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Instructional Systems Design and the Diffusion and Adoption of Technology: (Volume 1)

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Instructional Design & Technology

Instructional Systems Design and the Diffusion and Adoption of Technology

By Mark Parsons, Meghan Soldani, Josie Joswick Mendoza, Maria Satre, Brittany Spitz, Jasmine Bundy, Amanda Kline, & Miguel Ramlatchan
(Edited by Miguel Ramlatchan)

Instructional Systems Design and the Diffusion and Adoption of Technology (Volume 1)

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Instructional Systems Design and the Diffusion and Adoption of Technology
(Volume 1)

Chapter 1: The Diffusion and Adoption of Instructional Technology

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1. The Diffusion and Adoption of Instructional Technology

Miguel Ramlatchan, PhD

Key Points:

- Instructional design is the use of tools, techniques, applied theory, and technology to effectively communicate and accomplish learning objectives.
- The adoption of technology is a process that starts with knowing of the innovation, developing an opinion, making a decision, implementing the technology, then determining to continue, re-invent, or discontinue use.
- Diffusion is a function of time, where innovators, early adopters, early majority, late majority, and late adopters see and implement the benefits of the innovation.

Abstract

Instructional designers, instructional systems designers, and other educational technologists are, by their nature, innovators. These professionals apply and extend the applied science of learning, systems, communication, and instructional design theory to help students learn. Technology in some capacity is used to make the connections between subject matter experts, teachers, instructors, and their learners. It is common for instructional designers to seek new tools, techniques, and innovations for the improvement of learning, access, quality, and student satisfaction. However, the adoption and diffusion of new educational technology and innovation is a complex

process that depends on many variables. Understanding these processes and variables can help designers and technology leaders successfully implement positive change. This chapter serves as a brief summary of innovation diffusion models, organizational change models, and serves as an introduction to the work of other talented instructional designers who have explored specific aspects of educational technology adoption and diffusion. Together we hope that you find these cases, examples, and lessons learned insightful and help you plan for an innovation diffusion of your own.

Introduction

Why do some (many? most?) technology innovations fail? Why and how is it that some innovations are widely successful? How can instructional systems designers and instructional technologists plan for successful innovation deployments in their organizations? Answers are hard to come by, success can depend just as much on good planning and communication as it can on serendipity, luck, and other factors outside of our control. However, study and learning from research, models, success stories, and stories of failure, can help us improve our odds of success. That is what this book is about, an analysis of technology innovations, how and why they succeeded (or didn't), and how we as instructional professionals can apply lessons learned from these examples.

The talented authors in this book present a number of compelling educational technology innovations and consequences of innovations such as 1:1 devices programs, the diffusion of Zoom, augmented and virtual reality, gamification, online learning management systems, and the digital divide. These topics are presented in the context of classic diffusion and innovation frameworks including the types of adopters, the adoption bell curve, and the diffusion s-curve (Rogers, 2003). Though before we start exploring those topics… what is technology adoption and diffusion?

An innovation can be an idea, process, or new technology that may meet the needs of a group of potential users. Adoption is a user's choice to use an innovation. This choice is reached during an adoption process that includes knowledge of the innovation, persuasion and creation of an opinion, the decision, implementation, and confirmation

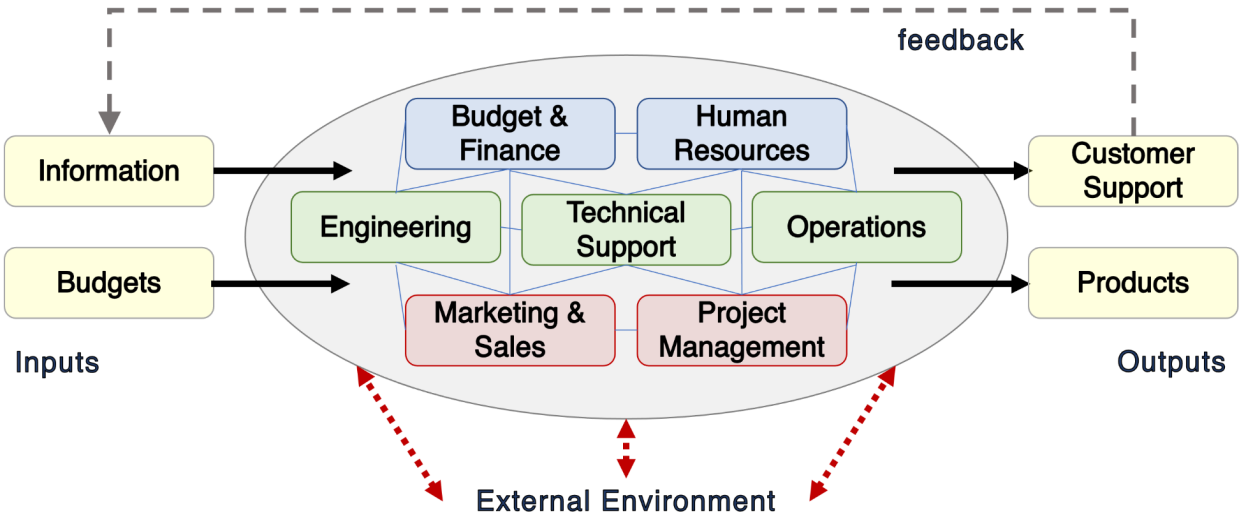
of the innovation effectiveness (Rogers, 2003). Diffusion happens on a larger scale and is the process of larger numbers of user's attempting to use the innovation. Understanding innovation diffusion will help change agents such as instructional designers successfully deploy new tools and techniques to help their learners. To begin this exploration, it is helpful to visit and review systems theory and communication theory.

Systems Theory

General systems theory can be used to describe many complex technologies, organizations, organisms, and other entities, endeavors, or objects with complex inner-related components. A system is a bound collection of components that work together to transform inputs, resources, and information feedback into actions and outputs (Von Bertalanffy, 1928). General systems theory originally described biological organisms, however the approach and model soon expanded to describe systems in many other disciplines (Von Bertalanffy, 1975).

An organization is a system (see Figure 1). The groups and departments within the system are interrelated and help each other reach common goals. For instance, teams of nurses, doctors, administrators, and staff in a hospital should all (in theory) be helping each other to provide the best care possible for their patients. Similarly, teams of teachers, IT staff, administrators, and other staff work together to serve their students. Complex systems have layers, often sub-systems that include the layers that deal directly with clients, layers that support client services, and layers that support the entire system (Altschuld & Kumar, 2010). Thinking about organizations as systems helps us understand the inner workings and inter dependencies within the system and how to approach diffusion planning.

Figure 1.
Organizations as Systems



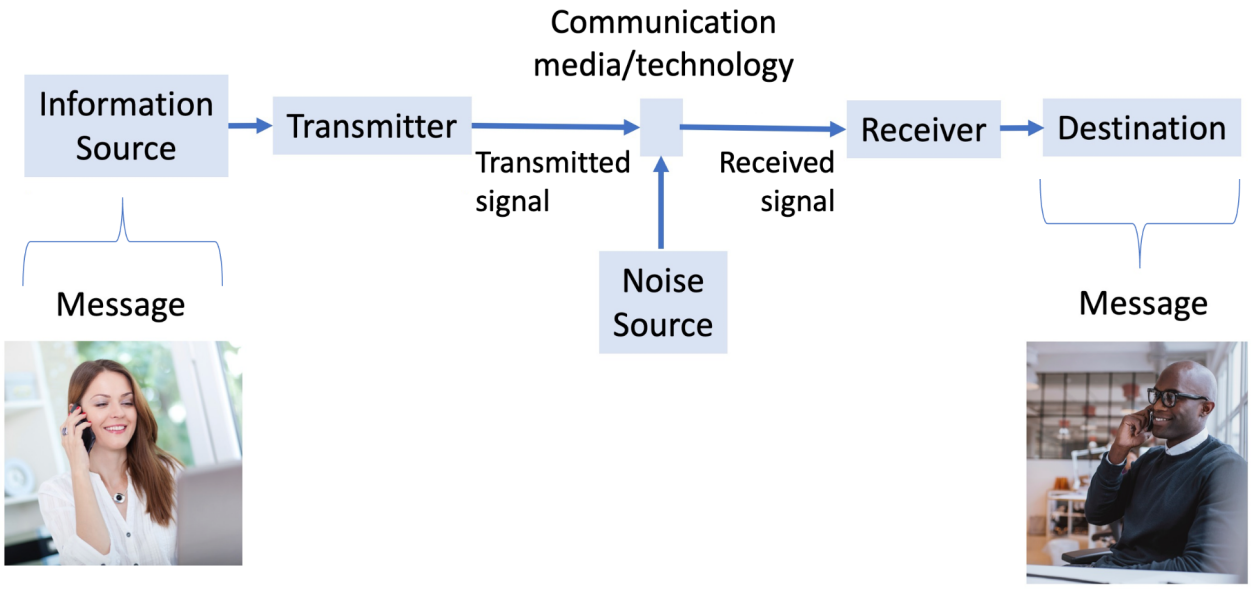
Note. Organizations are systems that have interconnected components that work together to use resources, feedback from outputs, and reaction, pressure, or information from its environment to accomplish common goals and outputs.

Communications Theory

Communications theory helps us model one-to-one, one-to-many, and many-to-many mass and interpersonal dialog, discussion, news, and other message deliveries. The original theory and model developed from the need to describe and design telephone systems (Shannon & Weaver, 1949). The model describes a message being encoding into signals that are transmitted over a network to another device that acts as a receiver that converts those signals back into the message (see Figure 2). Shannon and Weaver also describe noise sources that can impact the network and potentially damage the accuracy of the message. In the original context telephones are the devices, there is inherently a two-way connection established between each device, as such each device can function as both the transmitter and receiver. Erroneous electrical interference, signal loss over wires

and repeaters, and the user's distance from the microphone can all generate 'noise' or errors in the system (and the system should be designed to compensate). Another analogy could be the use of microphones, cameras, speakers, and displays on laptops to establish two-way communication using Zoom web conferencing as the medium connecting the devices. Another example would be an developer (message sender) designing instructional activities into an app that is downloaded from the Internet (communication medium) onto a student's iPod (receiving device).

Figure 2.
The General Communications Model



Note. While developed in the context of telephone networks, the model of interconnected devices using a network to send and receive messages between each other can be generalized and used to describe many applications.

Technology Adoption and Diffusion

Along with learning theory, general systems and communication theory form the basics foundation that other instructional design theory builds upon. Classic diffusion research started in the 1930s with the study of Iowa farmers and their adoption of hybrid corn seeds (Ryan & Gross, 1943). Researchers found that farmers adopted the new innovation not at once, but over time. The rate of adoption was impacted by communication flow, tolerance for risk, and the ability to see results. Similar research on weed killer adoption and diffusion found similar results (Rogers, 1958). The similarity of these findings compared to other innovation diffusion work in health care, social science, and marketing led to the development of a general model of diffusion (Rogers, 2003). This model describes a normalized distribution, along familiar "S" and bell curves that model the rate that innovation diffuses in a social system. Rogers compiled and analyzed previous research and theorized that there are a series of adopter categories, and that these categories strongly influence how quickly an innovation spreads and the percentage of growth over time. Table 1 summarizes how adopters of an innovation tend to be characterized.

Table 1.
Innovator Categories and Characteristics

- **Innovators**
  - **Tend to be venturesome, have resources, accept risk, and understand complexity**
- **Early Adopters**
  - **Are often opinion leaders, role model, trigger critical mass, are visionary and 'big picture' focused**
- **Early Majority**
  - **Tend to deliberate, research the innovation first, longer innovation-decision period, pragmatic and application focused**

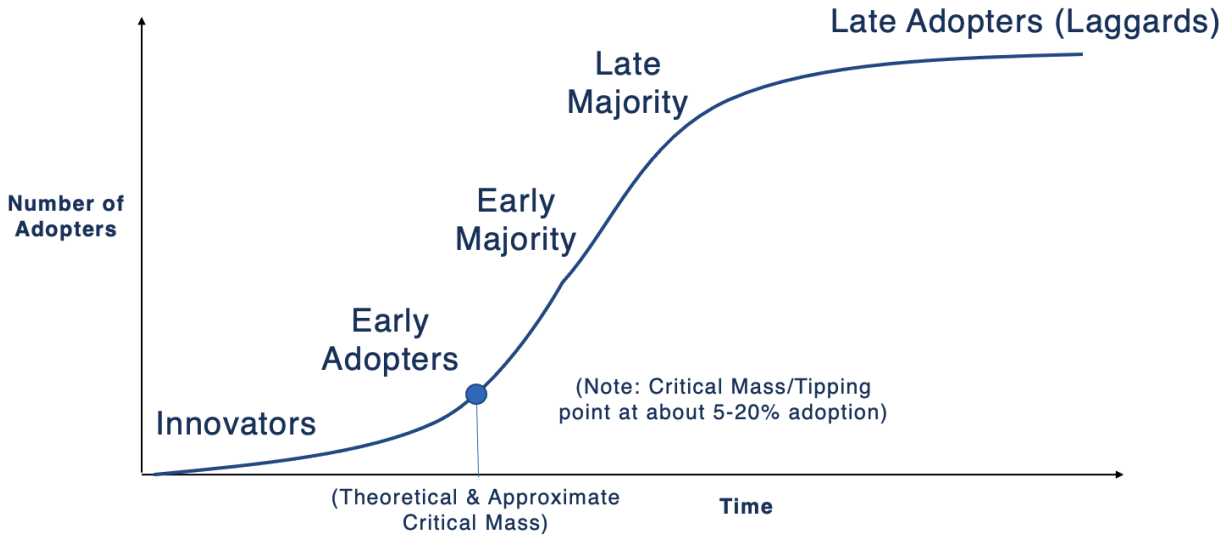
- **Late Majority**
  - **Tend to be skeptical, adopt out of necessity, willing to risk less resources, must be convinced of safe investments before adopting**

- **Laggards (Late Adopters)**
  - **Are traditional, suspicious of change agents and innovations, extremely cautious, require simplicity, the innovation may not meet their needs**

The adoption of an innovation starts slowly, adopted first by the Innovators. Innovators will tend to be fans of the technology, are eager to give it a try, and are comfortable with both uncertainty (in terms of the long-term effectiveness of the innovation) but also are willing to deal with an incomplete product. Early adopters will tend to have a vision that the innovation can help meet or accomplish, they are less concerned with operation support, and are also willing to risk resources on implementation. According to Rogers' research, there is a point where the adoption of the innovation will be self-sustaining, where 'word of mouth' or interpersonal communication will sustain the momentum of adoption. This concept is the point of "critical mass", or a 5 to 20% tipping point where adoption is escalated by the early majority (Rogers, 2003). At this point, the innovation is mature enough to reach mainstream users who have seen the innovation be successful. The theoretical average user will share characteristics of both early and late adopters. The late adopters will see that the innovation has worked well for others, the cost of ownership may have gone down, and there are support services available. The later adopters are called laggards by Rogers, though he admits that no ill intention is implied. However, the term "laggard" may reveal pro-innovation bias in the model (and the inherent and incorrect assumption that any and all innovation will follow the curve of this model). It could be that the innovation simply does not meet enough

of the late adopter's needs to be adopted any earlier. Figure 3 illustrates the classic adoption "S" curve.

Figure 3.
Adopter Categories and their Adoption of an Innovation Over Time

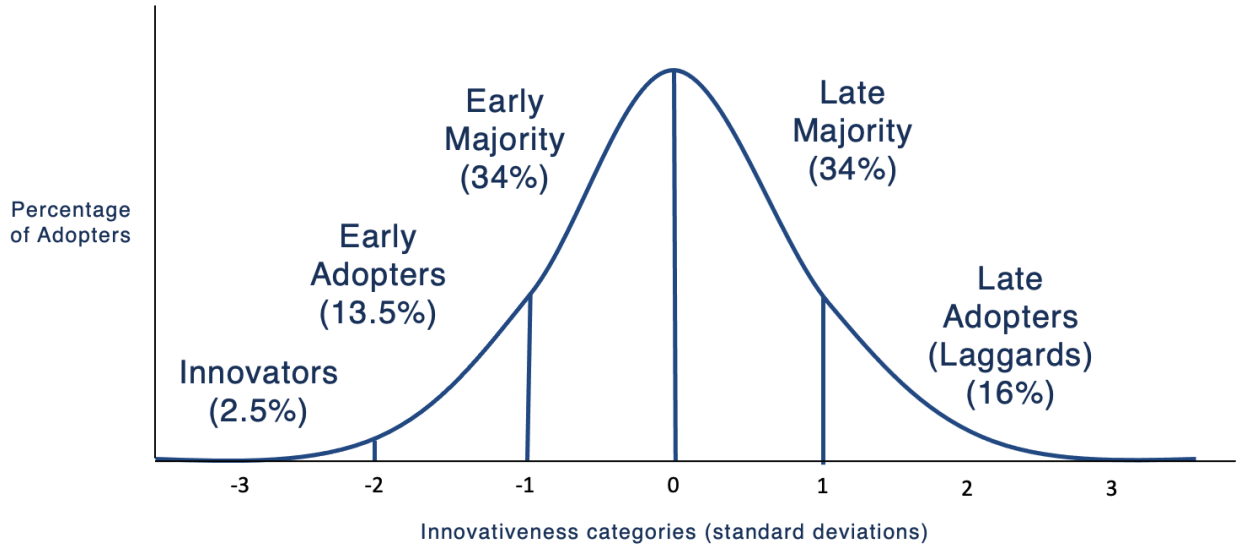


Note. Adoption starts slowly with eager Innovators and, if successful, will reach a point of crucial mass where the Early Majority will accelerate adoption, Late Adopters will slowly also adopt as the innovation reaches its theoretical 100% market saturation.

Plotting the percentage of adoption by user categories over time is another way to analyze a technology's diffusion in a marketspace or system. Rogers and others have found that this percentage function appears to take the shape of a classic, normalized bell curve (see Figure 4). The Innovators represent the smallest group, followed by the Early Adopters, the Early Majority and Late Majority are the largest groups, with the Late Majority actually being the third largest group (and ironically representing quite a large user group).

Figure 4.

The Innovation Adoption Bell Curve, or Percentage of Adopters over Time

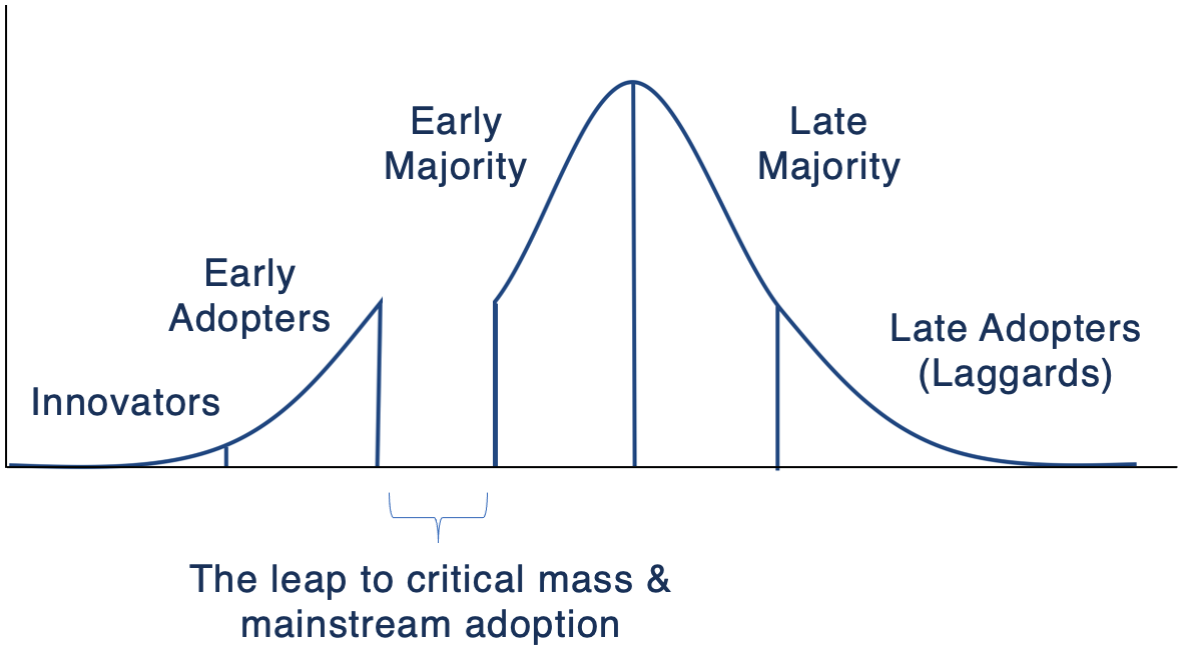


Note. Innovation adoption tends to follow a model characterized by statistical standard deviations, on a scale where the earliest Innovators fall outside of the 2nd standard deviation, and Late Adopters who fall outside of the first standard deviation from the center-most average.

The model, if used incorrectly by change agents or those encouraging the innovation's adoption, may suggest that any innovation can reach its lucrative Early Majority, Late Majority, and late Adopters categories if given time. However, history is laden with technology innovations, that while far more advanced than its competition, never reached critical mass and mainstream audiences (i.e. the Apple Newton, Sony MiniDisc, Sony BetaMax, GM's EV-1, and many, many others). Several practitioners have theorized that a significant distinction exists between early Adopters and the Early Majority that prevents many innovations from reaching wild success. The chasm model was first proposed by Lee James and Warren Schirtzinger while marketing consultants at Regis McKenna Inc. in the late 1980s and was soon adopted by Geoffrey Moore while also serving as a consultant at Regis McKenna Inc. (Desmond, 1989; Moore, 2014; Schirtzinger, 2022). Figure 5 illustrates this theoretical

gap between adoption categories and where a concerted focus has to be made by change agents.

Figure 5.
The Potential for a Chasm between Early Adopters and the Early Majority



Note. Early Adopters and the Early Majority have different needs, motivations, and tolerance for risk, which could explain why an innovation does not bridge the gap and reach mainstream users and extend growth.

In the bottom of the chasm is a metaphorical graveyard of educational technology innovations that include hardware classroom Clickers, Google Glass, Apple iTextbooks, Palm Pilots, Xybernaught wearable PCs, and free MOOCs (or were some of these fads, innovations that very temporarily reached mainstream beyond the Early Majority, but faded from use very quickly?). If we as educational technologists feel that an innovation is worth the risk and investment to be adopted in our organization, how do we get it across

the chasm? Table 2 describes several steps that can be taken to reach beyond Early Adopters.

Table 2.
How to get Across the Chasm

- ☐ **Segment your market (narrow focus on smaller, similar subsystems)**
- ☐ **Focus on meeting specific needs of a few small subsystems**
- ☐ **Simplify and standardize (make the innovation easy and reliable)**
- ☐ **Establish your credibility (a function of observable subject matter expertise, trustworthiness, and empathy over time)**
- ☐ **Build a social media communication plan that has an interpersonal focus (on the specific needs and questions of the potential user)**
- ☐ **Provide great support (remove the risk)**
- ☐ **Establish an opinion leader/reference for others (with testimonials posted online)**
- ☐ **Provide models, demos, examples, and references from other early majority users (whose needs and use cases match other potential users)**
- ☐ **Create a reputation for great service and quality**
- ☐ **After critical mass, repeat in other market segments and subsystems**

Note. Modified from McCroskey & Teven, 1999; Moore, 2014; ODU IDT 752/852, 2022; & Rogers, 2003.

Organizational Change

Instructional designers, or their clients, are often part of larger organizations, and successfully implementing innovation in large organizations is notoriously difficult. The biological system that is any modern organization must understand the need for the innovation, understand the innovation plan, and understand the consequences of not changing.

It is not that humans are afraid of change, they are afraid of loss (Heifetz et at., 2009). For instance, getting a raise, buying a new car, moving into a nicer house are all good changes and those experiencing those changes likely will be okay with those changes. However, a change where they lose their job, lose their car, lose their house, those are potential changes that create fear. Less dramatic examples in terms of fear of change include loss of comfort, security, reputation, time, money, power, control, status, resources, and loss of independence (Heifetz et at., 2009). Organizational change can be brought on via innovation in terms of new technology, new ideas, or generally any need for a system of humans to adjust their system to changes in their environment. It is important for educational leaders and instructional designers, and those who are looking to implement technology innovations to understand and plan for the resistance to innovation.

Many aspects of human behavior follow a normalized, bell-shaped distribution. We can safely assume that just about everyone in any given system will fall somewhere in the Rogers adoption curve. If the group is sufficiently diverse, the individuals in the system will tend to be distributed along the curve as Rogers and others have modeled (2.5% of them will be innovators, 17.5% will be late adopters, etc.). The resistance to technology innovation will likely come from the late majority and late adopters in the potential user base. In general, these are the audiences that want simplicity, an

innovation that very closely meets their needs, and support services (Moore 2014, Rogers, 2003). While it may be much easier to win over the early adopters and the early majority, who are more open to risk, new ideas, and helping to develop new tools and techniques, a different set of strategies will have to be implemented to get full organizational buy-in.

Are you an educator or instructional designer looking to implement innovation in your organization? Implementing innovation is difficult, innovation in an organization of complex humans is even more daunting. Volumes have been written on organizational change, a quick search on Amazon.com will yield thousands of options to help a manager or leader like yourself turn around or improve themselves or their organizations. The common themes through many of these guides is systemic structural change, behavioral change, and effective leadership. While an exhaustive treatise on the topic is outside the scope of this chapter, there are a few books considered by many to be classics in the field. Two books in particular have influenced me and helped me guide my organization through periods of significant change.

Cheese

Who moved my cheese? (Johnson, 1999) is the endearing tale of two mice and two humans. In summary, imagine a maze with two human-sized mice and two humans. All four left their homes each morning and walked a well known path through the maze to their cheese. Then one day the cheese was gone, the mice were able to adapt quickly and moved on, however, the humans had issues. There was a period of disbelief, confusion, and sadness before one of the humans decided to venture back out into the maze. The human had the courage to change, eventually found new cheese (and his mice colleagues), and hoped that his human friend would follow his trail to join him. Along the trail from the old cheese to the new cheese the human had left a series of arrows and messages for his friend (see Table 3).

Table 3.
Lessons Learned from Johnson's "Who Moved My Cheese?" For Successful Organizational Change

- ☐ **Change Happens**
  - ☐ They Keep Moving The Cheese
- ☐ **Anticipate Change**
  - ☐ Get Ready For The Cheese To Move
- ☐ **Monitor Change**
  - ☐ Smell The Cheese Often So You Know When It Is Getting Old
- ☐ **Adapt To Change Quickly**
  - ☐ The Quicker You Let Go Of Old Cheese, The Sooner You Can Enjoy New Cheese
- ☐ **Change**
  - ☐ Move With The Cheese
- ☐ **Enjoy Change!**
  - ☐ Savor The Adventure And Enjoy The Taste Of New Cheese!
- ☐ **Be Ready To Change Quickly And Enjoy It Again**
  - ☐ They Keep Moving The Cheese.

Note. The cheese in this business fable is a metaphor for whatever wants or needs you, or your organization, has (income, job security, more sales, a new product or service, etc.). Also note how the last step

to success is the same as the first. This book is a great read and is highly recommended.

Penguins

It is tough being a penguin, you're not able to fly, you are harassed by National Geographic, you live in the most inhospitable environment on the planet, and if you are the first to jump in the water looking for food then there's a good chase of getting eaten by a killer whale. In addition to that, you are the lone innovator and realize that your colony's iceberg is melting. This is the premise of *Our iceberg is melting* (Kotter & Rathgeber, 2006; 2016). The Innovator had to convince a diverse group of fellow penguins to reach out and find a new home. He is able to accomplish this by convincing a change agent and opinion leader, demonstrating evidence and data, overcoming irrational traditionalists, and communicating the seriousness of the situation. Kotter's penguins used this 8-step strategy in Table 4 to reach a new home and a happy ending.

Table 4.
Lessons Learned from Kotter's "Our Iceberg Is Melting" For Successful Organizational Change

☐ **Establish a sense of urgency (we need to change or we will very soon be extinct)**
☐ **Create a guiding coalition (a diverse set of minds to begin planning)**
☐ **Develop a vision and strategy (to focus efforts)**
☐ **Communicate the change vision (the goals, objectives, and plans)**

- ☐ **Empower employees for broad-based action (let the team bring ideas to the change agents, get and use feedback)**
- ☐ **Generating short-term wins (to help keep employees motivated)**
- ☐ **Consolidate gains and produce more change (reach goals and objectives with the team, continue to get and use feedback to adjust the system)**
- ☐ **Anchor new approaches in the culture (communicate that change is inevitable and will happen again, but that's okay)**

Note. Modified from Kotter, 1995; Kotter & Rathgeber, 2006; & ODU IDT 752/852, 2022. Other great reads from Kotter include *Leading Change* and *The Heart of Change,* both also deal with appealing to the emotional aspects of change, urgency and the need to change, and how to get others on board and motivated to change.

Conclusions and Future Directions

While the world has changed since the original research in the early to mid 20-century that led Rogers to the development of his diffusion and adoption models, I'd argue that humans have evolved very little since then. These lessons learned, theories applied, and findings condensed into Rogers' classic innovation diffusion models are still as relevant today as they were in the 1960s. Innovators will still take risks, later adopters will still avoid risk, and most of us will find ourselves somewhere along this spectrum depending in large part on the innovation, the severity of our need, and how well the

innovation meets our needs. Also, nearly all innovations still introduce indirect, unintended, and undesirable consequences, and more research is needed in this area to inform practice.

Future technology innovation diffusion researchers are encouraged to collect data during the innovation processes, rather than at the end or at some other later point. The longer the period between innovation diffusion and data collection, the less research participants will accurately recall their thoughts, actions, and feelings during the innovation decision and implementation processes. Technology diffusion research can often take on a pro-innovation bias, where the consequences of the innovation are assumed to be beneficial for those adopting the innovation (Rogers, 2003). However, learning from failed innovations can likely teach us more in terms of what change agents did or did not do, what assumptions were made about adopters, and what resources were invested in communication planning.

Technology diffusion in education is often different than in other systems and industries. In education, schools often find themselves with limited resources, meaning adopting the wrong technology solution can be a career change opportunity for the change agent. Not only could the risks be higher, but resources across schools are not equitable, describing a potential gap between those who can afford to innovate and those who can not (Rogers, 2003). Add to these traits that very often it is not the most capable technology that becomes the one that makes it to the mainstream; politics, serendipity, and just luck can sometimes strongly influence how a technology is adopted. Overgeneralized models often can not capture the nuances and complexity of the real world. However, a study of these models, applying the findings from successful diffusion cases, and learning from failed innovation efforts can help us prepare for our own projects.

Instructional design is an applied science that takes the lessons learned from many fields of study, as well as the applied research of instructional designers, and uses these ideas to further learning effectiveness. As such, instructional designers often find themselves as their organization's innovators, early adopters, change agents, and/or opinion leaders. Understanding how potential users will adopt an innovation, how that innovation can diffuse over time, and how change in the organization can be guided, are best practices that can

all be applied to increase the odds of a successful technology implementation.

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Instructional Systems Design and the Diffusion and Adoption of Technology

(Volume 1)

Chapter 2: Adoption and Diffusion of the Apple iPad

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2. Adoption and Diffusion of the Apple iPad

Mark R. Parsons

Key Points:

- A brief history of the Apple iPad
- Examines the adoption of the Apple iPad with emphasis on K-12 education
- Investigate the benefits and barriers of the Apple iPad in the educational setting
- A discussion of the impact of the iPad on K-12 education
- Explores how the iPad paved the way for the adoption of Google's Chromebook

Abstract

The Apple iPad was conceived before the iPhone but was announced and released after the iPhone. Since its 2010 release, over thirty different iPad models have been designed and developed. This chapter seeks to give a brief historical overview of the iPad. It will discuss the need, development, features, marketing, and how early adopters communicated about the device. Then, using Roger's Initial Assessment of the Diffusion of Innovations, this analysis will explore the different stages of iPad adoption, emphasizing adoption in K-12 education. The chapter will discuss the usage of iPads in the K-12 educational setting and the recent results of students' use in education. The chapter concludes with a discussion of how iPads helped lead to a 1:1 computer ratio within the majority of public schools and the

adoption of other technologies in education, like the Google Chromebook.

History of the Innovation

Apple's iPad attracted a lot of attention since its unveiling on January 20, 2010, and its release in March of the same year. The concept of the iPad and its features created a device that became adopted in the K-12 educational setting. Even after twelve years, the iPad is still utilized in education, and research will show that the device can positively impact learning.

The iPod, iPhone, and iPad were released within ten years, between 2001 and 2010, by the iconic American technology company Apple. Apple was the first company to reach $1 trillion in capitalization and is one of the most valuable brands in the world. Apple was created in 1975 by Steve Wozniak and Steve Jobs. Wozniak was considered an electronics genius, and Jobs was a business leader and innovator. Under their leadership, Apple created a new market for a misunderstood product. After its unveiling and before its release, computer specialists and journalists predicted the iPad would not be successful and recommended that their audiences not purchase the device (Viruena, 2019).

The experts were wrong. When the iPad was released in 2010, it sold three million units in eighty days (Apple, 2010). There are several reasons that the iPad was appealing. Apple did a fantastic job marketing the iPad. Instead of targeting current Mac users, Apple targeted iPhone users (Viruena, 2019). The iPad earned the nickname "the big iPhone" because the iPad was a mix between a personal computer and a smartphone. The iPad was never designed as a replacement for the iPhone. It was only meant to enhance the iOS experience.

Apple focused the release of the iPad on 2.5% of the people in society, known as the innovators (Sorman-Nilsson, 2012). By targeting the innovators, Apple created a wave of excitement. This exclusivity even caused the innovators to camp out and be the first to purchase the device. Limited availability added to the exclusivity. The influx of iPad

sales created a waiting period for early adopters. The early adopters who wanted the iPad had to wait because the device had become so popular. After the initial wave of excitement, Apple relied on user-generated reviews to help convince the early majority, late majority, and laggards to purchase the iPad. One such review showed an infant quickly navigating the iPad while making sounds of pure enjoyment (Hochberg, 2011). This video soon amassed millions of views and was even shown on NBC's "Today" show.

The iPad created a new market composed of a diverse audience of all professions and age groups. The marketing campaign and exclusivity created excitement for the device, and the features of the device were attractive, powerful, and easy to use. The iPad had a gorgeous aluminum and glass design, a 1GHz Apple A4 processor, different storage options (16 GB, 32 GB, and 64 GB), and ten hours of battery life (Costello, 2020). The iPad was sleek, portable, lightweight, fast, easy to use, and contained a touch screen. The first iPad did not have a camera, and the device was not cheap. Its starting price was $499. As of July 2022, iPads range from $329 - $799. The newer iPads have various features that keep the iPad competitive with other tablets. All generations of iPad except the first generation contain a camera.

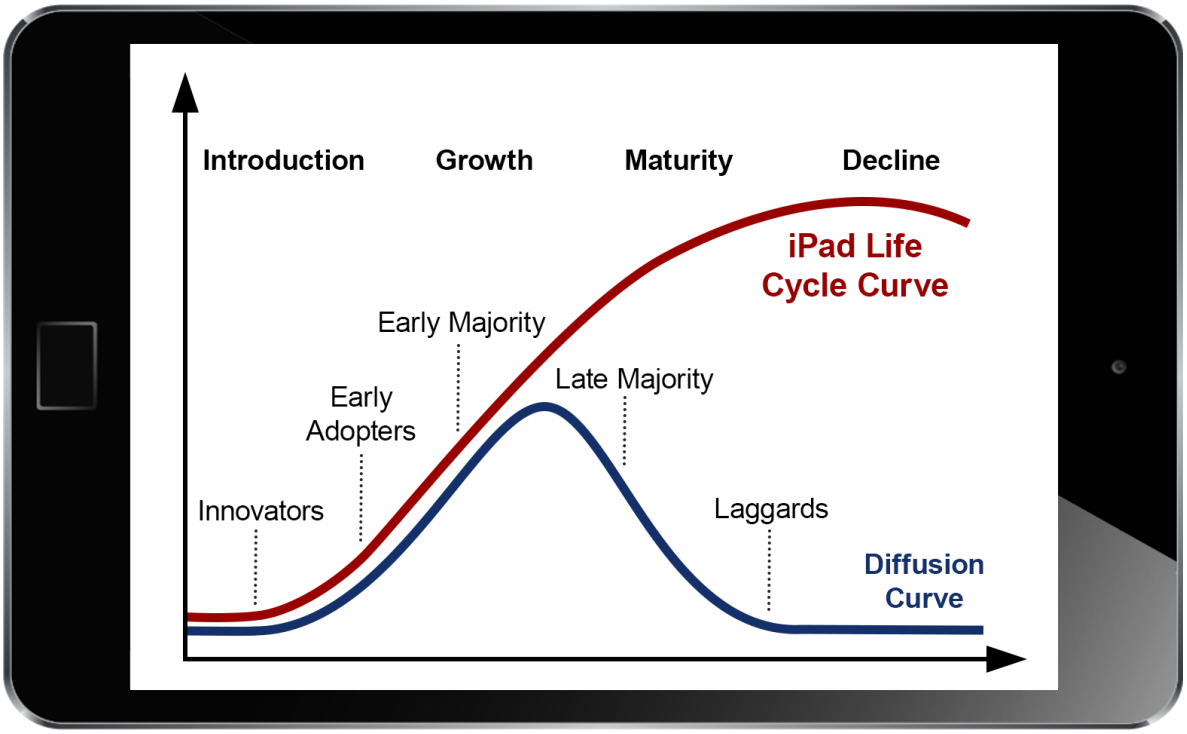
The conceptual idea of the iPad began before the iPhone. However, the first iPhone was revealed in 2007, several years before the first iPad. The idea behind the iPad was simple. Apple wanted to create a computer that resembled a book. Apple wanted this computer to be simple to learn. Apple also envisioned a computer that did not need to connect to anything (Hillard, 2018). The iPad was intended to operate without needing additional wires, cords, or connectors. With its ease of use, battery life, ease of transport, and the ability to download and purchase a wide variety of educational apps, the iPad attracted the attention of educators.

Adoption of the iPad

The adoption of the iPad began at its unveiling in January 2010. During the launch, Steve Jobs used words like "revolutionary," "amazing," "new," and "incredible" (Sorman-Nilsson, 2012). This event was broadcasted as a live event and served as a sales pitch for the iPad.

Jobs went on to demonstrate the ease of use of the iPad during the event. By doing so, he established a straightforward adoption use case for the device.

Figure 1
Roger's Classic Adoption Curves and the Apple iPad



The iPad adoption would follow the typical S-Curve adoption rate as described by Rogers, see Figure 1 (Rogers, 2003). When Apple went to the market with the iPad, it focused on innovators. These innovators sometimes stood outside Apple stores for days, waiting to purchase the iPad. These innovators were vital in the success of the iPad, and excitement and buy-in were created due to exclusivity and limited availability. The innovators wanted to be the first to own and use the iPad. Limited availability produced a reward-like scenario when

the innovators were finally able to purchase the iPad. As a result of the excitement, the innovators created videos and shared their experiences using the iPad.

In K-12 education, select teachers and technology leaders served as the innovators during this adoption phase. The teachers and technology leaders, who were part of the initial wave of purchasers, tested the iPad with select groups of students or other teachers to evaluate the benefits of the iPad in education. These educational innovators would have downloaded any available apps and shared their experiences with their colleagues. Teachers and technology leaders would share positive experiences with the iPad, such as virtual field trips, assistance in science exploration and simulations, and conducting assessments to improve student performance. These educational innovators would have either used their personal iPad or received an iPad for testing from a technology department or media center in their school district.

The second phase of diffusion and adoption of the iPad is when Apple's idea went from 2.5% and added 13.5% of the market. During this phase, early adopters joined the innovators. Innovators join when the product is new: early adopters buy in once they perceive a benefit (Rogers, 2003). Together, they make up 16% of the market. Having 16% of the market is not considered a success. 16% was a meager number when Apple was looking for most of the market. Included in the 16% are the change makers. These change-makers became advocates for the iPad.

So, who are the change-makers in education? The change makers in education could be a range of various roles. It could be teachers, administration, technology leaders, or any staff actively advocating for continuous school improvement. The change makers would see the potential benefits of using the iPad in education and want to use the iPad to improve student learning and achievement. At first, the change-makers would have been curious. They would have found ways to use iPads in the educational setting. These change makers were active members of the school. They participate and stay engaged in furthering the mission of the school or school system. Most importantly, the change makers would have modeled and shared their beliefs. They would share their experiences with their colleagues in a positive way.

As described by James and Schirtzinger, the point of most significant difficulty for the diffusion and adoption of a technology product is the transition from the early market to the market dominated by a larger group of customers (Schirtzinger, 2020). If the technology is not adopted, it falls into the Chasm described by Moore. Moore defined a chasm between early adopters and the early majority, and successful products must get across the Chasm (Moore, 2009). The iPad successfully leaped across the Chasm in K-12 education quickly after its release. The numerous features of the iPad made it beneficial to both educators and students (Harrison, 2010).

The subsequent adoption phase links innovators and adopters with the early and late majority (Rogers, 2003). At this phase, the early majority was not interested in the keynote address by Steve Jobs. The early majority join when there is a productivity gain. For the early majority to join, they need social proof of the iPad's usability and to observe the benefits. The innovators and early adopters created social proof, and their love of the iPad eventually helped Apple achieve 68% of the market (Sorman-Nilsson, 2012).

If you were to look at the percentage of teachers as staff members in a school district, you would find that teachers make up between 40 and 60 percent of the staff (National Center for Education Statistics, 2018). Teachers would make up a large percentage of the early and late majority. The early majority in education would have observed the benefit of the iPad and then wanted to use the iPad in the educational setting. Perhaps a music teacher wanted to utilize an iTunes playlist. A science or social science teacher may wish to warm up a class using a TED video. Any teacher or staff member could have used the early video conferencing applications like Skype. Many of the early majority would have found a benefit of now estimated two million applications available for download (Apple, 2022).

Five essential factors are critical for the early and late majority to adopt (Rogers, 2003). The iPad must have a relative advantage and keep an edge over comparable products. The iPad must be compatible to be assimilated into an individual's life. The iPad must be easy to use. If it is too complicated, people are unlikely to adopt it. There must be a way for the iPad to be experimented with or its trialability. Trialability for consumers is tested in the Apple store. Educator's trialability took

place when experimenting with an iPad in the educational setting. Lastly, iPads must be visible to others and attractive. These five factors fueled the adoption of both the early and late majority.

After the early majority adoption phase is the late majority adoption phase (Rogers, 2003). The late majority would only adopt the iPad once there is plenty of help and support. At this stage, the iPad would have uses beyond media consumption. Many of the late majority adopt the iPad as it benefits their professional lives. Much like the early majority of the iPad in the educational setting, the late majority is made up of mostly teachers and some other staff. The late majority benefitted from other educators' experimentation with the iPad and then decided to use it to enrich their lessons.

The laggards tend to be the last to adopt an idea (Rogers, 2003). Laggards have little to no influence on leadership. Laggards tend to distrust change makers. The laggards do not want to feel left behind and thus eventually adopt the idea. The laggards are some seasoned veteran teachers in the educational setting. These educational professionals are set in their ways and have a set of designed lessons. With the iPad, the laggard educational professionals would have resisted change until they had to join or were forced to participate by department heads, administration, or state standards.

Benefits and Barriers in the Educational Setting

The iPad was marketed for education as a textbook replacement (Kien, 2014). Apple's premise was that conventional paper textbooks hold students and teachers back from their full learning experiences. Apple felt that the weight of books and the old way of flipping pages were inadequate compared to the iPad's portability, graphics, and interaction (Kien, 2014). Apple declared that the iPad would make learning fun, and the student would gain a "study partner." However, the iPad served as much more than a textbook replacement. The iPad replaced the need for larger, more expensive devices like laptop computers. These benefits all served as reasons for the adoption of the iPad. This next section will outline the features of the iPad while looking at the benefits of its use in education and the barriers to its adoption in education.

The features and characteristics of the iPad make it an educational tool that can assist with learning in K-12 education. The height and width of the iPad resemble a children's book. iPads have a screen size of over ten inches, a multi-touch screen, and high pixel resolution. The iPad can also be viewed at 178 degrees both horizontally and vertically and can be switched between different viewing positions (Apple, 2016). The iPad is thin and lightweight, making it an effortless device to transport and handle.

A significant benefit of the iPad is mobility. Now, various forms of technology are used in education settings. In the early phases of adoption, smaller devices such as personal digital assistants or smartphones could have provided the user with a personal experience but did not support interpersonal and collaborative learning. It is possible that students would not achieve the same learning experience and involvement as they could on a device with a larger screen. Chromebooks are cheaper than laptops and weigh less but did not originally contain a touchscreen. This limited entry-level Chromebooks to interaction solely with a mouse and keyboard. More expensive Chromebooks included touchscreens. The most recent iPads have child-friendly design features such as a touchscreen, voice controls, switch controls, assistive touch, and alternative input. iPads contain hardware keyboard support, accessibility keyboard, back tap, touch accommodations, Siri, dictation, and predictive text. The iPad does not rely on the mouse and keyboard but does have the hardware to support one if needed.

Increased motivation and engagement are other benefits of the iPad. Unlike the conventional textbook, the iPad offered seamless learning. Seamless learning is the idea that students can learn whenever and wherever they are curious (Henderson & Yeow, 2012). This serves as a catalyst to increase student motivation. The iPad provides fast and easy access to information. Using an iPad allows students to move around and communicate with others physically. Portability enables students to explore any subject in any given location. Perhaps the most considerable engagement benefit is direct feedback. Students can receive immediate feedback when interacting with content on an iPad. This is not the case with conventional textbooks. The iPad increases engagement by encouraging students to be more creative. Students can

do everything from digital drawing, filming, editing, graphics work, and presentation creation. Collaboration is enhanced when students utilize an iPad. Teamwork is promoted since it can simulate face-to-face social interaction. After the first generation, all iPads contained a camera and video editing software, allowing communication to occur locally or globally. New education applications constantly emerge from the App Store. The iPad has several thousand educational applications available for download via iTunes via Apple's App Store (Apple, 2022). While some apps are free and some are paid, the iPad can connect educators to various education applications across every discipline.

Differentiation and individualized lesson planning have become increasingly popular teaching pedagogies. The iPad can help teachers make both concepts easier to implement in the classroom. Students have different learning preferences, and iPads can serve as a tool for educators to customize learning based on their needs. For example, if one student is a visual learner, they can watch educational videos. Kinesthetic learners could download and practice problems or participate in a simulation to learn similar content (Fleming & Mills, 1992).

Along with the potential benefits of mobile technology, there are downsides. There are many reasons the iPad was adopted in the education setting. There are also many barriers that the iPad encountered during its adoption and use. This next section will discuss the obstacles to the adoption of the iPad. Between 2011 and 2016, educational research showed that iPads were a potential distraction between students and their peers (Daley, 2017). While the iPad was intended to create collaboration, studies found that the iPad led to decreased academic performance and attention awareness. Listed in the study were reports of students using the iPad for shopping, gaming, and social media. Educators have less control over students who may be able to use instant messaging, play games, cheat on assignments, and visit inappropriate websites. Of course, this could occur if the device is not controlled.

The biggest drawback of adopting the iPad is the lack of equal access for all users. In 2010, only 76 percent of homes in the United States had internet access (Perrin & Duggan, 2020). Today, that number is close to 85 percent (Perrin & Duggan, 2020). But what about the

other 24 percent in 2010 and 15 percent today? Not every student would have equal access to the internet. The lack of equal internet access and connectivity is still the most considerable drawback of adopting the iPad in education.

Another major setback for the adoption of the iPad is that not all educators are equipped with the pedagogical strategies needed to be effective. All adopters would need training on fully utilizing and facilitating an environment for using iPads in education. For the laggards, new technology can be viewed as an unwanted intruder that alters the traditional ways of teaching. Laggards would resist the technology.

Early iPads lacked essential features and lacked technology support in education. For instance, the first-generation iPad did not have printing capabilities. Technology departments in schools were not prepared to allow educational apps to be downloaded. There were no measures to view student usage (Daily, 2017). Many times, resources were blocked, or the opposite, resources were too widely available. Students figured out how to bypass security measures and gained access to prohibited websites and apps. Technology departments were also ill-equipped to handle the technical difficulties and provide support during the early years of iPad adoption.

While many studies showed that the iPad increases student creativity, one study showed that the iPad decreases creativity with traditional drawing methods (Daily, 2017). This particular study compared the drawing results of students who drew with a pen-on-paper and those who drew on an iPad. The researchers found a significant decrease in the graphic scores in the iPad drawings. The result showed that the students are more likely to draw detailed artistic drawings with the traditional method.

The big adoption question is whether or not it is cheaper to replace the traditional textbook with iPads. A recent study figured it would cost roughly $180,000 to replace the average high school class's paper textbooks (Hein, 2015). Switching to iPads would cost them $430,000. The textbooks require a replacement around every five years. However, the replacement of iPads could be around the same timeframe. With textbooks being roughly 41% cheaper than iPads, this

is a significant setback for adoption. Most school districts would opt for more affordable devices like Chromebooks.

Impact on Education: Results

Apple, the marketing geniuses, produces impact statements for the iPad in education. These impact statements give an overview of the device's impact in the educational setting using case studies from specific schools throughout the United States (Apple Inc., 2010). The impact statement should be viewed as a marketing tool covering academic performance, engagement, and motivation. The case studies presented in the impact statement make a compelling argument for adopting iPads in the educational setting. While the iPad could have impacted these results, experienced educators will understand that many of the results listed are not solely based on adopting a single technological device. It should also be noted that some achievements may be challenging to measure, like higher-order thinking in high school students. The tables below summarize Apple's impact statement from 2019 (see Tables 1 & 2).

Table 1

Apple's Learning Effectiveness Use Case Academic Performance

Location	School Name	Result(s)
Coppell, Texas	Richard J. Lee Elementary	Increases in reading and math scores in Grades 3-5. Increase in science for Grade 5.
Southwest Ranches, Florida	Archbishop Edward A. McCarthy High School	National Merit acknowledgments increased 200 percent.

Waco, Texas	Bell's Hill Elementary School	Improved State of Texas Academic Readiness (STAAR) assessment scores in Grades 3-5
Liberty, Missouri	EPiC Elementary School	Increase using iReady scores; 33 percent increase in reading, 44 percent increase in Math
Oceanside, California	T.H.E. Leadership Academy	Gains in state assessments and a 50 percent decrease in disciplinary incidents
Fort Myers, Florida	Bishop Verot Catholic High School	Increases in SAT scores and increases in college scholarships
Austin, Texas	West Ridge Middle School	Increases in Grade 6-7 math exams
New York, New York	Marymount School of New York	All seniors graduate on time and go to college since the adoption
Harlingen, Texas	Zavala Elementary School	Improved State of Texas Academic Readiness (STAAR) assessment scores in Grades 3-5
Johnston, Iowa	Johnston High School	Claim students are 50 percent more engaged with higher-order thinking

Orange, California	California Elementary School	58 percent gains in student literacy
Mineola, New York	Mineola Middle School	Increased reading and math scores on state assessments
Orland Park, Illinois	Meadow Ridge School	Increase class time spent on higher order thinking activities

Table 2

Apple's Learning Effectiveness Use Cases Engagement and Motivation

Location	School Name	Result(s)
Senatobia, Mississippi	Magnolia Heights School	97 percent of students feel more engaged, 91 percent are more confident using technology, and 97 percent of their school excels compared to other schools
Claremont, California	San Antonio Continuation High School	Decreases in student suspensions
Compton, California	Thomas Jefferson Elementary School	Decrease in chronic absenteeism

Cerritos, California	Valley Christian Middle School	Positive results of student surveys after the 1:1 adoption of iPads

While discussing the impact of Apple's iPad on education, it is essential to look at two cases involving the adoption at a 1:1 ratio (such that each learner is assigned a device). Burlington High School in Burlington, Massachusetts, was one of the first high schools to launch over 1,000 iPads to all incoming freshmen in 2011 (Marcinek, 2010). Burlington installed Casper profiles on all iPads to track student usage based on student identification numbers. The Casper Suite allowed educational organizations to support, update, and monitor the use of iOS devices (JAMF Software, 2012). Burlington did not produce any facts or figures claiming that the iPads increased state standards or student motivation; however, Burlington is still adhering to the 1:1 ratio of iPads to students. This indicates that iPads in the school district have many advantages. Here is what Burlington discovered with their 1:1 adoption of iPads:

1. Using iPads to replace textbooks simply did not utilize the features of the iPad, and thus the device never reached its full potential.

2. Not every student was ready to adapt to technology. Many students preferred learning in the analog world.

3. Students had to be trusted and created a support system for technology issues

The Los Angeles Unified School District is the second-largest school district in the United States and serves over 600,000 students. The Los Angeles Unified School District failed with the adoption of iPads in 2011 (Lamb & Weiner, 2018). To summarize this case study, a new superintendent was hired for the district in 2011. This superintendent worked with Apple and began rolling out iPads to students in August 2013. Instantly the school district reported problems

with student security. Over 300 students at multiple schools deleted their security profiles. As a result, iPad usage was restricted to on-campus only. At the same time, teachers reported issues with device inconsistency. These issues included connectivity, lack of support, misaligned curriculum, and problems with the Pearson app. The Pearson app was supposed to serve as the replacement for textbooks and the main reason for use on the iPads. Faced with all of the issues, the superintendent pushed back the second phase of the rollout, ended the program, and resigned. The innovation was too immature at the time to support such a large-scale diffusion.

When technology is adopted, it must have a well-planned support system in place. This was not the case with the Los Angeles Unified School District and ultimately led to its failure. In their memo to California's Board of Education, the superintendent stated that one of the reasons the district terminated its contract with Apple was to take advantage of the ever-changing marketplace.

Paving the Way for Other Devices

Studies between 2011 and 2016 look at how iPads have positively and negatively changed student learning in the classroom (Daily, 2017). In 2017, most research studies investigated how schools began to shift away from using iPads and adopting Chromebooks (Daily, 2017). Why did this shift suddenly take place? This next section will examine how Chromebooks became the more frequently utilized device in education. And while Chromebooks may have a slight advantage in the market today, their use in education may not have happened if the iPad had not paved the way for their adoption.

One thing that certainly comes to mind when purchasing an Apple product is price. While Apple does have separate pricing for educational institutions, it is still more expensive than Google Chromebooks. A base-level iPad could still cost a school division around $300. Chromebooks charge $200, or schools can pay $20 per month. This monthly plan includes all hardware and software support and replacement of the Chromebook after three years.

The iPad has device limitations. One major limitation is the lack of a mouse and keyboard (Kucirkova, 2014). School districts

recommend using the iPad for early grades, but older students require using the mouse and keyboard for writing and while taking state assessments. This causes school districts to prefer Chromebooks over iPads.

With Apple, IT departments can utilize Apple School Manager. The implementation is straightforward and customizable. Apple grants 24/7 support through AppleCare. The iPad must be sent to Apple for repair if there is a hardware issue. This is one downside to technology management. With Google, the G Suite for Education allows unlimited users. These users can log into everything they need from apps, settings, books, videos, and class assignments. Google allows admin controls. Administrators can determine what applications can be accessed, installed, or blocked. Google Chromebooks offer 24/7 support.

Educational institutions adopting technology before 2020 may have been influenced by the Flash support that Chromebooks contained. From 2011 until 2020, iPads could never support Adobe Flash. Chromebooks did incorporate flash support. On December 31, 2020, Adobe stopped supporting Adobe Flash. The lack of support for Flash video could have prevented the early majority from adopting iPads.

Effectiveness of 1:1 Implementation

Schools have implemented 1:1 programs for over twenty years. A 1:1 program is best defined by an educational institution that provides one technology device for every student (Sauers & McLeod, 2018). Are these 1:1 programs effective in increasing student achievement and engagement? Earlier in the chapter, a Burlington High School case study regarding the 1:1 adoption of iPads was investigated. This case study demonstrated mixed results with implementing one iPad for every student. But, what does other research reveal? Research has shown that teachers favor school-connected and personally connected devices. For these programs to work, educators prefer guidance on the best use of the devices and adequate technology support (Luo & Murray, 2018). Drawbacks exist with 1:1 programs, including students using the devices for non-productive personal use. One study showed that students who participated in 1:1 programs did demonstrate a higher level of technology competency (Sauers & McLeod, 2018).

Unfortunately, the research on 1:1 programs is lacking, and the results are mixed (Gherardi, 2020).

Summary

The iPad was not the first tablet; several personal digital assistants and tablets were before the iPad. Tablets such as the Linus Write-Top, GridPad, MessagePad, PalmPilot, and Windows XP Tablet, came into existence before 2010 (Bort, 2013). So, what fueled the adoption of the iPad in education? The answer to this question lies within the marketing campaign and the device's features. The marketing of the iPad was well-planned and executed. Apple targeted innovators and released the product with limited availability. This created excitement and exclusivity. Soon user-generated reviews started free advertisements for the iPad. But marketing did not fuel the use of the iPad in education. The features of the iPad made it an excellent choice for educators. The iPad was lightweight, easy to use, connected without wires, had long battery life, and was attractive. Plus, the iPad is connected to the App Store, which contains 2+ million education applications.

The iPad adoption in education follows the typical S-Curve adoption rate described by Rodgers. Early adopters used the iPad once they saw the potential benefit of bringing the device into the educational setting. The innovators tested the iPad with select groups of students. The early majority began using the iPad once they observed social proof of its benefits. The late majority started using iPads in education once help and support systems were in place. Finally, the laggards adopted the iPad so they would not be left out or were forced by the educational administration.

The iPad has several benefits and several barriers to adoption in education. The benefits included an advanced touchscreen, lightweight portability, and various accessibility features. The iPad is able to increase student motivation and engagement, improve collaboration, help teachers individualize lessons, and has a lot of content readily available from the App Store. However, the iPad can be a distraction in

education because it is hard to control. Some studies showed a decrease in academic performance. It is costly, and teachers lack the training to utilize the device to its full potential. The most significant barrier to iPad adoption is the simple fact that not everyone has equal access to this device.

Several studies show the iPad has positive impacts in the education setting. These studies highlight academic performance, student engagement, and student motivation. However, the iPad has lost the majority of the market share in education to Chromebooks (Swartz, 2016). Chromebooks, and similar tablets to the iPad, share many similarities. These similarities include a robust application store, easy connectivity, and portability. Many of the Chromebooks and clone devices even have similar aesthetic features. The main reasons Chromebooks surpass the iPad in education are cost and IT management. Also, Chromebooks are easier to control and supply students with everything they need in the G Suite for Education. They also include built-in keyboards, which would be an extra accessory on the iPad and another aspect of the support workload.

It will be interesting to see what educational technology trends emerge following the years of virtual and hybrid learning created by the COVID-19 Pandemic. Will Chromebooks lose favor to a new device? Will Apple find a way to revamp the iPad so it becomes a more favorable device in education? Either way, the iPad will always be remembered as the device that was supposed to fail and ended up enriching the lives of millions of educators and students.

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Instructional Systems Design and the Diffusion and Adoption of Technology
(Volume 1)

Chapter 3: Diffusion and Adoption of Zoom in K-12 Classrooms

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3. Diffusion and Adoption of Zoom in K-12 Classrooms

Meghan Soldani

Key Points:

- Zoom continues to adapt its features and improve its user experience
- Prior to the COVID-19 pandemic, Zoom was on the uprise but the pandemic had a major effect of its success in becoming mainstream in our society
- There were many advantages and disadvantages to the video conferencing platform but some key unintentional consequences

Abstract

Technology has had both positive and negative effects on the education system. There are many different sites, resources, and platforms that have been created and used in the classroom. Technology has different effects on educators and students as well as the parents of young students. This chapter will discuss the diffusion and adoption of the video conferencing platform Zoom, the effects COVID-19 had on the program, and the consequences of its use.

Introduction

Zoom's features have continued to improve since its web conferencing software launched in 2013, this innovativeness has driven its success. The features that are discussed in this chapter are not exhaustive, but were pivotal in its usefulness for virtual learning, especially during the COVID-19 pandemic. Prior to the COVID-19 pandemic, Zoom was on the uprise and proving to be a top competitor in the video conferencing realm. Eric Yuan used customer feedback and satisfaction to persist with the platform, despite investor's and user's initial doubts. The adoption and diffusion of Zoom became mainstream because of its perceived usefulness and ease which is supported by research. Even though there has been a great deal of success with Zoom, there have been unintended consequences. Zoom fatigue and Zoom bombing are negative effects of the platform and will be discussed in this chapter.

Zoom's Platform

There are many features of Zoom that make it a user-friendly and successful innovation. Below is a table of the key features that allow teachers and students to virtually interact with one another (*Compare zoom features: Complete list of all 42 Zoom features* 2022).

Figure 1.
Zoom Features, and use in K-12 Virtual Classrooms

Feature	**Uses/Importance**
Meeting code	Meeting codes were offered as reusable, so if students were logging into the same class every day, they didn't need to type in a new lengthy code each time. This made logging

	into virtual learning easier for students and parents.
Participant Camera Feed	Users are able to see up to 100 others on the free version of Zoom, giving the feeling of face-to-face learning/meetings.
Microphone	Users are able to speak to one another and ask/answer questions in an educational setting.
Cross-Platform Messaging	Users are able to communicate whether using a mobile device, iPad, laptop, or desktop monitor. This made the platform more accessible.
Zoom Scheduling	The host of a meeting is able to schedule a meeting/class and send it out to participants. Participants can easily click on the link to pull up the program, quickly and easily.
Waiting room	Users can be sent to a waiting room to allow the host to make sure the meeting is secure and only for users that are participating.
Meeting Recordings	Hosts can record the meetings that they hold. This helps users be more flexible and not miss content and learning if there is a schedule conflict.
Assign Permissions Setting	Hosts can give screen sharing, chat and poll permissions if necessary. This allows the host to be in control for when students can share their screens and communicate through the chat/polls.
Filters/Virtual Backgrounds	Users are able to appear professional even if they are not sitting at a desk or in an office.

	Backgrounds and filters help eliminate distractions for other participants.
Chatbox	Users and the host can communicate through the chat to ask/answer questions.
Hand-raising	Users can click a button to raise a ‘virtual’ hand. This allows participants to let the host know they have a question/comment without verbally interrupting.
Poll	Hosts can access user thoughts and ideas through launching a poll. This allows for engagement and feedback.
Breakout Rooms	Hosts can put students into smaller groups to work together, while also having the ability to join the breakout rooms themselves.
Closed Captioning	Users have the ability to use Zoom-generated closed-captioning if necessary.
Screen Sharing	Hosts and participants can share their own computer screen. This is useful when presenting and also troubleshooting.
White Board	Hosts can launch white boards for students to engage and interact with content and one another.

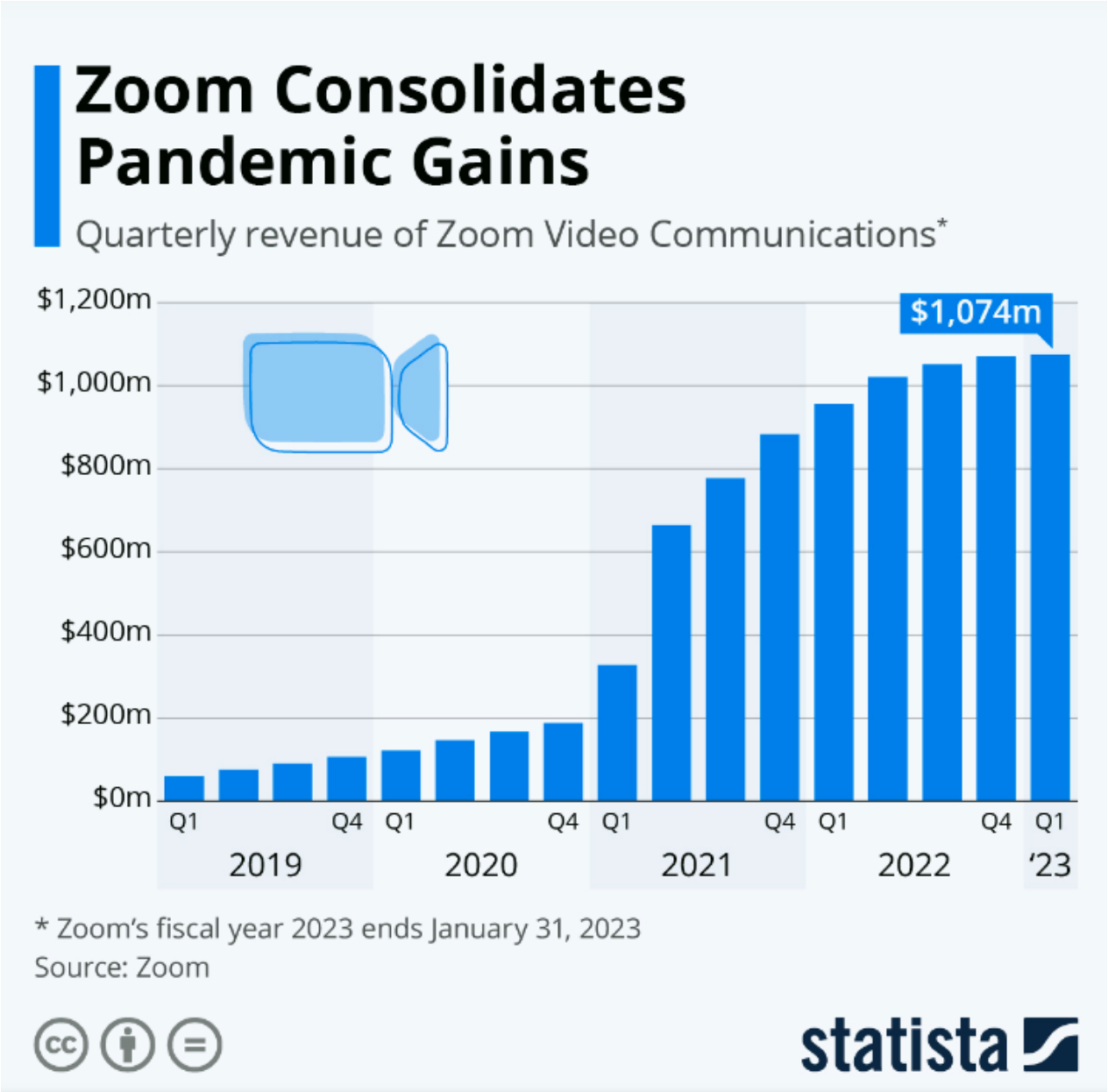
Note. Figure 1 shows the benefits and exemplifies the pros of using Zoom in an educational setting. As an educator teaching during the COVID-19 pandemic, I found Zoom to be the most effective tool for the unprecedented times we found ourselves in. Students were able to interact with their peers through the chat and polls. Engaging students was made possible with the tools and backgrounds and screen sharing.

Pre-COVID Zoom

Zoom was created in 2011 when the founder, Eric Yuan, left Cisco as a founding engineer for its WebEx video platform. The earliest versions of its software system and web conference app launched two years later. Then, Zoom went public in April 2019, and its shares surged 72% on its first day of trading (Kelly, 2020). In 2019 when Zoom first went public, it entered what was considered to be a crowded market in videoconferencing. Despite the saturated market and the company being a startup, Zoom became successful compared to its competitors. Even prior to COVID, users described Zoom as having a super-simple UX (user experience) that was superior and easier to use than competing video conferencing programs (Lev-Ram, 2020).

There are multiple factors that go into the success of Zoom, but it starts with how it differentiates itself from other video conferencing platforms. Anyone can send or receive an invitation, and a meeting will quickly be launched from a browser without the need to download an entire software app. Also, the free version of Zoom allows for up to 100 video participants, which surpasses other companies like Skype (Moolchandani, 2021). Zoom has had the ability to continue to succeed because it has continued to grow and improve since 2019. According to Zoom, there have been 268 release notes since 2019 (Zoom support, 2019). These notes included Zoom product changes, enhancements and bug fixes. Figure 2 below shows that even before the skyrocket of pandemic gains, Zoom was on the rise of success since it went public in 2019 (Moolchandani, 2021).

Figure 2.
Zoom Consolidates Pandemic Gains



Note. (Moolchandani, 2021)

Adoption and Diffusion of Zoom

Zoom has been on the uprise since it went public, but the COVID-19 pandemic set an unprecedented success for the platform. COVID-19 caused schools all over the world to shut down and abruptly move to virtual classrooms. All over the country, people were adopting the video conferencing program because of its tools and the ability it gave to teachers to continue to reach their students academically. Teaching/learning from home became a necessity and Zoom quickly became a mainstream innovation.

Zoom became a platform that, with creativity and intention, was able to engage and successfully teach students all around the world. Within four years, Zoom went from a small start up to being used by tens of millions of people around the world (Shah, 2020). The use and acceptance of a virtual learning platform are based on two key factors: perceived usefulness and ease of use (Fuady et al., 2021). Figures 2 and 3 below show the results of the perceived benefits of learning media from the book, *Analysis of Students' Perceptions of Online Learning Media During the COVID-19 Pandemic* (Fuady et al., 2021).

Figure 3.
Mean and standard deviation of the perceived easiness of learning media

Variables	Learning Platforms	Mean	SD	Category
Perceived ease	Zoom	3,6	0,54	Very easy
	Google meet	3,2	0,63	Easy
	Classroom	3,2	0,64	Easy
	LMS	2,9	0,70	Difficult
	Mean	3,2	0,63	

Source: research data analysis

Figure 4.
The mean and standard deviation of the perceived usefulness of learning media

		Mean	SD	Category
Perceived usefulness	Zoom	3,5	0,6	Quite useful
	Google meet	2,9	0,7	Quite useful
	Google Classroom	3,1	0,7	Quite useful
	LMS	2,9	0,7	Quite useful
	Mean	3,1	0,7	

Source: research data analysis

Note. The adoption and diffusion of the Zoom platform was successful and mainstream because of the perceived ease and usefulness (Fuady et al., 2021). On a 5-point Likert scale, users rated the ease and usefulness of technology tools, with Zoom rated higher than Google Meet, Google Classroom, and their organization's Learning Management System.

Having become such an integral part of students, parents and teachers' everyday lives, there were pros and cons to the constant use of this technology. Students were learning more than they would if there wasn't a video conferencing tool such as Zoom but there were also some unintended consequences that we saw from the platform.

Consequences of Zoom

'Zoom fatigue' is a term that is now widely used to describe the anxiety and exhaustion that comes from the constant logging in and participating in Zoom meetings/classes. According to Professor Gianpiero Petriglieri in Brennan's book *Engaging Learners Through Zoom: Strategies for Virtual Teaching Across Disciplines,* students and educators find it more exhausting and difficult to stay focused in a virtual classroom than in a face-to-face classroom (Brennan, 2020)). There's dissonance, meaning that we feel disconnected from the people

in front of us on our screen. Humans have a need and desire to connect with others and having to use a video conferencing platform for such a consistent amount of time takes away from students' and educators' sense of belonging. Not only does this affect our mental health but the amount that students are learning declines due to the lack of ability to pay attention to the instruction through the screen. According to Hadar and Wilken (2022), we can draw on the theory of media richness. This theory states that interactions held through 'richer' communication media yield better communication. Video conferencing platforms are considered more 'rich' than other media but not nearly as effective and 'rich' as face-to-face communication and learning.

'Zoom bombing' also has become a negative, unintentional consequence of the video conferencing platform. Zoom bombing can be described as an uninvited user joining a Zoom call and acting in a disruptive or inappropriate way. Concerns of Zoom bombing with groups of under-age minors increased the seriousness of Zoom's security issues. The platform was designed to be as user friendly as possible, and so less effort was made to ensure security. This became a bigger issue in K-12 classrooms because students were giving out their class codes to other students that weren't in their class. Links to classes were also being publicly posted by hosts and users on social media sites, for others to find. Zoom counteracted this by allowing hosts to add security to their meetings, having to allow each student in during meetings, giving meeting hosts control as to when someone can enter their meeting.

Conclusion and Future Directions

Zoom is an innovation that is now considered 'mainstream' because of its successful adoption and diffusion into society. This video conferencing platform has evolved and added many features that give users the ability to easily hold meetings or classes in a virtual environment. Students and teachers were able to connect with each other despite there being a global pandemic. All-in-all the platform has

been an integral part of our society, even though there have been some unintentional negative consequences that users experienced.

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Instructional Systems Design and the Diffusion and Adoption of Technology

(Volume 1)

Chapter 4: Zoom in Higher Education

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4. Zoom in Higher Education

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Key Points:

- In 2022, it is a simple process to video chat someone across the globe, but it was all made possible with the help of American Telephone and Telegraph Company (AT&T) in 1927.
- There are multiple video conferencing systems available such as Skype, Webex/Cisco, and Zoom. With the right marketing strategies, Zoom earned the win during the COVID-19 pandemic to aid in virtual higher education classes.
- Online examinations can be proctored with the assistance of lockdown browsers or Zoom software. Reg flags have been raised with Zoom video proctoring as many view this as violating students privacy.

Abstract

Think back to the Spring semester of 2020. What classes were you taking? Were they in person or online? Personally, I was registered for all in-person classes, but I had taken online classes in the past. When COVID-19 shook the world and in-person classes were changed to online, students were quite concerned about what this intaled. Surprisingly online classes have been around for a while, and with the power of Zoom, well thought online classes were a breeze for many students to navigate. Technology such as instant messaging and facetime are all diffused into Zoom to make up one platform, but as everything, it has evolved and will continue to.

Beginning of online learning

Distance learning has been circling the globe since the 1920s and 1930s using radio and television (Novak, 2012). University of Houston Television (KUHT), now known as Houston PBS, aired one of the first real-time college classes via live television, and continued to run educational material weekly (Writersm, 2022). Two years later, the University of Phoenix created bachelors and masters degrees. Today, according to the National Center for Education Statistics, during the fall of 2020 semester, 73% of postsecondary students were enrolled in online education courses (NCES, 2021).

You've Got Mail

The Advanced Research Projects Agency Network (ARPANET) in 1969 was the first electric mail system to link multiple computers together for communication. It wasn't until 1971 that Ray Tomlin designated the "@" symbol so emails could be sent to specific locations. Even with the "@" symbol designating email locations, in the 1980s email hosting sites or ISPs (Internet Service Providers), were created to connect users from across outside networks (Phrasee, 2021). Real time chat as a technology innovation was diffused by the general public starting in 1997 when AOL (America Online) created AIM (AOL Instant messenger). AOL messaging consisted of real-time messaging in group or private chat rooms and "buddy lists" (Maize, 2020). One year later, Yahoo launched their messenger system to allow messaging between users with their Yahoo ID (Maize, 2020). Another year after that, the first real competitor to AOL and Yahoo, MSN (Microsoft Network) launched their messenger (Maize, 2020). Finally in 2002, Apple iChat made a debut on the Mac OS X Op System and was compatible with AOL instant messaging (Maize, 2020).

Early Video Conferencing

Video Conferencing dates back to the 1870s, but the first live moving image was sent in 1927 by American Telephone and Telegraph Company (AT&T) Bell Telephone Laboratories from New York to the White House (Patrizio, 2021). The problem AT&T discovered was that

New York could see the White House, but the White House could not see New York. Finally, in 1931 the first successful two-way video call was between AT&T offices in Manhattan. A few years later, in 1936, Georg Schubert created Gegensehn-Fernsprechanlagen, or a "visual telephone system" (Patrizio, 2021). These video booths were set up in post offices and seemed to be a prototype of what modern video calling would be. AT&T's Bell Telephone Lab fabricated a 2-way video phone known as the "PicturePhone Mod I b" (Patrizio, 2021). The picturephone was showcased at the World's Fair in 1964 as the first video phone. Competition to AT&T's PicturePhone was announced in 1982, created by Compression Labs. This system was considered the first commercial group video conferencing system and had a hefty upfront cost of $250,000.

Fast Forward to 1991, PictureTel attempted to create a PC video conferencing system (Patrizio, 2021). The first desktop video conferencing platform, CU-SeeMe, was launched in 1992 through Macintosh OS and Windows in 1994. The more common video conferencing system, Polycom (now "Poly"), was founded by two PictureTel colleagues in 1990, then launched in 1992. This system had a triangular speakerphone and advertised its high quality audio which allowed both video participants to "speak and be heard" (Patrizio, 2021). As we know today, FaceTime and Apple's iPhone 4 were released in 2010. The iPhone 4 originally only supported Wi-Fi connections but later added 3G and 4G/LTE connections.

Higher Education Video Conferencing

Skype, Webex/Cisco, and most importantly, Zoom have helped online classes become a more engaging and inclusive environment, without the need for specialized, complex video conferencing rooms or systems. Skype launched in August of 2003 and was created by Estonian software engineers. Skype stands for "Sky Peer to Peer," and the original software allowed voice calls from computer to computer (Cowling, 2016). They later launched Skype 0.9, which allowed calls to landline phones from PC computers. In 2005, eBay purchased skype for 2.5 Billion and wanted to focus on a later unsuccessful streaming video service - Joost. Similar to chat rooms or AOL AIM, in 2006, Skypecasts were launched, allowing up to 100 participants to join for voice conversations. Two years later, Skype began to focus on adding video

calling to their software, and launched Beta 4.1 in 2009. This update allowed members to share their screen, and finally in 2010/2011 video calls were available for iPhone and Android users.

Zoom was founded by Eric Yuan in 2011. Eric Yuan has an interesting background, as he originally worked for WebEx, a company focusing on video conferencing. Yuan became the Vice President of engineering, and in 2011 he proposed to Cisco & WebEx a video conferencing system for smartphones. WebEx did not accept his proposal, so he quit his position and started his own business, Zoom Communications (Abhinandhinee, 2022). Zoom's first beta was released in 2012, with Zoom 1.0 released in January 2013 to the public.

Lastly, Webex was established in 1995 by Min Zhu and Subrah Lyar, under the name "ActiveTouch". In 2007, Cisco purchased Webex for approximately 3.2 billion and $57 per share (Cisco, 2007). Webex is a cloud-based video conferencing system with similar features to Zoom. Through video conferencing, participants can share their screens, and be broken up into private rooms, and meetings can be recorded then broadcasted. Through Slack and Microsoft Teams, participants can join video conferences and schedule and integrate meetings with participants using Outlook, Office 365, and Google Calendar.

Zoom Pre-COVID

Again, try to think back to classes prior to the COVID-19 pandemic. Online learning has been around for a long time, and the pandemic was not what made colleges years ago diffuse to online learning. Universities began to use Zoom integrated with online lectures so that students had a more flexible schedule and the possibility of a faster education track. By advertising to students that they could still work a part-time or full-time job while taking classes online, interested students. When thinking about students taking online classes, 62% work either a full or part-time job (Chapman, 2017). With colleges adding Zoom to their online classes, instead of students meeting in person, there are scheduled meetings, and students log on to join class. One main problem that educators and students stumbled upon, was having access to a computer, webcam, a reliable Internet connection, and getting logged into the chat. Prior to COVID-19 classes, I would consider Zoom to be new technology as I only used it in one online

class. With new technology, comes problems/solutions, but students and educators quickly caught on. Rogers introduced the classic diffusion curve that describes innovators, early adopters, the early majority, late majority, and laggards (Rogers, 2003). Zoom's growth in an already crowded sector was fueled by focusing on the needs of its innovators and early adopters to resolve issues and add the features that the early majority needed (Shah, 2022). The education and healthcare makerspaces were a particular area of focus. Zoom also focused on user needs, ease of use, support for mobile devices, and continued innovation. Innovations included Zoom Webinars, Rooms, Events, and Phone in addition to Zoom Meetings, breakout rooms, virtual backgrounds, and accurate auto-generated closed captioning. Before the pandemic, Zoom was probably already mainstream in higher education being adopted by increasing numbers of the early and late majority users. However, the pandemic further accelerated adoption.

Diffusion During the Pandemic

It seemed like a difficult task for colleges to transfer to online learning, but with Zoom and its clever marketing strategies, it was a mostly smooth transition for many. Personally, I have difficulties with online classes due to downloading software and understanding how to use it. Zoom marketed its videoconferencing system as a simple to use software that required no downloading (Moolchandani, 2021). With the click of a button, participants could access a meeting with the invitation link that was given by the host. Zoom also has a free version where a host can add up to 100 participants to one meeting (Moolchandani, 2021). This limit was generous as compared to other services. For instance, the competitor company Microsoft, who owns Skype, allowed a host to add only 50 participants to a meeting at a time (Moolchandani, 2021).

As classes transitioned to online, Zoom became more popular and in demand. Back in May 2013, a million users were logged in per day, compared to December 2019, when there were 10 million participants in daily meetings (Iqbal, 2022). In March of 2020, when the COVID-19 Pandemic struck colleges, Zoom reached 2.13 million downloads in a single day (Iqbal, 2022). Alongside TikTok and PokemonGo, Zoom was added to the exclusive list of apps being

downloaded over 300 million times in a single quarter. Zoom clearly grew thanks to the pandemic, and Zoom was considered “one of the fastest growing apps of the pandemic”, as their meeting participants increased by 2,900% (Iqbal, 2022). When comparing mobile apps, in March 2020, Zoom was downloaded 3.7 times more than Skype (Moolchandani, 2021). During the Spring 2020 semester, over 1,300 colleges switched to online learning platforms such as Zoom. When COVID-19 peaked, over 90,000 schools were using the Zoom platform for educational purposes.

With Zoom rapidly growing and more participants logging on than ever before, Zoom became the new standard in virtual classroom environments. Throughout 2020, over 45 billion minutes of webinars were hosted, and more features were added. Educators were able to break students into “break out rooms”, which allowed students to work in smaller groups or with a partner. If the host chose to record the session, students could return back to the recording to review, but this was also important for students who may have missed the lesson. Those students could easily access the recording, as well as a transcript below the video. A search feature was also added where students could search the transcript to easily find a certain topic or speaking point without rewatching the entire recording. Educators also enjoyed being able to poll students during a lecture, which frequently was used to make sure students were actively participating and not nodding off.

While there are direct, intended, and beneficial consequences introduced by technology innovations, there are also indirect, unintended, and undesired consequences (Rogers, 2003). Aside from all of the great things Zoom had to offer, there were some problems. In March 2020, the FBI issued a statement about hijacking virtual online classrooms. Classes and teleconferences were hacked by saboteurs which displayed and commented pornographic images, racial slurs, Nazi swastikas, and many other offensve images. Another issue arose during the Fall semester of 2020 during the first day of class. Zoom had an outage across North America and parts of Europe and Asia, where students were unable to join their scheduled class meetings. When trying to join, their screens were prompting them to wait for the host to start the meeting. Many classes utilized another platform, while others canceled that day of class (Lumpkin & Svrluga, 2020). While Zoom was very innovative in making its service as user friendly as possible,

one of the consequences of this ease of use was an initial lack of security features that Zoom had to correct. Zoom's growth has begun to slow, a possible indication that Zoom has reached its late majority and late adopter/laggard user groups (Iqbal, 2022). Without introducing further innovation, it will be interesting to see if Zoom can maintain the market share it created during the pandemic.

Personally, I have not encountered these issues. I think with all things technology, there will be problems/glitches, shortly after an update will be announced to correct the glitches. I definitely think online classes will be sticking around as they are convenient for students with jobs and for students with medical conditions who do not feel comfortable entering a classroom with COVID-19 and its variants.

Lockdown Browsers

In the educational setting, Zoom is commonly used for class lectures, but it has also been used to accompany lockdown browsers while testing. When classes switched to online, many teachers wondered how students would follow their college's academic integrity policy. In online classes that I have taken, the first question of the exam would be stating the college's academic integrity policy. If you understood and agreed to follow that policy, you would type your name or select "I agree". With that in play, students are still able to simply click yes, and then open their textbook to look up an answer without the instructor ever knowing. With that being said, Respondus was created as a browser that locks down a computer within a student's BlackBoard window. When students enable Respondus, they are unable to print, copy, visit another URL page, or view other applications on their computer (Marjanovic, 2021). This seemed like a great idea, but Respondus only locked down the device on which the exam was being taken on, such as a laptop. Students could still view a paper textbook, printed notes, access their cell phones, or even another laptop/iPad.

In 2013, Respondus launched a lockdown browser monitor system. Respondus Monitor was considered a fully automated proctoring system (Duotl, 2020). When entering the exam, students would allow their webcam to record themselves while answering each of the questions. When the exam was submitted, any flagged events and proctoring results would be sent to the instructor for review. While

testing, the system used facial recognition, but false flagging was occurring frequently. False flagging was noted to occur with students of color, inadequate wifi connection, inadequate lighting, or accommodation needs (Marjanovic, 2021). To avoid false flagging, instructors began to use Zoom to proctor exams. Instructors could set specific dates and times for all students to join a Zoom meeting and test as a class, or students could create their own Zoom meeting, record the session, then upload the video with their exam. As an educator, having students record their own session and being required to look through the recordings for cheating would be time consuming. As a student, if you were being recorded, would you really try to cheat? Proctoring students through zoom came with only a few mistakes, but mainly as long as the students have their microphone on, camera on, and the session is being recorded, they are good to go!

Students not only worried about exams being flagged, but what about their privacy while being recorded? While students are recording themselves taking their examinations, students are being forced to disclose their living arrangements (Tariq, 2021). Zoom does have a feature that can blur out the background of a participant's screen, but for testing purposes, filters usually have to be removed while testing. Students are also being forced to give full access to their computers and browser while using a browser lockdown software. When a software locks down a computer, how can a student be sure it is safe? As an undergraduate student, when I used the Respondus lockdown browser for testing purposes, as I would exit the exam, my home wallpaper was always reset to a factory wallpaper. If the wallpaper on my homescreen was being changed, what else was being changed? Another example of unintended consequences; privacy concerns have resulted in many institutions discontinuing their use of locked down browsers and other proctoring solutions.

Conclusion

In conclusion, even with video technology being around since 1927, it is still being actively diffused into education. There are several video conferencing systems for educators to choose from, but educators and students seem to have a favorite. Zoom offers easy accessibility, and has many features including break out rooms, recording available to

replay past meetings, and capabilities to proctor online examinations. For students, it is a concern that recorded examinations are a violation of their privacy, and while using a lockdown browser, who is really in control of their laptop? I think that online classes in conjunction with Zoom create a similar class style to traditional in-person classes. By adding Zoom meetings into online classes, it shows that technology has diffused into the educational setting, and I think it will continue to to diffuse as technology improves.

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Instructional Systems Design and the Diffusion and Adoption of Technology
(Volume 1)

Chapter 5: Immersive Extended Reality in Education: Adoption and Diffusion of Learning Technology

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5. Immersive Extended Reality in Education: Adoption and Diffusion of Learning Technology

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Key Points:

- Advancements in extended reality technology and reductions in product costs allow for increased accessibility of this technology in the classroom.
- There are more applications tailored to use in the gaming and entertainment industry than for use in classroom education.
- Use of immersive extended reality is increasing in education, but has not reached widespread adoption or diffusion.

Abstract

The invention and development of eXtended reality (XR) technology hardware and software applications can be traced back through many decades. The distribution of an open source programming kit for augmented reality (AR) in 1999, developments in computer and smartphone capabilities that increase device access as well as computing and graphics capabilities, and the release of several consumer-priced AR and virtual reality (VR) head-mounted displays in 2016 led to a surge in the development and adoption of XR application in gaming and entertainment (Elmqaddem, 2019). Sales of AR and VR technology continue to climb (BCC Research, 2018). Most of the expenditures for XR technology are for gaming and military

applications (Stevens, 2017), but the education market is the fastest-growing sector (BCC Research). Non-immersive VR applications and AR applications are readily utilized in education for little or no cost through applications such as PhET simulation in Nearpod and Google Street View. While immersive XR technology can align with today's constructivist pedagogy in education and promote increased learner engagement, diffusion of semi and fully immersive XR has not reached the mainstream level across educational levels and subject disciplines.

Introduction

Technology is omnipresent in our everyday lives. It impacts how business is conducted, healthcare is provided, communication is transmitted, and knowledge is gained. This is also true in the classroom, where the use of education technology can increase students' collaboration, interest in learning, and transfer of knowledge (Nagasubramani, 2018). Students can now connect with students in other locations, search for information on a global network, explore areas they could not usually travel to on a field trip, participate in experiments that might be difficult to access in a real-world environment, and receive individualized resources for instruction. These immersive experiences can be achieved by incorporating virtual reality (VR) and augmented reality (AR) into the curriculum. Though the development of eXtended reality (XR) technology began decades ago, recent device capabilities coupled with the reduction in device cost have made this type of technology more available for various educational programs. However, technology advancement does not directly lead to adoption and diffusion in the mainstream classroom. This chapter will review the development of immersive technology, events that impacted diffusion and adoption of the media, the current use of immersive media in education, the impact of utilizing immersive media in education, and the infrastructure needed to impact successful technology adoption.

History and Definition of Terms

Definitions

It is difficult to discuss XR learning technology without defining the associated terms. Extended reality is an overarching term for immersive technology in that XR hardware and software provide sensory input to the user that alters reality. Within XR, different types of technology applications are related to the level of immersion and user interaction with the technology (Table 1).

Table 1.
Type of Immersive Interfaces

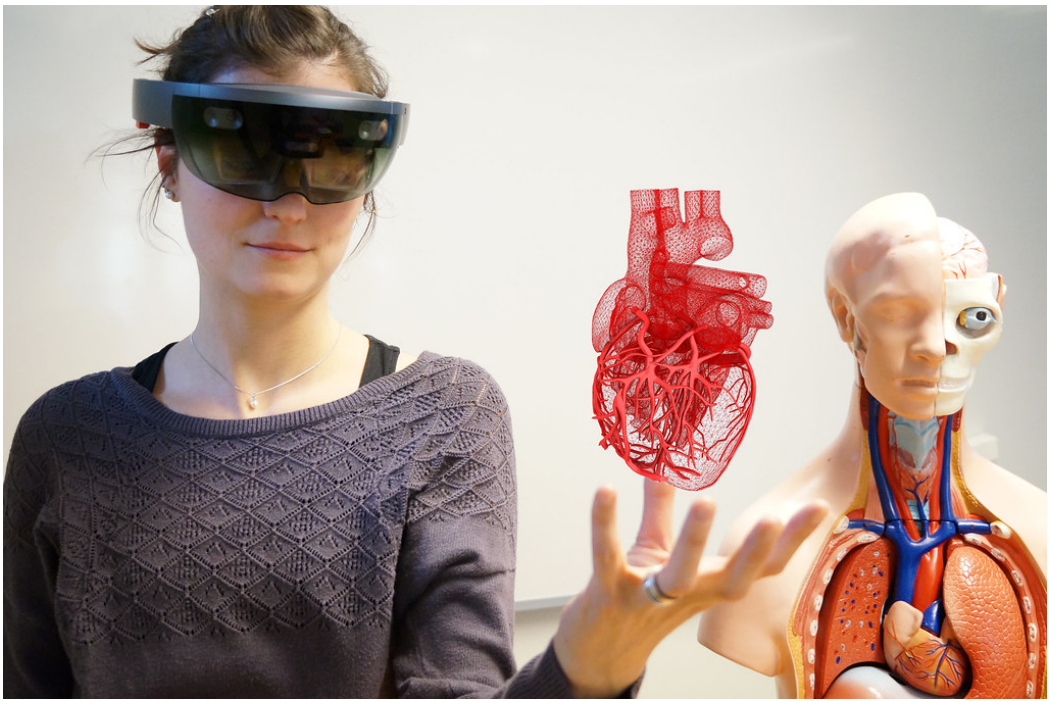
Interface	Description
Virtual Reality	● The user is immersed in a virtual environment through the use of their senses. The actions of the user in the real world have an impact in the virtual environment (Dede et al., 2017). ● Level of immersion in VR varies from non-immersive interaction with a screen and a mouse to fully immersive with the use of a head-mounted display (HMD) (Di Natale et al., 2020)
Multi-user Virtual Environment	● The user enters a simulated setting as an avatar. The digital avatar can interact with the environment and other users (Dede et al., 2017).
Mixed Reality	● Partial virtual environment achieved with wide field display and more realistic three-dimensional graphic. ● May include mixed reality simulators that mixed real-world mechanisms with virtual environments. ● The user remains connected to the physical environment and interacts through the use of a joystick or mouse. Similar to a flight simulator (Di Natale et al., 2020)

Virtual reality refers to technology that immerses the user in an artificial environment through various media such as video, audio, and haptics (Figure 1). As the technology continues to advance, it allows for multiple types of user input such as hand movement, head position, body position, eye movement, and facial expression, with the potential for even e-smell (Scudellari, 2018) and e-taste (Ullah et al., 2022). According to Sherman and Craig (2018), there are five elements of VR: a virtual world, immersion, sensory feedback, interactivity, and information intensity. The user interacts with a virtual world based on rules developed by the program creator. The level of immersion may be psychological and physical.

Psychological immersion relates to user engagement. In engagement research, this psychological concept is often referred to as flow, or an experience of absorption in an activity that is not prompted or forced (Nakamura & Csikzentmihalyi, 2014). Physical immersion relates to the sensory stimuli of the simulation. The experience should respond to user stimuli and change based on user input. The user should have an opportunity to manipulate items in the environment, such as picking up a stethoscope, adjusting the lighting, or moving to a new area in the video display.

The term Augmented Reality (AR) was coined in the 1990s and referred to head-mounted displays (HMD) worn by electricians that helped with an image overlay to assist with assembling wire harnesses (Elmqadden, 2019). This technology refers to an overlay of virtual items in a real environment (Figure 2). The user is not placed in a virtual environment, but their environment has additions from technology. When you use a smartphone app to see how a new piece of furniture will look in your room, you are using AR. AR usually has a tangible interface where the user can manipulate a physical object that has a digital effect, such as moving a mouse and having a cursor move on a computer screen (Dede et al., 2017).

Figure 1.
Virtual Reality and Educational Applications



(Creative commons CC BY-NC-ND 2.0)

The definitions of AR and VR vary by source and seem to intermingle and overlap. Dede et al. (2017) describe interface types as VR, mixed reality (MR), and multi-user virtual environment (MUVE). Conversely, Di Natale et al. (2020) classify MRs as a level of immersion instead of a type of interface. When I completed an Internet search on the history of the development of AR and VR technology, I found images of the same hardware as examples of both AR and VR. For this chapter, I will separate the types of interfaces that the student interacts with (Table 1).

In addition to different types of interfaces with XR, there are also a variety of types of immersion (Table 2). The level of immersion in the technology can help the user to suspend disbelief using sensory stimuli, actional, social, and narrative factors for psychological immersion. This component of XR technology is important to educational applications and the level of immersion is linked to learner motivation while participating in the experience (Dede et al, 2017). The user interaction

within the immersive environment may be limited to interaction within pre-programmed digital elements or allow collaboration with other users in multi-user virtual environments such as with PlayerUnknown or in health care simulations that allow multiple users to participate in patient care.

Figure 2.
Applied Instructional Augmented Reality

Note. K-12 classroom using an AR application on a phone or tablet to view a dinosaur and a volcano on classroom desks.

History

Extended reality technology has existed for decades. As with the definition of what classifies AR or VR, there is also some conflict on who first developed XR technology. Sherman and Craig (2018) trace early conceptual and technical advancements in XR to the development of the Stereoscope in 1838 (Figures 3 and 4). Stereoscopic photos and viewers combined two images to create a three-dimensional image that

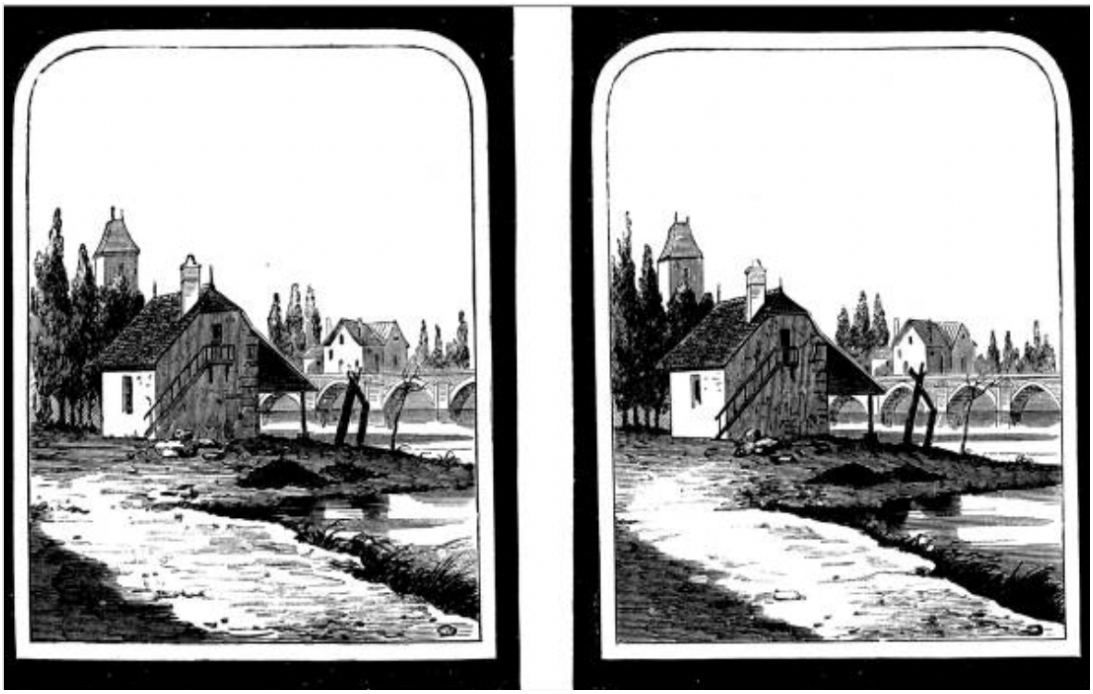
could be used as virtual tourism and a precursor to non-immersive VR. Arauza-Alba et al. (2022) trace the origins to 1957 with the development of Heiling's Sensorama Simulator which placed an individual into a capsule that provided a widescreen with sounds, smells, body movement/tilting, and wind stimulation. Dede et al. (2017) classify the onset of XR technology in the 1960s with the development of flight simulators that provided an MR immersive experience. Lastly, Elmqaddem (2019) traces the origin of the first digital headset designed in the 1970s by Daniel Vickers that combined the use of two screens for visual input.

Table 2.
Levels of Immersion in XR

Non-immersive VR	● Interaction with a 3-D world on a 2D computer screen ● User uses a joystick, mouse, or input device to interact - such as a videogame or computer simulation
Semi-immersive VR	● Immersion in a partially virtual environment with an immersive display with a wide field of view. ● Graphics have 3D depth/increased detail ● Includes simulators that partially replicate real-world mechanisms ● User remains connected to physical surroundings ● Interaction through mouse/joystick.
Fully immersive VR	● Immersion in a fully virtual environment ● Head-mounted display (HMD) with sight and sound immersion. ● High resolution of content with a full field of view with stereoscopic vision and head-tracking ● Uses handsets for interaction ● Example: HMD, CAVE systems

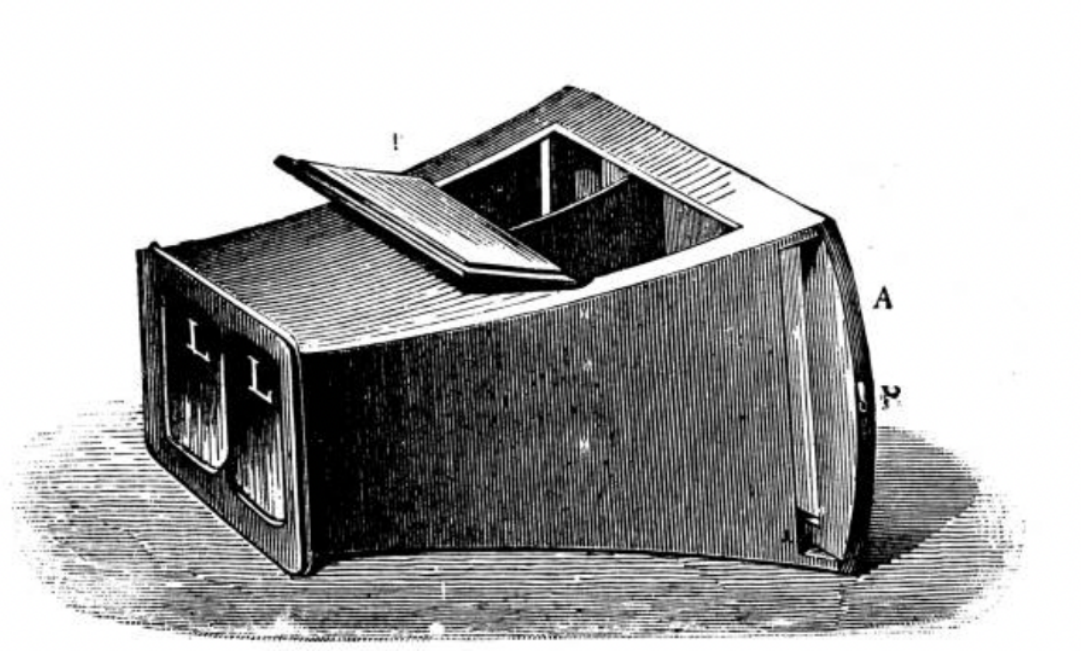
(Di Natale et al., 2020)

Figure 3.
Stereoscope Image



Note. Images such as these were inserted into a set of goggles to replicate a three-dimensional viewing experience

Figure 4.
Stereoscope Viewer



Note. Images placed in the goggles created a virtual 3-dimensional image.

Early models of immersive XR failed to reach mass adoption and diffusion with use during the 1970s to 1990s primarily in military training, industrial design, and healthcare purposes (Arauza-Alba et al., 2022). During this period, the development of the Data Glove allowed the capability for users to interact with XR through hand movement (Elmqadden, 2019). In 1999, AR programming moved closer to a larger market with the release of the ARToolKit which created an open-source library for AR applications.

In the mid to late 1990s interest in AR and VR waned with a focus on the development of the World Wide Web. Interest in XR technologies was reborn in 2012 with the Oculus Kickstarter campaign for crowdfunding to build an affordable HMD, or head-mounted display (Sherman & Craig, 2018). Oculus was purchased by Facebook, now Meta, in 2014, and the Oculus VR was released to the public in 2016, the year when VR became an overnight success. Oculus VR was released along with Oculus Touch handsets that allowed user input from

hand movements. That same year, HTC released the Vive HMD with handsets, Daqir released the Smart Helmet, Microsoft developed the HoloLens AR HMD, and Sony released the PlayStation HMD for use with their game console and controllers. Several other companies, such as Google and Samsung, followed suit with affordable VR headsets made of inexpensive items such as cardboard that utilized advances in smartphone technology to pair the smartphone screen and computing capabilities with a device to hold the screen in front of the user (Elmqaddem, 2019). In the 2000s, several MUVE games allowed for user interaction and immersion in game play and virtual worlds, such as SecondLife. This period also saw the release and mass appeal of massive multiplayer online role-play games such as World of Warcraft (Dede et al., 2017).

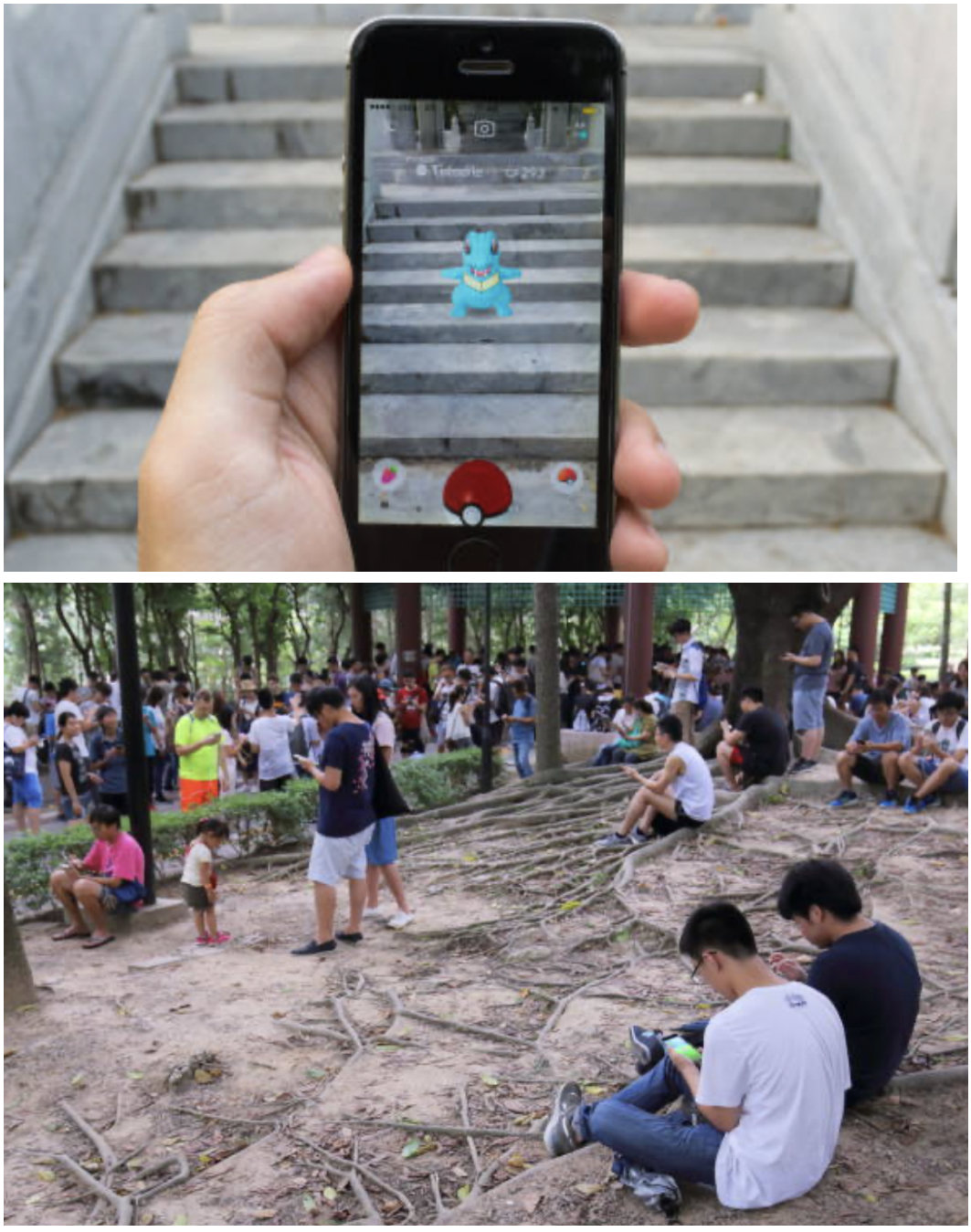
Augmented reality development soared in the 2000s with the development of smartphone apps (Blippar, 2018). In 2000 after the release of the ARTookKit, AR Quake released their first AR game that combined the use of an HMD, with a backpack for a computer and gyroscope. In 2005 AR tennis was released for use on Nokia smartphones. Who could forget the release of Niantic and Nintendo's Pokemon Go in 2016 (Figure 5)? This one app pushed AR into the mainstream with 500 million downloads in two months after it launched (Bauer, 2019). The use of this app was so great that social media giants Facebook, Twitter, Instagram, and Tinder reported declines in use in the first few weeks after Pokemon Go was released. With AR, smartphone users can see how furniture would look in their home before purchasing with the use of the IKEA place app, apply face filters in Snapchat, and use live mode in Google Maps to see virtual signs and direction arrows imposed over their view. New smart glasses released in 2021 from Snap, Lenovo, and Vusix have the potential to allow increased interaction such as hologram images placed in the user's environment to transform telephone calls into in-person conversations (Vizix, 2020). Oculus continues to be a frontrunner in HMD technology in terms of sales (Aslop, 2022). Parent company Meta is developing technology to enhance user experience and decrease side effects associated with poor focus or image updating (Zuckerberg, 2022). New developments include HMDs that have increased retinal resolution, user ability to adjust focus from a near object to a far object based on eye tracking technology, adjustments to fix optical distortions, and enhanced image colors to mimic nature. Newer technology developments can increase

the comfort with use, but often with an increased initial price point for purchase.

Adoption and Diffusion of XR in Education

Education technology has the potential to do many things in the classroom. It might grab student attention and increase learner motivation. It could increase communication and collaboration with other students. It could clarify concepts or provide more flexibility in the timing of lessons to individual student needs. It seems like all learning technologies start with great promise for user results with use, but many education technology advancements often fail to reach mainstream use. Several theories help to explain why some innovations reach mass appeal and others fail to take off.

Figure 5.
Pokemon Go Application and Groups of Users

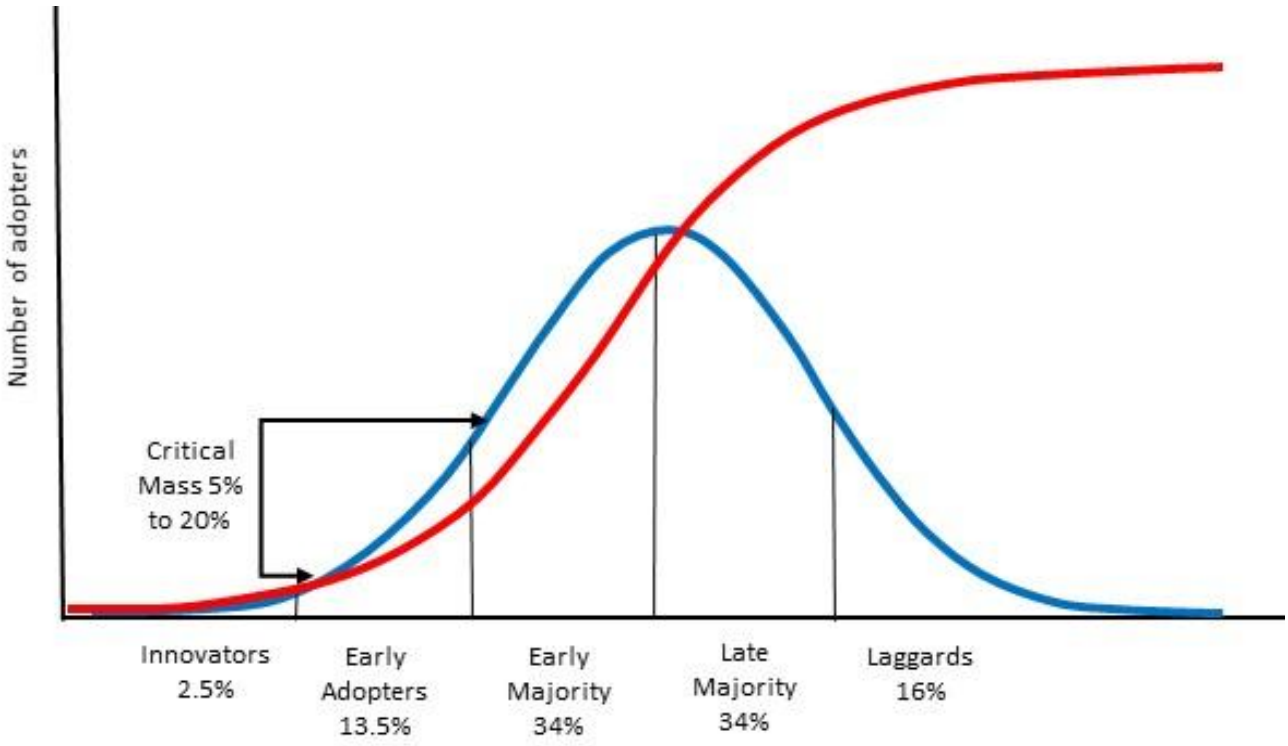


Note. Pokemon Go application using AR to project an image into real-world settings, and groups of Pokemon Go users congregating to capture game characters.

Rogers (2003) states that the four main components of diffusion of innovation advancement are the innovation itself, communication channels to spread the news of the advancement, time to adopt the innovation, and the structure of social systems using the new innovation. To enhance diffusion, the innovation must be perceived as an advantage over existing methods, compatible with existing values, relatively easy to implement or use, compatible with a trial of use, and demonstrate observable results with use. Rodgers notes that adoption takes place slowly at first with adoption by innovators who tend to be adventurous with an acceptance of risk who represent 2.5% of the population (Figure 6). From this point, early adopters, who represent 13.5% of the population and tend to be opinion leaders, see the big picture for use of the technology and tip the point of critical mass for sustained adoption. The rate of adoption at this point remains on a low slope on the adoption S curve. The adoption rate makes a steady increase as members of the early majority see the positive results of adoption by innovators and early adopters. The skeptical late majority represent 34% of the population and adopt the innovation after they are convinced by positive results from the adoption by 50% of the population. The final category of adopters, laggards, are very cautious of adopting innovations and only adopt after 84% of the population has taken the plunge.

Gartner Research (2018) defines a common pattern for adoption and diffusion of new technology in their Hype Cycle (see Figure 7). Similar to Rodger's view on diffusion, this model starts with innovation. As hype spreads on the future possibilities of the technology, the technology becomes more visible, but expectations can exceed the limits of the technology leading to a period of disillusionment. During this period, visibility of the innovation decreases along with interest and often funding. The innovation may survive the period of disillusionment and enter the slope of enlightenment if some early adopters achieve success with the use and spread the word to others with increased visibility and interest. After enlightenment, the innovation reaches mainstream use rapidly.

Figure 6.
Rodger's Adoption S-Curve and Adoption Categories



Note. Redrawn from Rodgers, 2003

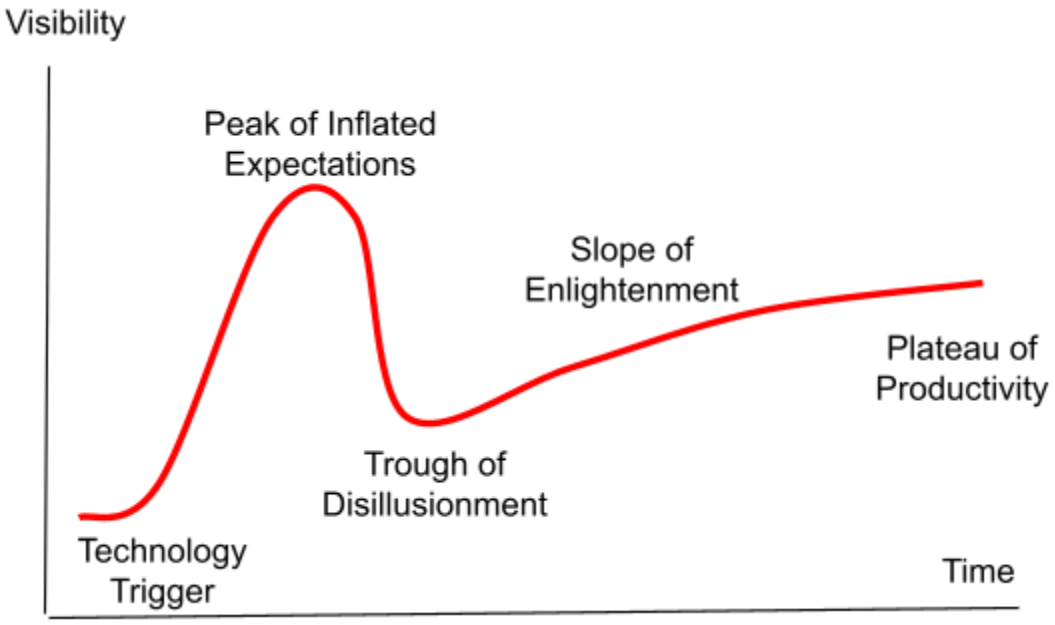
Extended reality has been in development for over fifty years and yet is still described as an emerging or beginning technology (Southgate et al., 2019) with industry leaders continuing to discuss the possibility of XR to transform education (Klopfer & Squire, 2008). Some of this seems to relate to confusion of what the technology can do or what its purpose is. In 2019, the Dean of the School of Medicine at Case Western Reserve University claimed that XR will be a key component of healthcare education programs (Elmqadden, 2019). Two years later, a journalist for CNN proclaimed Meta's Horizon World VR all as "ambitious" (para 1), "heart-pounding" (para 1), and "niche technology" (para 4) (Metz, 2021).

Sherman and Craig (2018) claim that immersive XR technology is in the Slope of Enlightenment of the Hype Cycle model (see Figure 7). They contend that the Technology Trigger phase is linked to several different events. The first was when Sutherland created the first

working HMD device, The Sword of Damocles, in 1968 at Harvard University. The second trigger was in 1989 when VPL Research, Inc. released an affordable VR technology for research laboratories. Sherman and Craig identify XRs period of Peak of Inflated Expectations between 1992-1995 when researchers hyped the technology but did not publicize information on the extended time that it would take to develop the technology. Immersive XR entered the trough of disillusionment from 1995 to 1998 when XR technology was too expensive for public use and the public focus shifted to the development of the World Wide Web. Technology advancements such as the development of smartphone technology, computing technology, and high-speed Internet pushed immersive XR technology to the Slope of Enlightenment (Elmqadden, 2019). Sherman and Craig also credit a 2012 Oculus Kickstarter campaign that became the first mass publicly affordable VR HMDs as a technology trigger, but this may have been a factor in getting from disillusionment to enlightenment.

The Plateau of Productivity will settle in at a level dependent upon the size of the XR market. Sales of XR headsets are continuing to rise with $4.93 million in annual sales in 2020 and $6.1 million in 2021 (Alsop, 2022). The two largest sectors for sales of VR and AR technologies in the global market are entertainment, with 30.44% of sales, and the military, with 19.78% of sales (BCC Research, 2018). Consistently, immersive XR technology is deemed effective and mainstream in the military and consumer gaming (Stevens, 2017). The education market, with 14.84% of sales, is the fastest growing sector of AR and VR sales (BCC Research, 2018). Currently, there are fewer applications for AR and VR technology in education which will likely improve with increased sales and demand. However, there are more available options for using AR in education due to accessibility on smartphones and tablets and AR glasses. There were 37 million users of AR in the United States in 2018 with an expectation of 67 million users by 2020 by 2020 (Blippar, 2018).

Figure 7.
The Hype Cycle

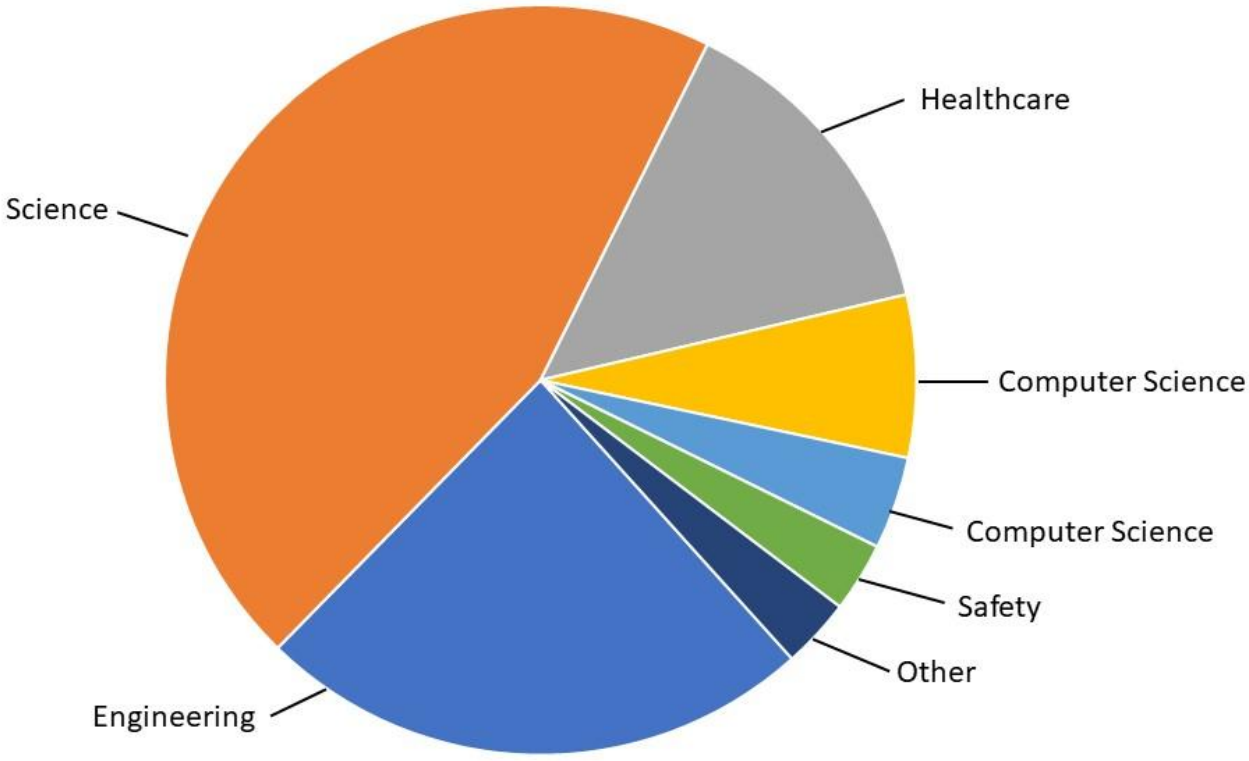


Note. Redrawn from The Gartner Group (2018)

Multiple surveys show that students, faculty, and parents have a favorable view of AR and VR in the classroom. A survey from Lenovo, as reported in Cureton, 2021, found that 54% of teachers and 41% of parents want to increase VR and AR use in the classroom. Vlasova (2020) reports on a survey that demonstrates that 90% of surveyed teachers believe that increased VR use in the classroom would provide personalized learning experiences for students and 97% of surveyed students indicated that they would like to attend a course that incorporated AR and VR. Dick (2021) adds additional summaries in support of AR and VR use in the classroom. A 2016 Samsung survey showed that 93% of teachers would like to incorporate AR and VR into the class with 83% indicating that their use would improve student learning outcomes. Seventy percent of 8 to 15 years olds and 64% of parents in a 2017 DigLitEY survey indicated that they are interested in VR learning.

With so much interest, is VR and AR prevalent in every classroom? There is limited data on the subject, but it seems to indicate that the use of XR in classrooms varies by subject and education level. As a parent and educator, I have witnessed many uses of non-immersive 2 dimensional VR immersion applications in classrooms. The immersion of semi and fully immersive experience tells a different story. A 2018 survey found that 50% of higher education institutions were partially or fully engaged in deploying AR or VR in the classroom (Dick, 2021). Similarly, Jisc (2019), a United Kingdom digital solution education research group, found that the most use was in higher education with 96% of universities indicating that they used AR or VR. However, this data only tells part of the immersion story. Use is limited to certain areas used by a few faculty members. While Jisc found that 96% of universities used immersive XR, only 9% of faculty actually used AR or VR technology in the classroom. The use of XR was typically limited to one or two departments (Jisc, 2021). Hamilton et al.'s (2020) literature review on XR in education found that of 29 published articles on learning outcomes, 25 were in higher education with 83% of the publications related to use in the subjects of science, engineering, and medicine (Figure 8). This is similar to findings from Jisc's survey with most educational use related to the subjects of healthcare, engineering, and technology.

Figure 8.
AR and VR Published Studies by Subject Area



Note. From data gathered by Hamilton et al. (2021)

Benefits of Using XR in the Education

EXtended reality has great potential to transform education. Instead of watching field trips on *The Magic Schoolbus,* students can put on an HMD and go on a virtual field trip to inspect the flow through the circulatory system, explore the Grand Canyon, tour the White House, or visit a historic site all from their home or classroom. A medical student can safely practice surgical maneuvers repeatedly until they are perfected before performing them on a real patient who could be harmed by an error. Students can complete chemistry experiments without coming into contact with flames or the purchase of

non-reusable lab supplies. Neurodiverse learners or those with a language barrier can participate in class activities through accommodations afforded by XR (Vlaslova, 2020).

The research on learning outcomes with XR is limited, but available studies show promise. Like with use data on use in the K-12 environment, data on the effects of implementation in K-12 environments is limited (Araiza-Alba et al., 2022). Sherman and Craig (2018) content that early researchers were more concerned with pressure to develop the technology than research on its usefulness. There are a few studies indicating usefulness in children. Learning through manipulation of items, such as with XR, is enhanced over the learning while watching others use the tool, even in infancy (Sommerville et al., 2008). Additionally, children learn more from sensory input, like that provided by XR, over more traditional teaching methods (Duhaney et al., 2008). Findings outside of the K-12 environment indicate that compared to less immersive education strategies, XR can improve cognitive gains (Elmqadden, 2019; Hamilton et al., 2020) and improve procedural skills (Dede at al, 2017; Hamilton et al.). The use of XR increases learner engagement and motivation with up to 100 % increased attention (Elmqadden, 2019) and increased enjoyment (Singhal et al., 2012) even with advanced concepts (Klopfer & Squire, 2008).

Interestingly, Lee et al. (2019) found that perceived enjoyment was one factor that could increase the intention to use XR in education. The use of XR in education fits the learner-centered paradigm as it offers new abilities to customize educational materials to learner needs and enhance learner engagement (Di Natale et al, 2020). The Constructivist paradigm encourages learner construction of knowledge from sensory input/interaction. The inclusion of XR is suitable for problem-based learning and can decrease the learner's cognitive load by eliminating distractions in the real-world environment (Vlasava, 2020). The inclusion of audio and visual input in immersive VR is consistent with guidelines set for use of multimedia to improve learning outcomes through dual coding (Mayer & Gallini, 1991). The use of three-dimensional images in XR, instead of two-dimensional images in non-immersion VR, decreased the extrinsic load of the lesson and allowed more focus on the lesson’s intrinsic load (Araiza-Alba et al., 2022). Wilson and Soranzo (2015) contend that when items that are three-dimensional in real life are presented in a two-dimensional

format, the learner may have difficulty transferring the lesson for knowledge assimilation.

Factors Affecting Diffusion

Despite the potential for education and student benefits with the use of XR, its use remains somewhat limited in educational settings. There are several barriers to the technology that should be explored to help identify if adoption and diffusion are possible and what interventions may help to aid the process.

Cost to Implement

The cost to purchase XR hardware and software was also identified as the main barrier in Jice's (2019) utilization survey. This is consistent with my own findings where cost was frequently cited as a barrier to XR use. To determine hardware costs, I performed an Internet search on July 23rd, 2022 to assess the price of popular AR and VR wearable technology (see Table 3). Prices ranged from $399.99 for a VR headset and headphones that required a separate purchase of a Samsung Galaxy smartphone for use to $3,500 for a Microsoft HoloLens 2 headset. Hamilton et al. (2020) found that the Oculus was the most common VR headset in their literature search, but they did not specify a version. In my search, Oculus HMDs range from $110 to $299. The second most common HMD was the HTC Vive which I found for $749. While the cost to purchase HMDs has decreased to a level that could improve consumer adoption, there are also additional costs related to the need to purchase software or software subscriptions, train faculty in how to use the technology in the classroom, provide support for faculty to incorporate XR in the curriculum, set up suitable space safe for use, and replace damaged hardware.

In an assessment of return on investment, change agents who are proponents of XR should assess if utilization of XR reduces other costs such as the reusable lab supplies that would no longer be needed or additional personnel to run a simulation who are replaced by VR avatars. Devices could be purchased to check out for use in multiple classrooms instead of attempting a 1:1 device approach. Free or open access software may be available to reduce costs and facilitate the

adoption of XR through a range of XR modalities such as HMDs, computer 3D 360-degree explorations, or 3D glasses (see Table 3).

Table 3.
Purchase Prices for AR and VR Wearable Hardware

Echo Smart Glasses for audio immersion	$249
HTV Vive Elite ViR system	$749
Meta Quest 2 headset with handsets	$299
Microsoft HoloLens 2 AR headset	$3500
Oculus Go standalone VR system	$110
Oculus Rift S deadest with handsets	$369.99
Rokid Air AR glasses	$349
Samsung HMD Odyssey+ MR headset and handsets	$899.89
VR headset and headphones for use with Samsung Galaxy	$39.99

Teacher Training and Curriculum Support

To effectively implement XR in the curriculum, teachers must receive training in how to set up the technology, how to use the technology with students, and how to incorporate the technology into the curriculum. While faculty realized that there was an emphasis on utilizing technology in the classroom, they may have little skills or training in how to use it (Childs, 2016; Jensen & Konradsen, 2017; Jise, 2019). Childs also noted that the more expensive and complex the XR technology is, the steeper the learning curve is for its use.

Table 4.
Open Source or Free AR and VR Software

Application Name and URL	Description
Anatomy 4D https://www.4danatomy.com/	AR app that allows visualization of human anatomy with images that can be moved and dissected
BioDive https://www.biodive.science/	VR software that immerses the middle school learner in a marine ecosystem to explore and track data on ecosystems of killer snails
eDrawings https://www.edrawingsviewer.com/	Contains AR and VR applications to transform engineering graphs into 3D models or to view designs in a real-world setting to assess impacts in the environment.
Exoplanet http://exoplanetapp.com/	AR application with sky map to visualize planets. Provides 3D visualizations of space that are updated daily.
GeoGebra https://apps.apple.com/us/app/geogebra-augmented-reality/id1276964610	AR application that displays user-created geometric shapes in the real-world environment that can be moved and manipulated.
Google Arts and Culture https://artsandculture.google.com	VR application with virtual field trips and 360-degree experiences that allow exploration of artwork, historic events, historic figures, artists, and art movements on a 2D screen.
Lifeliqe VR Museum https://www.viveport.com/47590167-b266-41f8-a1cc-5a4b294425b1	VR museum of over a thousand models for use in K-12 science and math education.
National Aeronautics and Space Administration https://www.nasa.gov/nasa-at-home-virtual-tours-and-augmented-reality	Online repository of virtual 3D tours for use with 3D glasses.
Nearpod www.Nearpod.com	Resource for developing classroom educational content. Contains a repository of

	360-degree VR field trips and 2D interactive PhET simulations.
New York Times Virtual Reality Teaching Resource Guide https://int.nyt.com/data/documenttools/virtual-reality-teaching-resource-guide/2f53bf8c259b3b2d/full.pdf	Guide to using VR in education with links to eight 360-degree VR videos with lesson plans for STEM and humanities classrooms.
Sharecare https://www.sharecare.com/pages/vr	AR and VR application with videos to promote health, human anatomy AR explorations, and VR simulations.
Smithsonian Institution https://3d.si.edu/collections/ar-experiences	Web-based VR application that offers 3D models of items in the museum collection that can be manipulated and explored on a computer monitor.
Touch Surgery https://www.touchsurgery.com/simulations	AR application that allows learners to complete over 200 simulations of surgical procedures

Facilitation of the adoption of XR in the curriculum should be coupled with professional development on best practices as well as practical skills for use and a support system to help troubleshoot use difficulties. Dicks (2021) called on policymakers in Congress to encourage the Department of Education to provide teacher resources for training and support in the use of AR and VR in classrooms. Felder and Proulix's (n.d.) teaching resource guide on using VR for the New York Times provides a model for implementation with sample lesson plans that could be used as a guide for developing additional support measures.

Additionally, the classroom with XR use will need technology access and a model for effective adoption (Richards, 2017). The classroom should have access to high-speed internet and a low learner-to-computer ratio. The XR activities must be accessible in the classroom, instead of a separate laboratory, since this approach leads to decreased contact with the classroom teacher and has resulted in decreased use of educational technology. The XR activity should be

aligned to the curriculum standards and linked to formative assessment activities. The XR activities can be included as needed to fit the needs of individual learners in the classroom.

Space for Safe Use

Partially and fully immersive XR can decrease learner perceptions of their environment and increase the potential for injury. While Pokemon Go brought AR into the mainstream, it also brought a discussion on user injuries. Within four days of the launch of Pokemon Go, a subreddit thread on the game contained a large number of posts on actual injuries and near misses caused by falls and collisions with objects from distracted game players (Tsukâyama, 2016). In response, a medical school in Arizona sent out a student advisory warning students to capture Pokemon carefully and remain aware of their surroundings. Game developers included warnings in the application to warn users not to capture and drive, to remain aware of their surroundings, and to refrain from trespassing to capture Pokemon on private property.

Immersive XR use with partial or full immersion should be incorporated in a space that is safe for use. The user should have a space that is at least 6.5 feet by 6.5 feet set up with Guardian boundaries to warn the user when they are near the edge of the boundary (Melnick, 2020). There should be an additional 2.5 feet buffer zone between the Guardian boundaries and any walls or immovable objects. The floor inside the area should be free from obstacles, thus minimizing user safety concerns. Hardware use that is wired poses additional safety concerns as the user could become tangled and fall or drop and damage the hardware. Utilizing a backpack to carry the computer running the software and store any loose or excessive length of cable in one early solution.

User Age

Immersive XR applications that run on a tablet or PC can be used with learners of many different ages. However, many of the HMDs state that the minimum age for use is 13 years old (Araiza-Alba et al., 2022). Furthermore, some HMDs may not fit a smaller, child-size head which could lead to discomfort and increase the risk of damage from a poorly fitting device falling on the floor.

There are a few types of XR developed for children to fit their size or limit the amount of immersion to help control negative side effects (Araiza-Alba et al., 2020). Google Cardboard uses a smartphone to provide the drive screen and computing technologies and can be sized for a child. Mattel manufactures a View-Master Delux VR that provides a less sophisticated immersion.

Ethics

Immersive XR can trick the brain into thinking that virtual experiences are real. Segovia and Bailenson (2009) found that some preschool-age children who participated in an immersion activity created false memories and remembered the event as if it happened in real life. Immersion experiences can also trigger real-world phobias such as a fear of spiders or a fear of heights (Araiza-Alba et al, 2022). Teachers who utilize XR in the classroom should consider the possible effects of use and plan for alternative experiences for users who are distressed by the immersion.

Side Effects with Use of XR

Users of high immersion XR may suffer discomfort from use. Cybersickness is a term given to motion sickness that can develop with immersion activities. Users may also complain of eye strain, headache, discomfort from wearing technology hardware, and injury falling due to a lack of spatial awareness (Jensen & Konradsen, 2017). Table 5 contains suggestions from Richards (2017) on measures that can be taken to improve the user experience in immersive XR and decrease discomfort. Those making a decision to adopt XR technology should preview the product to assess if images in VR disappear with head movement, or if the field of view is large enough with an HMD. They should plan to incorporate software that updates at a high-frequency rate, contains high-quality images, and reduces continuous movement.

Table 5.

Measures to Enhance Comfort with Immersive Technology Use

Field of View	● VR ○ A wider field of view is more realistic ○ Current HMDs support 90 degrees with the ability to look around for 360 degrees ● AR ○ Software that allows objects to disappear if the user moves past the field of view, breaks the suspended disbelief and decrease learner immersion
Fast update of visual image	● VR/AR require a speed of 90 frames per second ● CAVE AR systems require a speed of 30 frames per second ● MR requires a speed of 30 frames per second
Reduce motion sickness	● Images that update quickly ● Use of high-quality images ● Software that minimizes continuous movement
MR registration	● Project images onto high-contrast objects or utilize hardware that incorporates environmental scanning technology such as Lidar.
Fidelity of interaction	● User movements should create accurate and crisp movement in immersion

Note. From Richards, 2017

Conclusion

Immersive XR technology has the potential to transform education by providing a new way to interact with materials for constructivist learning in order to develop a deeper understanding, improve learning, build teamwork skills, travel to distant lands, and practice skills in a safe environment. Despite the potential, its adoption has mostly fallen into STEM, engineering, and health care subjects in higher education. Even with decades of technological advancements, partial and full XR immersion technology has failed to reach diffusion status, and its use in education remains mostly with innovators and early adopters. Barriers to adoption include technology costs, teacher training and curriculum support, space needed for safe use, discomfort for some users, young user age, limited educational software applications, and ethics related to tricks of the mind.

Immersive XR technology appears to be standing on the precipice of adoption and diffusion in education with an ever-increasing market share. A 2020 survey from Perkins Coie indicated that XR technology was poised to disrupt the education industry (Dick, 2021). Since that time, the Covid-19 pandemic produced a need for digital education solutions, and there are multiple reports of increased XR use with the need to move to reduced face-to-face learning (Cureton, 2021; Dick, 2021; Vlasova, 2020). Communication on the successes of XR use during hybrid and remote learning could be what this technology needs to jump the chasm between early adopters and the early majority to become mainstream.

To help push the use of XR technology forward, more support, technology development, and research are needed. Dicks (2021) called on the Department of Education to invest in research on the use of XR across the learning spectrum, provide resources for teacher support and training, and increase the development of age-appropriate software applications. Araiza-Alba et al. (2022) also called for the development of child-size HMDs and research on which specific XR applications improve learner performance as well as the effects of XR use on learner literacy and social engagement. If research is able to help share success stories of XR use and provide a structure for best practices, XR has a chance to become mainstream in education.

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Instructional Systems Design and the Diffusion and Adoption of Technology
(Volume 1)

Chapter 6: Video Games in Education

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6. Video Games in Education

Brittany Spitz

Key Points:

- Game-based learning and gamification have been around for years.
- Gamification, unlike game-based learning, has shown an increase in implementation within the educational community.
- The educational community understands that game-based learning has many benefits but requires more support for better utilization in the classroom.
- Diffusion of innovations with game-based learning rarely reaches past early adopters.

Abstract

Since around the mid 1900s, the video game industry has flourished with new devices and styles of games. Video gaming is a popular hobby amongst the population. Despite the popularity in the general public, video games included in classrooms as a method to learn is still not fully utilized to its full potential. Using educational games in a lesson has many social, creative, and engaging benefits. An increase in gamification has been more prominent in public education as a way to assess and engage students. Comparatively to game-based learning, gamification has shown more success with innovations. Game-based

learning tends to not make it past the innovators and early adopters. Introducing more popular video games into the curriculum and providing more technical support to educators would help break the barrier that prevents full adoption and diffusion.

Introduction

Do you consider yourself a "gamer?" When you think of the word gamer, your mind probably pictures an individual that devotes hours a day to a new PC or Playstation game. Do you find comfort in passing time with a game of *Solitaire* or *Candy Crush*? Have you recently posted your successful *Wordle* session on a favorite social media platform? Is it just me, or do you also look forward to your yearly visit to the dentist so that you have a chance to play *Pacman* on the arcade machine in the waiting room? If you answered "yes" to any of these, technically you are also a gamer.

One technological innovation that has exponentially increased in both users and revenue over the years is video games. A video game is played on an audio-visual device with input and output functions that can sometimes be based on a story (Esposito, 2005). Games are commonly played on computers, smartphones, consoles, and portable devices. Video gaming is a popular hobby that brings joy to many people regardless of age and ability (ESA, 2022).

At the beginning of my career as an educator, I felt well prepared and confident to provide engaging lessons. My education did not prepare me for the little technology support and an outdated curriculum that commonly plagues many public school districts. The realization set in that a more creative approach was needed to maintain the focus of twenty 6-year-olds with bland and monotonous content. Simple connections with students proved that video games were a hot topic. Conversations of newly released games and favorite streamers engaged commentary, whereas addition and subtraction did not. Ensuring the success of every student ended up requiring my start in game-based learning.

Introducing video games into education and gamification is not a new innovation. Gamification is the addition of game elements such as points, leaderboards, and badges, into non-game activities. Unlike gamification, game-based learning introduces, reinforces, or enriches

through play itself (Walter, 2022). The game-based learning rate of adoption in the education community only recently is slowly beginning to climb. If you were to walk into a classroom today, you would notice that many teachers still resort to traditional teaching methods or lack the means to bring video games into their lessons. Teaching with digital games is not a common practice even though the educational benefits are known (Rüth et al., 2022). In this chapter, we are going to take a deeper dive into the history, current adoption practices, reasoning behind the success and failure of the innovation, and how to possibly move forward.

History of Gaming in Education

Games and consoles have developed and soared in popularity over the last half-century. Starting with the release of William Higinbotham's 1958 Tennis for Two for an analog computer to the release of Sony's Playstation 5 in 2020, it is evident that the popularity of gaming continues to be present. Development of the systems adapted to mainstream adoption of the innovations with noticeable changes in accessibility. The 1972 release of the Magnavox Odyssey to be sold to the public was the first console and start of gaming at home. The Nintendo Gameboy in 1989 allowed for further accessibility with gaming on the go.

Today, we see games being played on smartphones, tablets, computers, consoles, and portable devices. With approximately 215.5 million Americans and 71% of American kids under the age of 18 playing video games for at least an hour a week (ESA, 2022), video games are a popular source of entertainment.

The benefits of gaming in education are not a new concept and date back to before video games became mainstream. In 1958, B.F. Skinner identified the importance of engagement and recognized the passive learning role students began taking in the classroom. To solve the perceived problem, Skinner developed and studied the use of teaching machines in educational environments. Skinner's teaching machines allowed individual students to move at their own pace, get immediate feedback, increase the challenge level, compare results, and essentially keep and try to beat their own score (Skinner, 1958).

As the video game industry exploded during the early to mid-1980s, early innovators began introducing gameplay into learning environments. Classic educational video games include the historical context in the Oregon Trail, Microsoft's Flight Simulator, and Mario Paint introduced digital art to a generation of young learners (Tremaine, 2022). Modern examples include the programming and game development in Minecraft, the introduction to physics in Angry Birds, and the problem solving and critical thinking in Civilization and Animal Crossing.

Advantages and Disadvantages

Introducing and utilizing video games in an educational setting has its advantages and disadvantages.

Once set up and introduced, it requires less management from the teacher as students engage in an educational game. One example of this is during center groups. Groups allow teachers to meet with small groups of students to target differentiated instruction for literacy or math. Group sessions are one of the most important times in a school day as they can be tremendously impactful to student success. While the teacher works with a small group, the rest of the class is engaged in other educational independent activities. It can be difficult to manage the rest of the class during this time while the focus is primarily on the students with the teacher.

Educational video games can be used to keep students engaged. *Prodigy*, a popularly used math game for primary students, can provide feedback on student learning rates and allow teachers to target specific skills for each student. For example, when the teacher begins a unit on telling time, they could go into the dashboard of the website and set it so the students would receive questions about how to tell time.

Video games are a supplement that engages the students with the material and allows them to learn difficult concepts in a space they feel comfortable (Lee & Templeton, 2008). Video games allow students to virtually practice real-world experiences like taking actions for desired outcomes, managing their attention effectively to complete goals, and safely taking risks to discover that failure is a way to learn (Seelow, 2022). Teaching with video games also speaks to young learners with a medium and context that they are used to. Playing video games can

impact and improve how students learn, communicate, and solve problems (Prensky, 2006).

Despite the advantages, there are also several disadvantages to utilizing video games in an educational setting. Teachers are often provided with several tools and websites to use without little training. Unsuccessful adoption can occur when teachers need to provide additional time to research and create a lesson outside of the classroom. With already so much on the teacher's plate, this can lead to burnout or lack of enthusiasm in setting up the resource.

Occasionally certain programs require training or professional development to allow for set up and implementation in the classroom. Unless the teacher is adequate and efficient with account creation and usability, additional time is required to implement fully. Without the necessary training, a program could not be utilized correctly in the classroom. The educational value of the content could be misused by the student. Some games could require more teacher intervention in order to be successful. Not correctly utilizing a program could negatively impact student success and engagement

Many games can be time-consuming to set up and maintain. For example, though advantageous for student-centered learning, *Prodigy* requires consistent effort to assign the new skill to students; however, once it is set up for the skill, you do not need to assign a new skill until the previous skill is generally mastered. This additional time could contribute to teacher burnout.

One problem for students that can and have been faced with is the age requirement on several popular video games. Many games have a rating attached which prevents schools from allowing students to play in the classroom. The age rating is due to the content in the video game, whether it is violence, language, or other negative influences.

An unanticipated result that has been recognized with the increase in video game usage is the toll on students' mental and physical health. In a study involving 1,178 American youth aged 8-18, it was found that about 8% were exhibiting symptoms of Internet Gaming Disorder (Gentile, 2009). Internet Gaming Disorder (IGD) is classified as a mental disorder related to addiction, and is now included in recent editions of the American Psychiatric Association's *Diagnostic and Statistical Manual of Mental Disorders*. A person is diagnosed with IGD when they experience five or more symptoms within a year (American Psychiatric Association, 2013).

Symptoms include:

- preoccupation with games
- withdrawal symptoms when gaming is taken away
- tolerance, resulting in the need to spend increasing amounts of time engaged in games
- unsuccessful attempts to control participation in games
- loss of interest in previous hobbies and entertainment as a result of and with the exception of games
- continued excessive use of games despite knowledge of psychosocial problems
- deceptive information provided for the amount of gaming
- game usage to escape/relieve moods
- jeopardizing or losing a significant relationship, job, or education/career opportunity because game participation

Adolescents experiencing problems associated with IGD could lead to serious health-related consequences (Pontes et al., 2016). The impact on students' health can prevent some potential adopters of game-based learning.

These unintended consequences of gaming can also contribute to classroom management issues for student interactions with the game. When familiar with a particular commercial game, redirection is necessary to keep students in a learning mindset (Marklund & Taylor, 2016).

Adopters of Video Game-Based Learning

Despite the major advancements in recent releases of new games and the knowledge of its benefits, many school systems, and teachers are considered late adopters of this innovation. The rate of adoption has not dropped completely, but rather continues to slowly incline.

A more recent increase in technology usage in the classroom was a result of the COVID pandemic. School systems were in sudden need of devices for each student to provide that access to an online classroom. Some schools that initially lacked the funds for additional devices suddenly had access to a vast variety of options. Teachers who relied on worksheets in their lesson plans needed to adapt to the drastic

changes. Teachers turned to game-based learning as a tool for the digital environment (Torchia, 2022).

The increase in online learning environments called for different strategies to maintain student engagement. Blooket, Gimkit, Kahoot, and Quizizz quickly became preferred methods to successfully engage many students. Often mislabeled as "game-based" learning, these types of websites actually are considered "gamification," which is presenting traditional multiple choice questions in a gamified environment (Litman, 2022). Teachers have used basic recall educational games for decades, but new adaptations have been using mainstream games, like Minecraft, for higher-level academic learning (Jones, 2018).

Adopters

Rogers (2003) categorizes adopters based on their innovativeness compared to others within a system; innovators, early adopters, early majority, late majority, and laggards. When assessing game-based learning's rate of adoption, or the speed with which an innovation is adopted, it is helpful to consider these categories to understand human behavior (Rogers, 2003).

Innovators, those first to adopt an innovation, are considered venturesome and launch the new idea into the system (Rogers, 2003). This small category of innovators typically would be a very select few teachers or technology leaders that initially test out the new game.

Early adopters are considered the role model for other adopters in a system and often are a key factor in the success of the rate of adoption (Rogers, 2003). Many early adopters are quick to jump on new technology innovations and enjoy technological advancements. This may be a teacher who enjoys gaming and wishes to engage their students further, knowing that the newer generations of students play video games outside the classroom.

If the innovation is communicated positively, early majority adopters begin to implement the idea. This group of individuals tends to be hesitant and less willing to take a risk. Early majority adopters tend to adopt the innovation before the average individual; however, only after the new innovation has proved itself to be generally reliable and effective. Individuals in this group may rely on the change agents and early adopters to communicate the benefits and provide guidance for successful individual implementation.

Individuals adopting after the average individual are considered to be in the late majority group. Teachers have to overcome obstacles and reservations about game-based learning but are convinced of the results (Groff et al., 2010). These challenges can be through missing support systems from administrators, colleagues, and professional development as well as missing needed resources within the classroom.

The term "laggard" is applied to the group last to adopt an innovation (Rogers, 2003). There could be several reasons behind their delay in implementation. Teachers that lack contemporary skills in technology and those in need of increased technical support find themselves dragging their feet regarding newer innovations. The scarcity of resources in many school districts puts a constraint on many technology innovations, including video gaming in education. Without professional development support, teachers may be required to spend their time researching the innovation and eventually choose to stay in their comfort zone of more traditional teaching methods.

Despite the difficulties of full implementation, many early adopters have successfully used video games in lessons. Gameplay experiences allow students to learn specific content, practice problem solving, work on collaborative skills, tap into creativity, and even learn important social-emotional skills.

Assassin's Creed in History

Video games often can be presented in a format that hides the educational content with impressive narration and theatrical gameplay. One game that does this well is the action role-playing game (RPG) Assassin's Creed series created by Ubisoft. Each game references historical characters and events hidden within a game that has soared in popularity across many devices. Ubisoft invests in the general authenticity of the game's environment and historical context, the result is players learning history during gameplay. While there are some creative deviations from historical events, often shown from the perspective of the fictional protagonist, the game developers try to keep environment design as true as possible to the historical context of the game. For instance, revolution era urban Paris, the frontier, New York, and Boston during the American Revolution, or ancient Greece and Egypt are based on historical references and scholarship.

In a 2018 Canadian study, researchers observed the educational impact on 329 high school students from three different Assassin's Creed games (Karsenti & Parent, 2020). The majority of the students had experience with the game; however, 44.9% stated they had never played it. With a game rating of Mature for an audience of 17+, the teachers did not use the actual video game but rather clips of gameplay, cinematics, and screenshots from the game itself. It was used as visual support for learning content. The result of the study provided strong evidence to show success in sparking student interest. It was also noted that the educator's teaching style played a large role in the student's successful understanding of the content.

A more recent addition to the series, Assassin's Creed: Origins, took its game a step further and included an educational spin through the Discovery Tour. In this add-on, combat and quests are replaced with a guided tour of Ancient Egypt. Players are able to interact with artifacts to learn about various aspects of the civilization, including important historical figures. Changes in-game content to reach younger audiences could have a profound impact on the rate of adoption.

Adoption Success and Reasons for Rejection

When analyzing the rate of adoption and development of video games, it is safe to assume that that innovation was successful and continues to grow. The pandemic additionally brought new players into the gaming world.

Despite the rapid success of video games in the mainstream, it is noticeable that video games in education have been slower to be fully adopted in the classroom. The intentions from teachers are there due to the beneficial results of student engagement; however, compared to the video gaming industry, it is not as well utilized in the classroom.

Comparing the advantages and disadvantages of implementation in the classroom shows that the advantages have the potential to outweigh the disadvantages. This makes instructional designers question what causes are involved that are preventing the adoption of this innovation. Why is it that designers and curriculum writers have known for decades that the impact could positively affect students, yet teachers and the current curriculum in areas continue to support passive

learning? With the increase in expectations on test performance, it does not make sense to me that the education system is so outdated.

One cause of this is the lack of provided materials in the curriculum and professional development to support game-based learning. Support through professional development is essential to promoting teachers' readiness to change (Chee et al., 2015). This lack of support leaves teachers needing to create or locate lesson plans on their own time, which is always after school hours due to the planning period almost always being compromised. Principals admitted that they seek teachers that are technology-fluent and able to create authentic learning opportunities when hiring, but believe that teacher training has been the biggest barrier to success with integrating digital content (Project Tomorrow, 2016). To be effective, teachers need to use technology, but there is often no time to train teachers on how to use technology.

Additionally, public schools often require teachers to follow the provided curriculum. Regardless of career experience, a hindrance to implementing video games in lessons is the need to follow the district curriculum (Hayak & Avidov-Ungar, 2020). This, in turn, tends to hinder creativity and freedom to implement new innovations. State and district testing put pressure on both teachers and students to perform. This also adds strain to the desire to take more creative risks, especially if the evidence is not apparent to support the risk.

An additional unanticipated result that has been encountered is the game content being too mature for audiences. Popular games, which would be ideally used, often are not appropriate for a school setting. Through my own personal experience, as a teacher who has occasionally played movies for my class for a reward or break, I needed to be extremely mindful of the rating. The movie always needed to be rated G and cultural or religious conflicts kept in mind. This made even searching for a movie difficult. How would I play movies with those restrictions? Simply, I wouldn't play them. This can come into play with video game ratings as well.

As seen with the Assassin's Creed scenario (Karsenti & Parent, 2020), the rating of the game impacted how it was delivered. This was adapted and instead of using the actual game, the narrative elements were used. Video games ideally will continue to release student-friendlier versions for school districts to use, like Assassin's Creed Discovery Tour and Minecraft Education. Using video games as

objects of reflection in a teacher-guided lesson is a promising approach for fostering specific skills, like media literacy skills (Rüth & Kasper, 2021). Once popular name games continue to develop and advertise to the educational community, adoption of video games into more lesson plans would likely be easier.

Conclusion

In studies using video games as a theme or incorporating them directly into the lesson, students have shown to be more engaged with the material and resulting in higher testing results. Given the significant gaming population, changes should be made to support teachers with more video games in the classroom.

Teachers often use various gaming mechanisms currently to enhance learning. Gamification websites (Quizizz, Blooket, etc.) have shown successful adoption and a large interest in implementation. However, there is a noticeable difference in the educational community adoption rate compared to video games and console development and adoption.

The implementation and adoption rate of the innovation could benefit when teachers are provided the materials and support. Bringing video games into the curriculum with more professional development options will allow for more teachers to experiment with implementation.

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Instructional Systems Design and the Diffusion and Adoption of Technology

(Volume 1)

Chapter 7: BlackBoard, Canvas, and Learning Management Systems

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7. BlackBoard, Canvas, and Learning Management Systems

Jasmine Bundy

Key Points:

- Online learning management systems were an innovation that brought standardization and organization to courses and program in education.
- Blackboard in particular grew quickly, first via innovation then through acquisitions and mergers.
- Blackboard has continued to lose market share to Moodle and now CANVAS, who have continued to innovate.

Abstract

Innovation is the application of new tools, techniques, and technology to meet needs. As an instructional innovation, learning management systems filled the need by colleagues and universities to organize course content and communication online, especially for distance learning courses and programs. Blackboard was an initial leader in introducing innovation into this newly created market space, however, a focus on acquiring innovation rather than creating it may be taking Blackboard down a path it can not recover from. In the meantime, learning management systems like CANVAS are introducing new innovations of their own, and are beginning to take market share from

Blackboard. Over the next few years it will be very interesting to see where this evolving case study in instructional innovation leads.

First Look at Learning Management Systems

Learning management systems (LMS's) are defined as a "software application that provides the framework that handles all aspects of the learning process - it's where you house, deliver and track your training content" (ShareKnowledge, 2022). From 1924 to the 1960s there have been machines and systems specific to fields such as mechanical engineering and typewriter-like devices with multiple choice question options. In 1969 the U.S Military Defense Commission created, developed, and used the ARPANET (Advanced Research Projects Agency Network), a precursor to today's Internet. In 1997 the SQL (Structured Query Language) database language was launched, Moodle in 2002, and SCORM (Shareable Content Object Reference Model) in 2004. Together, technology such as SQL, Moodle, and SCORM all set the groundwork for today's learning management systems that exist within organizations all over the United States and the world (Justin, 2022). The learning management system (LMS) Blackboard soon rose to dominance. The original purpose and needs gap filled by Blackboard was very innovative, to bring online consistency and organization to education. Several of Blackboard's early acquisitions included WebCT and ANGEL, which resulted in a 65% LMS market share in the United States in the mid to late-2000s (Justin, 2022)..

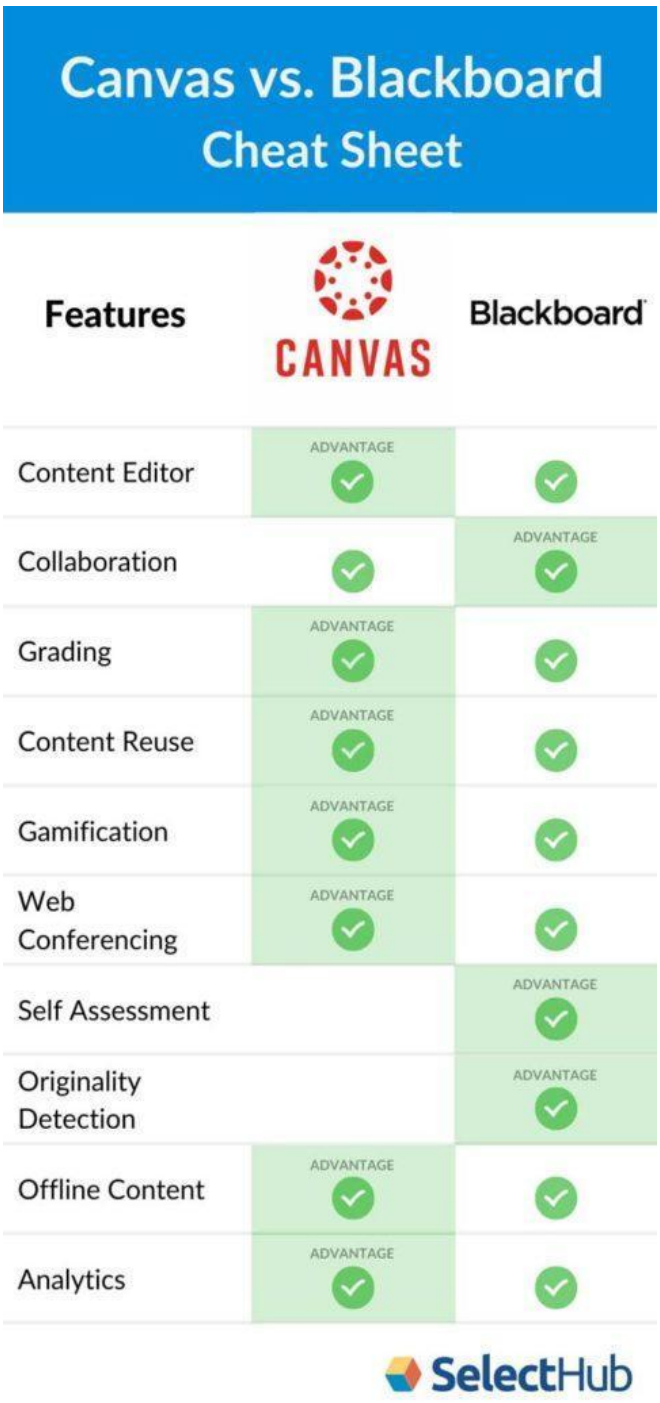
The Emergence of Blackboard and Canvas

Since being founded in 1997, Blackboard has made a name for itself as a leader in the LMS marketspace, specifically in higher education. Blackboard's early history has been a mix of many mergers and acquisitions. By 2006 Blackboard was being utilized by most college campuses in the United States, and by diffusion and adoption standards they had been extremely successful (Justin, 2022). Despite the strong start, they have also lost many clients in the last decade. Some suggest that they focused more on acquisition than continued

innovation. From 2002-2021 there have been a total of 11 acquisitions, and over thirty-plus total transactions since its launch (Justin, 2022).

Founded by two graduate students under the company Instructure, CANVAS has become the newly adopted LMS innovation across college and university campuses. As Blackboard contracts end and the meetings of persuasion take place (one of Rogers' steps in innovation adoption) many institutions have made plans to phase out Blackboard and sign new contracts with CANVAS due to advantages and features (see Figure 1). Based on user and instructor feedback during testing, early adopters found the platform to be more user-friendly for both students and faculty. It appears to be easier for new adopters to learn and utilize the system with little to no training. While trialability is a top perceived attribute, ease of use and relative advantage tend to be the most important attributes in the decision stage. As a result, the LMS market share between CANVAS and Blackboard is now about 34% and 21% respectively (Hill, 2021).

Figure 1.
CANVAS and Blackboard compared



Note. Green boxes indicate which LMS has the relative advantage (Selecthub, 2022**)**

Higher Education and the LMS

Learning management systems have allowed organizations to close gaps that exist within their organizational structure. While some may have adopted a system based on the perceived attributes (for more on perception and innovation adoption, please see the classic work of Rogers, 2003), there are many that have been able to streamline processes and procedures. During COVID19 many institutions moved course content to Blackboard, CANVAS, Sakai or other online systems to carry out their mission. Blackboard and CANVAS have made it possible for colleges and universities to seamlessly run programs entirely online or with a distance-education component. Therefore, helping campuses increase enrollment by providing work/life balance to students and mimicking the college classroom experience from practically anywhere in the world. Early adopters of learning management systems had a competitive advantage over others in higher education. Now, even most late adopting institutions have an LMS as most students expect some variation of online access to their instructional content (however, it should be pedagogically noted that simply having an online LMS does not constitute having true online classes that foster social presence and learning effectiveness).

For many institutions, the LMS serves as job aids to in-person classes. A one-stop shop where students can view the syllabus, submit assignments, replay lectures, access PowerPoint slides, and view their current grades. A popular application is for the LMS to serve as a scaffold to once or twice a week, in-person lectures over the course of a semester. Samarawickeremal and Stacey (2007) pick up from Rogers' (2003) work on adoption as well as why institutions need the LMS attributes that make sense in their own organization. These researchers specifically mapped the adoption of LMS's to Rogers adoption models, and describe how Roger's concepts can be used by institutions to plan for innovation diffusion in their organizations. With student persistence and retention being everyone's responsibility, assessment features have been instrumental in tracking student retention and key learning outcomes in general education courses. The reporting features available in Blackboard, under the Retention Center, provide data for at-risk students, missed deadlines, grades, course activity, and course access. These analytics support the efforts of Academic Affairs, and the Office

of Financial Aid at colleges and universities, which are responsible for reporting attendance to meet federal funding requirements. For institutions, this affordance has replaced their use of separate retention CRMs (Customer Relationship Management systems) and provides added value to an existing product. Opportunities for the LMS to be compatible with other products and be integrated with them is a win in the innovation adoption decision-making process. For instance, applications built on the Learning Tools Interoperability (LTI) standard can be integrated with various LMS platforms to add functionality and additional features (Clark, 2021).

Motivation to Adopt a Learning Management System

Boland (2020) conducted a case study on the adoption process of two universities: Monash University in Australia and Texas A&M University in the United States. Based on the characteristics of Texas A&M's motivation, the relative advantage and compatibility of Blackboard Vista was their most important decision criteria. The LMS needed to align with current practices of the institution and provide solutions and advantages to both students and instructors. Based on this strategy they believed that faculty could deliver better content and better engage students, specifically related to discussion and student engagement. Monash University on the other hand took a pilot approach so that the adoption would be motivated by faculty participants rather than a top down approach. The drawback to Monash University's pilot strategy, without having more systemic support, was limited access to features outside of basic settings and the immediate demand for further training and development on the LMS.

The Decision to Adopt and Implications

Historically the decision to adopt can be top-down at many colleges and universities, as was the case for Texas A&M's top-down approach. Monash University's process was bottom up, however, their two pilot programs had mandatory requirements. On one hand the faculty and students were empowered and on the other hand they were

just being told what to do next. In the study the users were required to participate in 15 ‘units’ in the first semester and 80 ‘unit’s in the second semester; they had little power in the decision-making process beyond the pilot study.

Rogers describes three types of adoption processes: innovation diffusion can be driven by an organization's administration, by consensus of its user base, or optionally by users (Rogers, 2003). LMS adoptions are often driven by an organization's administration, and so user buy-in has to be carefully considered and approached. Boland (2020) also discusses the implications of adoption in this study and references Rogers’ (2003) work regarding the absence of advantages and benefits. When these advantages and benefits are not definite it can lead to users rejecting the innovation. For both institutions the advantages and benefits met the needs of students and faculty.

Learning Management Systems in the 21st Century

Post global pandemic, the need for a learning management system has become a priority for organizations within and outside K-12 and higher education. Having an effective learning management system is now a critical means to connect students to peers, faculty, and the campus community, as well as an opportunity for other organizations to provide remote staff professional development on demand. New LMS entries such as Unboxed are interesting examples of instructional technology innovation. According to market research conducted by Unboxed Training and Technology, see Figure. 2, there are five trends that we can expect clients to look for when choosing an LMS in 2022 and beyond (Purcell, 2022). Taking into consideration what Rogers (2003) describes as positioning, the company “Unboxed” is looking to share its own LMS, called “Spoke”, with the world by directly applying the components deemed needed for early adopters when selecting a new LMS. Based on demonstrations shared on their website, they may be well suited for businesses who are looking to do more with employee retention, professional development, and supporting remote employee connections outside of other platforms such as Microsoft Teams. To compete in a crowded market space with much larger and established competitors, newcomer Unboxed and their new Spoke LMS platform

must attract early adopters. To drive growth and success, they must also build towards a tipping point that could lead to early majority and late majority clients.

Figure. 2.
Five trends we can expect clients to look for when choosing an LMS

1. **Customizable Configurations**
    a. **Onboarding**
    b. **Product and Systems Training**
    c. **Sales Enablement**
    d. **Coaching and Leadership**
    e. **Industry and Company Language**
    f. **Upskilling**
        i. **Recruit and retain expert-level employees**

2. **Microlearning**
    a. **Factoring in the attention span of learners of 8 seconds and creating videos with a 3–5-minute length**

3. **Gamification**
    a. **keeping score, comparing scores, levels of success or achievement, adaptive difficulty**

4. **Collaborative Coaching Compatibility**
    a. **easy ways for teachers and instructors to coach learners as they progress**

5. **Real-Time Analytics**
    a. **data collection and data analytics to be able to identify at-risk students and intervene**

Note. Modified from Purcell, 2022

Given the resources that organizations are investing into learning management systems, we can expect the return on investment to be requested in product deliverables. The ability to customize to the needs of the organization is critical to the product's ability to close existing gaps and prepare for the growth of the organization. This growth can be in size or even services offered which is a key strategy considering many contracts require a minimum of five years. The product needs to meet the needs of stakeholders and users, and ensure sustainability as outlined in the organizational strategic plan. In short, learning management systems are here to stay and companies providing them will need to have the gift of persuasion and applied innovation to acquire lucrative contracts.

Rogers describes an innovation diffusion cycle where innovators adopt the new technology first, followed by early adopters, the early majority, late majority, and finally laggard or late adopters (Rogers, 2003). At this point, especially after the observable results of institutions and classes forced online during the pandemic, even late adopters now recognize the need to have a learning management system to efficiently manage and organize resources online for students.

Conclusion

Learning management systems (LMS) have become an integral part of organizations and educational institutions. This integration ranges from delivering courses for degree completion, to the onboarding of new employees, to the continuous development of current employees. COVID19 may have increased usage and served as a reason for non-users to consider adoption, but the question remains, without a global pandemic does the software application fill enough gaps for the organization to receive a return on investment? Although having a learning management system (LMS) as a job aid to in-person instruction does not make a course an online or distance-education course, it is a direct integration of technology. With a call to action for digital literacy, this is one way for educational institutions to meet the needs of their district or department. For instance, Helmahdy (2021) believes that even beyond COVID19, that schools need to adopt a learning management system (LMS) in order to pivot, when necessary,

stay current, and track student progress. With systems constantly evolving there will always be a benefit(s) to the organization, however, the decision-making process will be filled with different audits on what matters most to the organization.

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Instructional Systems Design and the Diffusion and Adoption of Technology
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Chapter 8: High Speed Internet Access and The Digital Divide

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8. High Speed Internet Access and The Digital Divide

Amanda Kline

Key Points:

- The adoption of computers, mobile devices, social media, and the Internet has initiated the unintended consequence of the digital divide.
- The digital divide affects people of all ages all over the world.
- In order to close the digital divide, there needs to be a global shift in the perception of the Internet as a necessity versus a commodity.

Abstract

The digital divide is one of the unintended consequences of the rapid growth of innovations in computers, mobile devices, social media, and the Internet. The digital divide is caused by a lack of access to the Internet. This lack of access is caused by global racial, social, and economic inequalities. The digital divide affects all age groups and people worldwide. In order for the digital divide to be solved, there has to be a global shift in the perception of the Internet as a necessity versus a commodity. Internet providers, governments, organizations, and others will have to unite to lay infrastructure and connect the world digitally.

Brief History of High-Speed Internet Access

In the wake of the Cold War, Massachusetts Institute of Technology (MIT) computer scientist J.C.R. Licklider came up with the idea that would eventually become known as the World Wide Web (Jefferson Online, 2016). He wanted to connect computers across the world. He worked with other computer scientists and engineers at the U.S Department of Defense Advanced Research Project Agency (ARPA), and they came up with the ARPANET in late 1969. In the 1970s, Robert Kahn and Vinton Cerf created the Transmission Control Protocol/Internet Protocol (TCP/IP) to connect multiple computer networks (Jefferson Online, 2016). After this, Tom Truscott and Steve Bellovin expanded on TCP/IP and created the system USENET, full User Network, allowing users to transfer computer data via phone dial-up connections. In the 1980s, Dave Farber at the University of Delaware was able to take ARPANET and connect it to dial-up phone lines (Jefferson Online, 2016). Connecting to the Internet via dial-up phone lines was formally called PhoneNet, but commercially it was known as TeleNet. This innovation allowed people around the world to communicate via email. In the 1980s, local area networks, Ethernet, and domain names emerged. Finally, in the 1990s, the Internet began to become a global phenomenon.

Thomas Berners-Lee and others at the European Organization for Nuclear Research (CERN) developed Hypertext Markup Language (HTML). They gave rise to the World Wide Web after the discontinuation of ARPANET (Jefferson Online, 2016). With the birth of the World Wide Web, companies began to launch various websites and products, such as America Online, Amazon, Yahoo, and eBay. The 2000s saw the development of wireless Internet access and the evolution of the Internet, including Web 2.0, smartphones, Google, and YouTube (Jefferson Online, 2016). In the 2000s, an estimated 413 million people had access to the internet. In 2016, the number of Internet users exceeded 3.4 billion people. China, India, and the United States are the top countries with the most significant number of Internet users (Roser et al., 2015). High-speed Internet access is now nearly a prerequisite to online learning, most career paths, and social media participation.

Brief History of the Digital Divide

The digital divide concept emerged in 1995 in a report by the National Telecommunications and Information Administration based in the United States (Dijk, 2020). The term quickly spread globally. The world began to discuss and address it as a problem that needed to be solved. Jan van Dijk defines the digital divide as "a division between people who have access to and use digital media and those who do not" (Dijk, 2020). The digital divide affects society in multiple ways. The digital divide contributes to a lack of innovation and development in countries, businesses, society, and other aspects of life. This lack of innovation can lead to diminished economic growth for individuals, countries, and organizations. The digital divide leads to further societal inequalities by contributing to the exclusion of certain members of society. Since the Internet sends and retrieves information rapidly, members of society who do not have equitable access cannot adapt and innovate like those who have access (Dijk, 2020). Also, our global society is now dependent on Internet access to complete regular daily tasks at home and work. People without access cannot develop these crucial digital technology skills in society. This lack of access can negatively affect their ability to gain employment, complete daily tasks, and contribute to and keep up with societal change.

Internet Access, the Digital Divide, and the Effect on Education

Digital Divide in K-12 Education

Digital inequities in K-12 education have come to the forefront of educational organizations and institutions in recent years. Anderson and Perrin (2018) from the PEW Research Center used 2015 U.S. Census data to determine that 15% of households with students from the ages of 6 to 17 did not have access to the Internet. They also emphasize that Black and Hispanic households, especially those considered low-income, experience digital inequities more than other races. The COVID-19 pandemic exacerbated this issue. Vogels et al. (2020) also from the PEW Research Center, investigated how

the COVID-19 pandemic has increased the digital divide in K-12 schools. They determined that about 22% of parents report that their school-age children have to use public Wi-fi Internet access to complete their schoolwork. Also, 21% of parents reported that their children cannot complete schoolwork because they do not have a computer. This dependence on technology and Internet access also brings up affordability problems for families with lower incomes and raises infrastructure concerns for rural populations (Vogels et al., 2020).

The digital divide translates into socioeconomic, racial, geographic, and neurodiverse disparities among K-12 students. A study completed by Vidgor et al. (2014) completed a study of at-home computer access for students in grades 5-8 enrolled in North Carolina Public schools. This study found that overall, 86% of these students reported that they had access to an at-home computer. Amongst these students, only 78% of Black students reported they had access to an at-home computer, while 90% of White students reported they had access. They also investigated which students participated in the school's free or reduced lunch. It showed that out of the students that utilize this program, only 72% reported they had access to an at-home computer. Furthermore, PEW Research Center (2018) stressed that access to the Internet is and will continue to be an essential tool in education. Students' quality of education will continue to be negatively affected if the digital divide is not considered and resolved.

Without rectifying this digital gap, students will not have the 21st century skills necessary to succeed in their future. Ballesta et al. (2018) referenced United Nations Educational, Scientific and Cultural Organization (UNESCO) data, which states that the effects of the digital divide will cause a significant decrease in the development of new knowledge and technologies. Schools should also use technology and the Internet to make lessons more engaging and relevant for their students. School divisions worldwide must implement strategies, plans, and initiatives to begin closing the digital divide. Vogel et al. (2020) additionally argue that at-home computers reduce the cost of academic and non-academic activities. Students with at-home computers can use the computer for entertainment purposes, researching information, and completing assignments. Students with access to and utilize computers and the Internet have more significant opportunities to achieve digital literacy and the technological and

computing skills necessary for success in any future career path. According to Hampton et al. (2020), the digital divide causes students to take longer to do homework, limits the help they receive when they do not have a proper understanding of a topic, have a lower grade point average, and perform at a lower level on standardized tests. This effect causes students with limited or no access to become less likely to attend college or university and also less likely to pursue a career in the critical Science, Technology, Engineering, or Mathematics fields.

Adults and Seniors

The digital divide also appears in adult education. Education for adults in today's world is delivered electronically, whether in the workplace, college/university, vocational training, or other educational settings. The digital divide mostly affects adults with lower educational levels and socioeconomic status. Some of these adults have GEDs (tests of General Educational Development) or have dropped out of public education. Access to the Internet can provide these adults with formal education to learn in a low-stakes environment, such as their home, to practice skills they wish or need to improve (Centre for Educational Research Innovation, 2020). Adults seem to experience the digital divide from multiple perspectives. Adults see how a lack of access affects their lives at work and home. If these adults have children, they also see how it affects their children. This can be disheartening.

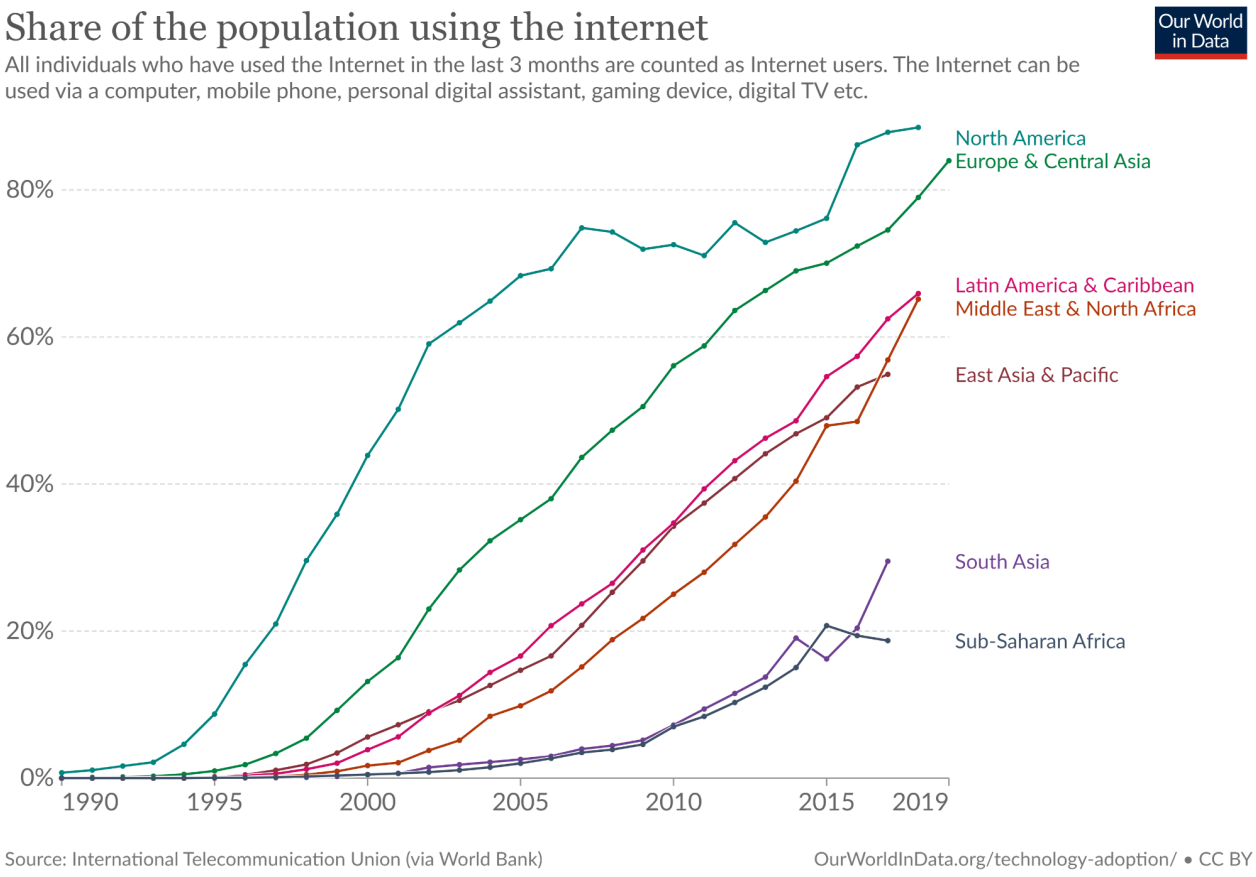
Often called the gray divide, the digital divide takes an interesting perspective on individuals over the age of 65. Only about 67% of this age group reported they used the Internet (Hunsaker & Hargittai, 2018). Some have adopted the Internet for entertainment, communication, or to complete daily tasks like banking or to learn something new. It has been shown that senior citizens with higher educational attainment are more likely to use the Internet regularly than those with lower educational attainment (Hunsaker & Hargittai, 2018). One factor that negatively affects the rate of Internet usage in this age group is health and cognitive decline (Hunsaker & Hargittai, 2018). As one's health declines, their ability to use the Internet also declines.

Senior citizens typically use the Internet for communication, health information, social media, banking, entertainment, and learning new skills. According to Quan-Haase et al. (2018), their study showed that this population group is divided into those that are reluctant or apprehensive to use the Internet and range to those that are considered experts in digital technology. It is a myth that this age group does not want access, but similarly to the other age groups mentioned in this chapter, race and socio-economic status can contribute to a lack of Internet access despite the desire to have access.

Internet Access, the Digital Divide, and its Effects Based on Geographic Regions

As one examines how many Internet users each area has globally, Internet access and inequities become apparent. As of 2017, around half of the world's population still does not have reliable Internet access, however, Internet access has been growing at unprecedented rates (Roser et al., 2015). Countries considered more developed and more affluent than other areas have a higher population that can access the Internet. On the other hand, populations in developing countries or with oppressive and restrictive governments, have less access to the global Internet than wealthier and less restrictive governments. (Roser et al., 2015). In Figure 1, North America, Europe, and Central Asia have consistently maintained a higher share of their total population that has access to the Internet in some capacity. South Asia is experiencing a spike in the population share with access to the Internet starting around 2015. While in contrast, sub-Saharan Africa has plateaued since 2015. (Roser et al., 2015). Globally, countries will have to continue improving their Internet infrastructure to keep up with the ever-increasing demand for high-speed Internet access.

Figure 1.
Share of the population using the Internet, 1990-2019

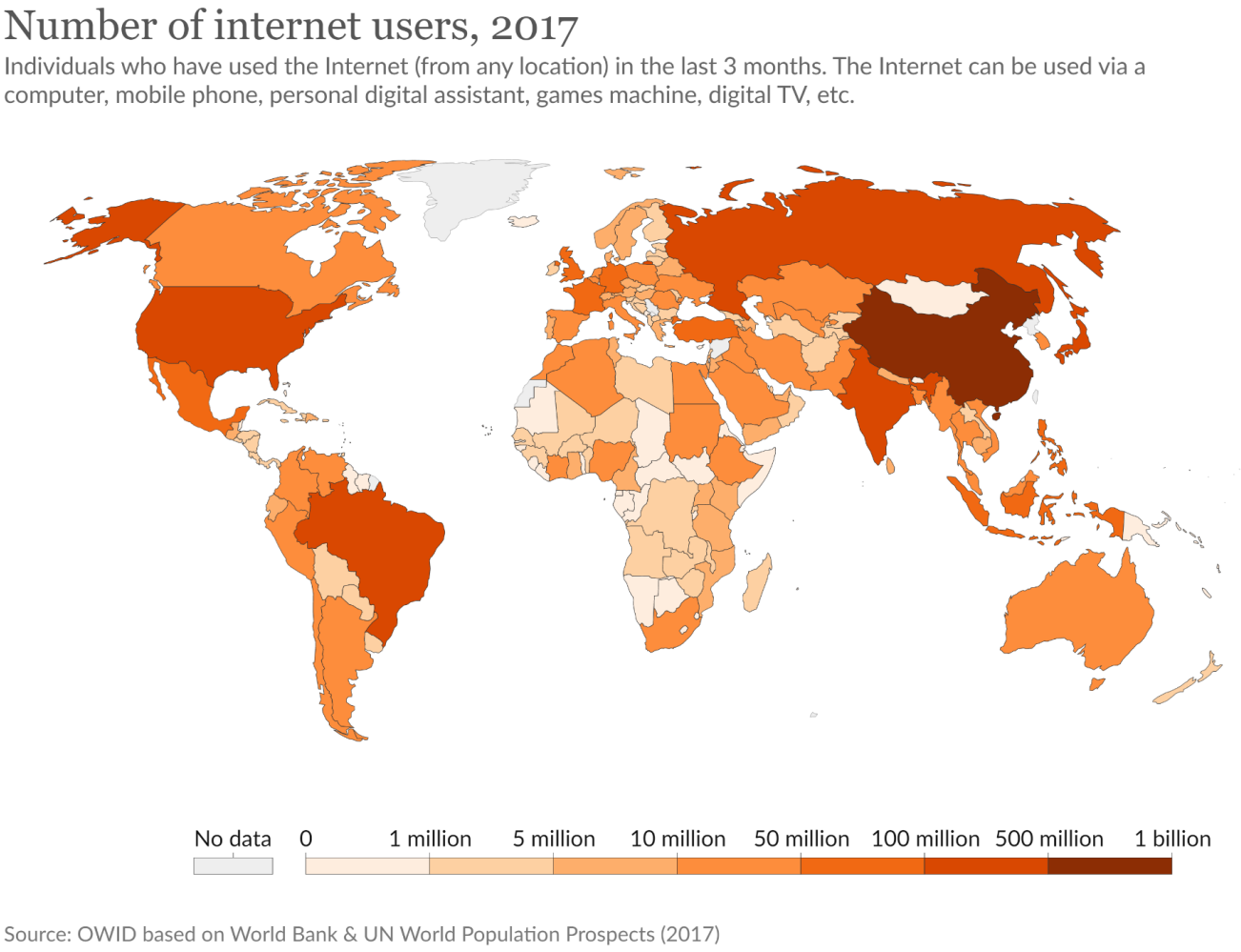


Note. Max Roser, Hannah Ritchie and Esteban Ortiz-Ospina (2015) - "Internet". *Published online at OurWorldInData.org.* https://ourworldindata.org/internet

The International Telecommunication Union, an agency of the United Nations, suggests that least developed countries are closing the digital divide by broadening global access to mobile access since now most of the world receives at least a 3G signal or better. Over 75% of the world's population owns a mobile device, but in less developed countries, this number decreases to just about 56% of their population (International Telecommunication Union, 2018). Only about 11% of the world does not have access to these mobile networks. This 11% mostly comes from Africa, South America, and Southeast Asia due to

lack of infrastructure and affordability. These areas often have sparse population distribution, low income, and already lack traditional communication infrastructure that would enable connectivity (Del Portillo et al., 2020). The map confirms this in Figure 2. On the map, in 2017, most of Africa, the Middle East, and Southeast Asia have the lowest concentration of individuals who have accessed the Internet in some capacity in the past three months.

Figure 2.
Worldwide Internet users in 2017



Note. Max Roser, Hannah Ritchie and Esteban Ortiz-Ospina (2015) - "Internet". *Published online at OurWorldInData.org.* https://ourworldindata.org/internet

Conclusion:
Guiding Change & Consequences

Closing the divide in terms of digital technology and equitable Internet access is a problem with multiple layers that need to be addressed by many stakeholders. These worldwide stakeholders include governmental departments, international economic and financial institutions, non-governmental organizations (NGOs), IT/telecommunications companies and organizations, educational institutions, public organizations, and providers of social and public services.

As mentioned previously, the International Telecommunication Union suggests that broadening mobile device access and mobile connection to 3G networks or better may be the way forward to assist in closing this gap (International Telecommunication Union, 2018). The International Telecommunication Union and the UN Broadband Commission have teamed up "to find scalable and replicable solutions to connect large rural offline populations at minimal costs and to find effective strategies for narrowing the usage gap across all regions" (Del Portillo et al., 2020). Verizon Wireless suggests that 5G is the answer to closing the digital divide. In the United States, only 65% of rural areas have access to high-speed Internet due to a lack of infrastructure (Verizon Wireless, 2021). Verizon Wireless insists that increased access to 5G could increase the gross domestic product of the United States by $800 billion in the next eight years. An increase in 5G high speed Internet access would create jobs, new business opportunities, and innovations that could now occur in the rural areas of the United States (Verizon Wireless, 2021). Forbes argues that the digital divide is not just a lack or inability to access the Internet; low-income households cannot afford to pay the providers. The lack of subscribers for Internet service providers affects their ability to expand their infrastructure and justify lowering costs (Mukherjee, 2022). If 5G is the cost-effective solution to the digital divide, then governments worldwide will have to continue to increase funding to bring broadband access to rural areas.

Further research into educational technology innovation's undesired, unintended, and indirect consequences is necessary (Rogers, 2003). Rogers' classic work also describes the inevitability

of unintended consequences of innovation, and the digital divide is the unintended consequence of Internet connectivity. The digital divide will continue until there is a global perception change of high-speed Internet access as a necessity rather than a commodity. Instructional designers must continue considering if their audience has access to high-speed Internet. Internet service providers worldwide must continue installing and improving infrastructure to expand connectivity. Governments must continue expanding their funding to supplement costs for low-income families and infrastructure for Internet service providers. Every person in the world needs to be an advocate for greater access to high-speed Internet. While this is a huge undertaking, it is necessary as the world continues to connect via the Internet, especially for access to instructional and educational content.

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