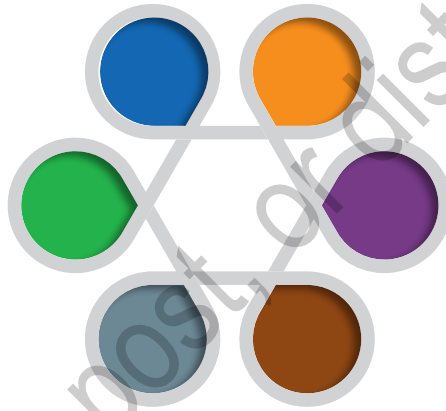


2

Education in the Age of Disruption



“Learning and innovation go hand in hand. The arrogance of success is to think that what you did yesterday will be sufficient for tomorrow.”

—William Pollard

Disruptive Innovation

In his seminal book *Disrupting Class: How Disruptive Innovation will Change the Way the World Learns* (2008), the late Harvard professor Clayton Christensen introduced readers to a concept called disruptive innovation. Disruptive innovation is a change that fundamentally transforms traditional ways of doing things. Disruptive innovations create new markets, products, and services. In doing so, they eventually disrupt existing markets, products, and services.

Today, there is a great deal of discussion about emerging innovations such as digital technology, cloud computing, big data, genetics, smart materials, mobile commerce, social media, biotechnology,

3D printing, nanotechnology, artificial intelligence, robotics, and neuroscience. These are just a few of the big disruptors in our world. They continue to fundamentally transform the way we work, the way we play, how we communicate, how we view our fellow citizens, and how we live in the world around us.

The primary driving force behind disruptive innovation is the incredible technological development occurring in our world today. That's because these disruptions allow us to do things that would have been unimaginable, even a few short years ago.

Let's take a closer look at how disruption happens. Disruptive innovation typically starts with the introduction of a new product but eventually becomes much more because the innovation results in a radical change in human behavior.

The iPhone as a Disruptor

As just one of many examples, let's examine the development of the iPhone and iPad. Apple introduced the iPhone in 2007. In retrospect, it's hard to believe that the iPhone was launched only 13 years ago. The iPhone was a fantastic new idea for a smartphone because it wasn't just a phone. It also had many other features built-in, including a new operating system that allowed users to communicate with the device using voice and natural hand gestures. The iPhone was cool and fun to use. However, at the outset, it would have been difficult to believe that this phone would change the world. Was it a disruptive innovation?

In the beginning, it was hard to see the connections between this device and how it would affect our lives. Many people thought all the talk about the iPhone was just hype. However, once people began using the iPhone, they discovered new ways of doing old things, as well as entirely new things they could do. For example, since people carried their phones with them all the time, they started using the iPhone to listen to music. Being able to store music on their phone meant people no longer needed to carry a Sony Walkman, Discman, MP3 player, iPod, or similar portable music players (Bilyeu, 2017).

As a result, sales of these other devices quickly declined. Formerly dominant products quickly disappeared from the market. As more people bought digital music, the iPhone, Apple Music, then Pandora and Spotify brought dramatic changes to the music industry. People didn't need to buy records, tapes, or CDs; they could purchase or stream individual songs and create personalized playlists and albums (FitzGerald, 2018).

Disruptions allow us to do things that would have been unimaginable, even a few short years ago.

People then shifted to playing digital games on their iPhones. As a result, sales of portable game devices dropped precipitously (Diver, 2017). And since people always carried their smartphones, they used it to take photos, which immediately and significantly cut the sales of point-and-shoot digital cameras (FitzGerald, 2018). Then people started using Netflix to watch videos on their iPhones. It was no coincidence that video stores like Blockbuster began to go out of business and live movie attendance started to drop substantially (Satell, 2014). People not only watched videos on their iPhones but also created videos and uploaded them to YouTube, which started a whole new era of global video sharing and viewing.

Meanwhile, as all this was happening, the banking industry was hit hard by the change in people's behavior as consumers shifted to doing banking online using their iPhones (McArthur, 2016). Simultaneous to this shift in behavior, shoppers started using smartphones to buy and sell products and services online rather than heading to the mall (Danzinger, 2018). The iPhone soon spawned a whole new smartphone industry built around touchable phones with glass faces. Meanwhile, telephone booths and landlines started to disappear (Kieler, 2016).

Three years later, in 2010, Apple extended the design of the iPhone by introducing the iPad. Its introduction created an entirely new digital tablet industry. Amongst many other things, the appearance of smartphones and digital tablets caused a fundamental shift in the way people received news and information (Walker, 2019).

The use of Facebook, Twitter, Snapchat, Instagram, and several other social media tools became hugely popular. At the same time, media companies were compelled to radically change the way newspapers, magazines, and other print media were delivered to ensure they attracted eyeballs and earned advertising revenue (Martin, 2018). Today, almost all media companies have online editions, as well as a social media presence, and many media companies have stopped or limited publishing printed versions (Forbes Communications Council, 2018).

Many more changes came from this one development—far too many for us to mention. But there is one more significant development we want to highlight. We are talking about a change so dramatic and substantial that no one could ever have guessed how one innovation could have repercussions and cause changes so monumental.

Within a few years of its introduction, the iPhone severely damaged the economy of an entire country. When the iPhone was first released in 2007, Nokia, a Finnish company, was the world leader in cellphone

design and sales. With the introduction of the iPhone, Nokia's sales started to decline steadily. Microsoft bought Nokia a few years back and almost immediately laid off more than 62,000 employees (Monaghan, 2013). Do you know anyone who has recently purchased a Nokia phone? Probably not!

At that time, other than Nokia, the logging and paper industries were two of Finland's other big employers. They employed tens of thousands of workers. When Apple introduced the iPad, everything started to change quickly. Sales of newspapers and magazines around the world began to plummet. The Finnish paper industry was hit hard by the abrupt decline in sales. Dozens of paper mills around the country closed, resulting in tens of thousands of Finnish forestry workers losing their jobs (Hodgkins, 2014). How could changes of this magnitude happen in just over a decade? That's the power of disruptive innovation!

Disruption Is Everywhere

The point is that the development of the iPhone and iPad is just one of the thousands of similar stories that are happening right before our very eyes. Disruptive innovation is continuously turning our world upside down.

For example, today, Uber, which has become the world's largest taxi company, owns no cars. Airbnb, which is the world's largest accommodation provider, owns no real estate. Alibaba, which is the world's most valuable retailer, owns no inventory. Facebook, the world's largest manager of information, creates no content. Amazon, the online retailer, until recently had no stores. Netflix, the world's largest movie house, has no theatres. And Spotify, which streams over 750,000 tracks and 40,000 hours of music every minute worldwide, owns no music (Goodwin, 2015).

We must emphasize that these examples are the proverbial tip of the iceberg. Yet all these changes occurred in just the past 13 years. If things have happened so quickly, what does the future hold for all of us? The point is, if disruptive innovation can disrupt successful businesses, which it has; if disruptive innovation can disrupt entire industries, which it has; if disruptive innovation can disrupt entire economies, which it has; and if disruptive innovation can disrupt an entire nation, which it has; we can't just assume the same thing can't or won't impact education.

As the former CEO of General Electric, Jack Welch, once commented, "When the rate of change outside an organization is greater than the rate of change inside an organization, the end is in sight" (Whitefield,

2013, p.16). Traditional businesses are not the only ones being replaced by disruptive innovation. Newspaper publishing, manufacturing, music, retail, banking, and postal services were all thriving industries 20 years ago. Today, these same industries have vanished, are struggling, are quickly declining, or are undertaking massive restructuring. That's disruptive innovation!

As parents, citizens, and educators, we must appreciate that if the digital world outside of education has been transformed because of disruptive innovation and constant global change, education will not be immune to the effects of these same dramatic changes. The problem is that some educators believe that change is something that happens somewhere else to someone else, like farmers, steelworkers, factory workers, customer service agents, or car park attendants. They assume that somehow education and educators won't be affected by these disruptive forces.

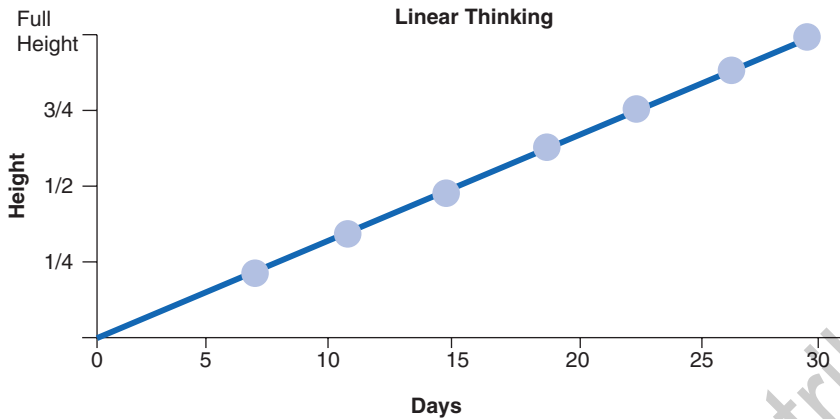
Based on current trends, it's easy to predict that over the next decade the education system both here and around the world will experience the very same kind of profound disruption and ongoing reconfiguration that Apple, Amazon, Spotify, Google, Facebook, and Twitter have already brought to our lives.

With disruption, there is always a ripple effect. Just like throwing a pebble into a pond, the ripples get bigger and bigger over time. And as these ripples grow in size, so does the disruption that happens in our lives. We see this clearly in the aftermath of the deadly combination of COVID-19; growing social, cultural, and racial upheaval; and increasing financial uncertainty in today's world.

What Is Exponential?

In the book *Living on the Future Edge*, the authors (McCain, Jukes, & Crockett, 2010) identified several global exponential trends occurring in our world today that we believe we absolutely could not ignore. *Exponential* is a word that we are encountering more frequently as we move further through the 21st century.

The big question is, what is exponential? And more important, what does it mean when we say that we are experiencing exponential change? What does exponential change look like? What does it feel like? How will exponential change affect our lives, our families, our communities, our schools, and our nations?

Figure 2.1 Linear Growth Pattern

To illustrate exponential growth, let's use the example of the growth pattern of a plant. Suppose you wanted to buy a plant to fill a bay window in your home. So you go to the local nursery, and you buy a plant the clerk tells you will grow to a height that will cover the entire window in 30 days. This plant follows a linear growth pattern. What does this kind of pattern look like?

Figure 2.1 is a graph of the growth of a plant that follows a linear growth pattern—a pattern that sees the plant grow to its full height, covering the window in 30 days.

In a linear growth pattern, after 10 days, you would see $1/3$ of the mature plant. After 15 days, you would see $1/2$. Finally, after 30 days of growth, the plant would have fully grown, filling the entire window. This type of growth would be very predictable. It's important to note that throughout much of human history, we have dealt with this kind of linear change—steady and predictable.

But what if instead, the person at the garden center sold you a plant that will grow to fill the entire window following an exponential growth pattern? A pattern where the plant doubles in size every day. What would this kind of growth look like, and how would it differ from linear growth?

Figure 2.2 shows what you'd see on Day 1. It's not very dramatic. There's absolutely nothing to see.

Figure 2.2 Day 1

On Day 2, there would still be nothing to see. Days 5–10 (Figure 2.3), still nothing to see here!

Figure 2.3 Day 10

Since nothing appears to be happening, let's jump ahead to Day 20. But before we do let's pause to consider if this was a linear growth pattern instead of an exponential growth pattern, how much of the plant would we see on Day 20? According to our calculations, we should see about 67% of the plant. Figure 2.4 is what we see on Day 20.

Figure 2.4 Day 20



Not very impressive, even though the plant is doubling in size every day. Following an exponential growth pattern, we still see very little, just a couple of green leaves. If you are doing the math, on Day 20, only $1/64$ th of the plant is visible. So let's jump ahead to Day 25 (Figure 2.5).

Figure 2.5 Day 25



If this plant was following a linear growth pattern on Day 25 we would see almost 85% of the plant. But even though we are experiencing exponential growth—even though the plant is doubling in size every day, the plant is barely over the rim of the pot—and there are only 5 days left in our 30-day growth cycle. So let's take a look at Day 26 (Figure 2.6).

Figure 2.6 Day 26

Something must be wrong—26 days in and all we have so far is stunted growth—and there are only 4 days to go. Let's move on to Day 27 (Figure 2.7).

Figure 2.7 Day 27

The nursery must have given us the wrong plant; it is never going to fill the entire bay window. How could it cover the window in just 3 days? Oh well, onward to Day 28 (Figure 2.8).

Figure 2.8 Day 28

We have reached Day 28 of a 30-day exponential growth pattern, and the plant is only $1/4$ of the height of the window. Anyway, let's see what happens on Day 29 (Figure 2.9).

Figure 2.9 Day 29

Okay, something is finally beginning to happen. The problem is that we're almost out of time and only half the window is covered. With only one day left it is incomprehensible that the plant can finish its growth pattern and completely fill the entire window. But here's the critical question to consider. If this plant doubles in size each day, what is going to happen tomorrow on Day 30 (Figure 2.10)?

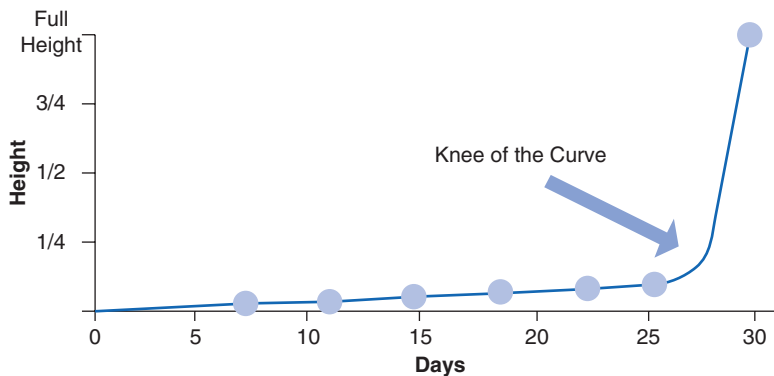
Figure 2.10 Day 30

Bang—the full plant explodes into view. The entire window is covered, and it seems like all the activity occurred in just 1 day! That’s the power of exponential doubling. The interesting point is that by the time people notice something is happening, the exponential growth pattern is about to kick in, and developments explode onto the scene with dramatic effect.

That’s the reason the COVID-19 pandemic seemed to come out of nowhere; it was quietly growing, and all of a sudden it was everywhere. For the same reason the internet seemed to explode out of nowhere. The internet had been around for more than 40 years, with only minimal impact on the general public. When exponential growth kicked in, the world was engulfed in a tidal wave of information that seemingly happened almost overnight. That’s the power of exponential growth. Once the doubling or tripling starts kicking in, change will occur at breathtaking speeds.

This kind of growth, depicted in Figure 2.11, has been behind most of the disruptive change we have experienced in the latter part of the 20th century and the first part of the 21st century. And this kind of growth will most certainly be behind almost all the disruptive change we experience in the near and distant future.

Figure 2.11 shows the growth of a plant that doubles in size each day. On the right-hand side, it has a telltale shift known as the Knee of the Curve. The Knee of the Curve represents the dramatic upswing that takes place in the last few days. The Knee of the Curve is the pivotal point for exponential change.

Figure 2.11 Exponential Growth Curve

Keep in mind, the Industrial Revolution unfolded over centuries. In today's exponential times, revolutions happen in a matter of years, sometimes months.

We want you to keep the shape of this graph in mind and remember the developmental pattern described in this chapter is behind all the trends we examine.

The doubling of small numbers is deceptive. Take a look. Start doubling .1, .2, .4, .8; at this stage, it all looks pretty much like zero. But after we reach 1, just 30 doublings later, we're at one billion.

That's where things stand at this moment regarding the rate of change. After Day 30, the line goes virtually straight up. The difference between linear change and exponential change is incredible. Inventor and visionary Ray Kurzweil (2010) explained, with 30 linear steps, you get to 30 but with 30 exponential steps, you get to one billion.

The challenge we face is that we are mostly linear thinkers in an increasingly exponential world.

Disruptive technologies are relentlessly transforming products, services, and industries. The only way to deal with this kind of dramatic change is to look continually into the future. We must pay attention to exponential disruptions, new technologies, artificial intelligence, biotechnology, and nanotechnology among many emergent trends. These are just some of the forces that are quickly upending our world.

We must always be trying to stay ahead of the curve. We must always be trying to plan and act with the future in mind. We must always try to detect new trends and project them out to their logical conclusions. We must start working *now* if we are going to be prepared to anticipate

The challenge we face is that we are mostly linear thinkers in an increasingly exponential world.

the unique opportunities and challenges that will inevitably confront us because of our fixed mindsets. We call this fixed mindset TTWWADI (That's The Way We've Always Done It) mentality—the inevitable resistance to change we all experience.

As we examine the exponential changes affecting education, and as we project these changes into the future, it's critical that we are continually asking, are we using linear thinking or are we using exponential thinking? It's also important we keep in mind that the world won't stop innovating on Day 30. In a world driven by relentless exponential change, what will our graphs—what will the world—look like on Day 31, or Day 53, or Day 1,777? Once exponential change hits the Knee of the Curve, the effect and the speed at which it happens is almost unimaginable.

HyperInformation

There have been a multitude of disruptive innovations whose ripples of impact have, and are, cascading through our lives. To illustrate our point, let's focus on some of the developments that are impacting what we do in schools today.

Specifically, we want to examine how information in the modern world is changing what educators need to emphasize in their teaching. We want to focus on HyperInformation, which is information structured and connected using hypertext and hyperlinks that can lead to InfoWhelm and information anxiety. This trend affects teachers directly because so much of education involves information. But before we examine this trend, we want to stop and consider this question for a moment. What is the primary skill developed by the vast majority of instruction that takes place in many schools today?

Our observation has been that there continues to be a strong emphasis on memorizing course content and procedures. This memorization is often done without students completely understanding what the material means on a deeper level. This approach to instruction has been in place for hundreds of years. The question is, does memorization adequately prepare students for the world that awaits them once they complete school?

To answer this question, let's look at the nature of information in the world today and consider what that tells us about how we should be preparing our students. Let's examine how HyperInformation has impacted the nature of information in the modern world.

Today, there's far more information available than ever before. Also, more than 90% of the scientists who have *ever* lived in all of human history are still alive (Jukes & Schaaf, 2019). The amount of research and innovation conducted has expanded exponentially as a result of all these people doing their work. Add to this the rapid explosion of the internet into our lives and the emergence of powerful new digital technologies.

So now what happens is new research and innovation become instantly available to anyone, anywhere on the planet. Also, global digital networks give people instant access to news and information about everything from natural disasters to politics to sports.

Wikipedia is just one indicator of how big this explosion of up-to-date information is. Wikipedia was created in 2001. Since then, more than 40 million articles in 293 languages have been added to Wikipedia. And more than 800 new articles are posted every day. When you do the calculations, 40 million articles are 1,000 volumes of 1,200 pages each, which represents more than one million pages in total or about 87 yards (80m) of shelf space. In September 2019 alone, there were more than 20 billion page views on Wikipedia. And keep in mind, Wikipedia is just one of many informational sites, including Google, Yahoo, YouTube, and Baidu, to name but a few (Neary, 2014; Wikipedia Statistics, 2019).

The amount of information in the world has quite literally exploded exponentially. To give you a sense of just how much information is now available in the online world, computer giant IBM tried to add up all the ones and zeros that comprise all the photos, videos, PDF files, email, web pages, instant messages, tweets, phone calls, and other digital data. They determined that by 2012 there were more than 900 exabytes of digital data being generated in the world *every single year* (McCafferty, 2014). Just how much is 900 exabytes of information? Well, if you printed out all that information in standard-sized books and piled them up, there would be so much data in 900 exabytes that, according to our calculations, the stack of books would extend from Earth to that “not really a planet anymore” Pluto. But wait a minute; we're not talking about just *one* stack of books; 900 exabytes of data is equivalent to 23 stacks of books that each reached from Earth to Pluto every year. And this number continues to grow exponentially.

By any measure, that's an overwhelming amount of information. And remember, this is based on projections of the amount of data that were made in 2012. Considering that we live in exponential times, we have to ask, how much data is being generated today? According to a recent

International Data Corporation (IDC) report, 90% of all the data in the world today was created in the past 2 years (SINTEF, 2013). Add exponential development into the picture, and you get an idea of the staggering amount of data that is available now and will be available in the future. As of 2015, only about 0.5% of all data is currently analyzed. That percentage is shrinking, as more data is created and collected (Bansal, 2014).

But we need to know that HyperInformation is about much more than just the *quantity* of available data. It's also crucial that we understand the *quality* of the information now accessible. That's because we are in the midst of a migration of the world's literary works to a digital format. In December 2004, Google announced it would digitize all the books in five major research libraries, including all the books in the library at Stanford University, Harvard University, Oxford University, the University of Michigan, and the entire New York Public Library's collection. Although this undertaking experienced some legal obstacles, the project managed to scan over 25 million books (Howard, 2017). As a result, there's a rapidly growing library of digital books that have been created.

Consequently, you can search for almost any book, by virtually any authors—*like us, for instance*—and instantly get a summary of all the books they have written. And when you search further, you can find the full text of an astonishing number of books. Today, it's not just about downloading content to computers. Disruptive technologies are providing us with amazing new tools for accessing information. Smartphones, tablets, wearables, implantables, as well as a whole range of new digital devices, are capable of displaying multimedia information.

These technologies will continue to transform the way we learn. To put this into perspective, not that many years ago, people read about world events often days after they occurred. Learning what happened was a second hand, after-the-fact experience. Today, people learn about things as they happen in real time, whether it's a hurricane in the Caribbean, a vote in Great Britain, a fire in France, a shooting in Texas, an earthquake in China, or a global pandemic. They can experience events as text, images, video, and sound at the same time.

They can also see historical images, video footage, and archival audio recordings that have been converted to digital formats. This kind of access means that today we can learn about both the current world as well as about history through firsthand experiences. For example, people can see images of Chairman Mao and the Chinese Red Army's Long March in 1934, or images of the rise of Nazism, or hear John

F. Kennedy as he outlines his plans to land a man on the moon, or watch actual video footage that records when astronauts first stood on the moon's surface.

Based on current trends, in the next few years, our students will likely have instantaneous access to virtually any single piece of information. We're talking about any text, photograph, video, painting, TV or radio program, webpage, blog post, tweet, or music produced by anyone around the world.

With the ongoing work of converting information into digital formats, people will likely soon have access to the entire works of humankind, from the beginning of recorded history, in all languages. All this information will be accessible to anyone, almost anywhere on the planet, wirelessly, within a fraction of a second. This vast digital library of multimedia information will be instantly available to anyone using powerful digital search tools.

What has been described here is just a brief overview of what we call HyperInformation. If all this is a reality now and not only in some indeterminate distant future, then we must ask some critical questions about how to best prepare students for the world that awaits them once they complete their schooling.

What does it mean—what will it mean—to be educated in this new world of HyperInformation? Does a predominant focus on memorizing prepare students for a world with anytime, anywhere access to more than one trillion web pages? What is the value of memorizing material when up-to-date data is instantly available through intelligent online searching tools? And if memorization is not *all* that's needed, what other skills do learners need to have to be able to function in a world of HyperInformation?

These are incredibly important issues that we need to think deeply about if we hope to do our job of helping our students prepare themselves for the future. If smartphones can deliver information anytime, anywhere, are there more critical skills needed for students' futures that should be taught rather than simple, easily transmitted, and memorized information?

How will students learn the new information gathering skills enabled by the electronic age? And, are those new skills a priority in our schools and classrooms today?

Where Do We Begin?

We know change is hard. We know change makes us feel uncomfortable. And we recognize it is easy to slip back into traditional assumptions

about how the world works. But this is not about you and us and our needs and comfort zones. Too often, we try to make massive changes in a very short period, and inevitably we fail. It's just too much, too quickly. What if instead, we woke up every day and asked ourselves what was the 1% improvement we could make today to better ourselves personally and professionally?

While the 1% strategy may sound counterintuitive, particularly given that we have just devoted an entire chapter to describing the dramatic effects of exponentialism, HyperInformation, InfoWhelm, and information anxiety, breaking things down into small, digestible pieces is one of the only consistently effective strategies you can use to avoid being absolutely overwhelmed by the constant white noise of our digital society.

Summarizing the Main Points

- Disruptive innovation is change that fundamentally transforms traditional ways of doing things, creating new markets, products, and services.
- As parents, citizens, and educators, we must understand that if the digital world outside of education has been radically transformed because of disruptive innovation and constant global change, education will not be immune to the effects of these same dramatic changes.
- HyperInformation is an excess of information potentially leading to InfoWhelm or information overload.
- Information in the modern world is changing what educators need to emphasize in their teaching.
- Today's schools must focus on the new skills needed to utilize digital technologies that make information instantly available to anyone.

Questions to Consider

- Why is change in our personal and professional lives so hard to embrace?
- Can you brainstorm several instances of companies or products that became obsolete due to disruptive innovation?

that changed a market or the expectations, needs, or wants of citizens?

- What is the significance of exponentialism to learners and educators?
- Why does the existence of HyperInformation require educators to rethink how and what they teach?
- How will students learn the new information-gathering skills enabled by the electronic age? Are these new skills a priority in schools and classrooms today?

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