The Impact of COVID-19 on the Evolution of Educational Technologies in America

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Introduction

> eLearning is changing. And, we will see new models, new technologies and designs emerge. So, let's drop the "e" – or at least give it a new and wider definition.

<div align="right">- Elliot Masie</div>

Since the early 1900s, educational technology has been a crucial part of the school experience. From the introduction of chalkboards and pencils to the development of computers and the internet, technology has continually evolved to improve and enhance the way students learn. In the 1920s and 1930s, technology in the classroom was fairly limited, with the main focus being on the use of blackboards and chalk. However, this began to change in the 1940s and 1950s, as schools began to introduce new technologies such as overhead projectors, filmstrips, and early forms of educational software (Cuban and Jandric, 2015).

As computers became more widespread in the 1980s and 1990s, they began to play a larger role in the classroom. Schools began to introduce computers as a tool for students to use for research and writing, and educational software programs became more sophisticated. The internet also became a valuable resource for students, allowing them to access a wealth of information for their studies (Cuban and Jandric, 2015)..

In the past twenty years, the use of technology in education has continued to evolve. The integration of technology and education has grown at an exponential rate with many schools now having wireless networks and a wide range of devices available for students to use, such as laptops, tablets, and smartphones. Educational software has also become more advanced, with many programs now offering personalized learning experiences and real-time feedback to help students succeed. Now, there are virtual learning programs that include pre-school classes, high-school

degrees, PHD programs, and everything in between. Over the past twenty years, In the early 2000's, it was not possible to gain a high school or college degree through the internet. The number of students who are opting to complete their lower education online has been increasing at a large rate, especially over the past few years (Michelle, 2021). The increased accessibility of education and knowledge is surely a great effect of the rise of online learning, and the transition to online learning during a time of crisis was warranted and necessary.

However, the integration of technology in education has not been without its challenges. There are concerns about the potential negative effects of excessive screen time on young people, as well as the need to provide equal access to technology for all students. These concerns are imperative to how we structure the American education curriculum, as America has fallen farther and farther behind the top countries in terms of educational rankings over the past 5 years. In 2018, the United States was ranked number one in the world across all subject areas. Now, we fail to reach the top ten in most categories (Amadeo, 2022). Additionally, there is the ongoing challenge of keeping up with the rapid pace of technological change and ensuring that teachers are trained to use new technologies effectively in the classroom.

This paper will analyze the evolution of educational technologies using the technological inevitability framework, as well as determine whether trends in this evolution have been caused by COVID-19 in 2020.

Part I. The Evolution of Educational Technologies in Schools

The evolution of educational technologies in schools has been a gradual process, with various advancements and innovations being introduced over time. A diagram showing the evolution of educational technologies is shown on the right on the next page (Figure 1). These

technologies have had a major impact on the way students learn and the way teachers teach and have played a crucial role in enhancing the overall educational experience.

The first online learning program, WebCT, was created in the late 1990's, however, it was a raw, stand-alone program that could not be integrated with or into any other systems (Cronk. 2022). It was mainly a tool used by teachers to help manage their courses and classwork. Flash forward to today, and this has completely changed. Almost every school district in the United States of America utilizes the Internet in their classrooms, and over half of the states in America offer online school for K-12 students – 35 to be exact.

One of the biggest advancements in educational technology has been the widespread adoption of online learning platforms and virtual classrooms. These platforms allow students to access educational materials, submit assignments, and participate in discussions from the comfort of their own homes. This has been especially useful for students who are unable to attend school in person due to illness or other reasons.

The COVID-19 pandemic, however, has had a major negative impact on the evolution of educational technologies in schools. As schools were forced to close and switch to remote learning, many students and teachers struggled to adapt to the
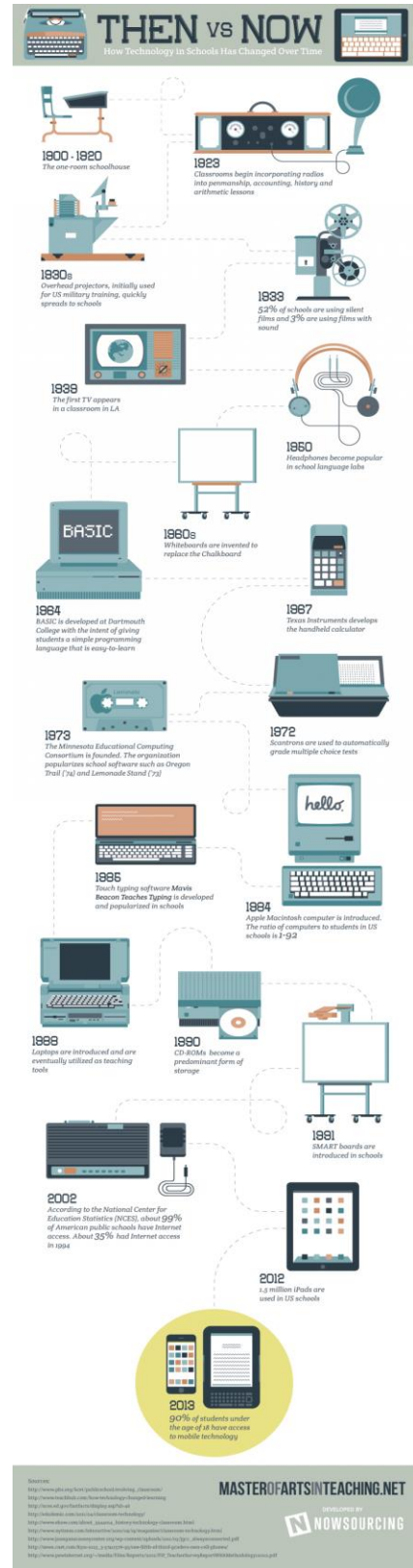

Figure 1: Evolution of Educational Technologies

new environment. Many students lacked the necessary technology and internet access to participate in online classes, and teachers struggled to deliver effective instruction in the virtual setting. The long-term effects of online learning and the redaction of interpersonal relationships has yet to be discovered. It is known that online learning increases accessibility and decreases the amount of physical bullying a student might have encountered while at school. However, online learning has been found to increase social isolation and to decrease communication skills (Carroll, 2021), both of which are detrimental to students, especially those of a young age. The long-term effects of such removal of human interaction have yet to be seen. Another issue that has been prominent in discussions of online learning is the detrimental effect that it has on students' eyes. Without including online learning, on average, young people between the ages of 11-24 already spend over 10 hours staring at screens (Bruce, 2020). When you include online learning, students would easily spend 12-16 hours a day staring at screens, which is over half of the day. How much of an effect do these factors have in the long term on the development of these students? As far as the short term, a study done by Krieg and Henson showed that students who take an online course did worse in the subsequent class than students who took a face-to-face course by an average of 0.22 grade points (Krieg & Henson, 2016).

In addition, the sudden transition to remote learning highlighted the need for better training and support for teachers in the use of educational technologies. Many teachers were not well-versed in the use of virtual learning platforms and other digital tools, and this lack of expertise hindered their ability to provide effective instruction.

Overall, the COVID-19 pandemic has highlighted the challenges and limitations of educational technologies in schools and has underscored the need for continued innovation and

improvement in this area. Despite these challenges, however, the evolution of educational technologies will continue to play a vital role in the future of education.

Part II. The "Inevitability" of Online Learning

Overlooked Ethical Issues

The implementation of online learning has been found to increase social isolation and to decrease communication skills– especially to those of a younger age (Carroll, 2021). In addition, online learning places a large amount of stress on students' eyes, with at least 8 hours of screen time a day. A recent study by the National Institute of Health showed that kids who spend more than two hours a day on screen time activities score lower on language and thinking tests. In addition, kids who spend more than seven hours a day on screens show a thinning of the brain's cortex, which is responsible for critical thinking and reasoning (Circle, 2021). However, a traditional analysis of online learning over the course of the last few years would emphasize the fact that education across the United States would not have been able to continue unless online learning was implemented. In other words, technological determinism would be cited as the reason
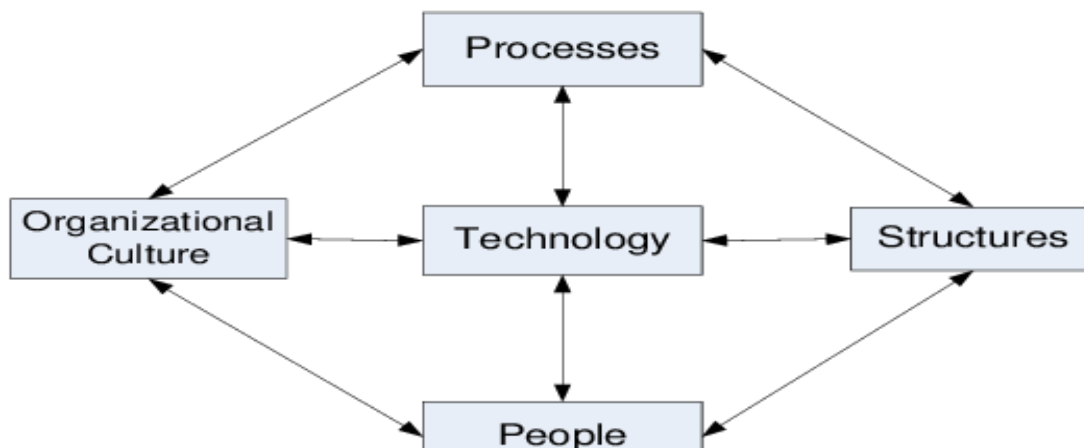

Figure 2: Technological Determinism Diagram

for most of the consequences. A diagram that explains technological determinism is shown above (Figure 2). This diagram shows how technology is at the center of all processes of life, and how everything in society stems from and builds into technology.

However, this disregards the notion that the developers of online learning were responsible for researching the long-term effects of online learning on students. This is where a method for exploring the inevitability of technology and the relationship with the engineers who created the technology can come into play. In the particular case of analyzing the rise of online learning, I will utilize the theory of technological inevitability as a means of dissection and analysis of the relationship between online learning and the engineers who created it, and to analyze how this relationship ended up affecting students and teachers in the United States of America.

Engineers must be conscious of consequences when creating technological systems

In order to utilize the theory of technological inevitability, the discourse of inevitability must be defined. The discourse of inevitability regarding technological development is seen as a marketing strategy – a means of selling what is "new" and the "future of technology" (Neeley & Luegenbiehl, 2008). However, this viewpoint of technological development lessens the ethical reflecting that engineering teams will go through while creating new products, as well as decrease the individual ethical responsibility that every engineer on the team has. This occurs because individual engineers start to lose themselves in the midst of the product and the overall company, and they let their own ethical compass be deteriorated by the prospect of the product becoming the "next big thing". Another reason for technological inevitability issues is due to the hierarchy of development processes. Every specific development or iteration done in a particular product or service just becomes part of the larger system. There is almost no individuality associated with and credit given to singular parts of a large product or service, which causes a disconnect between

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the engineers on the team and the members of society that they are making the product for (Neeley & Luegenbiehl, 2008). The engineers on the team do not get to see the full scope of the project they are working on until it is released to the public; by that point, they are already involved in another project, so they become numb to the actual consequences that the project might have on society.

Technological Inevitability and Online Learning

The technological inevitability framework applies to online learning because the engineers behind online learning did not research the long-term effects of online learning and how they might impact students. The engineers who created online learning modules did not think of the impact online learning might have if students were using it for 8+ hours a day, which was not the intended purpose of online learning when it first was invented. The original purpose of online learning was to supplement in-person learning – it was meant to reinforce concepts that were unclear to students at the time of learning it in class (Vintar, 2011). However, when the Coronavirus struck the United States, there was no other option other than to extrapolate online learning to all of America. The engineers who were behind this implementation were most likely aware that they had not done research on the long-term effects of online learning on children, but since education needed to go on, they had no choice but to go through with this implementation. This is where the technological inevitability framework comes into play. If the engineers who were tasked with the implementation of online learning would have thought for themselves rather than for the good of the company or the product, they would have realized the ethical consequences that came with prematurely releasing online learning to the entire United States. However, this is much easier said than done, as the situation that the engineers were placed in would not allow them to wait and thoroughly check the societal implications of online learning. On the other hand, if the engineers would have

thought of the long-term effects of online learning when they first made the product, it would have allowed them to implement online learning throughout the country knowing that there would be very little side effects or consequences.

The Relevance of Technological Inevitability and Online Learning

Technological inevitability is relevant today because it is the reason for many technological companies losing credibility with consumers and the general public. Companies such as Meta and Twitter are under heat for keeping customer data and selling it to other third parties. If the framework of technological inevitability would have been applied at these companies, individual engineers would have thought of the ethical consequences before ever implementing such a service. Similarly, online learning has been at the forefront of education for the past few years, and a large number of students have switched to online learning full time. Technological inevitability should have been applied to online learning to stop the long-term effects of too much exposure to online learning, however, it wasn't and that is why a large number of students are at risk of worsened health.

Part III. Technological Inevitability Pinpoints Potential Online Learning Improvements

As stated earlier, online learning can have devastating effects on a student's brain health. If we can change the way that online learning is administered, these negative effects can be minimized as much as possible. However, what aspects of online learning should be modified? How should we pinpoint what is the leading issue of online learning? In order to do this, this research paper utilizes the technological inevitability framework mentioned above. By using the framework, the main issues of online learning can be found. The main issues of online learning

are that students are forced to utilize their screen for too long, students cannot build social and communication skills while being online, and teachers are not able to connect with students in the same manner that they can while they are in person. In this section, I will discuss each of these issues in depth and a possible remedy for each one.

Excessive Screen Time

The first issue that I will address is excessive screen time for students who are in online schooling. As mentioned earlier, if a student spends over seven hours on a screen, their brain cortex, the part of the brain responsible for critical thinking, is at risk of damage (Legner, 2022). The average school day is about eight hours, so during online schooling, students were spending at least eight hours staring at their screens. This does not account for the amount of time that students were spending looking at their screens outside of school. On average, students from the ages 8-18 years old spend seven and a half hours on their screens, outside of school. If you add the two values together, this amounts to a total of 15 and a half hours of screen time for children while they were participating in online school. This is twice as much as the minimum amount of screen time necessary to cause damage to the brain cortex, and this level of screen usage was sustained for almost two whole years. The damage done to the cortex of children all over the United States is irreversible, and if online learning continues the way that it is, this could be a normal symptom for students all across America.

In order to lessen the amount of screen time for children, online school must be modified in a manner that doesn't remove any educational value from the students. One way that this can be done is by having students utilize textbooks instead of the online alternative. When students utilize digital textbooks with little guidance from their teachers, they tend to spend too much time reading the information while not actually processing it. This is due to the fact that teachers are

the ones who usually explain how to go about using a textbook and how to take notes efficiently and effectively. There were 56 cases of digital textbook related health issues during an in-depth interview that was held with forty elementary school students who had used digital textbooks for over a year. These students were given strategies to help themselves cope, but they were ineffective. These students were only successful with both coping with their mental health issues and with using an online textbook when instructor-led strategies were presented for reading online textbooks (Seomun, 2013). Thus, I believe that utilizing paper textbooks will help lower the amount of time students spend on their devices. Another way that screen time can be lowered is by assigning paper copies of homework. Most online learning programs have students complete online exercises. However, if paper copies were assigned, students would not have to stare at their screens when completing assignments, as they are already looking at their screens during the actual instructional period of the class.

Social Skills

Another major issue with online learning is students are not able to form social skills as easily as when they are learning in-person. The long-term effects of these lessened communication and social skills are still unknown, but it will surely impact the country. As far as trying to instill these social skills into students, there are several ways to do so.

The first idea that could be implemented is to allow students more time to talk amongst one another and have friendly conversation during class. This is a common occurrence in face-to-face learning but is almost non-existent in online learning (Michelle, 2021). In order to mimic this occurrence, I think that there should be more opportunities for open discussions during classes, especially in those of a younger age. Right now, most of the discussions occur when a teacher asks a question and expects an answer. If this were changed into a more of conversation rather than a

question and an answered question, this would allow students to break out of their shells and to build their communication skills.

Another way to implement more social skills is to assign group work. In students of a younger age, online group work is usually not the norm, as it is hard for younger children to facilitate these meetings and to actually complete their activities (Cuban & Jandric, 2015). However, in this case, this consequence should be overlooked due to the positive impact group assignments would have on these students.

Student-Teacher Connection

Finally, the last negative aspect of online learning that is imperative to repair is the lack of student-teacher connections. During primary and secondary schooling, the teacher plays a large role in the success of their students (Cuban & Jandric, 2015). Teachers have conversations with their students about grades, schoolwork, extracurriculars, and life in general. However, with online schooling, this connection went out the window. Teachers were no longer able to have conversations with students on the spot, and students did not have easy accessibility to speak with their teachers (Legner, 2021). Although students and teachers could, in theory, set up a meeting with one another to talk, this was not a normal occurrence by any means. It is also implausible to expect a primary school student to go out of their way to set up a meeting with their teacher to just talk.

One way to solve this issue would be to have a designated meeting time between students and teachers every month. This would allow teachers to talk to students about any qualms they might have, and students to do the same. It would also foster opportunities of connection between the students and the teacher. With these newfound opportunities of connection, students would

feel that they are actually part of the class, and not just another part of the screen. Teachers would also feel an obligation to help the students; this obligation dwindled during online schooling, as some teachers did not feel the need to make students understand concepts. They would just teach the class for the allotted time and then log out.

Conclusion

Overall, online learning seems to be detrimental to society, as students and teachers are currently being negatively impacted by online learning. Students are spending too much time on their screens during online schooling, which can cause serious long-term damage to the brain. However, there is no possibility of online learning being removed from our everyday lives, and the research that has been done was partially incomplete. I recommend researching what specific aspects of online learning actually cause harmful effects in students. If these detrimental aspects are found, then we can try and neutralize them so students will be able to effectively learn virtually without being afraid of negative long-term effects.

To effectively pinpoint what aspects of online learning are causing harmful consequences, frameworks can be used to see where the developers of online learning might have rushed the process in order to implement online learning country-wide. In this research paper, the technological inevitability framework was utilized to understand the thought process behind the rushed usage of online learning in the United States. Through the framework, it can be inferred that the engineers behind the choice to implement online learning were thinking for the good of the product and the companies, rather than the good of the students and the teachers. This oversight will have dramatic consequences if not addressed.

A change in how online learning is administered will not be simple; however, given the implications that online learning will have on the future generations of our country, it is imperative that the current online learning process is not beneficial long-term. Further usage of different frameworks to analyze online learning will allow our understanding of the topic to grow. Moving forward, the question that must be answered is how can we continue to allow access to online educational materials without forcing students to use an unhealthy amount of screen time? This issue must be solved in order to provide a safe and healthy environment for students to practice online learning.

References

Cronk, K. (2022). *E-learning- The Changing Tide in Education*. Education Technology Insight. Retrieved 27 September 2022, from https://learning-management-system.educationtechnologyinsights.com/cioviewpoint/elearning-the-changing-tide-in-education-nid-319.html.

Amadeo, K. (2022, January 20). U.S. education rankings are falling behind the rest of the world. U.S. Education Rankings Are Falling Behind the Rest of the World. Retrieved February 19, 2022, from https://www.thebalance.com/the-u-s-is-losing-its-competitive-advantage-3306225

National School Choice Week Team. (2022). *The Ultimate Guide to Online School - How Does Online School Work?*. National School Choice Week. Retrieved 27 September 2022, from https://schoolchoiceweek.com/guide-to-online-school/#:~:text=If%20you%E2%80%99re%20just%20getting%20started%2C%20here%20are%20steps,while%20others%20may%20have%20deadlines.%20...%20More%20items.

Michelle, E. (2021, October 7). Side Effects of Online Education. eLearning Industry. Retrieved March 8, 2022, from https://elearningindustry.com/side-effects-of-online-education

Krieg, J. M., & Henson, S. E. (2016). The Educational Impact of Online Learning: How Do University Students Perform in Subsequent Courses? Education Finance and Policy, 11(4), 426–448. https://doi.org/10.1162/edfp_a_00196

Carroll, A. (2021, September 18). Positive and negative impact of online education on students. World.Edu. Retrieved March 8, 2022, from https://world.edu/positive-and-negative-impact-of-online-education-on-students/

Kumar, R. M., & Krishna Kumar, R. (2010). IMPACT OF E-LEARNING ON TEACHER EFFECTIVENESS. Journal of Educational Technology, 7(3). https://files.eric.ed.gov/fulltext/EJ1098368.pdf

Circle, A. (2021, April 13). *Brain power: How screen time impacts kids' brains*. Brain Power: How Screen Time Affects Kids' Brains. Retrieved December 3, 2022, from https://meetcircle.com/blogs/stories/screen-time-effects-on-the-brain

Kwaske, I., & McLennan, K. (2020, October). *Why social interaction is important in online learning*. Why Social Interaction is Important in Online Learning. Retrieved December 10, 2022, from https://sopa.tulane.edu/blog/why-social-interaction-important-online-learning

Legner, L. (2022, April 22). *Kids' screen time: How much is too much?* Kids' screen time: How much is too much? Retrieved December 10, 2022, from https://www.osfhealthcare.org/blog/kids-screen-time-how-much-is-too-much/#:~:text=The%20Centers%20for%20Disease%20Control,Seven%20and%201%2F2%20hours

Seomun G;Lee JA;Kim EY;Im M;Kim M;Park SA;Lee Y; (2013, June 17). *Health effects of digital textbooks on school-age children: A grounded theory approach*. Western journal of nursing research. Retrieved December 10, 2022, from https://pubmed.ncbi.nlm.nih.gov/23780942/

Strengths and weaknesses of online learning. Strengths and Weaknesses of Online Learning | University of Illinois Springfield. (n.d.). Retrieved December 10, 2022, from https://www.uis.edu/ion/resources/tutorials/overview/strengths-weaknesses

Vintar, M. (2011, August). *Conceptual model representing the role of ICT in the E-government period*. Technology as the Key Driver of Organizational Transformation in the eGovernment Period: Towards a New Formal Framework. Retrieved December 10, 2022, from https://www.researchgate.net/figure/Conceptual-Model-Representing-the-Role-of-ICT-in-the-E-Government-Period_fig2_221561216

Teräs, M., Suoranta, J., Teräs, H., & Curcher, M. (2020). Post-covid-19 education and Education Technology 'solutionism': A Seller's market. *Postdigital Science and Education*, *2*(3), 863–878. https://doi.org/10.1007/s42438-020-00164-x

Cuban, L., & Jandrić, P. (2015). The dubious promise of educational technologies: Historical patterns and future challenges. *E-Learning and Digital Media*, *12*(3-4), 425–439. https://doi.org/10.1177/2042753015579978

Neeley, K. A., & Luegenbiehl, H. C. (2008). Beyond inevitability: Emphasizing the role of intention and ethical responsibility in engineering design. *Philosophy and Design*, 247–257. https://doi.org/10.1007/978-1-4020-6591-0_19