to qualitatively assess the impacts of technology on

[4] Educapital, Covid19: The New Mover and Shaker of the Edtech Market, 2020. Accessed 2 Nov 2021.

educational success in school classrooms within the Chicago region focusing on *access* and *implementation*.

The prevailing research has focused on the positive and negative impacts of education technology in a variety of contexts. These analyses range from success in improved score-attainment on primary school mathematics exams, to increased frequency and length of discussion on undergraduate field trips. It has also focused on establishing a set of principles that combine to provide a set of metrics through which we ought to be able to measure the success of mobile learning. I will therefore begin by discussing the current state of the literature on education-technology in a literature review.

In my findings I will first focus on the discussion of recent historical development of education technology. Here, I delve into interviewees' opinions on how education technology has changed over the past year, and I paint a picture of the current areas that education technology has lodged itself within the education system. I analyse three main aspects. Firstly, this includes how technology is a novel concept within an archaic education system. Secondly, I discuss how technology has been adopted as a method to increase the scope of educational resources. Thirdly, I discuss the ongoing occurrence and necessity of the internalisation of technology and its acceptance as a parallel medium of education to traditional methods. This section provides the framework for the *access*, *implementation* and *future* findings. The increasing scope of resources shows a positive movement towards both the widening of access-provision as well as the propagation of our understanding of education-technology implementation methods.

Secondly, I will focus on understanding the various layers of *access* within education technology. This includes access to the underlying necessary hardware, access to the internet, and access to educational programs using hardware and internet in tandem. Each of these layers have layers within themselves. Hardware is always changing: new models of technology are constantly being released with increased power and different functionalities. One example of this includes the

benefit of Google Chromebooks as providing hardware for many of the educational necessities. On the other hand, Google Chromebooks being browser-based mean they lack many features including downloadable programs such as Microsoft Office. My discussion of internet access looks at not only the number of Chicago students who have access to the internet, but also how this varies within communities and sub-communities. It also discusses the varying quality of internet - for example how different bandwidths are required for different functionalities. Thirdly, I examine the different layers of educational program access. These have the potential to offer the most-widespread educational access to students, however have many downsides such as remaining behind a price-lock.

Thirdly, I focus on implementational successes and failures of these programs, and analyse the difference between what I call *structural* implementation and *psychological* implementation. This is because the data I have collected has outlined firstly the structural delivery of education technology and its restrictions as determined by the *provider* and *in-built* restrictions. Here, I discuss a case study of the success and failure of the iXL and iReady preparation programs within two schools. When discussing *psychological* implementation - which I define as the delivery of education technology and its restrictions as determined by those to whom the it is delivered (the school and the teacher) - I discuss a case study of a program that failed as a result of the interactions teachers *chose* to have with it. This places importance on developing a framework by which teachers can internalise technology *and* apply their teaching skills into its implementation. In this third section, I discuss the direct effects of education-technology on students scores considering *both* my qualitative data, as well as linking my interview findings to quantitative data and existing literature in the field.

Fourthly, I look at what my data ought to mean for the future of education technology. I firstly look at the future of access. My data shows that there are a few key components: education-technology internalisation, resource-broadening and new tailored teaching methods. Education-

technology internalisation is vital for the development of incentives with respect to innovation. It also functions as a base for the broadening of resources: as the education-technology integration continues, more platforms will be produced to support a broader number of students at increasingly low costs. This development of new resources also functions as a catalyst for providing niche solutions to those who may have personal ailments that restrict their ability to access education, such as learning disabilities.

Finally, I discuss potential policy prescriptions. I advise firstly the continuity of access-provision schemes such as *Chicago Connected* to ensure that as many students as possible are able, in the first place, to unlock these resources via increased hardware and internet use. I advise secondly the development of research programs to a) supplement our current understanding of *how many students have access*, b) delve into more detailed access topics such as the access-balance within homes, and c) *understand what works* with respect to implementation on a structural basis of technological functions / features and on a psychological bases of teacher-technology-student interaction. I advise thirdly the creation of incentives for education-technology innovation to drive down development and implementation costs, reduce the risk of government investment, and supplement the existing research and literature surrounding the evolution of our understanding of what works in the classroom.

I have intended for this to be a specific review of the current state of access and implementation in education-technology, consisting of which how education-technology's use in the classroom can tackle a variety of issues: How does education technology help the teacher? How does education technology help the student? How does education technology help the school overall? I have related my qualitative findings to past research to assess what this means for academic achievement amongst students in order to relate my qualitative data to past quantitative results. I have made arguments such as *X program increased engagement according to Y. In Z literature, engagement is proven to increase academic achievement on these metrics*. My

overarching argument is that access and implementation ought to be - in that order - the two *key* considerations when moving forward with education technology policies.

Literature Review

As education-technology as a market is relatively new, it follows that literature discussing education-technology is in its relatively early stages. The key focuses of literature have focused on mobile-learning - which I use as a subset of education-technology, and which is my primary focus in this paper. It is discussed as '*mobile-learning*' because often education-technology is misconstrued as *any* form of technology in the classroom: microscopes, smart boards etc. In my literature review I have discussed *only* what relates to the fundamental principles of *access* and *implementation*. I have first looked at subject-specific content, which provides groundwork for the implementation portion of my findings. This is because different subjects are taught in different ways; math learning, review and examination is totally different to that of the social sciences or languages. Secondly, I have discussed the main principles covered by the literature. This includes access, but also others such as ubiquity and mobility. The literature has clear definitions for each of these terms, however these definitions overlap significantly nonetheless. *Ubiquity*, for example, overlaps with access in the sense that being able to study anywhere, anytime, leads to a wider spread of access. This applies to many of the principles discussed. Therefore, in the upcoming sections I attempt to paint a picture of implementationary design via discussing research into how different education-technology models have fared in a variety of subjects. I then discuss access as a component of the primary education-technology principles.

Impacts of Education Technology on Specific Subject Content

Research into the benefits of education technology has found conclusive results in a variety of subjects, and a breadth of ages and circumstances wherein students' use of mobile devices in different learning environments have exemplified their ability to effectively enhance students' learning knowledge. This includes significant improvements in a variety of subjects:

Science[5]. Among six mixed-ability classes in primary school, the experimental class performed better than the control class as via mobilised lessons allowed students to learn science in personal, deep and engaging ways. Another benefit to the usage of mobile technologies for supporting inquiry learning in- and out-of-class was the development of positive attitudes. This was thanks to, for example, listing ideas and connecting them using the Picomap technology.

Mathematics[6]. By implementing context-based game-based media, second grade elementary school students improved their addition and subtraction units significantly. Through a questionnaire following the study they found positive attitudes from the students and improved interaction with the material when implementing education technology and gamification. Furthermore[7], cloud-based models of learning mathematics allow the student to learn anywhere, any time, and showed positive responses to the provision of social media features and a learning material repository.

Language & Art[8]. A Taiwanese study looking into the benefits of learning English via on-screen video translations found positive improvements in listening comprehension, oral proficiency, reading, and writing following surgery responses. On average, only 2.7% of students preferred traditional learning to education technology.

Social Sciences[9]. A benefit of education technology is through improving the processing and delivery of content. Text summarisation is one important way to increase learner engagement through condensing texts into only their most important ideas. Results found that not only was the technology able to effectively generate summaries, but was also perceived as helpful to support social science inquiry-based education technology.

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[5] Looi, C. K., Zhang, B., Chen, W., Seow, P., Chia, G., Norris, C., & Soloway, E. (2011). 1: 1 mobile inquiry learning experience for primary science students: A Study of learning effectiveness. Journal of Computer Assisted Learning, 27(3), 269-287.
[6] Huang, S. H., Wu, T. T., Chen, H. R., Yang, P. C., & Huang, Y. M. (2012). Mathematics Assisted Instruction System of M/ ULearning Environment. In Wireless, Mobile and Ubiquitous Technology in Education (WMUTE), 2012 IEEE Seventh International Conference on (pp. 301-305). doi:10.1109/WMUTE.2012.72
[7] Mahamad, S., Ibrahim, M. N., & Taib, S. M. (2010). M-learning: A New paradigm of learning mathematics in Malaysia. International Journal of Computer Science and Information Technology, 2(4), 76-86. doi:10.5121/ijcsit.2010.2407
[8] Yu, Y. S., Lin, Y. Y., Huang, Y. L., & Hsieh, W. H. (2013). The Evaluation of use the mobile phone learning English in Taiwan. International Journal of Information and Education Technology, 3(2), 189-191.
[9] Yang, G., Chen, N. S., Sutinen, E., Anderson, T., & Wen, D. (2013). The Effectiveness of automatic text summarization in mobile learning contexts. Computers & Education, 68, 233-243.

Impacts of Education Technology on Learning Contexts

These benefits of education technology are also found within both informal and formal learning contexts – perks of mobile learning include adaptability to new circumstances. This includes an improvement in two-way interactions with peers, increased learning-related discussion[10] and higher motivation leading to improved learning acquisition in museum learning[11], as well as facilitated knowledge in field visits and walking tours via the integration of handphones and blended learning[12].

Furthermore, the implementation of technology within the classroom allows for much greater flexibility in classroom-design that expands beyond the current teaching status quo. education technology can facilitate the gamification of learning, which pairs knowledge acquisition with a game- based medium[13]. It has also shown many benefits in promoting in-class collaboration[14]; Kahoot is a prime example of how technology can be leveraged for such purposes in the classroom, wherein students compete against one another in online quizzes. Similarly, other classroom formats are made available through the employment of digital teaching methods. One example is the flipped classroom: learning is done outside the classroom and consolidation (homework, problem sets, etc) is done within. Such a format has many advantages. Students are able to go through their course at a reasonable pace, are able to spend more time in hands-on activities, and receive more personalised teaching. Teachers gain more insight into not only the current level of their students, but also how they learn. They are also able so re-structure their lessons to customise and update the curriculum to manage their classroom time more effectively. Finally, missing students will be able to attend their classroom remotely – something not possible

[10] Sung, Y. T., Hou, H. T., Liu, C. K., & Chang, K. E. (2010). Mobile guide system using problem−solving strategy for museum learning: a sequential learning behavioural pattern analysis. Journal of computer assisted learning, 26(2), 106-115.
[11] Hou, H. T., Wu, S. Y., Lin, P. C., Sung, Y. T., Lin, J. W., & Chang, K. E. (2014). A Blended mobile learning environment for museum learning. Journal of Educational Technology & Society, 17(2), 207-218.
[12] Menkhoff, T., & Bengtsson, M. L. (2012). Engaging students in higher education through mobile learning: Lessons learnt in a Chinese entrepreneurship course. Educational Research for Policy and Practice, 11(3), 225-242.
[13] Young, M. F., Slota, S., Cutter, A. B., Jalette, G., Mullin, G., Lai, B., Simeoni, Z., Tran, M., & Yukhymenko, M. (2012). Our princess is in another castle a review of trends in serious gaming for education. Review of educational research, 82(1), 61-89.
[14] Echeverría, A., Nussbaum, M., Calderón, J. F., Bravo, C., Infante, C., & Vásquez, A. (2011). Face-to-face collaborative learning supported by mobile phones. Interactive Learning Environments, 19(4), 351-363.

under traditional classroom setups.[15]

The Principles of Education Technology

The existing research has also developed a set of principles that provide definitional support to the concept of education technology. Advancing technology has led to mobile learning gaining significant attention, developing from a minor research interest to significant projects in a variety of settings, drawing on the emphasis of the following principles:

Mobility[16] & Access[17]. Sharples et. al postulate that technology has the ability to – and in some ways has become – a seamless extension of human cognition and memory. Similarly, this technology needn't be provided by the schools, who in fact will save money by allowing students to bring their own technologies into the classroom. Through this fusion of technology and education, and the ever-increasing coverage by mobile network providers, the mobility of technology by extension the mobility of education.

Immediacy[18] & Ubiquity[19]. These principles constitute the ability to check issues concerning studying regardless of place and time are key factors in the potential growth and success of technology in education. Kukulksa et. al describe the provision of ubiquitous access to knowledge for mobile workers and learning citizens through MOBILearn - a European-led development project. They found that young adults found use for MOBILearn as it was an alternative to the education system, and through blended learning activities found positive impacts on communication, creativity and collaboration. Similarly, the convenience and availability of education technology, as well as low barriers to entry of such education projects provides

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[15] Herreid, Clyde Freeman, and Nancy A. Schiller. "Case Studies and the Flipped Classroom." *Journal of College Science Teaching* 42, no. 5 (2013): 62–66. http://www.jstor.org/stable/43631584.
[16] Sharples, M., Arnedillo-Sánchez, I., Milrad, M., & Vavoula, G. (2009). Mobile learning: Small devices, big issues. In S. Ludvigsen, N. Balacheff, T. D. Jong, A. Lazonder, and S. Barnes (Eds.), Technology-enhanced learning: Principles and products (pp. 233–249). Berlin, Germany: Springer-Verlag.
[17] Parsons, D., & Ryu, H. (2006). A framework for assessing the quality of mobile learning. In R. Dawson, E. Georgiadou, P. Lincar, M. Ross & G. Staples (Eds.), Learning and Teaching Issues in Software Quality, Proceedings of the 11th International Conference for Process Improvement, Research and Education (17–27), Southampton, UK.
[18] Kynäslahti, H. (2003). In search of elements of mobility in the context of education. In H. Kynäslahti & P. Seppälä (Eds.), Mobile learning (pp. 41–48). Helsinki, Finland: IT Press.
[19] Kukulska-Hulme, A., Sharples, M., Milrad, M., Arnedillo-Sánchez, I., & Vavoula, G. (2009). Innovation in mobile learning: A European perspective. International Journal of Mobile and Blended Learning, 1(1), 13–35.

significant opportunities for educational issues to be attacked from a wider set of angles. Research into pedagogical perspectives of education technology has highlighted the 'authenticity, collaboration and personalisation embedded in the unique times-ace contexts of mobile learning' that allows for the enabling of approaches to learning from a socio-cultural perspective[20].

Concerns Surrounding Education Technology

This is not to say the implementation of technology in education has been uniquely a good thing – there is still plenty debate around the right balance of technology (which is rarely, as a proportion of time, used for learning purposes) in the classroom. The question of balance is less about exploring whether technology is useful or not, but rather about how the employment of technology may lead to negative effects. Without proper treatment, the performance of students using existing online learning strategies known to be 'effective' may be disappointing or even negatively affect students' learning achievements. This may be as a result of 'heavy cognitive load caused by an improper learning design.'[21]

Research Gaps

Although there is plenty of research looking at a wide range of aspects of mobile learning, there are nevertheless gaps to be filled. The present research covers an array of contexts surrounding a variety of endpoints regarding success. What is missing is the exploration into standardised exams. This is not only a huge space for potential entrepreneurs, but also for those who oversee the provision of education. High school standardised exams direct, in many senses, the direction students take beyond their high school years as well as school reputation; determining the effectiveness of strategies to employ education technology in the classroom is an extremely valuable endeavour. In my research, I will pinpoint the effectiveness of employment of education technology strategies into the classroom of students aged 16-18 preparing for standardised exams.

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[20] Kearney, M., Schuck, S., Burden, K., & Aubusson, P. (2012). Viewing mobile learning from a pedagogical perspective. Research in Learning Technology, 20(1), 1–17.

[21] Chu, H. C. (2014). Potential negative effects of mobile learning on students' learning achievement and cognitive load—a format assessment perspective

Methodology

Interview & Survey

In my collection of data, it has been my objective to receive viewpoints from as many perspectives as possible. That means that I have operated on the assumption that while some groups of subjects may have incredibly valuable insights within the current system and in the way that the education institution currently functions, they may not always capture other perspectives. Teachers, for example, may be able to to witness first-hand the improvements on a smaller scale – head-teachers, on the other hand, may have a strong grasp of the bigger picture, but less so the daily micro activities. Those who are involved with policy may, furthermore, have a broader perspective – for example in which they are able to compare areas which have or haven't implemented education technology. In other words, different people will draw greatly different conclusions on the various aspects of my thesis, meaning that by collecting a wide breadth of data, I have been able to plug the most important holes. My intention has been to extract a variety of insights from the three aforementioned groups.

This study interviewed 11 teachers, directors, tutors and head-teachers with experience in teaching. All had some form of experience with education-technology in the classroom. I also

I have ordered my foundational questions as follows:

1. How have you implemented education technology into your classroom? How have you seen it implemented?
2. What have been the main problems education technology has sought to address in your classroom and experience?
3. What results have you seen with the implementation of education technology a) in the classroom b) with respect to students grades c) with regards to solving inefficiencies d) with regards to solving socio-economic issues
4. How has education technology allowed you to adapt the classroom? How has it changed your job as a teacher / headteacher / policymaker?
5. How do you see the future of education technology? What does this look like in the short-term and the long-term? What would your ideal be given the unlimited potential of education technology?

Although these questions are fixed as a base for each interview, I believe it's been important to allow each interview to take a natural flow – meaning, if it went off piste because of the interviewee's personal opinion, then I've explored that. This means interviews were more flexible than rigid. Similarly, I have tailored interviews to each interviewee's background. As a result, I some interviews had more questions than others, and moved in different directions. These questions have served as a core to my research, and will hopefully provide me with meaningful data that tackle each point of my findings section.

Participation & Outreach

All my interviewees, and potential interviewees, I reached out to via email - whether this is their personal email or their organisation's depended on the availability of their personal emails online. I planned to conduct roughly 12 interviews, give-or-take three; I managed to collect 11. The interviews were conducted over zoom. For the interviews I will have been a part of, transcripts were made from the recordings using Otter.ai. I maintained a policy of respecting the requests of each interviewee: meaning, if an interviewee didn't want to be named or recorded, this would be honoured while using as much information as possible within those boundaries. My data has been analysed by highlighting the transcripts I create or notes that I take, and using the sections most relevant and specific to the paper at hand. Of course, there are strengths and limitations of this technique. The primary strength of taking true, in-depth qualitative data is that it allows me to truly gain the perspective of each interviewee. By exploring their experience, I was able to develop a very clear picture of the paths they have taken, as well as how they see the future of the education-technology sector with respect to what they are doing. The primary weakness is that many viewpoints I imagined would carry some conflicts, and so it may be a challenge to find a synthesis between them. Similarly, qualitative data relies on perceptions that are subjective, and that can be manipulated by forces unrealised and external to the question at hand.

I have listed in the table below those I have interviewed. Per my plan, the participants interviewed have all been through a variety of levels and adopted a variety of roles within the education system; from co-ordinating the IB for their school, to tutoring a variety of exams in many countries, to directing academics. However, I maintained the focus on those with Chicago-specific experience. Over the past decades, they have seen the progression of technology in the classroom. I intended to get as much information as possible from this experience in the field, with respect to the integration of technology in the classroom, and ultimately education technology.

Interviewee	**Role**	**Date**
Mark Hooley	- IB Geography Teacher, IB - Ed-Tech Founder	12/3/2021
Sebastian Weiss	- A-Level Geography Tutor - Ed-Tech Founder	12/28/2021
Mr English (pseudonym)	- UK School Deputy Head	12/30/2021
Shantà Robinson	- Assistant professor at the University of Chicago - Former 9-12 Social Studies Teacher, Charlotte-Mecklenburg School District	2/18/2022
Eric Reyes	- Former high school mathematics teacher, Baker College Prep & Chicago Bulls Prep	3/1/2022
Sam (pseudonym)	- Administrative assistant at educational initiative	3/1/2022
Katie Malcolm	- Professional school counsellor at McCutcheon Elementary School	3/5/2022
John Lim	- Former high school teacher, Noble Network of Charter Schools	3/6/2022
Stephanie Shen	- Former English teacher, Miami-Dade Public Schools	3/6/2022
Michael Havazelet	- Former teacher, Humboldt Park region (anonymous school)	3/7/2022
Aracelis Janelle Sharon	- Aracelis Janelle Sharon, dean of instruction, Chicago (anonymous school)	3/8/2022

Findings

1. Mobile Education in the Classroom: A Novel Phenomenon

Section Interviewees

Interviewee	Role	Date
Mark Hooley	- IB Geography Teacher, IB - Ed-Tech Founder	12/3/2021
Sebastian Weiss	- A-Level Geography Tutor - Ed-Tech Founder	12/28/2021
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Katie Malcolm	- Professional school counsellor at McCutcheon Elementary School	3/5/2022

Interviewee Foreword

In this section, I intended to paint a wider picture of the education-technology field and understand how it has evolved over time from perspectives both inside and outside the classroom. I have attempted to focus more on Chicago, however my findings have led me to believe that these changes occur at a wider scale, as opposed to specific cities. These changes may happen more or less quickly, however they are generally homogenous regardless of geographical location. As a result, Mr. English's perspective as a deputy head of a UK school will be just as valuable as Katie Malcom's as a school counsellor at a Chicago elementary school.

For this section, the *unique* aspect of my interviews come from the variety of timelines operated by each interviewee. Some interviewees taught only in the early days of education-technology. Some taught only in recent times in the current ed-tech landscape. Some have experience teaching over the past 15 years and have seen the transition first-hand. This, I believe, is extremely valuable in developing unique qualitative aspects to the research.

> *So when I was a high school teacher, the biggest problem we had is students who had their cell phones and they were a little flip phones, and they wouldn't be trying to text and they would be pushing three buttons to text one letter, you know. So we didn't worry about technology impeding on the learning process.*
>
> - Shantá Robinson

Mobile, smart education in the classroom is a novel phenomenon. It is only *recently* that we perceived technology as a potential infringement upon the learning process. Shantá Robinson - an assistant professor at the University of Chicago, and former grade 9-12 Social Studies teacher between 2003-7 - admits the view of technology at the time was that it was *external* to this learning process. The hardware capabilities of mobile technology were limited to 2-inch screen, non-touch flip-phones *at best*. Similarly, the software capabilities of mobile technology were largely non-existent, outside of playing *Tetris*, or making a phone call.

It is only more recently that we have begun to perceive technology as something that is no longer necessarily external, but has the potential to be internalised. In this section, I will explore these two shifts in the state of teaching, with the intention it acts as a foundation for the development of my findings. In order to understand the value of education technology, we should answer the questions, *what was high school education like **before** this technology existed? What were the values upon which this education was built?* Finally, *how do the values of education technology supplement, overlap with, or detract from, traditional education*?

1.1 An Archaic System in a Technological World: Technology's Integration into the Classroom

> *In each course, students need to prepare their workbooks, revision guides, textbooks, syllabuses, computers, notes, and past papers. It takes a long time to set this up and prepare - and as a result students get distracted easily.*
>
> - Mr. English

One of the most important themes evident from my data is that the pre-technology state of education relied on a variety of physical hardware. Students needed several books: one to learn, one to study, one for notes, and more for practice. Not only was this a system that is remarkably tedious for students, but as technology, communication systems and the internet progressed, the opportunity

cost of this process gradually increased. The role of the development of education technology in this one respect is to *reduce* that opportunity cost. Mark Hooley describes how '*distractions* [such as] *Facebook, Instagram and TikTok are just one click away, at all times*'; in shortening the distance between deciding to study, and actually studying, education technology reduces the likelihood of experiencing these distractions. Students are constantly facing tradeoffs, and recognise that they have a choice between studying, and not studying: it is important that the enjoyment gap between these two states is *not too large.*

> *We never had issues with mobile phones prior to, really, 2005. Of course there were distractions and some students would focus in class more than others - but the question of social media and its usage, Facebook and whatnot, or posting reputation-damaging things online was not something we considered. By the time you finished your years at secondary school, this had become a somewhat persistent issue.*
>
> - Mr. English

The decade between 2005 and 2015 was crucial in developing the extensivity of smart technology usage amongst the younger generations. This includes firstly the broadening scope of what mobile phones are able to do, and secondly the wide uptake of these devices. Mr. English, former teacher and Deputy Head at University College School, London, describes the period in which there was this gap, and claims that there *still is* to some degree: while many aspects of our lives have been technologised - we use our smart devices to buy anything, to travel anywhere, and to communicate with anyone - the education-technology space is still yet to find its *Google*. Mr. English claims this gap was larger half a decade ago; as any phone-usage was *exclusively* un-educational.

> *I worry because of social media. I work a lot with kids, so we have a lot of stuff that happens on Snapchat, and Tiktok, outside of school, and then it kind of bleeds into the school. So I deal with a lot of conflict, about things that have happened online. So, I mean, that's a big, a big reason we we would take them.*
>
> - Katie Malcolm

Katie Malcolm, a professional school counsellor at McCutcheon Elementary School (under the umbrella of Chicago Public Schools) describes how in the past, strict no-phone policies were

implemented for students. Unlike other interviewees I have spoken to, she mentioned that this is a policy that is still largely in place. And the historically high technology take-up and technological literacy is yet to fully translate into technological responsibility: mobile phone usage often has a net-negative impact when *existing* in the classroom. Interestingly, although this policy hasn't been rescinded, she described how for many classes phones are selectively given out in order to support class activities such as, online quizzes or group participation.

1.2 Increasing the Scope of Resources

> *It's important to be able to use that technology these days. Because mobile phones are so advanced, you can do so much with them. So, why not use them to your advantage in the in the classroom to help learning?*
>
> - Sebastian Weiss

At the same time, the exponentially-increasing capabilities of smartphones have opened up the vast realm of possibility in the digitisation of educational materials. Among those I interviewed, there seemed to be two main lines of thinking. Firstly, that technology in its current state is generally incompatible with the average lesson, in the average classroom. The logic behind this, as Malcolm and English mentioned above, is that all the software encapsulated within is simply too distracting: students' lives are lived increasingly through the lens of social media, which by extension is through the physical framework of the mobile phones that students carry. On the other hand, the second line of thinking is that which Weiss and Hooley discuss. In our technological era, there must be a point of friction through which this technology passes in order to find what works, and what doesn't. Our smartphones have become so capable that it would be irrational *not* to put those 'smarts' to use. The only way to accumulate qualitative and quantitative data points, testimonials, and catalyse the development process of education technology is through trial and error, and rewarding successful endeavours.

It is important to note that the data I've found makes it clear these lines of thinking are *convergent*, rather than *divergent*, and that those on either side of this question reason *towards* each

other, rather than *away* from each other. What I mean by this, is that each side recognises the importance of and potential for many significant aspects of technology. The main difference comes not from their ideas, but rather the implementation of these ideas. I would categorise these differences under a *cautious* versus *brazen* framework. *Cautious* teachers are more careful with the implementation of technology in their specific context, and prefer to take a safe, ensured route when teaching the content of their class. *Brazen* teachers are willing to take more risks, and are eager to test and trial new technologies with their classes even if the chances of success may be lower.

Ultimately, my interviews have shown that on the fundamental question of whether education is a valuable application of new technologies, the answer is a resounding *yes*. As time passes, cautious teachers are increasingly inclined to implement technologies that seem to work, just at a slower pace. The general trend amongst teachers is the feeling that these resources will *eventually* be put to use in an educational context.

> *Most of my colleagues used the program as punishment. So they would log their entire classes in negative points. And so over time, it had no effect, or even a negative effect, on the kids. But then in my class, I only did rewards. And so it was all positive reinforcement. So I found it to be very useful. And then so in the following year, they asked me to teach a seminar on how to use this. But there was no buy in because other teachers already had a bad experience with it.*
>
> - Stephanie Shen

Stephanie Shen, a former English teacher at Miami-Dade Public Schools between 2014-17, and current student at the UW School of Medicine and Public Health, discusses the teacher-facing side of technology uptake. She describes a program implemented in her school that facilitated the reward of points to students following behaviour. Teachers allocated either positive or negative point values to students, which both the students and their parents could see. She argues that the uptake of this technology was heavily dependent on the teachers' selected use-method: teachers who used the program as a facilitator to *punish* students had very different interactions with the technology to those who used it as a facilitator to *reward* students. Although there is a very important implementation aspect here, I will discuss this later.

When examining the mindset around rendering technological resources into the learning environment, the teacher-resource interaction is often as important as the student-resource interaction. If the technology does not help - or even hinders - students, this is just as much of a consideration as if it does the same for teachers. Similarly, in an example such as the one above, we see that this point-allocation system benefitted teachers in their ability to develop a triangular relationship between teacher, student and parent, and facilitated the provision of feedback. However, given the negative effect on students, there was no take-up. As a result, we are left with a two-way cost-benefit calculation that takes into account both the effect on teachers and students. This is another idea I will revisit later when discussing implementation.

1.3 Internalisation of Technology

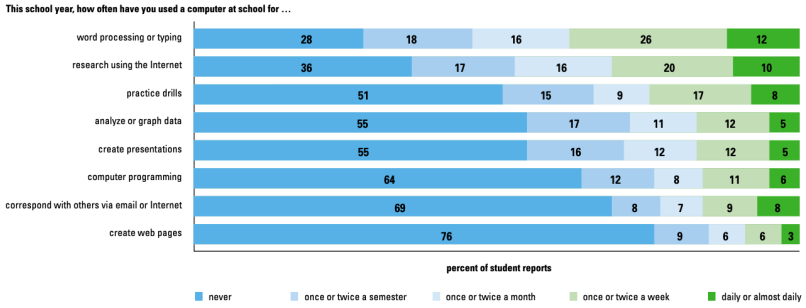
> *We saw technology as external to the learning process. The issue I've seen with that is because a critical mass of folks had those technologies at their hands. We assumed everyone had that technology at their hands. So as teaching change as curriculum change, we started saying, technology is central to education instead of external.*
>
> - Shantá Robinson

Ultimately, as the scope of resources, and potential resources, widens thanks to the growth of smart technology, the internalisation of technology is a necessary feat. This is a point which *all* of my interviewees have made: phones and laptops can be distracting, however they are so omnipresent in the lives of students that there is a necessary internalisation process. Shantá Robinson describes this very clearly in the quote above; enough students have had access to technology of a certain level of capability, which makes inevitable the acceptance of this technology in schools.

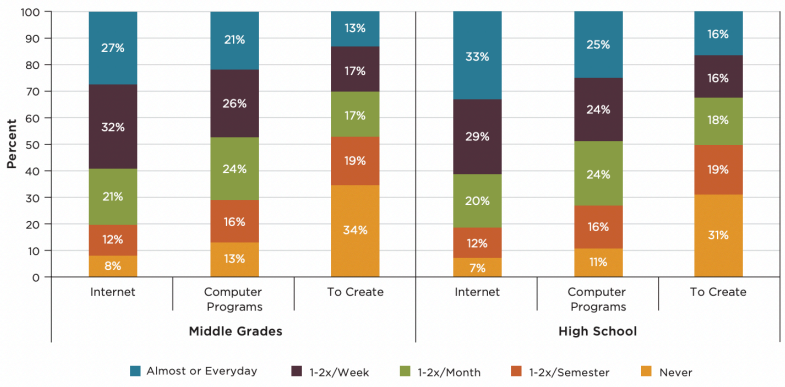
In *Educational Technology: Availability and Use in Chicago's Public Schools*[22], a 2001 report reviewing the use of education technology in the Chicago Public Schools system, backs up this context. The extent to which students used their technology was extremely limited: when

[22] "Educational Technology." UChicago Consortium on School Research. Accessed April 18, 2022. https://consortium.uchicago.edu/publications/educational-technology-its-availability-and-use-chicagos-public-schools.

looking at the core areas – English / reading, social studies / history, math and science – only one-quarter of students used technology weekly for all their core courses. This was highest in English class, where 57% of students reported they would complete *at least some* of their assignments using technology. On the other hand, 62% of CPS students *never* used technology for a math assignment during the 2000-01 year. Overall, 36% of students did not use technology, to any degree, for any of their classes.



Naturally, this is somewhat unfathomable today. In *The Use of Technology in Chicago Public Schools 2011*[23], only 10 years later, only 7% of students at the high school level reported never using technology, to any degree, for any of their classes (*figure 2*).



> *There was definitely the question of doing something they weren't. One day I actually got around it. I said 'you're allowed to listen to music.' Bring your headphones, you can listen to music as you're studying. This is meant to be your practice, right? They try to make it as much of a study session rather than like, 'hey, you have to do this'.*
>
> - Eric Reyes

[23] "The Use of Technology in Chicago Public Schools 2011." UChicago Consortium on School Research. Accessed April 18, 2022. https://consortium.uchicago.edu/publications/use-technology-chicago-public-schools-2011-perspectives-students-teachers-and#:~:text=Between%2020%20and%2030%20percent,in%20and%20out%20of%20school.

Eric Reyes, a former high school mathematics teacher at Baker College Prep and Chicago Bulls College Prep between 2014-19 describes his *onboarding* of technology into the classroom. Initially, he describes a largely no-phones policy: during class and review sessions, materials had to be worked through and there was little leeway for any technology outside of laptop note-taking. His moment of processing the internalisation of technology came through allowing technology to be used, but in a positive and integrated manner.

This example is very important, as it signifies the value of repurposing existing technology to be used as a positive reinforcement to class time. Reyes made the point, additionally, that by enforcing strictly negative measures, teachers enter into a battle *against* the technology. By permitting selective and limited use, he found that students were less inclined to misuse their devices or take advantage of what they viewed as a privilege given to them.

What Reyes argues is somewhat counterintuitive: many teachers I spoke to were under the impression that increased device-usage leads to a higher probability of student distraction. In fact, I believe the opposite is closer to the truth. As aforementioned, students use a very significant portion of their time outside the classroom on their phones. Mr. English likens the removal of mobile phones in the classroom to going cold-turkey with addiction issues:

> *Taking away students' phones, these days, often actually distracts them. I've seen some students have physical reactions to their phone being confiscated, or put away. Of course there's a deeper problem there, but I think it also shows that nowadays it's often better to not have that distance too far. Not always, of course, but often. It's sort of like going cold turkey; it's very difficult.*
>
> - Mr. English

Cultivating a relationship with the technology is crucial. However, there is a variety of issues that need to be tackled before this can happen. All my interviewees mentioned the importance of access and implementation as crucial elements to facilitating the success of technology: without access, it doesn't exist. Without proper implementation, the results of this technology are often in fact negative for both the student *and* teacher. In the coming sections, I will discuss both access and

implementation, as well as how they have been impacted throughout the COVID pandemic. Finally, I will discuss the implications for the future of ed-tech and mobile learning.

2. Access

Section Interviewees

Interviewee	Role	Date
Mr. English (pseudonym)	- UK School Deputy Head	12/30/2021
Shantà Robinson	- Assistant professor at the University of Chicago - Former 9-12 Social Studies Teacher, Charlotte-Mecklenburg School District	2/18/2022
Eric Reyes	- Former high school mathematics teacher, Baker College Prep & Chicago Bulls Prep	3/1/2022
Sam (pseudonym)	- Administrative assistant at educational initiative	3/1/2022
John Lim	- Former high school teacher, Noble Network of Charter Schools	3/6/2022
Michael Havazelet	- Former teacher, Humboldt Park region (anonymous school)	3/7/2022
Aracelis Janelle Sharon	- Aracelis Janelle Sharon, dean of instruction, Chicago (anonymous school)	3/8/2022

Interviewee Foreword

In this section, my findings were focused primarily on access issues with respect to Chicago. As a result, I have focused on my interviews with those who have either taught in Chicago, or have had insights that can reasonably be extrapolated the discussion of access in Chicago. I believe the question of access is *not* homogenous across geographical location; it is not even homogenous within the city of Chicago. Furthermore, its heterogeneity within the city of Chicago is *unique*. Therefore, I have omitted data from my interviews with Sebastian Weiss, Mark Hooley and Stephanie Shen. The data I used from my interview with Mr. English was very minor, and was not specific to Chicago.

For this section, the *unique* aspect of my interviews comes from the Chicago-specific focus. Ed-tech-related access issues are yet to be explored in the literature with respect to Chicago. Thus, by understanding the relationship between ed-tech and access *within* Chicago, this qualitative data adds a unique perspective to the literature.

> *Not everyone has access to that centralised technology, not everyone has has access to those beautiful iPhones. And some people have access to the phones themselves, but they don't have data. Other folks don't have it at home, say, when the pandemic started. Then CPS comes out and says, now we're going to help all these people get broadband internet at a fraction of the cost. And my whole thing was that 'you've known that we needed to help young people and their families with that for many years now!' And the pandemic gave them a type of window in which they can do that, and no one would question it. Our politicians weren't going to question it. Parents and other folks were going to question it. But that's been a necessity for a long time.*
>
> - Shantá Robinson

Needless to say, efforts to create valuable and innovative technologies are futile without access to them. In the world of those are are not able to have hardware, software, or internet, the development of education technology or education technology platforms is almost totally irrelevant. In short: *what's the point of developing Khan Academy if I don't have internet access? And what's the point of providing me internet access if I don't have a device that can connect to the internet?* In this section I will break these aspects down along the lines of hardware, internet, and software.

2.1 Access to Hardware

> *Providing access to the actual hardware technology, having CPS applied quality laptops that can connect to all the different programmes that you know, the student is going to need, is always going to be a challenge.*
>
> - Sam

I was fortunate to speak to a former administrative assistant who worked amongst students in within schools, who asked for their name to be rescinded and their identity anonymous. I will call them Sam. Their insight brought up the initial review of the variety of access issues relating to educational technology. They argued that oftentimes, people view access as one-dimensional: for example, people claim that *'students in Chicago have very little internet coverage, so by increasing internet coverage they can finally make use of online platforms!*' Or, '*schools don't have any of the hardware required, we need to put in an order of chromebooks so that we can integrate technology into the classroom!'* These claims get much more complicated when taking into account the capabilities of these access pieces.

> *But Chromebooks, I believe, are only browser based. And students couldn't access everything that they needed sometimes. So there was a bit of a switch between a Chromebook versus a full laptop, to access all those other functionalities… In reality, there are so many different layers of access.*
>
> - Sam

As Sam describes, the reality of access is that it is a crucially multi-layered issue, and there is no 'quick fix'. Certain provisions can be made to adjust who is able to get access to certain elements of education technology, but these are generally marginal tweaks and offer no groundbreaking solution. Furthermore, each layer is broken down into further layers. As aforementioned, upgrading to chromebooks provides access to an internet browser, which provides access to online platforms. However, it does not provide access to Microsoft Office, for example, or other software that is often crucial to the process of education.

The question of hardware is critical because it generally takes up the largest portion of the money-spend when it comes to education technology: if we imagine an iPhone at $1,000, internet connection at $40 / month and the educational-use software being largely free, we would initially that the initial barrier is the largest. However, it is these first-step devices are also those that provide the highest marginal benefit, and support the user far beyond their education technology capabilities. As a result, the provision of private ownership is something my interviewees have explained schools think relatively little about. As Robinson describes, a *critical mass* of students was reached long ago that spurred this transition towards internalising technology.

That being said, there is still a portion of students that lack the necessary hardware. Robinson argues that it is on the shoulders of school districts and generally-speaking the political realm to ensure access to hardware. In 2019, CPS *embarked on a three-year initiative to modernize technology across the district*[24]. CPS explains as follows:

> *The technology modernization program provides students with the tools they need to succeed in a 21st century economy and ensures equity of access to high-quality*

[24] "Bridging the Digital Divide: A Device for Every Student Who Needs One." Chicago Public Schools. Accessed April 18, 2022. https://www.cps.edu/school-reopening/remote-learning/technology-devices/device-allocation/.

> *digital learning opportunities for every student. This is another step the district has taken to narrow the digital divide and provide all our students with a rigorous education.*
>
> - CPS

Interestingly, this was prior to the pandemic. Even despite COVID's impact and eventual forced remote-work, there was the recognition of the importance of providing technological devices to students. Again, however, there are multiple layers to the provision of such technology in terms of examining access. Sam described logistical issues in her experience with the deployment of these devices.

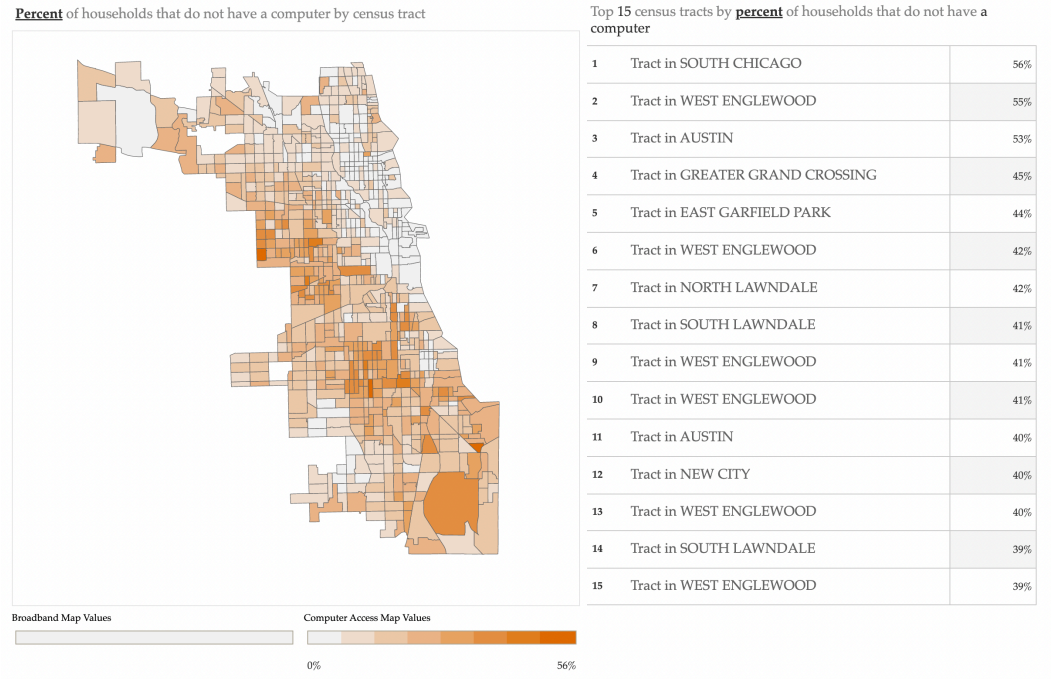
> *I think logistics is one of the main priorities. You know, just getting families to come in, pick up the laptops. And sometimes laptops will break down, so you need to return them pick up a new one. I think, if I had to take a guess it's just the district had never done this mass deployment before. And it was a learning curve.*
>
> - Sam

When it comes to hardware provision, deployment can be very difficult. As Sam mentions, facilitating the logistics of the deployment program is key to successfully broadening the scope of access. There are a few unique aspects exclusive to hardware (unlike internet or software) that complicates this. Firstly, physical hardware requires physical hands: recognising *who* needs hardware is the initial challenge, but so is ensuring that those who need it, ultimately receive it. As Sam mentions, the procedure of collecting a laptop - then maintaining it - is something that needs to be addressed in the conception of these initiatives. Secondly, unlike the internet or its platforms, hardware breaks; and when it breaks, the internet and software are now out of the access reach for students.

As the COVID pandemic hit, there was significant research effort invested into understanding the landscape of access with respect to computers in Chicago. Figure 1 shows the census tracts by percentage of students that do not have computer access. In South Chicago, as many as 56% of households do *not* own a computer, meaning access to remote learning was totally impossible. Olivia O, an Englewood parent describes the issues she suffered from whereby the

distribution of hardware technology was far from sufficient with respect to levelling the playing field with respect to access. She cites the challenge of effectively participating in remote learning that many families face.

> *I received one Chromebook but I have three school-age children at home. I'm also a college student and would normally go to the library to user their computers. But I can't do that now. We're all in the house trying to share one Chromebook and a cell phone. It's really hard to be both a parent and teacher without the things I need to do it.*
>
> - Olivia O[32]



Top 15 census tracts by percent of households that do not have a computer

1	Tract in SOUTH CHICAGO	56%
2	Tract in WEST ENGLEWOOD	55%
3	Tract in AUSTIN	53%
4	Tract in GREATER GRAND CROSSING	45%
5	Tract in EAST GARFIELD PARK	44%
6	Tract in WEST ENGLEWOOD	42%
7	Tract in NORTH LAWNDALE	42%
8	Tract in SOUTH LAWNDALE	41%
9	Tract in WEST ENGLEWOOD	41%
10	Tract in WEST ENGLEWOOD	41%
11	Tract in AUSTIN	40%
12	Tract in NEW CITY	40%
13	Tract in WEST ENGLEWOOD	40%
14	Tract in SOUTH LAWNDALE	39%
15	Tract in WEST ENGLEWOOD	39%

Figure 1[25]: Census tracts by percent of students that do not have computer access.

Sam describes this issue at an institutional level in describing how her *school didn't have computers, [they] didn't have access to technology. And so there was a huge disconnect.*

Ultimately, there are a few truly important points I've found in my data with respect to access. Firstly, access is necessary and foundational for the ed-tech space; without it, the market has no worth. Secondly, access is a multi-layered issue. What seem to be solutions often only move the ticker slightly, and provide only marginal benefits to the ultimate use of technology in the classroom. Thirdly, teachers believe the provision of hardware rests on the shoulders of the school

[25] "Digital Equity Coronavirus." Kids First Chicago. Accessed April 18, 2022. https://kidsfirstchicago.org/digital-equity-coronavirus.

and education boards; not the schools themselves. Finally, deployment and maintenance of hardware is vital for uptake of technology in the classroom.

2.2 Access to the Internet

> *The vast majority of our students didn't have computers at home, they definitely didn't have broadband internet at home.*
>
> - Shantà Robinson

Following hardware, the next vital component is access to the internet, which within itself is a multi-layered issue. Many interviewees discussed internet as a significant barrier to education for students, especially in the Chicago Metropolitan area. In April 2020, Kids First Chicago - an education advocacy group - and the Metropolitan Planning Council released *Digital Equity in the Coronavirus Era*[25] that brought to light this digital divide. The most stark finding indicated that one in five children in Chicago lacked reliable in-home internet, with increasingly large gaps across Black and Latinx neighbourhoods, as well as those in the South and West (although this disparity is largely correlated between race and geographical location). Areas with the largest gaps in internet connectivity included Austin and Humboldt Park, where 33% of residing children lacked internet access, and West Englewood, where 46% of residing children lacked internet access. These numbers translate to over 110,000 children across Chicago.

When discussing access issues with my interviewees, I intended to collect data from a variety of different perspectives. Fortunately, I was able to speak to teachers who had an understanding of the issues having been on the ground - and who had seen their *own* students suffer -, as well as academics who understood the practical policy matters and were able to discuss the success of past policy implementations.

Internet access has increased drastically over time. Shantà Robinson, who taught in the 2000s, describes how internet took on a different role to what it does now. The internet - or *web* - was used with the intention of finding *some* information. High school students, she explains, relied on physical copies of textbooks, notebooks, homework, and review guides. Access to the internet

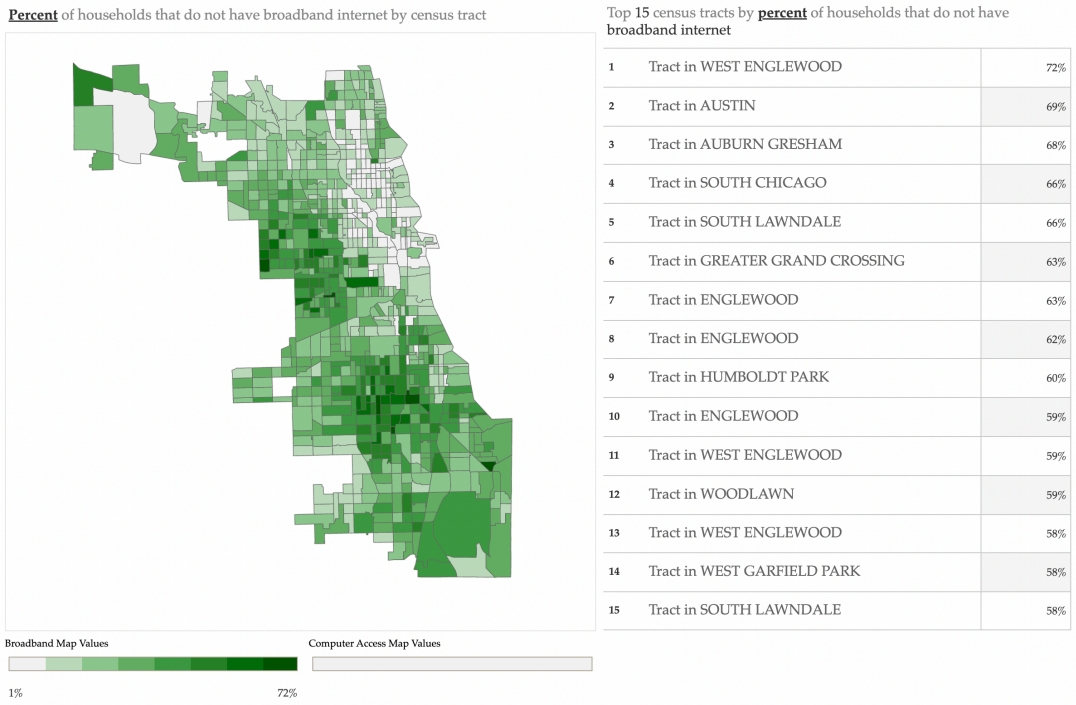
was useful for some purposes such as email and research. However, email was largely outside the scope of high-school teaching: all required homework would be submitted in person, physically. Technologies that required internet, such as Canvas, were not yet created. At the same time, high-school level content exploration was relatively undeveloped. This includes online programs to support teaching and / or learning, as well as digital textbooks, or YouTube tutorials. As a result, the internet was seen, according to Robinson, as '*external to the learning process.*'

> *So as time has gone on, and all of a sudden, more people have access to the smart phones. And smartphones are truly smart, they can do really amazing things. Instead of punishing students for using their smartphones, [we should] incorporate smartphones somehow in the classroom, make them a part of the learning process instead of external to it.*
>
> - Shantà Robinson

As teaching entered the 2000s, a process of internalisation with respect to education technology was undertaken, and with it the increase in widespread internet access. Gradually education became increasingly reliant on internet access; alongside this process, two main things happened: firstly, internet access rose. More and more students had internet connection in the home, and therefore were able to use it for their classes. This internalisation of internet access into the classroom precipitated - and to some degree facilitated - the internalisation of smartphones. Secondly, online programs were developed for educational supplementation. This includes learning management systems such as Canvas and Firefly, as well as self-learning platforms such as Khan Academy.

Naturally, this spread was not even across financial and socioeconomic zones. As of March 2020, predominantly white, and more affluent, neighbourhoods showed rates of connectivity upwards of 85%. Kids First Chicago describes how '*you would need to combine more than 15 community areas north of Lincoln Park to find an equivalent number of children under 18 without broadband access across Chicago's North Side as just the two community areas of Austin and Englewood.*' At the same time, full community-area aggregation still does not effectively capture

the picture of the inequity; in some areas fewer than 40% of households have connection to broadband. Figure 2 below shows the percent of households that do not have broadband internet by census tract.



Top 15 census tracts by percent of households that do not have broadband internet

1	Tract in WEST ENGLEWOOD	72%
2	Tract in AUSTIN	69%
3	Tract in AUBURN GRESHAM	68%
4	Tract in SOUTH CHICAGO	66%
5	Tract in SOUTH LAWNDALE	66%
6	Tract in GREATER GRAND CROSSING	63%
7	Tract in ENGLEWOOD	63%
8	Tract in ENGLEWOOD	62%
9	Tract in HUMBOLDT PARK	60%
10	Tract in ENGLEWOOD	59%
11	Tract in WEST ENGLEWOOD	59%
12	Tract in WOODLAWN	59%
13	Tract in WEST ENGLEWOOD	58%
14	Tract in WEST GARFIELD PARK	58%
15	Tract in SOUTH LAWNDALE	58%

Figure 2[25]: Census tracts by percent of students that do not have broadband internet access.

> *In today's world, connectivity is everything. In providing connectivity to tens of thousands of families across the city, 'Chicago Connected' provided opportunity to those who need it the most. Nowhere has this impact been felt more than in our communities of colour.*
>
> - George Cardenas[26]

On Friday, April 17, 2020 Illinois joined over thirty other states in extending its mandated statewide school closure through the remainder of the 2019-20 school year in response to the public health crisis; almost all of my interviewees discussed the variety of roles COVID played in the classroom. Although the effects of the pandemic caused a plethora of issues inside and outside of education, my data highlights that the impacts of COVID operated in two primary capacities:

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[26] "Mayor Lightfoot Announces Programmatic Expansion of 'Chicago Connected,' the City's Groundbreaking Initiative to Close the Digital Divide, as Kids First Chicago Releases Impact Data on the Program's First Anniversary." City of Chicago :: Mayor Lightfoot Announces Programmatic Expansion Of 'Chicago Connected,' The City's Groundbreaking Initiative to Close the Digital Divide, As Kids First Chicago Releases Impact Data on The Program's First Anniversary. Accessed April 14, 2022. https://www.chicago.gov/city/en/depts/mayor/press_room/press_releases/2021/june/ChicagoConnectedExpansion.html.

1. *As a Highlighter:*

> *The need for internet access has been going on for a while now, but remote learning is making it more evident.*
>
> - Claiborne W., CPS Parent

Following the lockdown orders, students suffered from a lack of optionality with regard to education-delivery. This included primarily the inability to attend in-person classes. Given a lack of downloaded software or other internet-free resources to serve as a direct replacement for teaching, internet access became entirely foundational to educational continuation. As a result, underlying issues were *highlighted* as a positive by-product of the pandemic. John Lim, a former high school teacher within The Noble Network of Charter Schools describes this phenomenon:

> *You don't really realise it. Like, when you break your leg. You take for granted, being able to just walk around, even even something simple, like a cut on your finger or something like that. There are certain foods you can't eat if you have a cut on your finger, or there are certain things you can do regularly. You are forced to do things differently, and you don't realise what that is until it's taken away from you. But at the same time for a lot of a lot of our students. They didn't even have it to begin with, right. And so like, that was like an entirely new world for a lot of our students for sure.*
>
> - John Lim

In March 2020, CPS released '*remote learning guidance that outlined expectations, strategies, and available resources for schools to implement remote learning beginning April 13*.' [27] What followed was an initial recognition that CPS would require wider aid to ensure that adequate internet support was available; as above, almost 100,000 students lacked such support, and the support levels varied significantly across race and socioeconomic status. It is through this highlighting effect that COVID brought to the forefront major issues pertaining to internet access, and the ensuing research into how to solve these underlying problems..

This is important in the context of education technology in our understanding of its potential reach, and as a foundation for widespread education technology flourishing into a successful endeavour. Although hardware access is upstream from internet access, my interviewees made it

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[27] Kids First Chicago, Metropolitan Planning Council. 2020. *Chicago Connected.* Chicago, IL.

clear that given Chicago's circumstantial conditions and constraints, the highlighting of these underlying issues is vital towards providing a base upon which the implementation of education technology can be built. Shantà describes how COVID's illuminatory effect on these problems incentivises the discovery of their solutions:

> *And my whole thing was you've known that we needed to help young people and their families with that for many years now. And the pandemic gave them a type A window to which they can do that. And no one would question it, our politicians wasn't going to question it, parents and other folks were going to question it. But that's been a necessity for a long time.*
>
> - Shantà Robinson

2. *As a Catalyst:*

> *Well, now in my inbox I probably get a dozen messages a week about new program offerings, and each one claims to be more effective and cheaper than the last. I'm not sure if this is just for what we teach here, but I would imagine this is pretty much happening across the board, for other international exams as well. This is a good thing, of course - I suppose COVID has made the free market do its job.*
>
> - Mr. English

If the highlighter effect involved a bottom-up approach to offering education technology solutions, the catalyst effect involves a top-down approach. By this, I mean that the former uncovered significant underlying issues with the infrastructure necessary for modern education. The latter effect involves the recognition of these problems, the anticipated progress towards nullifying these issues, and the resultant plans.

In *Digital Equity in Education in the Coronavirus Era,* the Metropolitan Planning Council highlighted the aforementioned problems pertaining to Chicago internet access. This catalysed the development of solutions, spearheaded by *Chicago Connected* - a government-led and philanthropically-funded program to provide high-speed internet service to these 100,000 students' households. As explained by the Mayor's Press Office, this '*first-of-its-kind program will be one of the largest and longest-term efforts in the nation to provide free, high-speed internet over the course of four years to dramatically increase internet accessibility for students and help build a permanent*

public support system for families in Chicago.'[28] Furthermore, Ken Griffin describes how the evolution of this issue provides a sustainable solution that tackles the '*persistent access issue through a public-private investment in broadband, with philanthropic partners bridging the program's initial costs*.' This initiative is a powerful equaliser in providing access, specifically in this context by developing and improving student access to digital, remote learning.

> *Many teachers now have this idea that it's going to be virtual for a long time, and that it's inevitable. The actual physical space of a classroom crumbles away and deteriorates. Some people think that people are going to have AI goggles and be in a chemistry lab. Maybe 2020, around the start of the pandemic, one of my students was the first to kind of present that idea to me, and I though, wow, that's a completely new thought. But as we've ventured into AI and all of this shift to remote everything, it opens up a world of possibilities.*
>
> - Sam

The world of education technology is especially important now given these developments, and the effects that have been noted by my interviewees. New opportunities in the classroom have been opened up thanks to providing simply the *ability* for digital education. In context, the highlighter and catalyst effects of the COVID pandemic have redirected education towards the realm of technological thought, and caused it to head in that direction *at a faster rate*.

Ultimately, access to the internet is a vital factor as it allows students to use online softwares - which I will discuss in the following section -, as well as ensuring consistent education-delivery. Although internet access remains a subset of hardware access, it is nevertheless necessary to ensure as many students as possible have access to education regardless of circumstantial barriers. Furthermore, internet access allows for the use of new, modern technological platforms when going through schooling.

2.3 Access to Educational Platforms

> *And, you know, it's not just the internet, but it's the hardware as well, as people may own phones, but not laptops. If you can't really type in so if they have the*

[28] "Chicago Launches Groundbreaking Initiative to Bridge Digital Divide, Providing Free High-Speed Internet Access to over 100,000 CPS Students." City of Chicago :: Chicago Launches Groundbreaking Initiative to Bridge Digital Divide, Providing Free High-Speed Internet Access to Over 100,000 Cps Students. Accessed April 14, 2022. https://www.chicago.gov/city/en/depts/mayor/press_room/press_releases/2020/june/CPSInternetAccess.html.

> *internet, and the hardware. Then they still need to actually access, these platforms, which sometimes you have to pay for them… So I'd have students who used the platforms we had access to for gamified learning and for learning things for reading and math.*
>
> - Michael Havazelet

Amongst educational platforms, there is a significant amount of variety across access metrics. Part of the argument for SAT / ACT optional university applications refers to these varying degrees of access. This is not limited to the realm of already-existing programs, but extends vertically downwards (wherein access to hardware and internet correspond to success on these standardised exams) and upwards (additional, extra-curricular private mentoring which has the same effect). Nevertheless, when we consider the individual layer of access with respect to educational platforms we find a varying degree of utility. Some of the most interesting data from my interviews came from breaking down educational platform access to *individual* access - whereby students and parents tend to take the decisive action with regard to the purchase of or signup to an educational platform -, and *institutional* access - whereby schools take this final decisive action.

> *As the deputy head of a school we really face two roles. First and foremost, that's to provide as positive an educational experience while they're at school, and anything that is connected to the school. For example homework, clubs or whatnot. But secondly, and secondary, it's to help the students find an incentive or motivation to learn. We want them to want to learn. Technology can be great for that, so we try to encourage them to find and share resources amongst themselves and with their teachers… We know some of the students use the internet to sort-of self-revise. This is usually YouTube, and there are a few great websites it seems. Others are pretty fortunate to be able to pay for the more heavy-duty stuff. One site called UpLearn, for example - it's great, but it costs $200 per year, per subject. Few students can afford that.*
>
> - Mr. English

If we consider the SAT or ACT exams, there is a huge market that provides a significant amount of value. Havazelet explains that despite this, programs which provide the *highest* value to students are often price-locked, and therefore only available to specific socioeconomic regions.

Prepscholar, for example, charges $399 per year. This is simply unattainable for a large majority of the Chicago population.

The issue with individual access, as described by English and Havazelet, is relatively simple. They each argue in their own way that the public sector is limited in its ability to support students on this level: *the government isn't going to pay for students' Prepscholar memberships*, says Havazelet. Public support programs exist, such as BBC Bitesize which supports students in the UK with their GCSE exams, however this doesn't escape the issue of price-locking higher-quality programs.

Chicago schools have also experimented with technological platforms. This, however, is often focused on *maintaining* and *supporting* in-class activities, meaning that attendance can be maintained regardless of whether students are there in person, and their activities such as labs can be done regardless of being in a lab environment. Aracelis Janelle Sharon, a dean of instruction at an anonymous public school, described her experience with educational platforms as two-pronged with respect to access. Firstly, she describes financial restrictions. This includes fixed costs by which certain programs entail sign up costs as well as initial purchase of the required hardware, alongside recurring costs - wherein companies charge yearly subscriptions to carry over the delivery of their product. Given the sunk costs entailed from initial purchase, schools are often heavily-incentivised to retain these programs despite the low marginal benefit. Sharon describes some of these technologies as a *gift that never gives back*.

> *Our facility, which has only four lab rooms, and we have our capacity which is 900 students per lab room. This means that we have other classrooms being used for science. And so we don't have the ability to be doing what you would have expected to be doing frequently. And so we have to look at simulations instead. And for the costs of simulations, we look at the ticket price for somebody like that for just a year. Again, we have to end up committing to multiple years which can easily be $10,000, for one annual licence for a grade level. So, it in theory, yes, fantastic product, we have no lab states, so we use it. But the annual cost and renewing it is where we get stuck, because as a public school, your funds have to zero out at the end of the year. And then you have to project what your school*

> *improvement should be for the next year. And that's a ticket price to keep going right?*
>
> - Aracelis Janelle Sharon

Sharon describes an interesting balance between the exchange of financial resources for physical goods versus digital goods, wherein schools must decide whether to invest into maintaining a robust digital system, or whether to develop and improve physical infrastructure. In the example above, Sharon's school faces the decision between building new physical labs and supporting digital labs. I believe the discussion of taking into account the cost-benefit analysis of this decision over time is of particular importance: in understanding educational platform access we must look at the cost-benefit with each decision. Access remains somewhere within this balance, Sharon claims, as she must weigh *how many* students are able to participate in the physical realm versus the virtual realm at each price point, over a prolonged period of time.

The opportunity for ed-tech here comes from developing efficiencies in these programs. Sharon points out that this program is relatively new, and that fostering a sense of competition is necessary not only for the improvement of the technology - in this case better virtual labs with more features, better graphics, more accurate representations and so forth - but also as an opportunity to decrease these technologies' development costs. In decreasing their costs, they are able to be provided to schools at more reasonable prices.

Furthermore, these technologies are relatively early, meaning that they rely on both digital and physical infrastructure for their maintenance. This is not limited to the example of the virtual lab, but also platforms such as Canvas and Schoology. Despite achieving remarkable results as learning management systems - Reyes, Weiss and Hooley remarked on improved homework turn-in rates, better teacher-student communication and fantastic grade-tracking features - this is nevertheless at the cost of maintaining this infrastructure. Sharon explains how the cost of maintaining these programs *include* all that is required exterior to the technology itself creates another factor to consider:

> *We have platforms like Canvas, or Schoology. So now we're building out things to house all of these technologies, and the apps and sync them and the SSOs, the single sign ins, because that also requires now the cost of a technology department?*
>
> - Aracelis Janelle Sharon

In conclusion, there are a few key elements of successful access-provision of educational platforms. Firstly, we must consider how students and parents can independently venture to find their own resources. English explains below:

> *And with the process of making sure our students have the tools they need at their disposal, we're fully aware that much of the learning is done outside the classroom. We'd like to say that in-class teaching and whatever homework our teachers set is enough for them to get what they want on their exams. But that isn't really the case, especially with the higher-achieving students. They're the ones that push themselves and take their own initiative - but again that's just because they actually have the willpower to get through and spend that extra time searching for what they need. Ideally, we have a program that they enjoy using, and we can remove any friction that they would have to study. Like Century, for example.*
>
> - Mr. English

Secondly, we ought to consider institutional and school-based access to these platforms. These are rarely cheap, and so developing a framework by which we can understand the cost-benefit dynamic over a range of time would be an important feat in projecting the ed-tech landscape. This includes taking into account both fixed and variable costs, with a particular importance on long-term fixed maintenance costs. In doing so, the calculation of access-provision becomes clearer for the parties at hand. Furthermore, this ought to include an understanding of the interaction between technology efficiency, as well as infrastructure development and maintenance costs. Over time, the cost to maintain the infrastructure for the platforms will fall as they become increasingly efficient and robust. By having a structure in place to understand how these variables affect one another, we will be able to comprehend better how access varies with these technological progressions.

3. Implementation

Section Interviewees

Interviewee	Role	Date
Eric Reyes	- Former high school mathematics teacher, Baker College Prep & Chicago Bulls Prep	3/1/2022
Stephanie Shen	- Former English teacher, Miami-Dade Public Schools	3/6/2022
Michael Havazelet	- Former teacher, Humboldt Park region (anonymous school)	3/7/2022
Aracelis Janelle Sharon	- Aracelis Janelle Sharon, dean of instruction, Chicago (anonymous school)	3/8/2022

Interviewee Foreword

In this section, my findings were focused primarily on access issues with respect to Chicago. As a result, I have focused on my interviews with those who have either taught in Chicago, or have had insights that can reasonably be extrapolated the discussion of access in Chicago. I believe the question of access is *not* homogenous across geographical location; it is not even homogenous within the city of Chicago. Furthermore, its heterogeneity within the city of Chicago is *unique*. Therefore, I have omitted data from my interviews with Sebastian Weiss, Mark Hooley and Stephanie Shen.

For this section, the *unique* aspect of my interviews comes from direct, real experience with education technology programs *over time.* This means that the data I have looked at examines the success and failures of different programs and their implementation with first-hand experience. Reyes and Shen are able to discuss first-hand results and provide a chronological timeline of *how* and *why* they implemented this. Although the success of different ed-tech programs has been evaluated in the literature, I believe this data is unique in its ability to dissect the various aspects of implementation from conception to final form.

> *Implementation is something that is really important. You know, you can take the same product and implement it great, and it works great. And the results are great. And then you can implement it badly, and it has no effect.*
>
> - Aracelis Janelle Sharon

The most common theme throughout my interviews has been the discussion of implementation. Almost all of my data has discussed both successes and failures of various programs and for a variety of reasons under the umbrella of implementation. Most importantly, I found two things. Firstly, that the quality of the platform was far less correlated with success of the program than I had initially imagined. A high quality program with serious potential often failed for no reason other than poor implementation - and given correct implementation, the program would have succeeded. Secondly, that the design of the platform is just as important with respect to implementation as the attitudes of the teachers. For example, developers of a platform may have done everything correctly, and provided all the necessary tools required for the success of the technology. However, because of teacher or student misuse there is little ultimate uptake in the product.

I have discussed implementation second to access because *there is no implementation without access:* access is upstream from implementation. My data has also shown that the issue of access is very different to that of implementation; they don't *really* overlap. Therefore, in this third section of my findings I discuss the importance of implementation in the classroom, and explore two case studies that I believe effectively highlight what *good* implementation looks like, and what *bad* implementation looks like.

3.1 Structural Implementation: iXL vs iReady

In some ways, the difference in success between iXL and iReady is the perfect example with respect to highlighting the importance of implementation: they practically have the same name. I spoke to Eric Reyes and Stephanie Shen about their experience with specific technologies in the classroom. Reyes discussed the value he was able to get from iXL, and Shen discussed the failure in

her school of iReady. In examining this case study, I will first discuss what worked with iXL, and then what didn't with iReady. I will then discuss how implementation played the primary contributing role in these programs' results.

3.1.1 iXL

iXL is a personalised learning platform offering comprehensive K-12 curriculum including math, language arts, science, social studies and Spanish. In each age group, there are specific *skills* that are tested. For example, shown below is one question in the *Prime or Composite?* quiz for a seventh grade math student. If you answer correctly, your *questions answered* log increases, and so does your *SmartScore*.

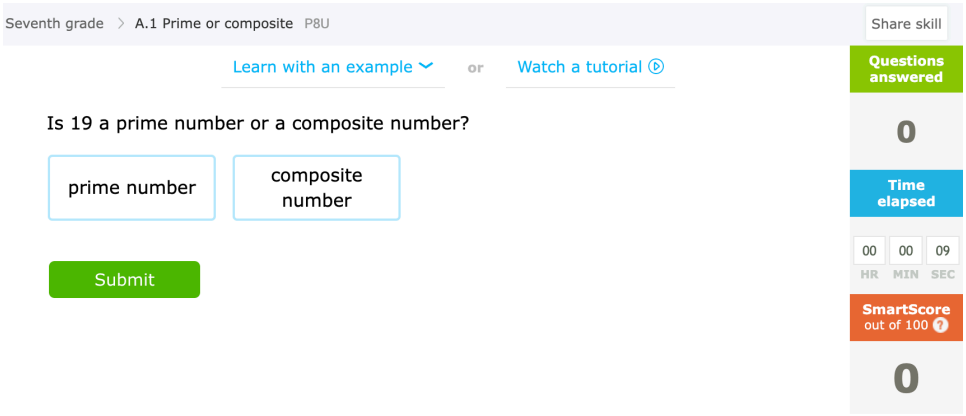

Figure 3: iXL sample quiz

> *I used iXL for my non AP students, just because it was good for reps. It's very easy: you just have your kids join it, and then there are practice problems online. If they have an account, they can get a little points and stuff. That was really good for them because I think there were a lot of concepts that they needed to study that I could just be like, alright, work on iXL. And it was actually a great level.*
>
> - Eric Reyes

Although the *quality* and *quantity* of reps, as Reyes highlights here, are important I believe what is worth extrapolating is the freedom with which students are able to study. There are very few restrictions with the program, and students were able to learn at their own pace. At the same time difficulty levels were named on a letter scale [A - G], as opposed to rank or percentile. As a result, students were always being given positive reinforcement as they studied. Reyes estimates 80% of

the students would work through the problems with fidelity, which he deemed very successful as far as classroom-work goes. Reyes also explains that given he used iXL for his non-AP students he was thus able to re-structure the class so that specific focus points could be directed towards specific students.

> *Once I was able to kind of use the iXL platform in conjunction with my own classroom teaching - I was teaching calc and pre-calc kind of in the same year, which is really not something I was able to do until I got this curriculum - I saw those results go from a 3 point growth, to a 10 point growth.*
>
> - Eric Reyes

Reyes argues that there were two primary factors that contributed towards the success of iXL. Firstly, the freedom permitted by the program allowed students to work *at their own pace*. As a result, given tracking of the students' progress Reyes was able to speak to students individually and understand they were progressing. He explains how if he saw a digital struggling marker on a student's screen he would be able to go to them and ask '*hey, how are you doing with this? Let's work through it.*' Furthermore, Reyes argued that the system developed by iXL supported students in gaining confidence in their studies: as they moved up ranks, they would become increasingly motivated that they were learning, and increasingly engaged with the material as a result. Due to the digital medium through which students were practicing, the initial frustration of getting a question wrong rapidly wore off: they understood how the program worked, and had experience with getting it right. The failure of an individual question had no lasting effect as students were *used* to the program and understood that eventually, they would get it right. This, Reyes argues, is a valuable note of digital content engagement.

The primary positives from iXL are the amount of leeway and freedom provided by the platform, and the factor of engagement. Nothing is forced upon the student in iXL; students work at their own level, their own pace, build up their own account, and have their own, personal interaction with the platform. As a result, Reyes describes this increase in engagement as a positive impact on the classroom. As above, following the use of iXL he remarks on results *going from a 3 point*

growth, to a 10 point growth. This is in perfect juxtaposition to Stephanie Shen's experience with iXL's counterpart *iReady*.

3.1.2 iReady

As explained by iReady's website, iReady is an online program for reading and/or mathematics that will help students' teacher determine their students' needs, personalise their learning, and monitor progress throughout the school year. i-Ready allows teachers to meet their students exactly where they are and provides data to increase your student's learning gains. Shown below is a sample diagnostic test run by iReady, designed to determine the level a student is at. The program measures time taken, lessons passed, current streak, as well as lesson pass rate. This is a very similar offering on principle to iXL.

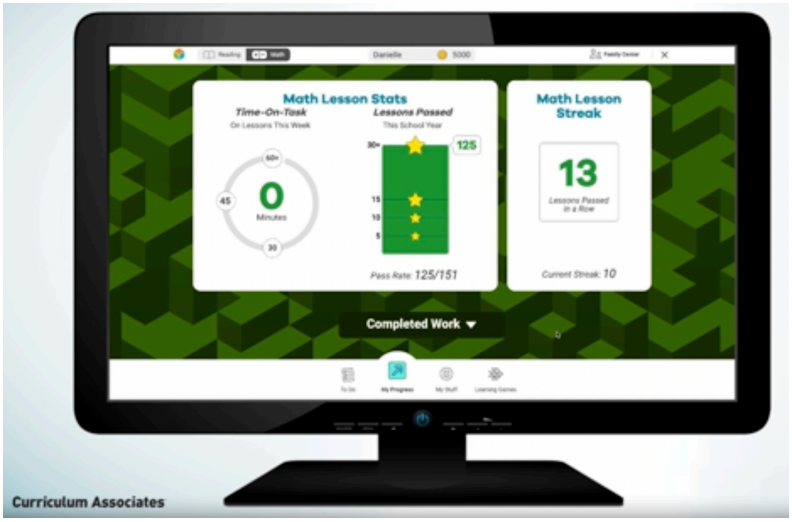

Figure 4: iReady sample quiz

> *Before this programme, students would take like a test in the school year that would evaluate their proficiency and place them by level. When the kids are on the computers by themselves, they basically start with lessons at their level. Initially iReady was to be used as homework. But then because kids at our school, don't have access to technology, they started to have to do it at school. There was a lot of negativity and pressure around this programme, because our district would see how many minutes we were logged in to the programme. And so it was just like, so ridiculous. Because if I only have X number of minutes with my students, I don't want to spend, like 60 minutes with a logged in. It became a balancing act between what I thought my students needed, versus what my administrators were telling me.*
>
> - Stephanie Shen

Despite the similarities in content and design of both iXL and iReady, their implementation was completely different. Shen explains that the school she taught at frequently received visits from the district to see if the program was actually being used. At the same time, teachers were required to fulfil time quotas on the platform with the incentive of additional state money. What ultimately happened is that this arbitrary minute quota had been placed. At the same time, students only had so much *schooling time*, and teachers only had so much *teaching time*. As a result, tried and tested methods were forced out and replaced by iReady's digitised platform.

This is vastly divergent to the principles upon which iXL was based. Instead of iReady offering increased levels of freedom, it restricted them; Shen describes this implementation as a needless imposition on the teachers. And despite providing a similar grading functionality whereby students could track their progress, see where they're at and identify weak-points in their understanding of the content, iReady had net-negative effects on their students. There was also no improvement in student engagement despite the digital medium.

> *I did not see any, academic gains from using this programme. It became such a chore for the kids to go to the computer lab once or twice a week just to meet their minutes. So it really took the joy out of learning.*
>
> - Stephanie Shen

When looking at the difference between iXL and iReady, we beg the question: *would iXL have succeeded if it followed iReady's implementation method, and would iReady have failed if it followed iXL's implementation?* Despite this being a yet-to-be-proven counterfactual, my data implies that the answer here is *yes*. iReady itself was not necessarily a bad program; in fact it is still running today (years after Shen's experience with it), which implies some degree of continued success. However, the way in which Florida state decided to implement the program within schools that took iReady on-board was undoubtedly unsuccessful. Unfortunately, I was unable to record an interview with another user of either of these programs to get a third perspective on their respective successes.

3.2 Psychological Implementation

Despite the previous section placing a major focus on structural implementation of digitised educational programs, this is only one angle of implementation. We can consider structural implementation to be the chassis within which technology is delivered *to the school*. The other significant findings in my data have involved teachers' interactions with the technology, which is the next step in *how* it's implemented. Therefore, we can consider structural implementation to be *how the technology, upon being delivered to the school, interacts with the various actors in the educational institution*.

> *I used it to track the student's performance, it had a sticker system. If they do well, you can reward them, and it plays a cute sound. If they do poorly, it has a sad sound. Students would hear someone get rewarded for being quiet, so the whole class was really quiet. Most of my colleagues used it as punishment. They would log their entire classes in negative points. Over time, it had no effect on the kids. But in my class I only did rewards; it was all positive reinforcement. I found it to be very useful. However, in the following year they asked me to teach a seminar on how to use it. There was no buy in because other teachers already had a bad experience with it.*
>
> - Stephanie Shen

Unfortunately, the name of the program mentioned by Shen is unavailable. However, as she describes it had a very simple system: students would be rewarded or punished based on their behaviour in class via a positive or negative points system. This could then be reported back to parents and used as student feedback.

Shen outlines the aspect of teacher optionality when using the platform: teachers had the *choice* of whether to engage with the program and use it positively or negatively. The implementation here was not dependent on any prior technological or human-enforced structure; teachers were not forced to use the app, and the app itself placed no restrictions on how it could be used. However, as a result of misuse, the project was quickly binned by the teaching authority at the school.

We can also take this in the context of iXL and iReady. If we imagine that there were no use-restrictions on either of the platforms and as a result any restrictions placed were up to *only* the teacher implementing them, we would likely have similar results. For example, if Eric Reyes imposed a time quota on students to use iReady in the form of '*you must use iReady for sixty minutes a day*' then this would likely render worse results than it had. Furthermore, we can delve into the specificities of the implementation restrictions. For example, if Reyes instructed his students to log sixty minutes daily, versus complete 10 lessons daily. This may take each student a similar amount of time - however, it is wholly imaginable that those instructed to complete sixty minutes would spend half their time on other distractions and leave the program running in the background.

3.3 Implementation in the Context of Chicago

> *I would have kids that were home alone, and trying to navigate the technology on their own is very different. I'd have a lot of kids where they were going into informal child care settings. One little boy that had learning disabilities would go to his aunt's house because his mother was an essential worker at the time. And there were 12 children in this small apartment. So when he'd come on Zoom… he would have to go to a closet where it was quiet. I'd often have kids calling in from a car or going shopping. These are the sorts of issues where you see the all of the forms of inequity and scarcity really intersecting with the technology and and being made explicit in ways that weren't obvious before.*
>
> - Michael Havazelet

Education technology implementation within Chicago correlates significantly to the varying degrees of socioeconomic disparity faced across the city. Havazelet describes the plethora of issues in effective educational delivery with respect to his own students - largely stemming from unfavourable home conditions. He claims the case above is commonplace among the less-fortunate Chicago regions. Aracelis Janelle Sharon ties issues of internet access together with issues of technology implementation:

> *The thing though, is what kind of internet right you need. If you think about your phone, what is the the bandwidth? What are the data limitations? And are those limitations troublesome?*
>
> - Aracelis Janelle Sharon

Furthermore, we can refer back to Olivia O., the Englewood parent who described the process of receiving *'one Chromebook but [having] three school-age children at home… We're all in the house trying to share one Chromebook and a cell phone*.' These highlighted issues are primarily tackling access over implementation - however I believe this data goes to show how access and implementation are, in the context of the heterogeneous socioeconomic conditions of Chicago, intertwined.

3.3 Implications of Implementation

The importance of implementation, naturally, stems from student results. Teachers reported positive implementations of education technology, but this is only important if positive implementation leads to positive results. This positive implementation can be both on the teacher side (e.g., increased teaching freedom, improved class flexibility) and on the student side (e.g., increased hours of studying, increased engagement with the material). In the above section, my interviewees have discussed each of these at different points in their interviews, and here I will synthesise these findings into understanding what these positive results can - and have - looked like in terms of end-point metrics with a focus on the implementationary values of freedom and engagement..

Freedom Teacher freedom is a critical element of student success. New classroom designs such as flipped classrooms - which have been adopted even into many of the UChicago course curriculums such as Global Warming - mean that a greater amount of material can be tackled with the same number of resources. This is really a form of efficiency gains. Reyes describes how having been able to *use the iXL platform in conjunction with [his] own classroom teaching, [which is] not something [he] was able to do until [he] got this curriculum - [he] saw those results go from a 3*

point growth to a 10 point growth. Although not all my qualitative data cited quantitative point-growth results, this is a prime example of how technology can improve student performances. Zheng et al. describe finding the flipped classroom to have a moderate effect size for learning achievement and learning motivation[29]. Of course flipped classrooms are only one possibility pertaining to educational freedom, but go to show how these freedom-enhancing classroom designs can improve student results. The student-focused elements of freedom such as *mobility* and *ubiquity* are discussed above in my literature review, and be extrapolated here.

Engagement Student engagement is an important factor when considering student success. Stephanie Shen describes her experience with the digital behaviour-reward program, wherein students can be digitally assessed and given positive or negative point scores. This is one of the metrics where it's really difficult to measure quantitative results, and it is outside the scope of this thesis to discuss to what degree engagement increases test scores. However, studies have shown that *engagement had positive, statistically significant effects on grades and persistence between the first and second year of study for students from different racial and ethnic backgrounds[30].* Furthermore, Kuh et al describe how *equally important, engagement had compensatory effects for historically underserved students in that they benefited more from participating in educationally purposeful activities in terms of earning higher grades and being more likely to persist.* Therefore, if we understand the qualitative results with respect to engagement that Shen describes, this serves as an indication from the literature that this results in further academic achievement.

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[29] Zheng, Lanqin, Kaushal Kumar Bhagat, Yuanyi Zhen, and Xuan Zhang. "The Effectiveness of the Flipped Classroom on Students' Learning Achievement and Learning Motivation: A Meta-Analysis." *Journal of Educational Technology & Society* 23, no. 1 (2020): 1–15. https://www.jstor.org/stable/26915403.

[30] Kuh, George D., Ty M. Cruce, Rick Shoup, Jillian Kinzie, and Robert M. Gonyea. "Unmasking the Effects of Student Engagement on First-Year College Grades and Persistence." *The Journal of Higher Education* 79, no. 5 (2008): 540–63. http://www.jstor.org/stable/25144692.

4. The Direction of Education Technology

Section Interviewees

Interviewee	Role	Date
Shantà Robinson	- Assistant professor at the University of Chicago - Former 9-12 Social Studies Teacher, Charlotte-Mecklenburg School District	2/18/2022
Eric Reyes	- Former high school mathematics teacher, Baker College Prep & Chicago Bulls Prep	3/1/2022
Sam (pseudonym)	- Administrative assistant at educational initiative	3/1/2022
Katie Malcolm	- Professional school counsellor at McCutcheon Elementary School	3/5/2022
John Lim	- Former high school teacher, Noble Network of Charter Schools	3/6/2022
Stephanie Shen	- Former English teacher, Miami-Dade Public Schools	3/6/2022
Aracelis Janelle Sharon	- Aracelis Janelle Sharon, dean of instruction, Chicago (anonymous school)	3/8/2022

Interviewee Foreword

In this section, my findings were focused primarily on the discussion of what the future looks like for education-technology access and implementation. For the question of access, I focused on interviewing *only* those within the Chicago region. This is because Chicago has a very specific contextual access situation, meaning I did not feel there would be adequate external validity from observations from those outside the city. When discussing implementation, I left some leeway as I believe there *is* external validity to the implementation question despite geographical diversity.

For this section, the *unique* aspect of my interviews comes from on-the-ground, balanced perspectives of education technology. I avoided using data from interviews with Weiss and Hooley in order to maintain neutrality throughout. When considering other literature, I believe this paper has both kept to extracting honest viewpoints but also given a sense of freedom and leeway when discussing education technology. Therefore, these interviews in this respect have been unique in their openness and neutrality.

> *We can also use it to expand horizons. We can also use it to give hope to children. We can also use it to expand access to everything that is possible about about their future selves. And I think that's something and then to show them how to do that on their own right, to empower them to do the next step.*
>
> - Shantà Robinson

With an understanding of the present state of access to and implementation of education technology in Chicago high schools, in my fourth findings section I will explore what my interviewees imagined the future of education-technology to be. Within the realms of both access and implementation, I believe there is not only a clear direction, but also Chicago-related developments. My findings here have been very interesting as they range from very general, wide claims (such as education technology can serve as a catalyst for students to understand and develop their life goals) to very specific (such as education-technology developments ought to facilitate communications in within certain educational niches). I have broken down this section by first looking at my data with respect to access, and secondly with respect to implementation. I have opted to begin with the data that takes a wider scope, and narrow these observations and ideas down as each section progresses. In the subsequent section, I will explore policy goals with respect to this, wherein Chicago's public policy leaders can take a decisive role.

4.1 The Future of Access

> *It has to be who parents, teachers, and in the school districts to embrace technology, instead of punishing students for using their smartphones, incorporate smartphones somehow in the classroom, make them a part of the learning process instead of external to it.*
>
> - Shantà Robinson

Robinson makes an intriguing argument that, at a wider scale, the embrace and ensuing internalisation of education technology is key to its success. In my first findings section, I discussed the evolution of ed-tech over time; some of the most important findings related to what some see as technology in the classroom developing into an infringement on class. Katie Malcolm discusses how there has become a constant battle between teachers and technology as students find themselves *stuck to their phones*. Furthermore, she says that school policies such as phone-

confiscation during class hours was initially successful, however became problematic as phone addiction spreads. Hence, as Robinson argues, a process of internalisation is necessary for education technology to reach its full potential.

This internalisation process is key to overcoming the present friction. Mr. English stakes the claim that *in any important change, those who who contribute to this change must undergo a paradigm shift. Kuhn talks about this in The Structure of Scientific Revolutions - but of course it's not limited to just that. This certainly applies to education, as well.* What this means for education is that the integration of technology into the classroom is necessary for the future of ed-tech to remain bright.

This relates to the importance of access as it encourage the adoption of technological hardware and software. The first step to ensuring widespread access is the *acceptance* that education-technology is important. As an analogy, when moving from using gas to electricity in our lightbulbs, it was necessary for electricity to be recognised as an *important* with respect to its function. Using wood, for example, is not recognised as *important* when discussion the provision of light. The same theory goes for education; we have determined textbooks, study guides, notes, past exams and so forth as important to the learning process. We have also recognised the importance of teacher-student interaction as important. COVID highlighted the importance of technology as a means of maintaining access to education. The next vital step is understanding technology as an important element of the classroom. With this understanding, incentives are created to develop and improve the state of technology as a function of education.

> *When it comes to the direction of ed-tech, there are people trying to create supply where there is no demand. I remember somebody called me and they were said, "Here's a program that connects people's numbers. So if I'm a teacher, I could text my students and vice versa. So it was very visible to parents. I was thinking it was cool, because it means I could get finally get in contact with the students and parents and everyone was on the same platform. But they came to me and said "you seem to be have trouble getting contact with students." This was the case - their parents too. Many people we've talked to have trouble getting contact with*

> *teachers, which is a foreign concept. So it's difficult. Where there is demand, it's on the curriculum side, it is on the remote learning side.*
>
> - Eric Reyes

When discussing the future of education technology, Eric Reyes focused solely on increasing the efficiency of spreading access to resources. We are at-present in a relatively early stage in our understanding and development the market; Reyes argues that it's important to identify solutions step-by-step. He cites the example of developing very specific products that tackle very specific educational issues. This, Reyes claims, is not the way forward *right now*.

This observation links to Robinson's as it implies the need for *internalisation* of technology. The specific problem described is not of a lack of quality of program, but rather the readiness for individuals involved in the education process to accept these solutions. Without this initial paradigm-shift, students and parents will be reluctant to accept full adoption of such technologies (in this case provide personal information such as a phone number).

Furthermore, Reyes highlights the broadening of access as *the* vital first component of widespread education technology adoption. This includes making-virtual courses, revision material and practice questions. This point is also specifically access-focused, in the same way that the development of Khan Academy has supported access to more students. Exams such as the AP or SAT / ACT in Chicago *can* have their resources digitised - doing so efficiently means that access to high-quality resources can be expanded.

> *So I guess specifically, as an English teacher, you want your kids to like love reading and writing. And for me, like, I found that through reading fan-fiction. And maybe the language isn't very good, or whatever. But as long as you get people interested in reading, then that's how you build endurance to read more difficult and more dense things. And so for me, I really wanted like my students to be able to read whatever they wanted to read at their level at their pace. And I know that there are a lot of apps available for that, as well as things that even guide students on following the lines if they have like any learning deficits. Then, there are apps that like keep kids focused on one line at a time and reward them for making progress. So I would have loved to be able to use some of those tools in my classroom.*
>
> - Stephanie Shen

Another element of access comes through broadening the means of receiving education. Shen discusses not only how niche issues *can* be tackled, but also how access can be widened through these specific solutions. The current system, Shen argues, is relatively limited; and since students learn at different paces accommodations are necessary. This often disrupts the class and makes learning less efficient, she argues. As a result, access to education is limited across the board, and disproportionately limited to those who have such disabilities.

In Shen's example, following the internalisation of technology into the classroom, not only will further issues - such as access - heterogeneity become highlighted, but become a focus for new technologies. She describes how reading fan-fiction inspired her interest in reading and writing, and teaching. However, for many students this isn't *really* possible on two levels. Firstly, access to fan fiction is not available to all. Secondly, those who do have access may be limited by learning or reading disabilities. This principle applies to more than just the literary niche of fan-fiction of course; maths, social studies and language suffer from the same issues, Shen claims. Therefore, by allowing education-technology into the classroom, we will be able to tackle these niche issues with which solutions that have not been historically present.

Although at first sight Shen's discussion of niche solutions for niche issues may seem contradictory to what Reyes advocates, it is important to keep in consideration that, with respect to access, my data suggests a *process*. This does not mean immediately developing all that could be created within the ed-tech sphere. Rather, it means taking gradual steps - first understanding there needs to be a paradigm shift, and secondly broadening access with a focus on *quantity*. From there, niche programs can take charge through understanding the successes and failures of various technologies and apply these to specific problems such as dealing with students who have learning disabilities.

> *There's that study that is often cited where your zip code determines your educational success more than the factors of your parents' income, your aptitude on your middle school tests, and all of those other things combined. Now, the nice*

> *thing is even if you grew up on the south side of Chicago, can that student engage with resources they couldn't hit before? Can that student engage with students they wouldn't have engaged before? So instead of just interacting with students, and in their class, right, in their zip code, can they combine south and north side? You know, where we have combined class and / or combined resources, right? I think that direction is where we're going. Teams can be more agile, more remote and, and potentially diverse.*
>
> - John Lim

With respect to Chicago, Lim points out the imperative of finding solutions to these heterogeneous access issues that lead to the Chicago educational divide. By developing resources with widespread access potential, steps forwards can be taken to ensuring not only a high quality education system in the city, but an equitable one as well. This relates to Reyes' point above: access-expansion is the future of ed-tech, *before* niche efficiency-gainers.

Access is a multi-layered issue, and so prior to new technology developments must be an initial process of fundamentals distribution. This includes both the distribution of hardware and internet, as Sam describes below, which in combination facilitate access to online educational platforms.

> *I think the Internet will continue to be, you know, the financial challenge for some families until we can figure out how to offer reliable low cost internet to some of our lower income families. That's always going to be a challenge.*
>
> - Sam

Once this is achieved, however, Reyes believes that improvements and innovations of access-widening programs such as iXL are the most important first step. Weiss describes how *BBC Bitesize* in the UK is a valuable tool developed by the public sector for GCSE (age 16 exams) students. He suggests a similar program designed for the Chicago educational system would prove very valuable.

4.2 The Future of Implementation

> *We also assume that because they're young people, this generation is so good at using technology, that they know how to use it for their benefit. And that they know how to use it in positive ways. And that's a fallacy. I think it's a fallacy to think that teachers know exactly how to use it. Because teachers have to learn to*

> *teach. It's not something that you're born and it's like, you know what, you're a good teacher. Now, you're just born a teacher. I don't think that happens.*
>
> - Shantà Robinson

The fundamental point with implementation in the future involves lubricating the path by which the internalisation of technology can take place. Implementation is what provides this; how *easy* is it to use for both student and teacher to *use* the technology? Robinson points out that simply because technology is commonplace, technological literacy accompanying this is a '*fallacy*'. This brings in the interesting point that new technologies require new skills - different variations of technological literacy are necessary to be able to fully equip these platforms, apps, programs etc. Ensuring that upon the adoption of of these, skills are taught, is key for the future of the success of the programs.

This ties into my argument made in the implementation section wherein incentivising further education technology development leads to increased ease-of-use. As new platforms are created, these new platforms put emphasis on understanding the style of adoption. This is a result of having a broader and more complete view of which platforms are successful, and which aren't. Furthermore, there is an understanding of *depth* by which certain platforms may provide similar offerings, but end up being successful as a result of the success or failure of sub-sections of these individual platforms.

> *It's much easier for everybody to take [exams] online. We get the results almost instantaneously. Schools will get the contract of the state exam, from CPS for example. We're outsourcing it to them so we all end up using certain programmes. The only paper tests we take are for students that have accommodations: a learning disability, or another reason that you couldn't take it on the computer. These days, that's the only way you will get a paper copy of the exam. It's been this way over the past few years, and it seems as though this will be increasingly the case for more and more exams in the future.*
>
> - Katie Malcolm

Alongside this, Katie Malcolm believes that additional processes of the educational system will adopt technological interventions. She initially described her experience with phones in the classroom as somewhat intrusive, and found that gradually certain technological classroom

additions - using Kahoot as an example - were vastly beneficial to teaching. Stephanie Shen makes a similar point in describing how *[schools] take a lot of their tests online. But much of the time, students are actually pretty unfamiliar with them. For example a lot of my students can obviously read and write very proficiently, but when it comes to typing they don't have a computer at home. So they type with their two index fingers, really slowly*.

However it is testing, as opposed to learning, where state interventions are forcing technological take-up. Exam providers work closely with the public sector, Robinson explains, to supply the content and quality of education. So something like a *digital exam* is really a method to find efficiencies and not have to spend money on paper and ink. I believe it is possible that this is where ed-tech innovation starts. Students' yearly learning is often dependent on the exam. Revision is focused on exam-based preparation, as that is what a) benefits them and b) benefits the school. Therefore, it is reasonable to believe that certain important parts of the learning environment should aim to reflect the exam environment.

As discussed in section two, a key element of implementation is how it allows for freedom within the classroom. There is no downside to technology implemented with freedom: at worst, it is simply not used. At best, however, we see the results of such implementation come in the form of those outlined by John Lim below. My interviewees have discussed two primary aspects of this freedom:

1. **Student Freedom**

> *If I can focus on acquiring the information outside of the classroom, then I can focus on applying and evaluating and engaging that information in the classroom. For example, if students read chapters three through six outside of the class, and then come to discuss it, you will probably leave with a greater depth of knowledge and information and how to use that information in schools. Versus if you came to class every week and spent the time reading chapters three through six in the classroom. So flipped classrooms in terms of engaging student learning on a depth that they hadn't before were already becoming a thing.*
>
> - John Lim

Flipped classrooms are a relatively modern idea - or at least their take-up has come with modern times. Lim explains how students are able to learn with greater depth: by being given additional optionality in their studying, they can develop an understanding of the material at their own pace and on their own time. As a result, Lim has identified an improvement in depth of understanding, as well as engagement with the material.

The other consideration is that of the students' parents. With this technological freedom, parents of students are able to take a more active role in their children's educational attainment. By providing students optionality, technology widens the breadth of time in which they are able to study. This means that both homework *and* learning can be done in the home. Furthermore, digital programs that can be adopted by parents means that they will be better-able to track their children's progress with the material.

2. Teacher Freedom

> *Technology could get me to a place where I can have a discussion, but with the students specifically. So I would know they needed to practice X. I could go up to a student when I noticed, for example a little iXL thing, where I could say, hey, how you doing? I'd say, hey, let's just talk about this. It was like a really easy conversation to have, and technology empowered me to do that. But, if I had just let them go, they would have just kept spinning their tires, and nothing would have changed, right? So that's where I thought my role is.*
>
> - Eric Reyes

The second aspect of freedom involves teachers' freedom to *provide* education and be able to support students at the teacher's own pace. This can include as Reyes describes, flipping the classroom to allow for the breakup of students across skill levels. This way, teachers can choose to target specific sections of and students within their classes. Reyes explains that this model has been undergoing increased adoption that is correlated with improvements in technology facilitating it. He also claims that amongst teachers he works with, that there is unanimous agreement such a model is often beneficial to students.

> *I think about the technology standards, just the idea of creation and innovation, but also environmental stewardship. So what what is this doing? And how is this creating more access, not just to your local community, but more culturally responsive and global access. So that definitely is where I'm seeing it go towards, but it is also meaning that we have to be more mindful of managing it. And, and sort of like, what, how it's used and why it's used. So our students for sure, are very savvy, but they are definitely not. They're savvy consumers, but they are weak at contributing. So you know, and I think that's the place we're really pushing*
>
> - Aracelis Janelle Sharon

Finally, Aracelis Janelle Sharon brought up an interesting point about where the direction of ed-tech ought to go with respect to social and environmental responsibility. And when considering the implementation of education technology, we ought to consider in parallel the degree to which it can *last*. This is, of course, an existential question; there is no future of ed-tech if environmental or social costs of its implementation outweigh the benefits. Sharon argues that this comes from a number of different angles. Firstly, from the perspective of solving sustainability issues within schools; *paper* education has a cost on the environment. Secondly, from the perspective of maintaining sustainability with newly-introduced technology; this includes metrics such as energy consumption and the footprint of technological hardware.

Policy Prescriptions

Given the direction of education technology - or at least the perceived and suggested direction of education technology - we ought to understand with this should mean for policy moving forward. It is important to note that education technology is still in its early days of both development and adoption. It is also key to understand that this is in many ways not a public sector focus nor necessarily an area relying on a public sector solution. There is still significant room for growth, and a significant amount of financial gain to be generated, meaning private firms will likely be the drivers of innovation. Finally, given its youth, new ventures remain risky; given this risk, the expected return of public sector investment in new projects will have an expected return that some may argue is a misuse of taxpayer money. Therefore, I believe that in some senses, *there isn't much the government can do*. Specific policies regarding education technology do not have a set policy agenda nor are understood to be commonplace.

That being said, within the realms of this thesis, specifically access and implementation, Chicago has been - and ought to continue - focusing on ensuring a wide range of access. In my policy prescriptions, I advise the continuation of access-provision, the development of research programs, and the incentivisation of the market.

A. Access

First and foremost, I would advice Chicago public education officials to continue providing access to technology and internet for all. *Chicago Connected* is an important initiative. With over 100,000 Chicago students lacking the necessary technology to access ed-tech, ensuring that initiatives are developed to achieve near-complete widespread access is undoubtedly fundamental to the success of education technology in the classroom.

At the moment, Chicago Connected has over 40,000 families enrolled in their program, 35 community organisations supporting digital equity and literacy, and has supported 228,000 students

in expanding internet service. These are fantastic results given the initiative only launched two years ago.

B. Research

The second key component of public ed-tech is understanding the educational landscape of Chicago in as much depth as possible. Research is beneficial to the city of Chicago, CPS and education technology in two ways:

Understanding the Problem Firstly, research such as that conducted prior to *Chicago Connected* allows us to understand the *who, where* and *why* of the problem. At the moment, Chicago has succeeded in understanding broad numbers and estimates of who is missing necessary technology and internet, however has not been able to evaluate further. I have discussed examples of households with twelve children, as well as households with one Chromebook shared between a family of five. In this case, access provision may come in the form of building dedicated study spaces. However until we have the research we do not have any concrete conclusions.

Understanding the Solution Secondly, the main difficulty in directly funding education-technology programs our relatively primitive understanding of it. As discussed in my findings, there are both positives and negatives, efficiencies and difficulties in its implementation. Research is one important way to be able to develop metrics of success of these programs, and then evaluate education technology based on those metrics.

C. Incentives

The third and final component of my policy prescriptions is to develop incentives for the propagation of and innovation within education technology. This provides a reasonable balance between risk and reward, as both cost and risk are lower. It also serves as a method by which we can discover and evaluate the success (or lack thereof) of methods within education technology. It is not within the scope of this thesis to discuss what these incentives may be, as none of my interviewees discussed this.

Conclusion

Education technology is a truly important phenomenon in the 21st century. As other industries have taken off in the *technologisation* of their various goods and services, education has, relatively-speaking, lagged behind. As a result, we have seen a certain friction between technology and the classroom. However, that is not to say that this is changing: technology has become, over the past decade, increasingly welcomed into the educational world. In my findings, it was clear that *access* and *implementation* are the key factors that must be considered as education-technology grows. *Access* includes access to hardware, access to internet, and access to education-technology platforms. Access is multilayered - and within each component we find further layers; there is no one-size-fits all solution to the *access* problem. *Implementation* includes firstly structural implementation: including the product's *in-built* features and restrictions upon delivery as well as the product's *supplier-decided* features and restrictions upon delivery. Implementation includes secondly psychological implementation: including how the educational actors at play decide to use the app. On both these fronts, there is a clear indication of a high-potential future in the ed-tech space. With respect to public policy interventions, I advise public sector individuals to encourage initiatives to increase the reach of access-provision, to embark on research projects to understand the issues of access as well as the efficacy of education-technology features, and to develop incentives for the free market to encourage innovation in the education-technology sphere.

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