New Trends in Information Technologies and Their Integration in University Curricula: a Brief Study in the Context of the FETCH European Thematic Network

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Evolution of Information Technology (IT)

Main problems

- University curricula usually follow IT evolution with a certain **delay**
- IT progresses are often subject to **individual preferences** and local constraints

Market and industry need fast and flexible adaption of computing education to their constantly increasing requirements

- Organizations such as ACM and IEEE have proposed authoritative IT curricula recommendations, but always with some delay
- These curricula cannot be updated very frequently

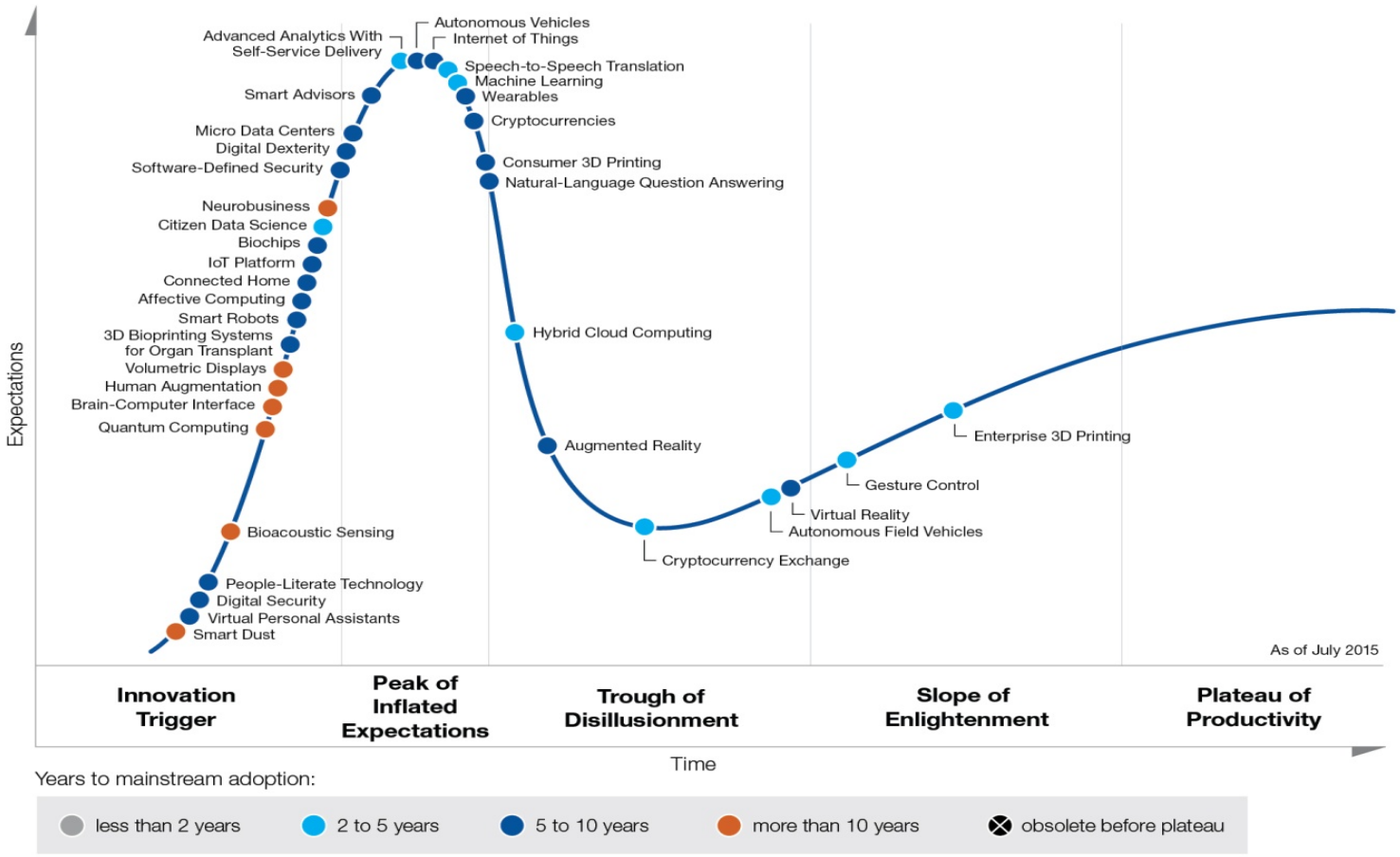
IT Topics – ACM Classification (2012)

ACM Computing Classification System

1. General and reference
2. Hardware
3. Computer systems organization
4. Networks
5. Software and its engineering
6. Theory of computation
7. Mathematics of computing
8. Information systems
9. Security and privacy
10. Human-centered computing
11. Computing methodologies
12. Applied computing
13. Social and professional topic

IT Topics – Gartner's Hype Cycle (2015)

Gartner



Europe 2020 Initiative

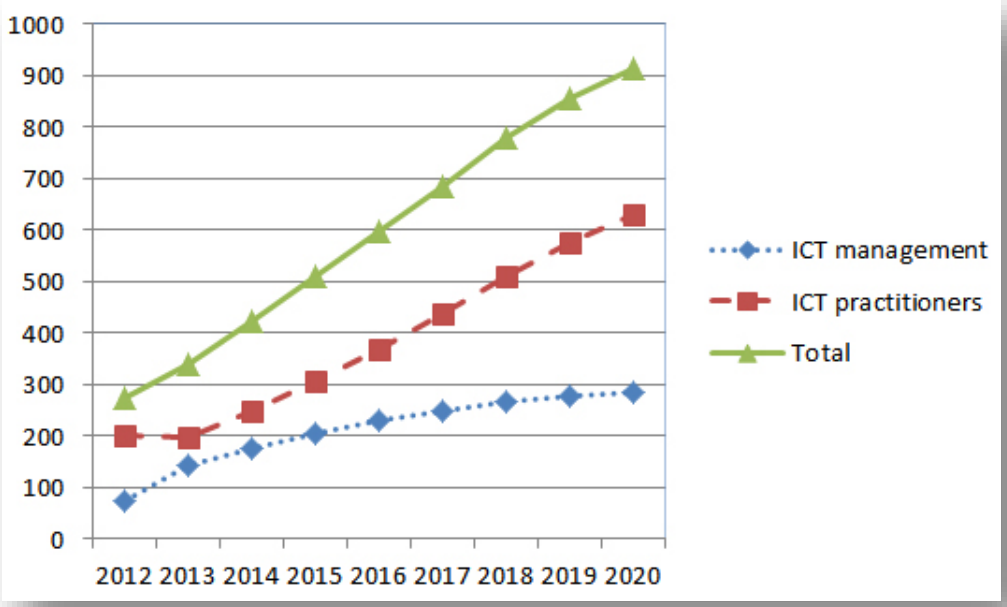
Promotes delivering growth that is:

– **Smart**, through more effective investments in education, research and innovation

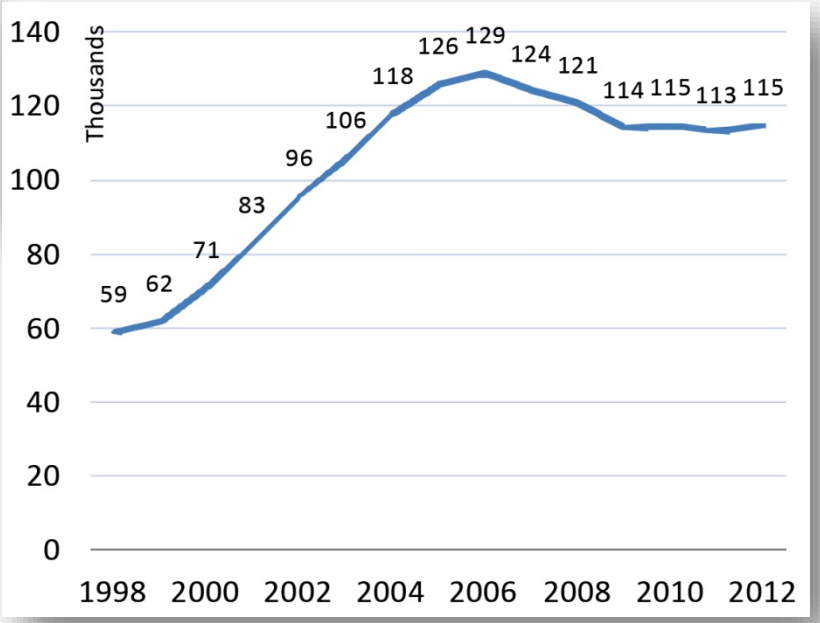
– **Sustainable**, thanks to a decisive move towards a low-carbon economy

– **Inclusive**, with a strong emphasis on job creation and poverty reduction

ICT Workforce Demand in Europe



Forecast (in thousands) of ICT jobs demand in Europe in the years 2012 – 2020



Evolution of the number of European ICT graduates in the years 1998 – 2012

NMC Horizon Report > Higher Education Edition

Directions of *NMC Horizon Report* ***2013***

- Tablet computing
- Games
- Analytics software
- 3D printing
- Wearable technology

New directions of *NMC Horizon Report* ***2016***

- Development in heterogeneous environments
- Learning analytics
- Adaptive learning
- Augmented and virtual reality
- Affective computing
- Robotics

A Survey Study Connected with FETCH

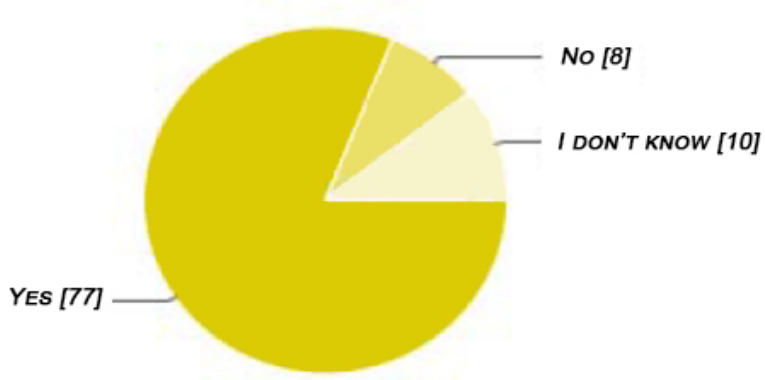
Online survey developed within *Work Package 3*

- Four areas:
  - Computer Science (CS)
  - Computer Engineering (CE)
  - Software Engineering (SE)
  - Information Systems (IS)
- Three categories of respondents:
  - Professors (95 respondents)
  - Alumni (69 respondents)
  - Industry Representatives (35 respondents)

Survey - International Standard Curriculum Guidelines

Professors questionnaire

Do you think that international standard curriculum guidelines should be extensively applied to define university curricula in the areas of CS, CE, SE and IS?



Yes	**77**	81%
No	**8**	8%
I don't know	**10**	11%

YES
mainly (65%) because it is important that all students in all countries acquire comparable competencies…

Survey – Suggestions for Changes in Curricula

Professors questionnaire

Possible courses or changes that should be included in CS, CE, SE and IS curricula, in order to enable them to better meet current and future needs of industry, include:

- Cloud Computing
- Mobile Software Development
- Computer and Information Security
- Big Data
- Web Programming and services
- Considered less relevant: Agent-based Programming, Algorithms, Computer Science and Economy, Ethics and Laws, Functional Programming, Game Programming, Professional Java Programming, Social Media

Survey – Current Jobs

Alumni questionnaire

Most common current jobs include:

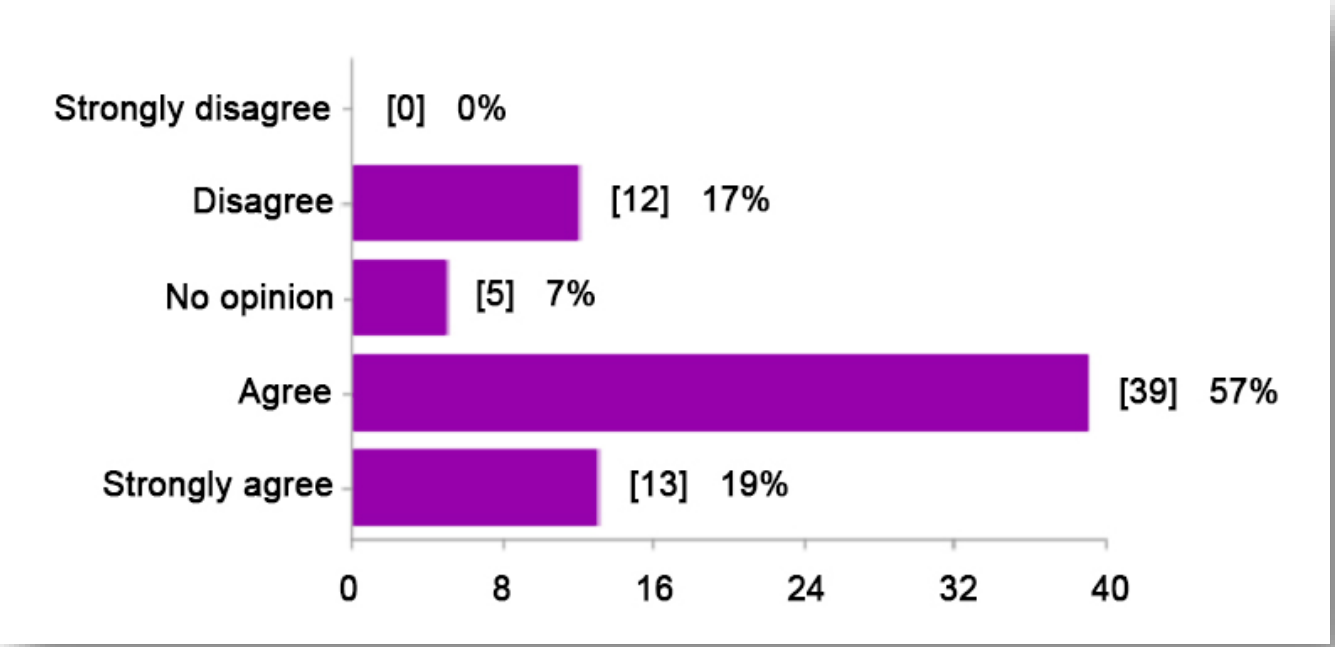
- Software developer
- Lecturer/Teacher
- Administrator/Coordinator
- Consultant
- Project manager
- Researcher
- Commercial/Marketing

- Manager
- Mobile developer
- Data analyst
- Database administrator
- Software analyst
- Web developer
- Application Engineer

Survey – University Programs

Alumni questionnaire

Did university programs prepare you well for your current job?



Survey – Suggestions for Changes in Curricula

Alumni questionnaire

Based on your professional experience, are there any courses or changes that should be included in CS, CE, SE or IS programs in order to enable them to better meet current and future needs of industry?

- Interpersonal relations, communication skills and soft skills
- Web technologies
- Mobile technologies
- Entrepreneurship and enterprise patterns and principles
- Suggested by single respondents: Advanced software engineering and programming, Applied statistics, Business intelligence and Data mining, Change management, Client-side Web programming, Human-Computer Interaction, Information systems software (such as SAP), IT Project management, Law and business systems, Sales of IT products

Survey – Most Useful Courses

Alumni questionnaire

Which are the top five courses that have mainly helped you in your job?

Computer Science
- Programming languages
- Algorithms and complexity
- Software engineering
- Software Development fundamentals
- Operating systems

Computer Engineering
- Algorithms
- Database systems
- Computer architecture
- Programming fundamentals
- Software engineering

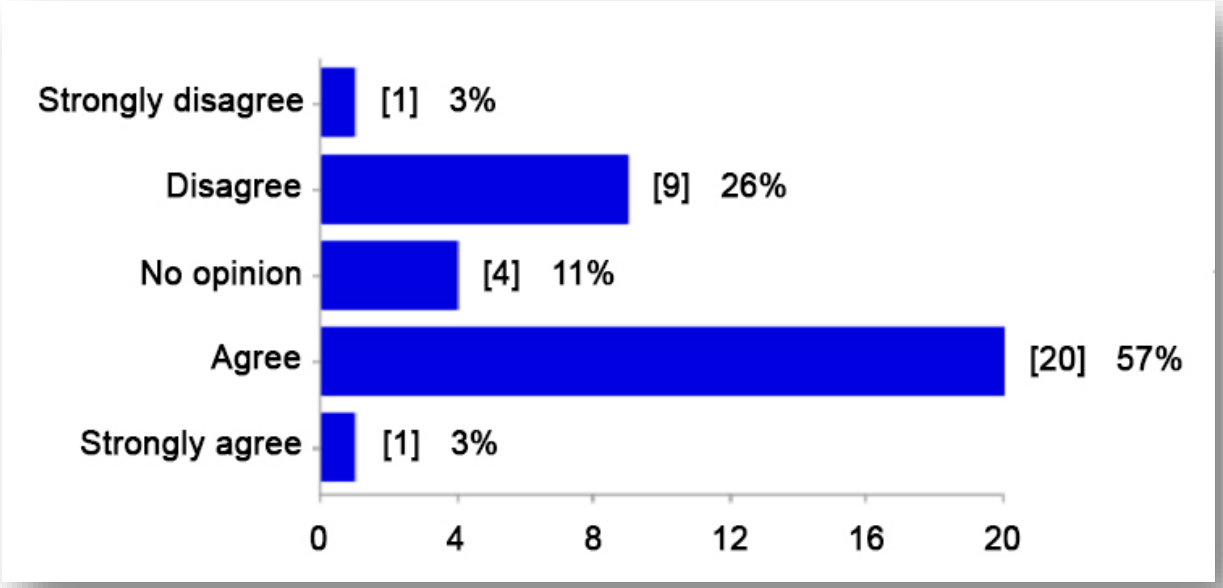
Software Engineering
- Software design
- Software modeling and analysis
- Software management
- Software processes
- Software quality

Information Systems
- Systems analysis and design
- Data and information management
- IT project management
- Foundations of information systems
- Enterprise architectures

Survey – University Programs

Industry Representatives questionnaire

Did university programs prepare employees well for their current job?



Survey – Suggestions for Changes in Curricula

Industry Representatives questionnaire

Based on your professional experience, are there any courses or changes that should be included in CS, CE, SE or IS programs in order to enable them to better meet current and future needs of industry?

- Object Oriented programming languages
- Communication and social skills
- Agile methodologies
- Design patterns
- English speaking and writing
- Mobile technologies
- Practical skills
- Project management

- Suggested by single respondents: Agent-based programming, Databases, E-learning technologies, Ethical issues, Industry software solutions, Mathematical skills, Networking, Operating systems, Problem definition and modelling, Software engineering, Staying up-to-date in technology, Strong theoretical grounding in computing subjects and Web technologies

Survey – Suggestions for Changes in Curricula

Common suggestions from *Professors*, *Alumni* and *Industry Representatives*

- Programming skills
- Web technologies
- Mobile technologies

Common suggestions from *Professors* and *Alumni*

- Big data / Data mining
- Information security

Survey – Suggestions for Changes in Curricula

However…

- The provided answers do not consider all promising topics
- Some promising topics (e.g. Big data and Cloud systems) are actually a combination of traditional topics (e.g. Data mining, Pattern Recognition, Artificial Intelligence, Grids, Virtualization, etc.)
- Recommendations should be sufficiently flexible to be applicable in different contexts (taking also into account local differences in culture and economic development)

ESFCET 2020

European Strategic Framework for Computing Education and Training 2020

Priority Area *A*

Adoption of international standard curriculum guidelines

- Bachelor's programs:
  - *CS2013* for Computer Science (by ACM and IEEE Computer Society)
  - *CE2004* for Computer Engineering (by ACM and IEEE Computer Society)
  - *SE2004* for Software Engineering (by ACM and IEEE Computer Society)
  - *IS2010* for Information Systems (by ACM and AIS)
- Master's programs:
  - *GSwE2009* for Software Engineering (by iSSEc)
  - *ACM-AIS for Information Systems 2006* for Information Systems (by ACM and AIS)

ESFCET 2020

European Strategic Framework for Computing Education and Training 2020

Priority Area *B*

Integration of recent relevant topics in existing standard curriculum guidelines

- Web technologies
- Mobile technologies
- Big data
- Cloud computing and High performance computing
- Information Security

Conclusions

The evolution of computing curricula should be based on well-established resources and approaches such as:

- **Standard curriculum guidelines by international organizations**
- **Long-term European and national policies**
- **ICT jobs market monitoring and extrapolations**
- **Gartner's Hype Cycle for Emerging Technologies**
- **Periodic surveys among key stakeholder groups in computing (professors, industry representatives and alumni)**

ESFCET 2020 goes towards such direction…

Thank you for your attention!