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The Education and Human Capital Requirements Roundtable

Exploring Approaches to Lifelong Learning for the 21st Century

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<http://www.curriculumredesign.org>

TABLE OF CONTENTS

Introduction

The Role of Business

A Multi-Disciplinary Roundtable on Human Capital Requirements

Trends Having an Impact on Education and Global Employment:

1. Digital Technology:
2. Impact of Automation/Communications and Offshoring on the Demand for Skills
3. Structural Unemployment and Jobless Recoveries

New Problems Require New Thinking, New Solutions

More Education – or More Relevant Education?

The Roundtable Presentations:

1. Bernard Meyerson, VP Innovation, IBM
2. David Autor, Professor, MIT
3. Dan Treffer, Professor, University of Toronto
4. Nicole Smith, Professor, Georgetown University Center on Education in the Workforce
5. Riel Miller, Founder, XperidoX

Quotes from the Discussions

Suggestions for Immediate Action from the Participants

Some Additional Thoughts About STEM

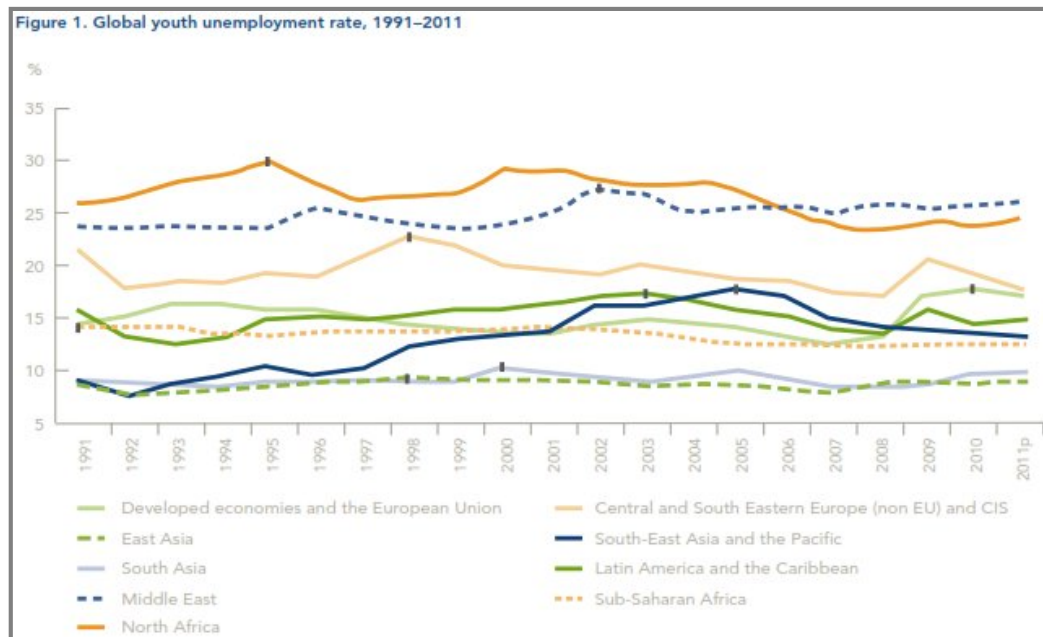
Conclusion

Introduction

The 21st Century has brought daunting challenges to individuals and societies around the world.

- On the global level, there is growing concern about the potential effects of planetary warming and the unintended consequences of globalization.
- On the national level, leaders struggle with economic instability and sometimes violent demonstrations of public dissent.
- And on the personal level, rapid socioeconomic and technological change is having a profound impact on individuals worldwide, as people in both developed and developing economies seek financial security, personal satisfaction, and meaning in their lives.

For example, as of this writing, three years after the official end of the 2007-2009 recession,¹ overall U.S. unemployment remains stubbornly above eight percent.² And youth unemployment currently ranges from 10 to 25 percent in most regions of the world, climbing to above 45 percent in Spain and Greece, with ominous implications for the future.³



Education can play a significant role in addressing these challenges and alleviating some of the disruption that comes with change, – but only if education is widely available. In addition, systems of education must be reformed to become demonstrably effective at providing people

¹ http://www.cbsnews.com/2100-500395_162-6884342.html

² <http://www.bls.gov/news.release/empsit.nr0.htm>

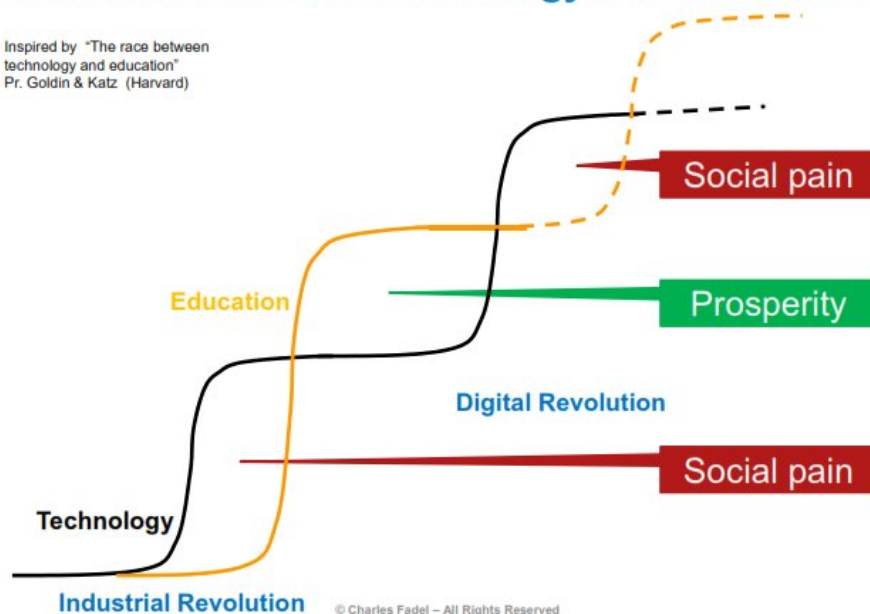
³ "Global employment trends for youth 2011" International Labor Organization

with the skills and knowledge they need to survive and prosper in an increasingly interconnected and technology-driven global economy.

Just as it did during the Industrial Revolution of the 19th Century, however, education lags behind technological growth:⁴

The Race between Technology and Education

Inspired by "The race between technology and education"
Pr. Goldin & Katz (Harvard)



Taking steps to encourage and help education catch up quickly and keep pace with technological development is in everyone's interest as societies and individuals attempt to meet the global and personal challenges of the new century.

The Role of Business

In earlier centuries, when technological and societal change occurred more slowly than it does today, the fragmentation of broad social responsibilities into discrete policy areas (e.g., the strict delegation of education policy and curricula to the control of government officials and academics) may have been sufficient for bringing education up to date with technological development. In an increasingly fast-paced world however, where technological advances impact business and society much more quickly – where both societal needs and employability are urgent, global concerns – the business community can be a strong and vibrant force for education change, provided it speaks altruistically with an unwavering voice, and through visible coalitions working together to:

- Transcend the requirements of any single entity while leveraging their individual brand power to gain visibility and impact;

⁴ Goldin & Katz, "The race between education and technology" 2008, Harvard University Press

- Continue to remind education systems that not making decisions *is a decision*;
- Lobby governments to fund modern data collection tools and techniques;
- Maintain a steady direction in pursuit of concrete and achievable goals, even as some members and individuals come and go;
- Encourage the replacement of obsolete topics of study with a new focus on relevant knowledge, skills, and character; and
- Enable economists, futurists, psychologists, educators, and professionals in many other disciplines to come together and offer fresh insights to help determine, explicitly and unambiguously, “what people need to learn for the 21st Century.”

A Multi-Disciplinary Roundtable on Human Capital Requirements

To that end, on February 24, 2012, The McGraw-Hill Research Foundation and the U.S. Council Foundation convened in New York City a wide-ranging “Roundtable on Education and Human Capital Requirements”.

The Roundtable sought to bring together and elicit advice from experts on how to get ahead of – and not merely keep pace with – the disruptions of 21st Century life in order to help build lasting “economic resilience” into our world via revamped education curricula.

The diverse experts who participated in the Roundtable (see appendix for a complete list): evaluated the completeness of the information available about current conditions and trends; discussed their possible direction in the future (while avoiding hard and fast predictions); and explored ideas as to how education systems could most effectively meet the challenges of today and tomorrow.

The Center for Curriculum Redesign, founded specifically to find answers to the question “What should students learn in the 21st Century?”, was asked to assemble the group and serve as discussion leader.

What took place was an invigorating, no-holds-barred and free-wheeling cross-disciplinary discussion in which the participants respectfully challenged each other’s – and even their own – core assumptions.

This white paper provides a recap of the challenges involved, the ideas put forward throughout the day for addressing those challenges, and summaries of the formal presentations made by five of the participants. There is also a selection of quotes from the wide-ranging discussions that punctuated the proceedings.

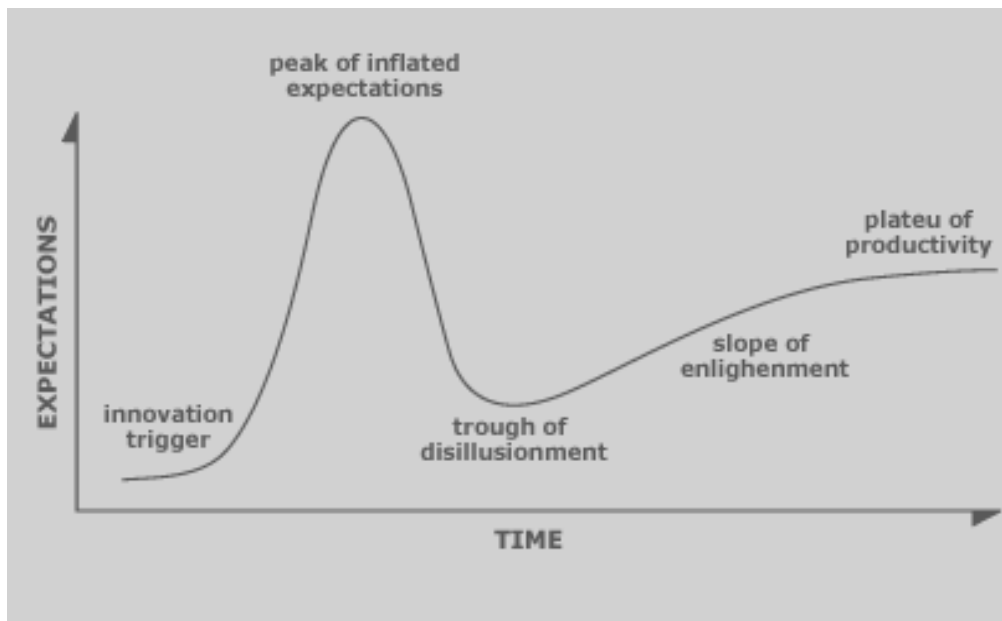
Trends Having an Impact on Education and Global Employment

1. Digital Technology

Digital technology's exponential growth over the past few decades is both enabling and rapidly compounding economic polarization and unemployment around the world.

Computing: Although automation has, in one way or another, been a disrupting factor since the Industrial Revolution, there is concern today about artificial intelligence (AI) and its potential to replace human tasks in ways difficult to imagine or contemplate.

AI may not have lived up to the fantastic predictions made for it in the 1980s, but certain recent events indicate it will soon have greater impact as it passes new thresholds of capabilities. Technological development often follows a “hype cycle”⁵, illustrated in the graph below. An overly enthusiastic phase is often followed by a period of disillusionment before the new technology begins to deliver on its promise. This is consistent with “Amara’s Law”, which states: “We tend to overestimate the effect of a technology in the short run and underestimate the effect in the long run.”⁶



⁵ Gartner Group: http://en.wikipedia.org/wiki/Gartner%27s_Hype_Cycle

⁶ Roy Amara: http://en.wikipedia.org/wiki/Roy_Amara

Chess was the “canary in the mine” for AI in 1997 when, in a highly publicized chess tournament⁷, World Champion Chess Master Gary Kasparov was defeated by a combination of brute processing power and human programming. A decade later, Kasparov came to the conclusion that his own strategic skills, coupled with tactical technology, could open up new horizons in his abilities. “What if instead of human versus machine,” he asked, “we played as partners?”⁸

More recent progress in AI has enabled computers to take on formerly intractable problems, raising the bar and moving us into a new world where computers can do many of the things formerly done only by humans. To take just a few examples:

- Google’s autonomous (self-driving) vehicles have driven through California more than 200,000 miles with only one minor accident;
- IBM’s “Watson” computer beat the celebrated Jeopardy quiz show world champion;⁹
- Computerized trading now represents more than 70 percent of all securities transactions.¹⁰

Rapid advances in AI have given rise to a deep fundamental concern: the potential for machines to *innovate* and even *invent*.

Humans consider creativity their ultimate “refuge,” and yet a number of incremental innovations are threatening that position. Any pattern that can be rule-based can be automated. Art is being computer-generated, with experiments such as “The Painting Fool”¹¹ and “Femme Fractale”¹² that stretch the limits of computer-assisted creativity.

Communications: Communications technology has also vastly improved over the past decade, allowing not just near-zero-cost for audio and video over communications platforms such as Skype, but also instantaneous transfers of data-rich files from one side of the planet to the other.

This means data processing tasks of increased complexity can now be located anywhere there are high-speed connections to the Internet. This has led to the offshoring of tasks such as X-ray interpretation, copyediting, legal discovery, and indeed any task involving the evaluation or manipulation of symbols or images that can be digitized and sent instantly around the world at little cost.

⁷ http://en.wikipedia.org/wiki/Deep_Blue_versus_Garry_Kasparov

⁸ <http://www.nybooks.com/articles/archives/2010/feb/11/the-chess-master-and-the-computer/?pagination=false>

⁹ <http://www-03.ibm.com/innovation/us/watson/index.html>

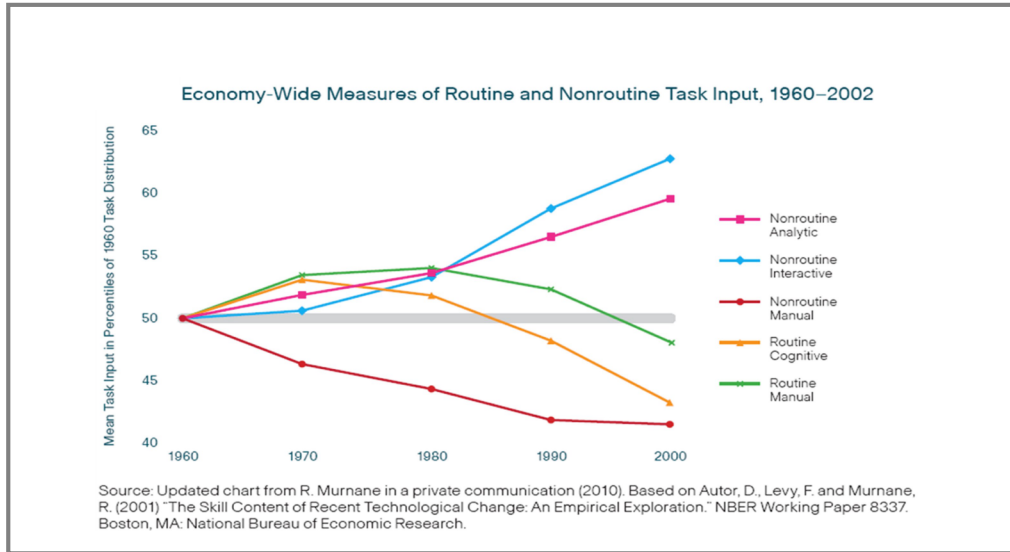
¹⁰ Rob Iati, The Real Story of Trading Software Espionage, AdvancedTrading.com, July 10, 2009

¹¹ <http://www.thepaintingfool.com/>

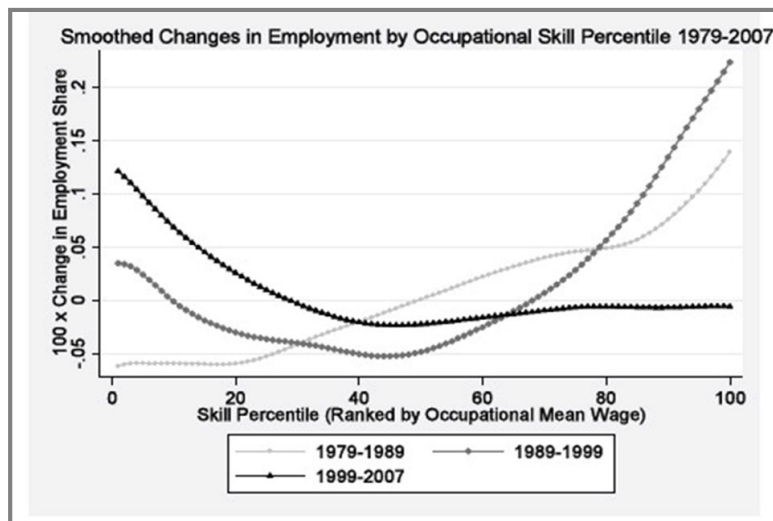
¹² <http://www.idsia.ch/~juergen/femmefractale.html>

2. Impact of Automation/Communications and Offshoring on the Demand for Skills

For decades, economists have been tracking the changes in relative demand for skills.¹³ The data show that “rule-based” skills are easier to automate and likely to be moved offshore, particularly if they are not “personally delivered”,¹⁴ as shown below:



But, as stated by Golding/Katz¹⁵ and described by Acemoglu/Autor,¹⁶ below, even high-level skills might be hollowing out:



¹³ Levy & Murnane, "The new division of labor" 2004, Princeton University Press

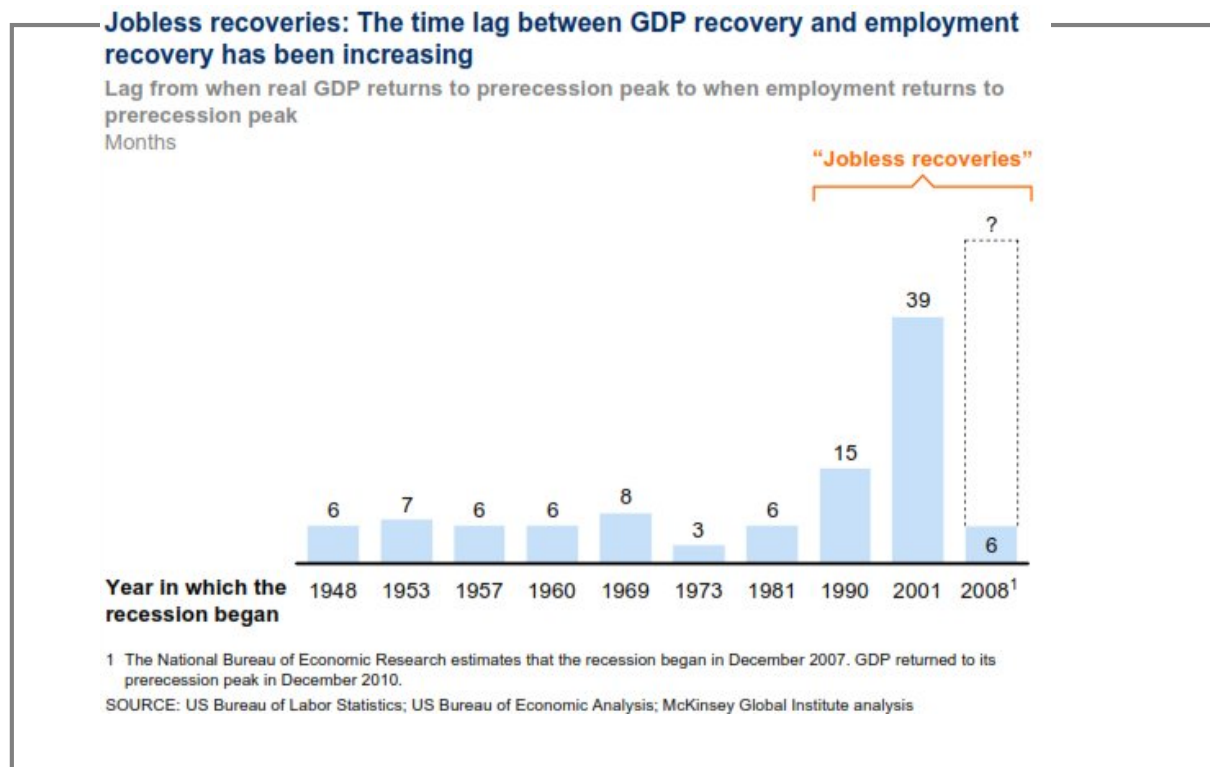
¹⁴ Blinder "How Many U.S. Jobs Might Be Offshorable?" CEPS Working Paper No. 142 March 2007 and Blinder & Krueger, "Alternative Measures of Offshorability" CEPS Working Paper No. 190 August 2009

¹⁵ "Advancing technology does not inevitably produce an increase in the relative demand for skilled and educated workers" P6 of "The race between education and technology"

¹⁶ Acemoglu/Autor, NBER <http://www.nber.org/papers/w16082>

3. Structural Unemployment and Jobless Recoveries

There are also concerns about general structural unemployment, as some job types become permanently displaced by technology, such as cashiers replaced by bar code readers and toll booth collectors replaced by radio frequency. As shown below, the time lag between Gross Domestic Product (GDP) recovery from recession and a return to pre-recession employment has grown dramatically over the past two decades:

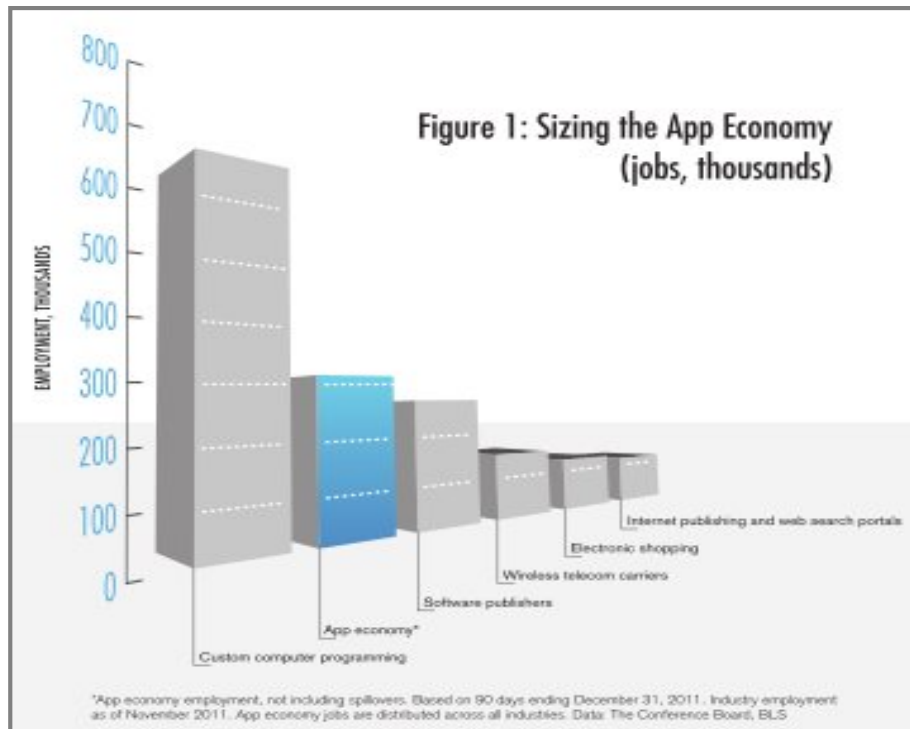


New Problems Require New Thinking, New Solutions

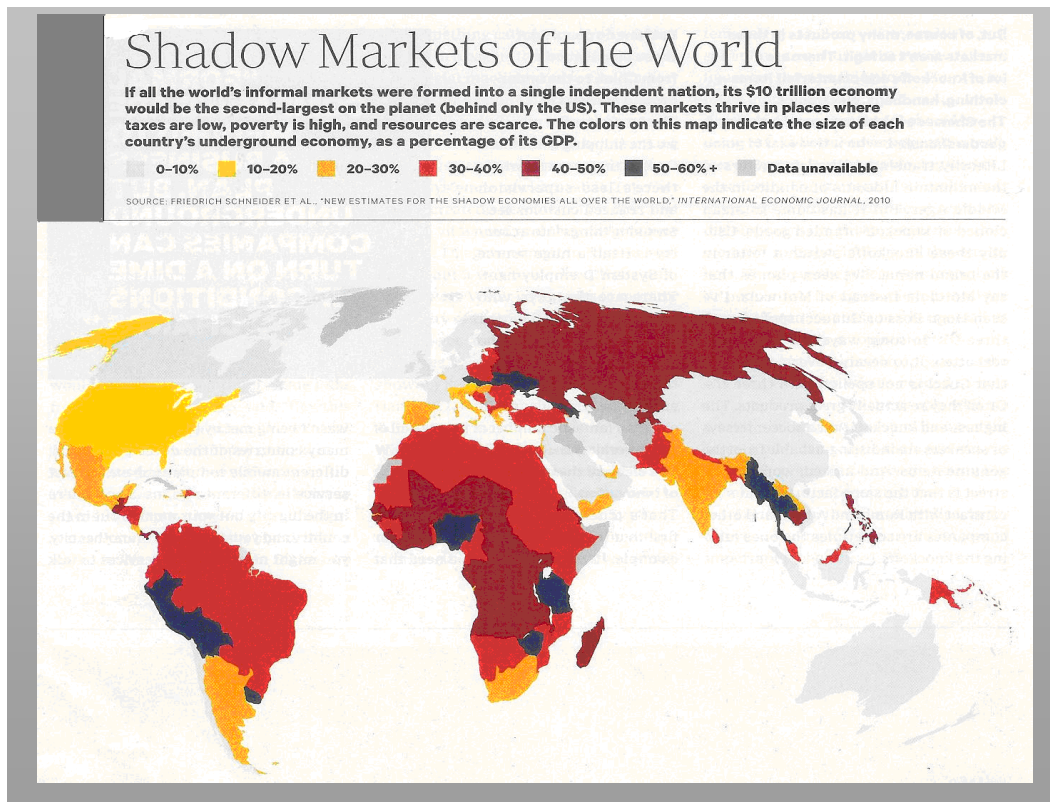
One of the questions we wanted to explore in the Roundtable was: do we have the right tools to address the above issues? Are we attempting to solve new problems and react to new experience with outdated thinking or obsolete measurements?

It is not clear our economic measures are appropriately tracking the new kinds of jobs being created. For instance, new tech giant Facebook directly employs only about 3,000 people, while the largely freelance economy of Smartphone applications is estimated¹⁷ to be the second-largest in software development in the U.S.:

¹⁷ "The App Economy" by Dr. Michael Mandel, February 27, 2012



All the while, in developing economies, trillions of dollars flourish in businesses that operate under the radar of official measurement, from street stalls to phone cards to running shoes.¹⁸



¹⁸ Robert Neuwirth "Stealth of Nations: The Global Rise of the Informal Economy" and Schneider, Friedrich (2010) 'New Estimates for the Shadow Economies all over the World', International Economic Journal, 24: 4, 443 — 461

More Education – or a *More Relevant* Education?

Is more education the answer? Or, rather, a more relevant education?

Much of the protest and frustration being expressed in the world recently – from Tunisia to the Occupy Wall Street movement – originates with educated people who feel they are being denied economic opportunity. They have aspirations and yet feel they are at a dead end because their education has been revealed as not relevant to the demands of today's global labor market.

Another question: Does raising education levels globally raise all standards of living? Or will it raise some while lowering others?

The developed and developing countries of the world are like two reservoirs with unequal levels of water. Now that digital communications technologies connect them, the two levels are beginning to equalize.

We have been seeing the result of this when it comes to impersonal, routine jobs for the past couple of decades. Manufacturing and other automated jobs have increasingly relocated to China, Mexico, Eastern Europe, and other places where routine labor is cheap. In the recent past we saw it happening with white collar and mid-management jobs, with copyediting and customer service phone jobs going to India. And today we are seeing it picking up steam with advances that allow the offshoring or automation of personal services, such as medical tourism, fully automated factories, transportation technology, and even robot prison guards in South Korea.

What will happen as people with advanced degrees in developing countries are able to do the kind of abstract analytic work for far less money that had previously been performed exclusively in developed countries? What will happen as personal services become increasingly automated or capable of being outsourced to cheaper markets?

And what will happen when computers begin to encroach on innovation and creative design?

Economists inform us that the benefits of technology and globalization are bidirectional. They say that, over the longer run, the disruptions caused by new technologies and global labor market trends will even out; populations will adapt and all sides will eventually benefit. This may be correct empirically, but it is not a popular short-term position for the unemployed and their policymakers—nor is it comforting -- as their pain is immediate.

The Roundtable Presentations

Five of the 12 Roundtable participants were asked to make formal presentations, and everyone – including invited observers – was encouraged to participate in the discussions that took place in between.

Following is a summation of each presentation, punctuated with quotes from both the presentations and the discussions.

1. Bernard Meyerson – Vice President, Innovation, IBM

“Don’t underestimate what geeks can do.”

Meyerson began with a graphic depiction of how the scale of computer performance has grown since the first IBM computers were shipped in 1956.

“In 1956 I was a child. If I had grown at the same rate computing power has, I would now be so tall, my body would extend so far into space, that the moon would clip my ankles as it moved around the Earth.”

This level of computing power allows for the handling of what Meyerson called “Big Data.” As an example of the benefits that can come from being able to process huge amounts of data quickly, Meyerson mentioned work done at the University of Toronto that allows doctors to predict which newborns might be susceptible to deadly sepsis infections.

“For babies, there is nothing to provide any obvious clues when they are at risk of sepsis – until it is too late. Using Big Data techniques, health-care workers are able to monitor and analyze all of the medical sensor data from babies. This allowed doctors to discover something no human being would have ever seen: A healthy baby’s heart rate varies, but the heart of a child at risk of sudden death from sepsis *stops* varying. Being aware of this change in heart rate quickly can mean the difference between life and death.”

Big Data also allows the creation of computer systems that can learn and adapt, leading to systems like Watson, the IBM computer that defeated a Jeopardy champion, and Wellpoint, a learning program in development that might soon be able to diagnose human health problems faster, and with greater accuracy, than human doctors.

“Learning systems learn and retrain themselves,” Meyerson said. “Having a Big Data learning system working for you is like having a genius at your side.”

2. David Autor – Professor, Massachusetts Institute of Technology (MIT)

“Educated people earn more at everything. Even educated baristas earn more than baristas with less education.”

Autor noted that there are two trends on a collision course in labor markets around the world: 1. the polarization of job opportunities and 2. stagnation in educational attainment.

The polarization in the job market is having its biggest negative impact on middle-income jobs, Autor said.

“On either end of the scale there is growth: High-end professional and management jobs and low-wage ‘drudge’ jobs are both growing,” while opportunities for those with only some college or a high school diploma are shrinking.

“The difference in earnings between a high school and a college graduate has doubled since 1980,” Autor says. “We are at a high water mark when it comes to the differential in pay between low-educated and high-educated wage workers.”

“The good news is that women are getting more educated.”

In 1980 males were about seven percentage points more likely to have completed a four-year college degree by age 34 than women. By 2007 that had reversed, with women eight percentage points more likely.

Moving on to automation as a polarizing factor, Autor agreed that automation can be disruptive, but added “it has its limits.”

“Your vacuum cleaner cannot walk upstairs or clean itself,” he pointed out, adding that many activities that appear difficult – like playing chess, winning at Jeopardy or diagnosing medical problems – might be easy for computers. On the other hand, many simple tasks – like digging a ditch – create challenging engineering problems.

None of which means we should give up on educating people, Autor said. Education, he pointed out, offers huge earnings advantages in all trades.

“It would be a mistake to conclude ‘we’re going to have all these low-wage service jobs now, so there’s no point in educating people.’ Educated people earn more at everything. Even educated baristas earn more than baristas with less education.”

Autor’s conclusion: “Education is the only thing that has worked for raising prosperity over the centuries. We don’t know why, but it creates its own demand. The more educated people there are, the more you need.”

3. Dan Trefler – Professor, University of Toronto

“The world is complex. We should not run away from complexity.”

Trefler, an economist, challenged the widely held belief that the percentage of value added to the U.S. economy from manufacturing has been collapsing for the past 50 years; the claim often made is that it has gone from approximately 25 percent of the U.S. economy to half that between the 1960s and today.

“Over and over, we’re told that by government economists,” he said, “and it is fallacious.”

When measured properly, he says, taking into account changes in the price of goods over the same time period, one gets a very different result.

In fact, Trefler says, “the share of value added overall to the U.S. economy and the share added by manufacturing alone have been going up at the same rate when measured properly.”

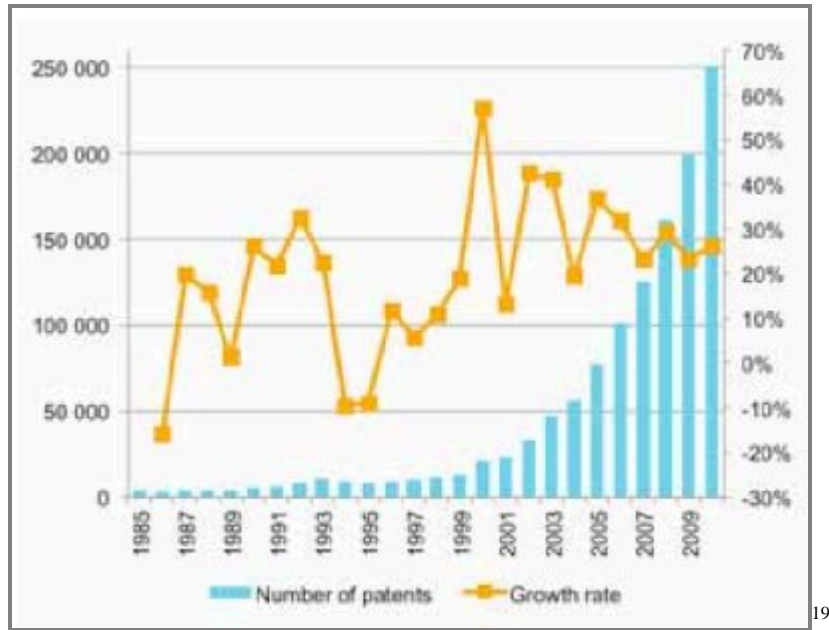
When Trefler asked government economic officials why they did not account for price changes when computing manufacturing’s share of the economy, he was told doing so would be “too complex,” beyond what the public would be able to understand.

Trefler disagrees.

“The world is complex. We should not run away from complexity, nor should we get lost in it.”

Instead, he said, we should always ask, “what is ‘the third option’ that can take us out of the either/or of the conflict and provide a better answer?”

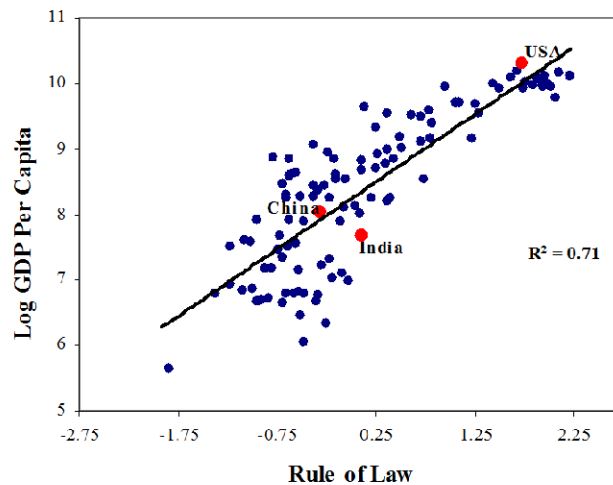
Trefler also challenged the notion that developing nations like China were a threat to the prosperity of other, more developed countries. He pointed out that the number of patents filed by the Chinese was skyrocketing.



19

But while a more innovative China made the country more competitive, it also made the Chinese government more likely to strengthen copyrights that protect innovation and other laws that support the rule of law.

“Countries with institutions that promote the rule of law are rich,” Trefler points out.²⁰



“And countries that value education are rich. These are two powerful correlations.”

¹⁹ <http://www.kairosfuture.com/en/publications/chinas-three-waves-innovation?pub=Chinas-three-waves-of-innovation>

²⁰ Kauffmann et al, 1999 as cited by Trefler in: www.rotman.utoronto.ca/~dtrefler/papers/Offshoring_NAFIC_For%20Posting.ppt
www.mcgraw-hillresearchfoundation.org www.uscib.org

When it comes to reforming education, Trefler concluded, “It’s not about the hard choices. It’s about putting everything on the table and finding the right balance. Good decisions are not the hard ones; they are the ones that create a new option, achieving a resolution.”

4. Nicole Smith – Professor, The Georgetown University Center on Education and the Workforce

Smith focused on STEM (Science, Technology, Engineering and Math) education.

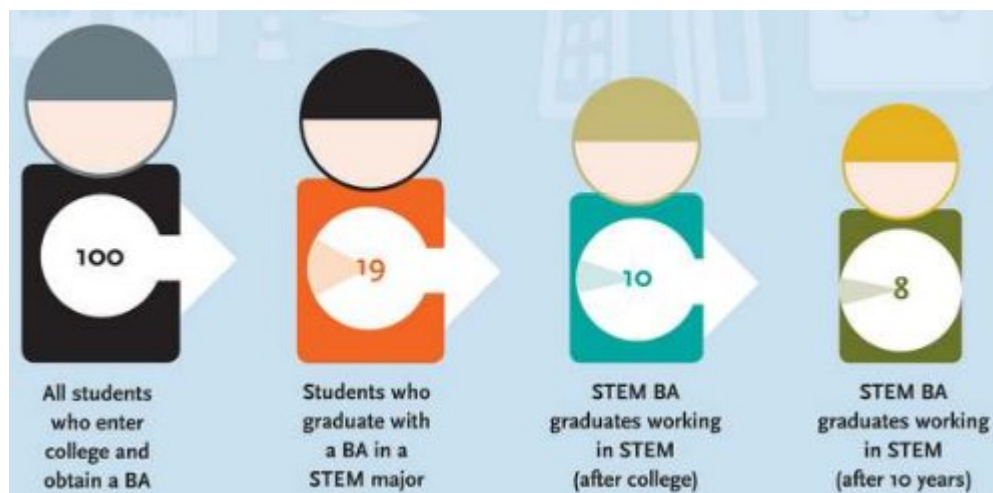
“We found that people are studying STEM, but not necessarily working in STEM fields. We call it STEM diversion. The U.S., for instance, produces five students in the top quartile in math to get one STEM worker.”

Minorities are under-represented in STEM fields, Smith said, but added that STEM, by its nature, is a more equal-opportunity occupational sector than most.

“It is the only occupational field in which Asian males are paid better than anyone else, and has the smallest gender wage gap,” she said.

Women in all occupations earn about 76 cents for every dollar earned by men, with forty percent of that gap unexplained. But when you confine the gender wage gap to STEM occupations, it lowers to only ten percent unexplained.

Out of 100 male students who get a BA, 19 will get a STEM degree, but only eight will be found working in a STEM field ten years later.



Where do they go? Some go into STEM field management. So they’re still in STEM, but not writing code or working on a lab bench.

“Finance gobbles up a lot of them,” Smith said.

5. Riel Miller – Founder, XperidoX

“We are living through a time similar to the Industrial Revolution: Not anticipated before, not understood during.”

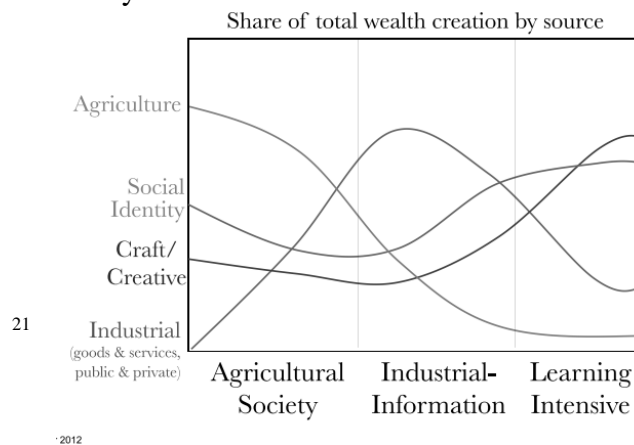
“I am a futurist,” Miller said right up-front, adding “but I make no predictions. All predictions about complex systems are wrong. You can predict that the sun will rise, a comforting assumption, but if it does you certainly have no idea what will happen under the sun. Complex systems are not deterministic.”

At the same time, Miller says, “what we imagine about the future makes a big difference for what we see and do right now. You made it to this meeting because you decided to assume it would happen. You imagined a successful commute or a functioning subway as your way to get to the meeting and you did it. The impact of our imaginary futures is very practical.”

Miller pointed out that our challenge is not to find out what the future will be, but to take advantage of the fact that we cannot know what the future will bring. This is the only way, he said, to take advantage of the amazing fact that our universe is not deterministic.

“If we think the future is going to be about high-tech and that these tools will require a lot of time to invent, produce, and learn how to use, we will worry about having the right number of engineers, enough factories, and widespread computer skills. If, on the other hand, we think that tomorrow’s technologies will be like the automobile, then maybe we should invest time and resources elsewhere, since today you don’t need to be an auto mechanic to use automotive technology and only a few engineers and factories need to be devoted to producing cars.”

By imagining different futures, Miller shows us how the kind of future we invent can change how we understand the present. He uses a detailed analytical model, developed in part at the Organisation for Economic Cooperation and Development (OECD) in Paris, to describe what he calls a “Learning Intensive Society”.



²¹ Riel Miller, XperidoX consulting

Miller uses the example of 3-D printing and the “desktop factory” to help us imagine an economy that changes the basic organization of supply and demand. In the unique creation Learning Intensive Society the divide between those who produce and those who consume largely disappears. Miller dubs this the ‘murmuration’ economy. A murmuration is a flock of starlings flying in a huge swarm, a swirling and totally fluid constellation, without a center or periphery, spontaneously flowing into different patterns.

“Murmuration is a visual metaphor for a new kind of economy, with no fixed relations between buyers and sellers,” Miller says, “just clouds of unique creation working together in collaborative communities of economic interaction.”

Miller insisted he was not trying to predict a specific future or claim that one particular future is better than another. His point was that if we use the future differently, inventing imaginative futures that incorporate systemic discontinuity and novelty, then what we see and do in the present may change. It also gives us a new edge in our efforts to be agents of our own lives.

Quotes from the Discussions

Discussion among the participants took place during and after the formal presentations. Following are some noteworthy comments made during the day:

“What does all this tell us about the trajectory of what people should be learning at different stages of their lives? What does it mean in kindergarten? In middle school. Skills are acquired over a lifetime now. [But] the people who do go back for more training are [most often] those who have acquired baseline skills first. You need the basics. – Andreas Schleicher, Deputy Director of the Education Directorate, OECD

“You need ‘the table stakes.’” – Bernie Meyerson, Vice President, Innovation, IBM, (a common U.S. business metaphor meaning “the minimum resources or skills needed to compete.”²²)

“What the high school diploma means now [in the U.S.] is that you live in a family stable enough to keep you in high school for 12 years, and nothing else. It doesn’t even mean you can work at McDonald’s. We keep saying it’s important to graduate high school. But it’s not even ‘table stakes.’ We need stackable, portable credentials”. - Jeff Livingston, Senior Vice President, McGraw-Hill Education

“Are we asking the wrong questions? Old paradigms? The old notion of education as being consumable, discrete, episodic? Front-loaded? You load up on it and are set for life? We’re making assumptions based on the past. We need leading indicators, not old data. For example, nobody studies corporate learning, which spends three times what is spent on college.” - Doug Lynch, former Vice Dean, Graduate School of Education, University of Pennsylvania

²² http://en.wikipedia.org/wiki/Table_stakes

“If we see people with STEM skills moving elsewhere, is it a bad thing or a good thing? STEM skills might just be useful for a lot of fields. Maybe everybody in society should have better STEM skills. – Andreas Schleicher, Deputy Director of the Education Directorate, OECD

“We have this elitist view of higher education. But it’s very expensive. We have to start looking at post-secondary differently. And sure, there’s also a lot not to like about the for-profit trade schools.– David Autor, Professor, MIT

Suggestions for Immediate Action from the Participants

To meet opportunities and minimize the pain of disruptions, education systems have a significant role to play in accelerating adaptation through the transition. From the Roundtable, there were many recommendations for such changes that need to be researched more comprehensively:

- Focus first on early childhood, where the best return on investment lies. Among other techniques, pair each child with a caring adult, if a caring parent is not available. This has been shown to have the largest single impact on a child’s future chances;
- Build resilience into education systems, improving their ability to respond to rapidly changing needs by allowing for as much as 30 percent or more of customization and adaptation of curricula (which will have the extra benefit of being better adapted to each child’s needs and learning styles);
- Push for *mastery* of the foundational curriculum through middle school – the “table stakes.” Be explicit about STEM’s and Humanities’ role and value. Emphasize quantitative literacy and applied mathematics for all, not just for the few who get into STEM jobs;
- Focus on processes to reach deep understanding of the knowledge areas covered. Shift the mindset from knowledge or skills to knowledge and skills. Focus on both knowledge and its application though 21st Century skills,²³ such as creativity/innovation, critical thinking, communication, and collaboration;
- Improve the connection between school and work-based learning via apprenticeships and internships. Open up the teaching profession to practitioners from the world beyond the educational environment, who can move back and forth between the two;
- Rethink the front-end-loading of education, as in many cases formal education is continuing well into adulthood via personal reskilling and corporate training. Develop micro-credentialing and “stackable” certificates, which would evaluate and validate skills;

²³ Trilling and Fadel “21st Century Skills – Learning for life in our times” 2009 Wiley

- Develop a better understanding of the role of corporate training and development and its contribution to life-long learning. Business and corporate training is currently much larger than the entire U.S. higher education sector; and
- Place increased value on informal learning avenues (such as after-school programs, museums, etc.) as critical supplements to the inevitable gaps in formal learning.

Some Additional Thoughts About STEM

Professor Nicole Smith's presentation about STEM and the discussion following raised some intriguing questions that we did not have time to discuss thoroughly.

Are some professions and fields more conducive to overall employment growth than others²⁴? Are STEM professions more needed for this extrinsic value? After developing the scenarios we want to see occur, how do we engineer our systems accordingly? Are there more creative models to rethink economic progress?

The economic argument for enhancing the quantity and quality of STEM graduates is often stated forcefully, usually accompanied by statistics showing how many more engineers China or India is currently graduating compared with the number of young people studying STEM disciplines in the U.S. and Europe.

But the proposition that we need to focus primarily on the development of STEM skills to boost global economic competitiveness is not fully understood.

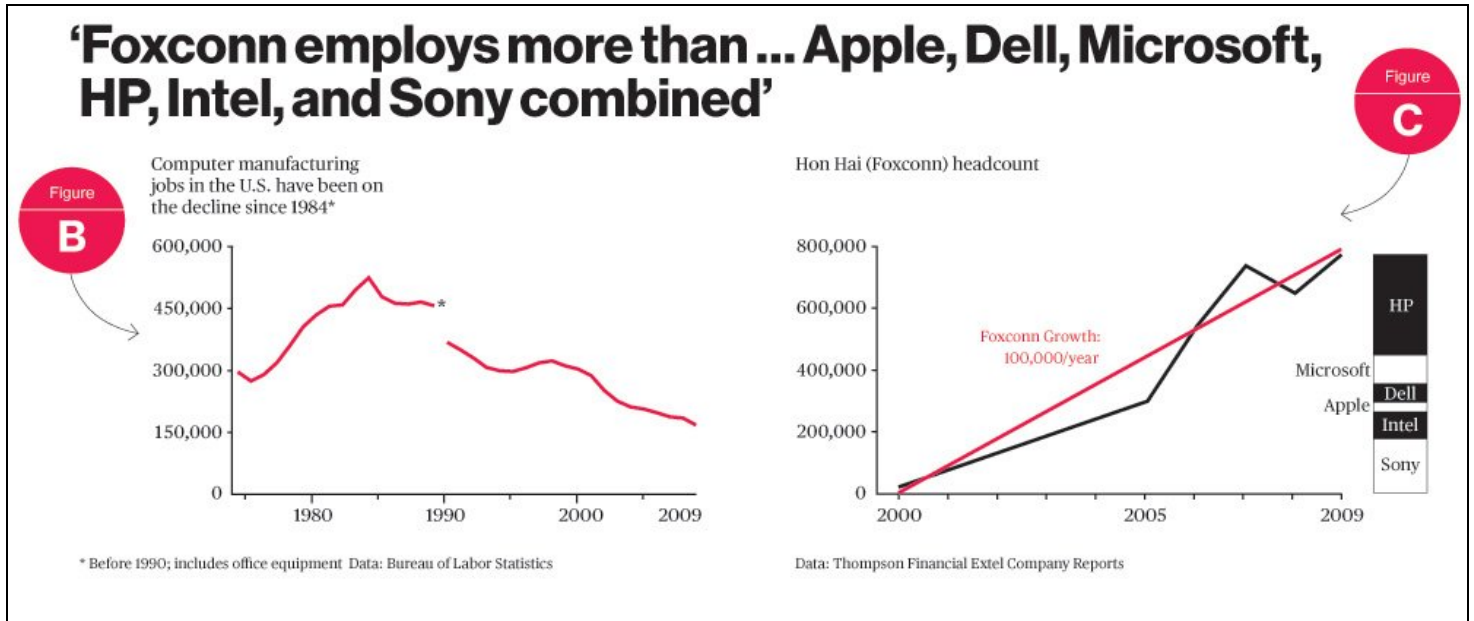
For example, do STEM professions necessarily create more jobs locally? The linkage between technology development and jobs is not as clear as it once was. During the process of "creative destruction" (e.g., Amazon vs. Borders), it is not clear whether there was a net gain of jobs or merely a transfer of jobs.

Manufacturing, which relies heavily on advances in technology for efficiency and competitive advantage, created many long-term jobs in the 20th Century. However, those jobs were filled largely by unskilled or minimally skilled people. Now, in the 21st Century, technology is advancing to the point where even non-routine tasks can be automated. As a result, more and more manufacturing jobs now require skilled and educated people who can operate and service complex machinery. Research also indicates the presence of a multiplier effect, stated as follows:²⁵ "Each 100 jobs in manufacturing supports 291 jobs elsewhere in the economy, compared to 154 jobs supported in business services and 88 in retail trade."

²⁴ "Allocation of Talent, Implications for growth" 1990 National Bureau of Economic Research, Murphy et al

²⁵ http://www.epi.org/page/-/old/workingpapers/epi_wp_268.pdf

Ex-Intel-CEO Andy Grove²⁶ has suggested that economists misunderstand the importance of manufacturing in the technology innovation chain. It is scaling that creates the vast majority of jobs. For instance, General Motors at the peak of its valuation had ten times more employees than Apple at the same peak.). He is also concerned about the loss of symbiosis between design and manufacturing, endangering design in the long-run.



The economic case for STEM based on “public good” benefits is also perhaps not sufficiently understood, and could dwarf the STEM-specific occupational benefits. In other words, what is the value of a population understanding the importance of vaccinations, or being less drawn to gambling, by understanding probabilities better?

The value of emerging person-to-person interactions – such as personal scale manufacturing, local creative exchanges, and trades (including, for instance, locally-grown food) – needs to be better tracked and analyzed.

We did not have answers to many of our questions about the ultimate value of STEM education, but one thing was clear: versatility is a necessity for economic resilience, so there is a need to teach both STEM and Humanities more broadly to everyone. The supposed divide pitting STEM vs. the Humanities is a false dichotomy.²⁷

²⁶ Bloomberg Businessweek Commentary July 1, 2010: Andy Grove: How America Can Create Jobs

²⁷ C.P. Snow “The Two Cultures” http://en.wikipedia.org/wiki/The_Two_Cultures

Conclusion

The world is living through challenges that are only becoming more complex. Technological and societal change is occurring so quickly and so fundamentally that future events cannot be predicted with any confidence, and the impact of current events cannot be fully understood even as we are living through them.

Education, in particular, is not keeping pace with rapid technological development nor with global economic and societal change.

Predictions are usually wrong. Economists, futurists, actuaries, and others who deal in projections all know that their projection trajectories begin to veer off course the minute they are made. Policymakers in both government and business, however, often desire certainty, preferably infused with models and ideas that correspond to their own experience and knowledge of what worked in the past.

Present models of economic analysis do not seem to factor in adequately the forward impact of technology, as well as its structural limiting factors (e.g., legal, financial, social, etc.). Governmental data collection is not sufficient to facilitate the analysis of the questions posed above. In particular, we are missing leading-edge industries, informal industries, and leading indicators not rooted in models of the past. We need to embed a feedback mechanism to continuously fine-tune projections.

The one idea that continued to surface from many of the participants during the day was: it is no longer “this or that idea or strategy” or “this or that model” that is needed when thinking about the future of education, but “this and that.”

Old models, which lock us into one way of thinking or looking at educational reform through the lens of only one model to the exclusion of all others, are no longer viable. Events are moving too fast. The future is too unpredictable. We have to expand our thinking, consider all possibilities, and take the best from all models and disciplines.

What is clear is that there is an urgent need to bring to the fore a deeply cogent, synthetic, open-minded, and continuous conversation – accompanied by policymaker input, expert opinion, and popular awareness-building – about how we can all act together to transform our educational systems to respond effectively to global 21st Century needs and aspirations.

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