Living on the Future Edge

keynote perspective

Introduction

We're living in a bold new time—a time of evolution, transformation and discovery. Our new digital age has provided us with technological wonders we never thought possible, and a relentless acceleration of change in our everyday lives. It's this change that is ushering in a time in which our children will be the creators and architects of a world we can't even imagine.

In a world where change is the constant, you can't trust your eyes because what you see will be replaced tomorrow. You think your eyes are showing you reality when in fact, they are showing you history. The only way to see the reality of a world on the move is to look for global trends. These trends are the very essence of 21st century life and learning, and you'll discover them for yourself right here.

We start off this perspective with the exponential doubling process of Moore's Law, and its relation to the exciting world of Photonics. We'll dive into the fascinating fields of Biotechnology and Nanotechnology, and what the astonishing advances in these worlds of science may hold for the future of mankind. We'll also take a close look at the phenomenon of the Internet, and how the dynamics of its continuing evolution, coupled with the ever-evolving digital logic of Moore's Law, have given rise to what can only be called InfoWhelm—likely the greatest threat to education as we know it today.

By carefully examining the significance of these vital global exponential trends, this perspective profoundly challenges your fundamental assumptions about the world we live in and the future that awaits us. You're about to experience the rush and the wonder of how it feels to be Living on the Future Edge.

Let's Talk About Change

We face a world on the move! In the last few decades, the technological advances we've witnessed have altered our world radically. Change is often subtle and sneaky. It's often difficult to understand; not just what's going on, but the actual scale and scope of the change and its very nature.

In today's times of radical changes, we are not just talking about temporary change and then going back to status quo. We are talking about constant and never-ending change—change for today, tomorrow and forever.

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Today, we live in exponential times. This means that change is beyond our ability to comprehend. Exponential times offer change that transforms social life, intellectual horizons, social traditions and practically every aspect of our lives; the way we work, play, learn, and how we view each other and the rest of the world.

The Global Exponential Trends

What follows are 6 exponential trends that are definitive of today's exponential rate of change:

- Moore's Law
- Photonics
- The Internet
- Biotechnology
- Nanotechnology
- InfoWhelm

Trend 1—Moore's Law

Gordon Moore, cofounder and first Chairman of Intel Corp., wrote an article in 1963 in which he predicted that based on chip technology at that time, the processing speed of any electronic computational device would double every 24 months, while the cost of its production would simultaneously decline by 50 percent—so you'd get twice the power for half the price every two years. This prediction has remained uncannily accurate for the last 50 years.

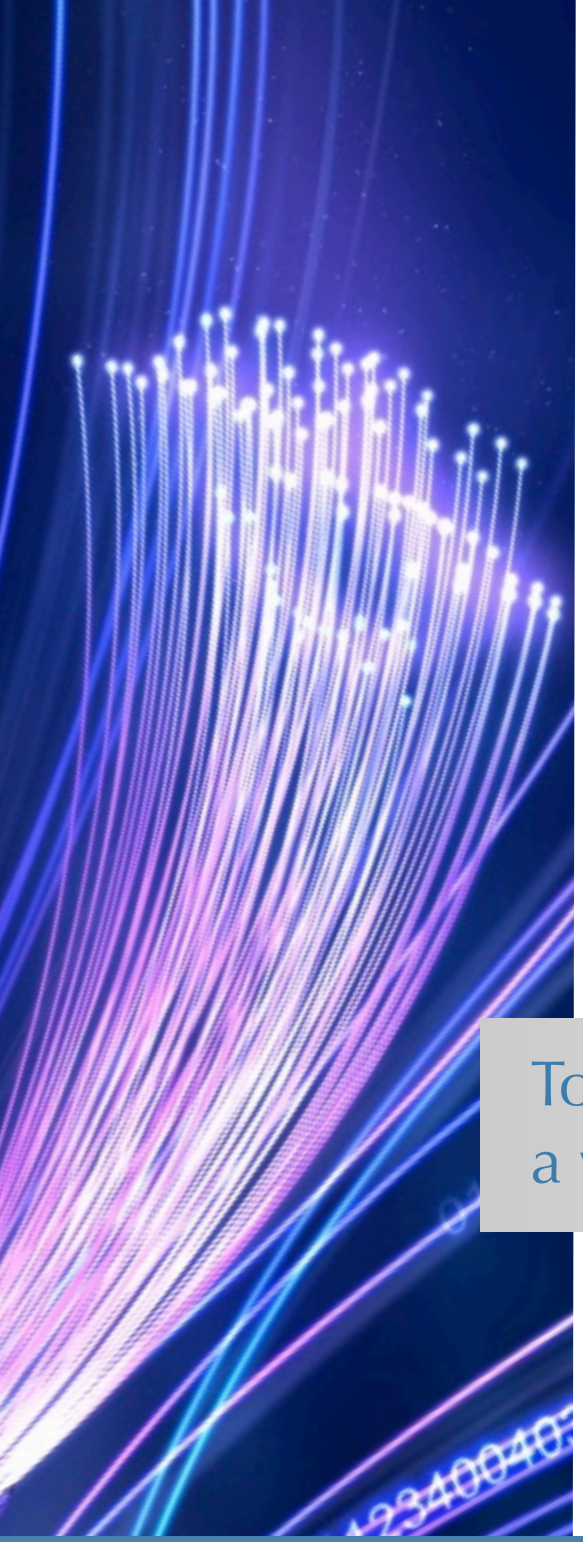
In 1978 a computer with 8K of RAM (it takes 1024K to make one megabyte) would cost $250-$350,000. The following year PCs appeared on the market. The cost of these machines was reduced to $5000. By 1984, the Mac had been introduced and disk drive space had tripled to 400K. Processing speed had gone from 2MHz to 10MHz. Despite a 15% rate of inflation, the cost for this new technology had been reduced to $3900. Later that year Gordon Moore wrote another article revising Moore's law . He claimed that chip technology was now developing every 18 months, not every 24 months.

What is the future of Moore's Law? The man himself tells us that based on current chip technology the exponential doubling of his theory will continue for another 15 to 20 years at least —perhaps even another 50 to100 years.

What about the graduating class of 2021-2022? What kind of technology will be common to them? What will be common to us one generation from now? Imagine a computer with 200 terabytes (200,000 Gb) of RAM and a 40 terabyte (40,000 Gb) hard drive. Imagine these machines processing at 1.2 terahertz (1,200,000 MHz). Would you be willing to spend $1.37 for such a device?

The next generation of students will likely be looking at technology measured in terms that are billions if not trillions of times more powerful than the technology we have right now. For our generation this is a problem, because we remember remember a time where these technologies didn't exist. But for students today, they have always been a part of their lives and now they take them for granted..

What are the implications of Moore's Law for education? Technological processing power and speed doubling every 12 months (soon to be 6 months), while the cost to purchase is cut in half.



Trend 2—Photonics

When it comes to bandwidth how fast is really fast? Using a coaxial cable and a cable modem you can get downloads speeds exceeding 15 MB/sec., fast enough to fill a DVD's contents in 38 minutes. A single strand of fiber optic cable, thinner than a human hair, can exceed download speeds of 10 trillion bits per second using photonics, or laser light of varying colors and frequencies. So, 10 trillion bits/second is 425 DVD's per second, or 150 million simultaneous phone calls. Whole fiber optic cables typically contain 800-1400 strands. But that's still not fast!

Photonics is following in its own exponential growth pattern, just like Moore's Law. The amount of bandwidth you can buy per dollar is tripling every 6 months—increasing at anywhere from 4 to 6 times the rate of Moore's Law. It will continue to triple for at least another 20 years. We'll be measuring bandwidth speeds in the billions and even trillions by then. Currently we are in the stone age of optical/digital communications.

With WiFi as today's standard, WiMax and WiBro are closing to fiber speed wirelessly and continuously through the air, even at distances several kilometers away from the source or in a plane at 40,000 feet or in a car at 70 mph. So where is all this leading? Essentially, the Internet will be everywhere. You'll be online no matter where you are. 15 years ago students only had to compete for jobs with kids from this or a neighboring city. That same competition comes today from both people and machines, in places as far away as Shanghai, Mumbai or Singapore.

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The world is increasingly flat, and today's economy is based on new skills and knowledge that require a whole new vision for education in the 21st century. Our students need to be prepared to thrive in this new flat world that doesn't even exist yet, to solve problems we haven't begun to think about, and to use technologies we haven't yet invented.

Trend 3—The Internet

The Internet came out of practically nowhere. In 1990 there were less than 20 users of the World Wide Web on the planet. Today there are over 2.1 billion users in more than 180 countries, with an additional 150,000 users having been added in the last 24 hrs—that's 113 every minute.

In that same time 6 million new websites have been uploaded and 100 billion e-mails sent (including 250 billion spam) at about 1.2 million per second. The amount of bandwidth required for all this is estimated to be tripling exponentially every year.The problem is you can never have enough bandwidth.

Developers and designers are constantly pushing the limit with internet; things like video, flash and web-based applications. Maybe you've heard of some of these:

Facebook and Myspace —60% of the online population uses a social network, with an average user going online 5 days a week and at least 4 times a day for an hour each day.

Twitter —A micro-blogging tool, the new portable fax machine of the 21st century, and the new method of distributing news. According to Twitter Blog, Twitter averaged 50 million "tweets" a day in February of 2010—an average of 600 per second, and a 1,400% increase from the previous year.

YouTube —Currently storing about 140,000,000 videos with 100,000,000 viewings each day. This indicates a trend toward video replacing e-mail, texting and blogging for the younger generation.

Wikipedia —It has more than 8 million articles in 253 languages. In addition, over 1 million new articles have been added in this past year. It updates breaking news in real time.

Wikiversity —Offers tutorials or courses for fostering learning. It supports learning communities and their materials and activities.

Ebay —Ebay is a modern-day yard sale, a global digital flea market. It had only 30 employees in 1998 and today has 13,000 with more than 230 million customers world-wide, and is engaged in more than 100 million auctions at any given time.

Skype —Currently has more than 100 million registered users. Have a teleconference with one or many, anywhere on the planet for little or no cost.

Second Life —A VLE (virtual learning environment) with over 7 million accounts. It creates avatars - virtual identities that allow users to socialize and interact, and work and learn in virtually created environments. Some recent graduates from Bryant and Stratton College earned their degrees virtually through 2nd Life.

SciLands —A virtual continent devoted to science and technology education. NASA offers training and information on this program.

Podcasts —In September 2004 a Google search for the term "podcasts" would have yielded a mere 11 results. That number has grown since then to in excess of 172,000,000.

Today, the Internet is becoming a major working and learning environment. One day you'll walk and talk your way through researching or using digital devices. Think video games are addictive? Wait until kids are fully immersed in virtual reality. Not to acknowledge the Internet's profound significance is kind of like not using a car simply because at one time we rode horses.

Trend 4—Biotechnology

Biotechnology uses biological processes to develop products or create technological solutions to problems. It's used in many fields—pharmacology, medicine, agriculture, and mining amongst others. Biotechnology has been around almost forever, since nomads selected specific wild seeds to grow crops. Today biotechnology is used to create all manner of powerful and innovative new drugs and products. But this is just the beginning and only a sliver of what's already happening.

Now we're beginning to see the emergence of *pharming*, where genetically engineered transgenic animals (animals with human genes transplanted/spliced into them) are used to produce pharmaceuticals through their milk or blood, or their body parts harvested to be used for human transplants.

Other plants have been harvested as neutraceuticals. They are engineered to produce everything from treatments for Parkinson's and MS, vaccines for herpes, diarrhea, cholera, malaria, and

anthrax, to cancer vaccines grown in tobacco. Literally, you eat the plants and you are vaccinated against various diseases.

The great explorers of today aren't mapping continents, rivers, mountains, cities, or planets. They're mapping the genetic code of all living things.

And how about lab-grown meat? The scientific goal is to develop an industrial version of the process in five years. If they succeed, slaughterhouses will become a thing of the past. Cultured or in-vitro meat could be coming to a supermarket near you.

Custom-Made Body Parts

In Boston, this field of biotechnology is being used to create custom made body parts; lose your ear to cancer or an accident, and then use your own tissue to grow a new ear. Soon biotechnology will allow arms, legs, fingers, or any other body part to be regenerated like a salamander does. In the age of land mines and improvised explosive devices this holds great hope for the nation's soldiers and other high-risk professions.

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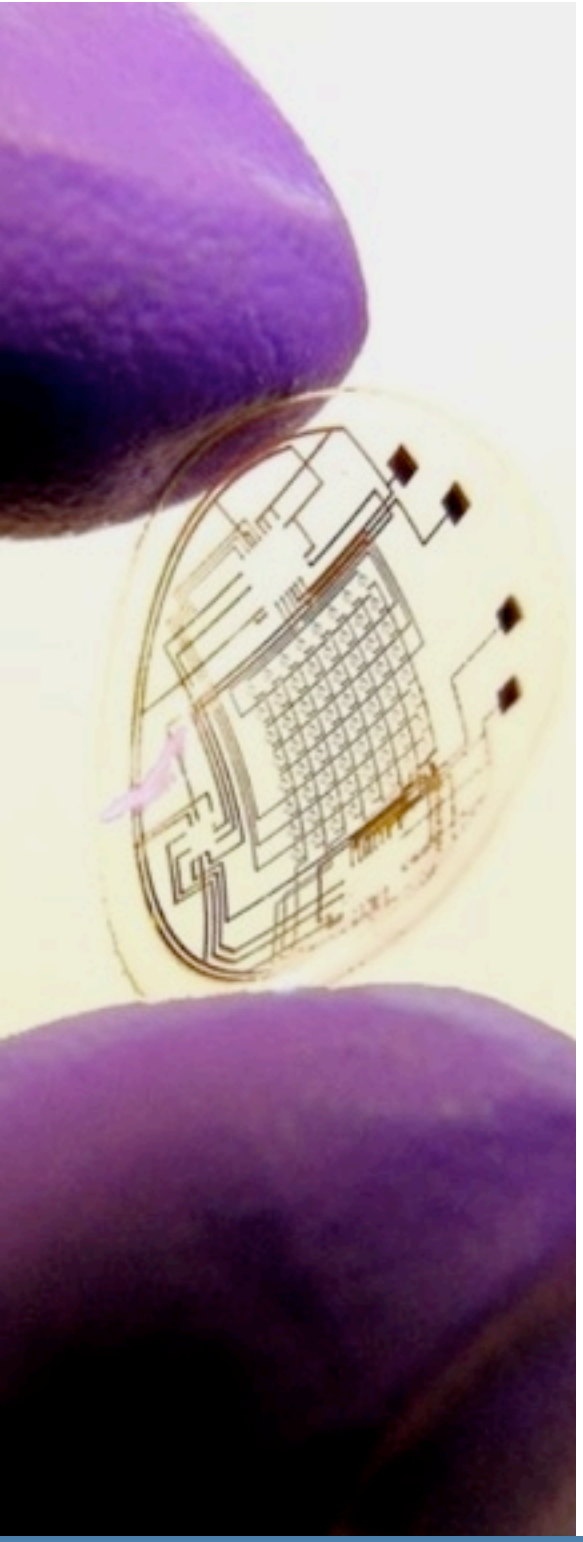
The Human Genome Project

This all happened because of the Human Genome Project, which commenced in 1993. The purpose of the HGP was to create a road map to the entire genetic script to identify the genes responsible for 3,000 to 4,000 hereditary diseases like Huntington's, cystic fibrosis and muscular dystrophy. The other aim was to identify the genes suspected to play a part in cancer, heart disease, diabetes, Alzheimer's and many other common diseases. By completing a genetic map scientists hoped to create gene therapies and target-specific drugs to act on the cause and not just the symptoms of disease.



This is an incredibly complex task. We're talking about billions and billions of bits of information, more than 200 terabytes of new data every year—that's equivalent to sorting and using a million new encyclopedias. You could spend an entire lifetime reading a copy of one person's genome and you would barely finish much less understand or remember what you read.

It was initially expected that it would take at least until 2020 for the 1st 85% draft of the human genome to be completed. The first draft to 95% was actually completed on June 26th of 2000, with the complete 99.9% draft made public on April 19th, 2003. So how could it happen so quickly? The answer is Moore's Law and the rest of the exponential trends.

Since 1983 the cost of sequencing a single gene has collapsed from $150,000,000 in 1983 to less than $25 today. As a result, genetic data is doubling every 6 months. We're beginning to realize that you can't separate information technology and biotechnology. What we are seeing is just the beginning of the digital genomics convergence.

Within a few years your entire genome could be downloaded to a chip, a gene card or the Internet. You'd be able to go to a supermarket or drug store and buy a kit. You lick a test strip and self-diagnose yourself for colon cancer, breast cancer or Alzheimer's. You then go to a genome doctor, who is a physician who will use the gene card to forecast potential illnesses and prescribe preventative drugs custom designed to your DNA.

Trend 5—Nanotechnology

Do you remember way back in the 70's when you bought component stereos? You bought an amp, a pre-amp, a tape deck, speakers, and a record player. In 1983 along comes the Boom Box, a technological hybrid which fused together separate devices. There was an unanticipated power that comes with the synergy of previously separate devices. Today, we have *smartphones*. It's a phone, a digital camera, and a camcorder. It plays videos, sends emails and text messages, surfs the web, and it wirelessly transmits music and video to TVs amongst many other things.

This is technological fusion. Because of technological fusion coupling with Moore's Law, these devices are already doubling in power and at the same time getting smaller.

As chips become smaller electronics will instead be embedded in our environment, woven into our clothing, and written directly to our retinas from eyeglasses and contact lenses. Already cars can contact the dealership to arrange for repairs before we realize there's a problem. The next networking frontier goes beyond desktops, laptops or cell phones. It includes appliances and products talking to one another. Just imagine a refrigerator talking with the grocery store saying "send milk, bread and chocolate".

Trend 6—InfoWhelm

Technological doubling has caused a parallel change in the knowledge base. Facts are obsolete faster and knowledge built on these facts is less durable. The boundaries between conventional disciplines break down and alter our very societies, changing everything about our lives. Yet, the majority of our schools have not conformed to this trend. Information still has value but is now more perishable.

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Google can search for more than just text and images, and has distributed hundreds of free tools and services for internet use:

- Texting and blogging
- Academic research
- Video clips
- Financial information
- Recipes
- Phone numbers and addresses

The new Google Book Search is digitizing 60 million books from the world's finest libraries. Searches for authors and subjects and keywords yield astounding results on any book you can imagine, right down to individual pages. What about the implications for research, going to the library or a book store?

Just as the microchip has transformed the music, TV and film industry, book publishing will be unrecognizable in the near future. How will traditional libraries compare to this type of technology? Very soon we will have the same access to information as iPods and iPhones. You could one day carry the sum of all human knowledge—literally in the palm of your hand.

This is what these developments are leading to. What implications does this have for the skills people would need to use this technology? And are schools preparing our students for this world? Today, kids are as comfortable using these new devices and technologies as we are reading a book. How do we modify the curriculum to accommodate this access to multimedia information?

How Far Have We Come?

The world's first digital computer called the "Eniac" was built in Philadelphia in 1946. It took up two floors of an entire building, and one of those was just for the cooling system. A programming cycle took a team of 10 technicians 2 weeks of flicking switches. In those days, people were amazed at what this thing could do—14 ten-digit calculations per second!

And today? We can place 10 million times that computational power onto a microchip that is so small, you could accidentally inhale it without even realizing you'd done it.

Nanotechnology is currently being used to create nano-machines and nano-subs. These are microscopic computers, machines, and robots about the size of a virus which can be swallowed or injected. If you have a clot or arterial clogging, they can provide microscopic technology to remove the blockages bloodlessly.

This will mean non-invasive surgeries of neurological systems. It will mean re-programmed viruses and bacteria designed to deliver molecular doses of chemotherapy to target specific cells allowing us to move from emergency interventions to deliberate and personal intervention.

What Lies Beyond

Moore's Law, Photonics, the Internet, Biotechnology, Nanotechnology, and InfoWhelm—Based on these trends, what are some of the ways our world may change in the next few years? What are we doing to prepare our communities, our workers, our schools and ourselves for the changes to come? What things are now evident to you that weren't apparent when you started reading this document? What do we need to do to begin to prepare our families, our communities and ourselves to help them move from where they are to where they need to be if they are to effectively deal with the changes these trends will bring upon us?

The state of things today was perfectly summarized more than 100 years ago by the great British American philosopher Alfred North Whitehead when he wrote:

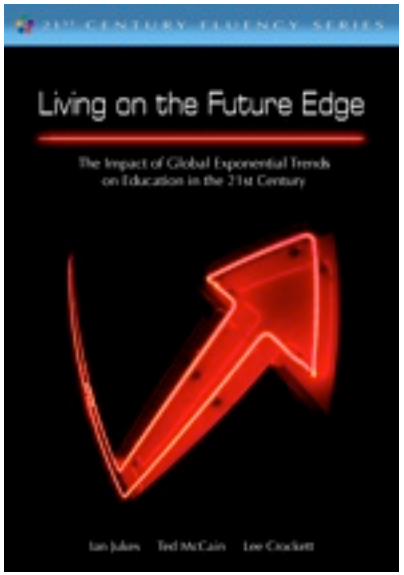
> ***"It is the business of the future to be dangerous. The major advances in civilization are processes that all but wreck the societies in which they occur."***

Our biggest challenge is both comprehending and accepting the scale of change - change so rapid that the very nature of change is changing! We tend to hang on to old ideas and assumptions about the world, but if we do this we run the risk of crashing headlong into the future. And this is perfectly summarized by the great philosopher Erik Hoffer, who wrote:

> ***"In times of radical change, the learners inherit the earth, while the learned find themselves perfectly equipped for a world that no longer exists."***

There is an idea that somehow education and educators are immune to the effects of global change. But are there challenges to the way you've always done things? Are things happening that will force you to let go of tradition and habit in order to survive? How are schools going to manage these exponential trends?

Don't let yourself be left behind ... because change is happening now, and things are changing exponentially!



the book and dvd

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