The Impact of the 4th Industrial Revolution on Engineering Education

The Need of a Brave Paradigm Change

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"Education is what remains after one has forgotten everything he learned in school"

Albert Einstein
• In 15 years, **we will have no one to teach**. The professional jobs for which we prepare students will be done by intelligent machines.

• The pedagogic pendulum will **swing back towards the lecture** as the importance of an analytical mind becomes appreciated once more.

• **Exams** that emphasize mastery of taught knowledge will no longer be the primary tool for judging student performance.

• Technology has found a place in universities, but **nothing significant has changed**.
• **Devices will replace academic faculty** by 2030. The concept of individual campuses will slowly disappear.

• We will see a form of higher education that truly values a **broader range of characteristics** than those linked to subject knowledge or employability skills.

• The real game changer will be viable measures of **comparative student learning outcomes**. These will lift teaching to a status closer to that enjoyed by research.
One Internet Minute

A Day in Data

The exponential growth of data is undeniably true, but the numbers behind this explosion - fueled by internet of things and the rise of connected devices - are hard to comprehend, particularly when viewed in the context of a single day:

- **500m** photos uploaded to Instagram daily
- **4PB** of data produced by Facebook, including
  - **350m** photos
  - **100m** hours of videos
- **320bn** emails sent every day (2017)
- **306bn** emails sent as of March 2016
- **294bn** Facebook status updates
- **28PB** of data generated from wearable devices as of 2020
- **65bn** messages sent on WhatsApp and other messaging apps
- **95m** photos and videos shared on Instagram each day
- **463EB** of data is created every day by 2020

### Data Units

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Symbol</th>
<th>Smallest Unit</th>
<th>Largest Unit</th>
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<tr>
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</table>

Access this report at [https://www.visualcapitalist.com/how-much-data-is-generated-each-day/](https://www.visualcapitalist.com/how-much-data-is-generated-each-day/)
# Data Units

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Unit</th>
<th>Value</th>
<th>Size (in bytes)</th>
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<tr>
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<td>bit</td>
<td>0 or 1</td>
<td>1/8 of a byte</td>
</tr>
<tr>
<td>B</td>
<td>bytes</td>
<td>8 bits</td>
<td>1 byte</td>
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<tr>
<td>KB</td>
<td>kilobytes</td>
<td>1,000 bytes</td>
<td>1,000 bytes</td>
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<tr>
<td>MB</td>
<td>megabyte</td>
<td>$1,000^2$ bytes</td>
<td>1,000,000 bytes</td>
</tr>
<tr>
<td>GB</td>
<td>gigabyte</td>
<td>$1,000^3$ bytes</td>
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<tr>
<td>TB</td>
<td>terabyte</td>
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<tr>
<td>PB</td>
<td>petabyte</td>
<td>$1,000^5$ bytes</td>
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<tr>
<td>EB</td>
<td>exabyte</td>
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</tbody>
</table>

**2025**

- 463 Exabyte Data
- 212,765,957 DVDs per day!
Two Important Development Drivers

• An often exponential growth in many fields of human life (as for example)
  o increasing production of knowledge
  o fast (and accelerated) development in science and technology
  o the growing field of engineering
  o …

• The need of a new pedagogy (or better pedagogies?) to fulfil the resulting needs in Education on all levels

INTERNET
Milestones in Industry and Education

1.0
Book Printing
1450

Education

2.0
Chalk Board
1814

Industry

3.0
Internet
1993

4.0
'Digitalization'

21 November 2019
WEC2019 Melbourne
The Mega Trends – Digital Revolution

- Internet of Things (mainly based on Mobile and Wireless Technologies),
- Cyber-physical Systems / Digital Twins
- Autonomous Systems
- Cyber Security
- Closed Ecosystems or a Circular Economy
- Sustainability.
The Disruptive 4IR Technologies

- Additive Technologies
- Robotics / Cobotics
- Nanotechnology
- Genomics
- Artificial Intelligence (AI)
- Virtual Reality (VR)
- Cloud, Edge, Fog Computing.
An Example

- Todays **Block-Chain Transactions** need the same power than Denmark
- The **Internet** considered as a country is the 6th **largest consumer of energy**
- Google’s **data centers** need the same electric power as a city with 200,000 inhabitants
- One **search machine query** needs 0.3 W and produces 0.2 gram of CO₂ (4 Mill. queries/sec → 3,900 MW / 800 kg CO₂)
- Streaming of a **90min HD movie** needs 0.6 kWh (4 km electric car)
- Every **music album** produces 14 grams CO₂ (only USA 250 Mill. kg CO₂)
  - **One email** about 4 grams (with big attachments up to 50 grams)

- **About 3% of the global CO₂ emission already come from computer centers**

  **Note: Internet traffic doubles every 1.5 years.**
Sustainable Development Goals

1. NO POVERTY
2. ZERO HUNGER
3. GOOD HEALTH AND WELL-BEING
4. QUALITY EDUCATION
5. GENDER EQUALITY
6. CLEAN WATER AND SANITATION

7. AFFORDABLE AND CLEAN ENERGY
8. DECENT WORK AND ECONOMIC GROWTH
9. INDUSTRY, INNOVATION AND INFRASTRUCTURE
10. REDUCED INEQUALITIES
11. SUSTAINABLE CITIES AND COMMUNITIES
12. RESPONSIBLE CONSUMPTION AND PRODUCTION

13. CLIMATE ACTION
14. LIFE BELOW WATER
15. LIFE ON LAND
16. PEACE, JUSTICE AND STRONG INSTITUTIONS
17. PARTNERSHIPS FOR THE GOALS
Whenever you are asked if you can do a job, tell them, 'Certainly I can!' Then get busy and find out how to do it.

Theodore Roosevelt
(1858 - 1919)
Challenging Elements for Modern Engineering Education

- the impact of **Globalization** and **Digitalization** on all fields of human life and in all areas of the society,
- the enormous and driven growth of the **Area of Engineering**
- Terrific **acceleration of the life cycles** of engineering products/results

- the **Changing Focus** of Engineering shifting from more technical subjects to subjects directed to Information Technologies and the daily life of mankind
- the **Increasing Complexity** of technical systems, which are more and more connected with non-technical systems
- the requirements of a sustainable and **Circular Economy**
Present Engineering Education

We are currently preparing students for jobs that don’t yet exist . . .

. . . using technologies that haven’t yet been invented . . .

. . . in order to solve problems we don’t even know are problems yet.
Challenges That Will Drive the Largest Number of Jobs in the 21st Century

- Make Solar Energy Economical
- Provide Access to Water
- Provide Energy from Fusion
- Restore and Improve Urban Infrastructure
- Develop Carbon Sequestration Methods
- Engineer Better Medicines
- Advance Health Informatics
- Manage the Nitrogen Cycle
- Secure Cyberspace
- Engineer the Tools of Scientific Discovery
- Enhance Virtual Reality
- Reverse-Engineer the Brain
- Advance Personalized Learning
- Prevent Nuclear Terror

Source: [www.3ds.com](http://www.3ds.com) Grand Challenges for Engineering
Challenging Elements for Modern Education

- A new technological fundament of learning, the so-called Technology Enhanced Learning (TEL)
- **A new learner generation**, who is online at any time and expects to be more active
- The necessity to create individual learning paths

- An increasing area of engineering
- A near exponential acceleration in product and service developments
- A changing focus of engineering
- The enormous number of high qualified engineering graduates needed globally
The whole educational ecosystem must be dramatically renewed in a disruptive manner:

- Instead of acquiring new knowledge we have to teach new and relevant competences and skills and build individual “identities”.
- Instead of classroom based teaching we have to ensure a context-aware personalized learning.
- Instead of life-long degrees and certifications we will have more and more on-demand and in-context accreditation of qualifications.

From Demetrios Sampson
A New Paradigm in Engineering Education

• Fundamental Education in Math and Science
• Inquiry based Engineering Education (project and problem based)
• Including Entrepreneurship, Critical Thinking, Business Management in the curricula
• Pay attention to Ethics and Sustainability in Global Contexts
• Taking into account the latest findings in Engineering Pedagogy
• Teach the students how to learn

Lifelong Learning
A New Pedagogy

• Shorten the learning phases,
• Active learning,
• Game based learning,
• Project based learning,
• inquiry learning spaces, …
New Pedagogy: Peer Learning

0% lecture
0% teacher
0% mooc

100% hands-on
100% projects

100% collaborative

Peer evaluations
Gamification
Individual pace

Examples:
CODE University Berlin
42 IT School Paris

From: Olivier Crouzet
How to Do the Change

- “Doing” is better than “Thinking”

- providing an environment that encourages and facilitates **practical experiential learning** by all involved

- **Pedagogy is more important than Technology**, action learning modes, different learning environments and opportunities for participants

- “integrative learning” (deep level connection between the process of learning, reflective self awareness and experiential learning)

- the teacher !!!
“The greatest accomplishment by Christopher Columbus was not that he arrived in the New World and discovered America, but that he had the courage to start this endeavor.”

Stefan Zweig
1881 - 1942
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