Enjoying artistry

Source: The Painting Fool
The Impact of Technology

Charles Fadel
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IN MORE DEVELOPED COUNTRIES

Source: “Tough Choices or Tough Times” 2007, National center on education and the economy

Race up the Value Chain
Accelerating Change Demands Different Skills

Economy-Wide Measures of Routine and Nonroutine Task Input, 1960–2002


e.g. consultants

e.g. engineers

e.g. assembly work

e.g. paperwork

e.g. plumbing
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Non-Routine

Non-Routine
Impersonal
(hard to automate, increasingly offshored)

Non-Routine
Personal
(hard to automate, remaining onshore)

Routine

Routine
Impersonal
(automated and offshored)

Routine
Personal
(increasingly automated, remaining onshore)

SKILLS

Sources: Blinder for X-axis, Levy/Murnane/Autor for Y-axis

Impersonal
DELIVERY
Personal
The Race between Technology and Education

Inspired by “The race between technology and education” Pr. Goldin & Katz (Harvard)
Non-Digital Displacement Technologies
# Offshoring Health Care

<table>
<thead>
<tr>
<th>PROCEDURE</th>
<th>TYPICAL COST IN A U.S. HOSPITAL</th>
<th>TYPICAL COST ABROAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart Valve Replacement¹</td>
<td>$177,665</td>
<td>$16,500 in Turkey</td>
</tr>
<tr>
<td>Heart Bypass¹</td>
<td>144,317</td>
<td>14,500 in Turkey</td>
</tr>
<tr>
<td>Spinal Fusion¹</td>
<td>103,761</td>
<td>14,750 in Germany</td>
</tr>
<tr>
<td>Hip Replacement¹</td>
<td>100,047</td>
<td>12,896 in Turkey</td>
</tr>
<tr>
<td>Knee Replacement¹</td>
<td>65,918</td>
<td>12,787 in Turkey</td>
</tr>
<tr>
<td>Gastric Bypass²</td>
<td>32,927</td>
<td>5,000 in India</td>
</tr>
<tr>
<td>Shoulder Arthroscopy¹</td>
<td>32,500</td>
<td>5,800 in Thailand</td>
</tr>
<tr>
<td>Vaginal Hysterectomy¹</td>
<td>31,474</td>
<td>4,800 in Turkey</td>
</tr>
<tr>
<td>Lap Band²</td>
<td>30,000</td>
<td>6,500 in Mexico</td>
</tr>
<tr>
<td>Facelift²</td>
<td>15,000</td>
<td>3,440 in Malaysia</td>
</tr>
<tr>
<td>IVF Treatments²</td>
<td>14,500</td>
<td>2,180 in Korea</td>
</tr>
<tr>
<td>Dental Implants (each)²</td>
<td>2,800</td>
<td>900 in Costa Rica</td>
</tr>
</tbody>
</table>

**SOURCE:**

¹Companion Global Healthcare Inc.; ²Medical Tourism Association
Impact of Technology

- Routine Skill
  - Typing clerk → Bookkeeping
  - Security video monitoring → Robot patrols
  - Legal discovery → Legal Opinion

- Nonroutine Skill
  - Radiologist → Pathologist
  - Surgeon
  - Court proceeding
  - Policeman
  - Taxi driver
  - Autonomous vehicles
  - Telepresence
  - Telemedicine

- Impersonal delivery vs. Personal delivery
Google Autonomous Vehicle

140kmiles in 2010,
no accidents
“Computational Pathologist”

“Computers found more accurate than doctors in breast-cancer diagnosis”

Science Magazine November 10, 2011

“Computational Pathologist” by

Stanford Schools of Engineering and Medicine
Even modeling

H&M admits using a mannequin as digital model with “no flaws”

Source: Le Monde Culture & Idees, December 24, 2011

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Displacement due to Technology

Ox $\rightarrow$ Harvester

Horse $\rightarrow$ Automobile

Lab Mice $\rightarrow$ Assays (not soon enough…)

Humans:

Scribes $\rightarrow$ printing press

Washers $\rightarrow$ washing machine

Cashiers/Attendants $\rightarrow$ bar code scanner

Healthcare/Finance/Services/Jeopardy champions $\rightarrow$ Watson

etc
IBM One-Two-Three-Four punches
SyNAPSE (chip) + BlueBrain (system) + Watson (software) + Cloud Computing (infrastructure)
Evolution of Access to Information

Quantity x Speed

Antiquity

Renaissance

Industrial Revolution → Modern Times

Internet Age

Time

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Technology Acceleration

Doubling Time (months):
- 9
- 12
- 18

Performance per $ spent

Optical fiber bandwidth (bps)

Storage density (bits/sq-cm)

Si chip density (# of transistors/area)
Even more impressive… Algorithmic progress

- Production planning model solved using linear programming:
  - 1988: 82 years
  - 2003: 1 minute

- A factor of roughly 43 million in 15 years
  - ~1,000 due to increased processor speed,
  - ~43,000 due to improvements in algorithms!

- ~30,000 for mixed integer programming (1991→2008)

Source: Professor Martin Grötschel of Konrad-Zuse-Zentrum für Informationstechnik Berlin.
Brave New World

Human Genome mapping (2005)

“Technology today can do in five minutes a decoding task that would have taken a year to complete a decade ago”

Eric Lander, Founder, The Broad Institute

*Improvement by a factor of 1 million in ten years*
More to come

- iPhone: $400 price point
  - 40T in 2015
  - 40E in 2025

- Video record your entire life (2025)
- ExoBrain (2025-2030)

Already possible in the Cloud!
Distributed Computing - Folding@Home
Quantum Computing’s Promise

“A quantum computer of just 150 QuBits would have the power of all of today’s supercomputers”

Alan Aspuru-Guzik, Harvard University

Performance reached:
• 2005: 1 QuBit
• 2009: 2 Qubits
• 2010: 16 QuBits
• 2011: 84 QuBits
• 2012: 128 QuBits ($10M!)
DNA Computing

- 1994: “7-point Traveling salesman problem”
- 2004: “An autonomous molecular computer for logical control of gene expression”
The difficulty in forecasting technology

It took an extra decade! (linear part of S-curve)

- Techie part mostly correct
- Some second-order effects were missed: (exponential part of the S-curve)
  - Music
  - Cameras

- No forecast of third-order effects (combinatorial) \(\Rightarrow\) confluence of technologies (Internet, shopping, etc)
Can you forecast better?

“3-D Printing Spurs a Manufacturing Revolution”

[Image]

“It’s about going from the Model T to something like a Mini that has 10 million permutations.”

Scott Summit, co-founder Bespoke Innovations
Who would have thought of …

- 15 years ago: Bioinformatics
- 5 years ago: Optogenetics
Misperceptions might be hardwired

Dehaene, Izard et al., 2008; and Siegler and Opfer, 2004.
But they are trainable

So we should train exponential thinking too!

Dehaene, Izard et al., 2008; and Siegler and Opfer, 2004.
NYT Readers’ Forecast, December 2011

<table>
<thead>
<tr>
<th>Year</th>
<th>Category</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>Computation</td>
<td>Computer on a Chip</td>
</tr>
<tr>
<td>2015</td>
<td>Computation</td>
<td>Persistent Computer Memory</td>
</tr>
<tr>
<td>2015</td>
<td>Artificial Intelligence</td>
<td>Routine Voice Interaction</td>
</tr>
<tr>
<td>2015</td>
<td>Transportation &amp; Lifestyle</td>
<td>Mobile Wallet</td>
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<tr>
<td>2015</td>
<td>Transportation &amp; Lifestyle</td>
<td>Consumer 3D Printing</td>
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<tr>
<td>2017</td>
<td>Transportation &amp; Lifestyle</td>
<td>Predictive Pre-Purchasing</td>
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<td>2017</td>
<td>Transportation &amp; Lifestyle</td>
<td>Automated Restaurants</td>
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<tr>
<td>2019</td>
<td>Communication</td>
<td>Universal Translator</td>
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<td>2019</td>
<td>Communication</td>
<td>Ubiquitous Tracking</td>
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<tr>
<td>2019</td>
<td>Communication</td>
<td>The Mobile Web</td>
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<tr>
<td>2019</td>
<td>Communication</td>
<td>Internet Romances</td>
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<tr>
<td>2020</td>
<td>Computation</td>
<td>Universal Medical Database</td>
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<tr>
<td>2020</td>
<td>Computation</td>
<td>The World is Explored</td>
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<td>2021</td>
<td>Computation</td>
<td>Simulated Actors</td>
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<td>2022</td>
<td>Computation</td>
<td>Premade Decisions</td>
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<td>2023</td>
<td>Computation</td>
<td>Smart Clothing</td>
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<td>2024</td>
<td>Computation</td>
<td>Holographic Displays</td>
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<td>2025</td>
<td>Computation</td>
<td>Quantum Computing</td>
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<td>2026</td>
<td>Computation</td>
<td>Programmable Organisms</td>
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<td>2027</td>
<td>Computation</td>
<td>Genetic Data Storage</td>
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<tr>
<td>Year</td>
<td>Category</td>
<td>Event Description</td>
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<tr>
<td>------</td>
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<tr>
<td>2030</td>
<td>COMPUTATION</td>
<td>Dr. Computer</td>
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<td>2031</td>
<td>TRANSPORTATION &amp; LIFESTYLE</td>
<td>Curing Cancer</td>
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<tr>
<td>2032</td>
<td>ARTIFICIAL INTELLIGENCE</td>
<td>Simulated Animal Tests</td>
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<td>2033</td>
<td>ARTIFICIAL INTELLIGENCE</td>
<td>Robot Wars</td>
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<tr>
<td>2034</td>
<td>TRANSPORTATION &amp; LIFESTYLE</td>
<td>Cash is Outlawed</td>
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<tr>
<td>2035</td>
<td>COMMUNICATION</td>
<td>Full Life Recording</td>
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<tr>
<td>2036</td>
<td></td>
<td>No Red Lights</td>
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<tr>
<td>2037</td>
<td></td>
<td>Everyone Telecommutes</td>
</tr>
<tr>
<td>2038</td>
<td></td>
<td>Understanding Animals</td>
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<td>2039</td>
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<td>Digital 'Life' and Evolution</td>
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<td>2040</td>
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<td>Cybernetic Intelligence</td>
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<tr>
<td>2041</td>
<td></td>
<td>Artificial Intelligence</td>
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<tr>
<td>2042</td>
<td></td>
<td>WiFi to the Brain</td>
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<tr>
<td>2043</td>
<td></td>
<td>Flying Cars</td>
</tr>
<tr>
<td>2044</td>
<td></td>
<td>Life Out There</td>
</tr>
<tr>
<td>2045</td>
<td></td>
<td>To Mars and the Moon</td>
</tr>
</tbody>
</table>

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More to come… Things
More to come… Robotics
More to come… Biotech


Validating the Interactome - The Scientist - Magazine of the Life Sciences [http://www.the-scientist.com/article/display/14769/#ixzz1cAg1h53e](http://www.the-scientist.com/article/display/14769/#ixzz1cAg1h53e)

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More to come… Neuroscience
More to come... Nanomaterials
More to come... Virtual Reality
“The future is already here – it's just not very evenly distributed.”

Science-Fiction author William Gibson, quoted in The Economist, December 4, 2003
“We are currently preparing students for jobs and technologies that don’t yet exist... to solve problems that we don’t even know are problems yet.”

Richard Riley
Former U.S. Secretary of Education
So what do students learn in…

… an ambiguous/uncertain era, with ubiquitous search and A.I.?

Among other things:

• *Technical fluidity* - working WITH the Machine

• Versatility

• Critical thinking

• *Synthesizing/integrating*

• Creating!
Technical fluidity: Chess as example

- “Human strategic guidance combined with the tactical acuity of a computer was overwhelming.”

- “Weak human + machine + better process was superior to a strong computer alone and, more remarkably, superior to a strong human + machine + inferior process”


How about learning Processes?
Versatility as a strategy

Broad Knowledge

Single vs Multiple
Deep Expertise

m-shaped Individual, not just T-shaped
Innovation follows patterns \( \rightarrow \text{automatable} \)

Source: Invention Machine “IM Labs”
“The dancing salesman problem”
Divergence Between Technology & Culture

Source: Professor SHIH Choon Fong President, National University of Singapore, 2007
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“At the dawn of the third millennium, scientists claim their right to intervene in a field, which was once considered to be under the exclusive competence and jurisdiction of philosophers and churchmen: the field of values.”

Rita Levi Montalcini
Nobel laureate
Saturation scenario - bust
“Event Horizon”: What if formal education cannot catch up?
Searching for Happiness

Chinese Proverb

If you want happiness for an hour – take a nap.
If you want happiness for a day – go fishing.
If you want happiness for a month – get married.
If you want happiness for a year – inherit a fortune.
But if you want happiness for a lifetime – help someone else.

(Source: Bernie Trilling)