ON THE FUTURE OF HIGHER EDUCATION

Co-sponsored by:

NWO Netherlands Organisation for Scientific Research

STW connecting innovators

DARWINIAN AND NON-DARWINIAN ADVANCES IN CURRICULUM, DIDACTICS, TECHNOLOGY, AND MANAGEMENT

@Large Research
Massivizing Computer Systems

http://atlarge.science

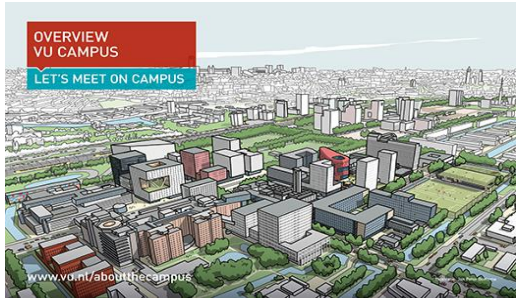
VU VRIJE UNIVERSITEIT AMSTERDAM

@Alosup

Prof. dr. ir. Alexandru Iosup

VU AMSTERDAM < SCHIPHOL < THE NETHERLANDS < EUROPE

Amsterdam
founded 10th century
pop: 850,000



VU
founded 1880
pop: 23,500

The Netherlands

Europe

VU UNIVERSITY AMSTERDAM

MASSIVIZING COMPUTER SYSTEMS: OUR MISSION

1. Improve the lives of millions through impactful research.

2. Educate the new generation of top-quality, socially responsible professionals.

3. Make innovation available to society and industry.

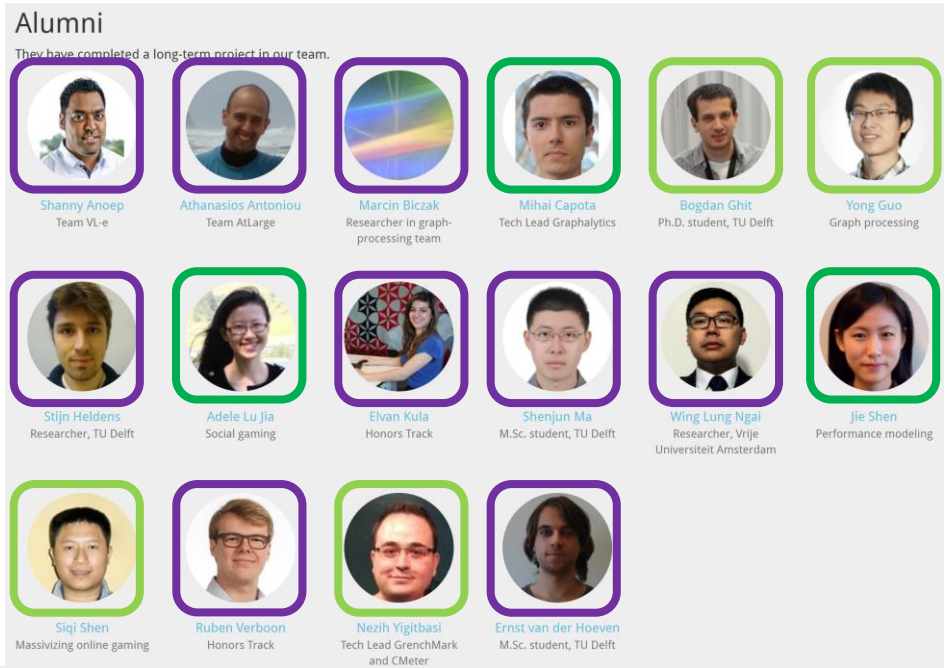
VU VRIJE UNIVERSITEIT AMSTERDAM

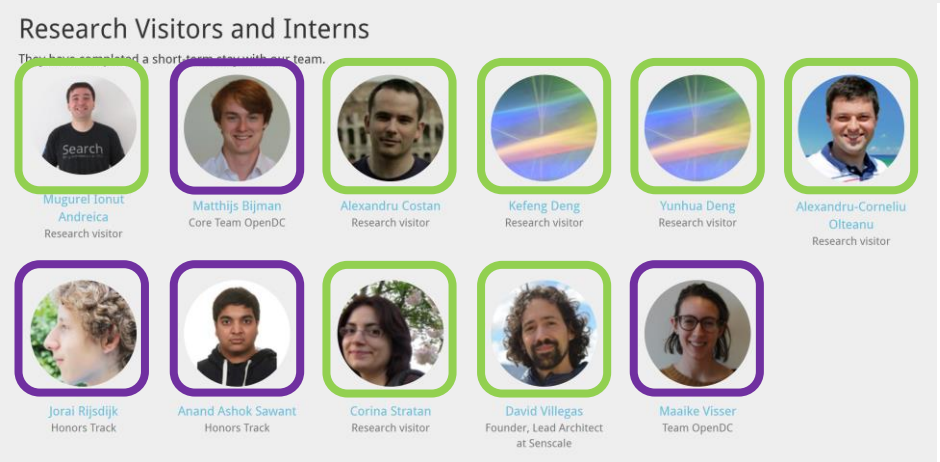
http://atlarge.science/about.html

TU Delft

ATLARGE RESEARCH: OUR TEAM

- Professor
- Assistant Prof.
- Teacher
- Post-doc
- Ph.D. student
- Scientist

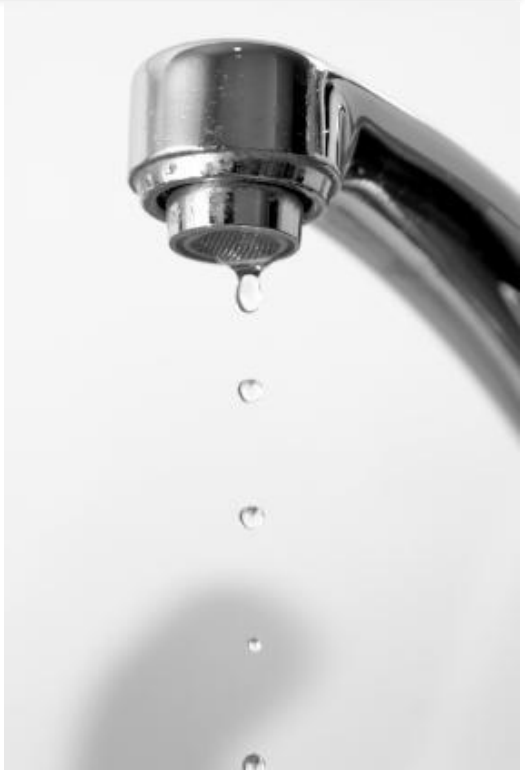




http://atlarge.science/people.html

THE CURRENT SITUATION: THE LEAKING FAUCET

Top-quality technical university +
Top-quality university, both the Netherlands



"P-in-een" of an important BSc track	<50%
Completion "in time" of the BSc	<50%

(What do students think about it? What does the society? What do you?)

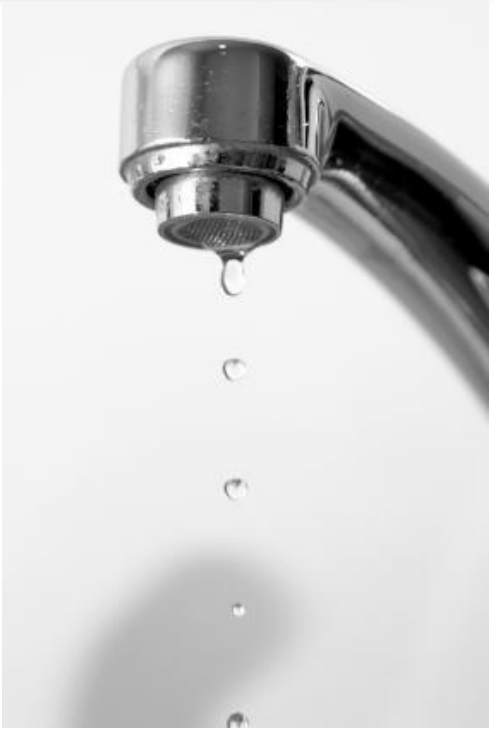
THE BLAME GAME

Team work, first 2 minutes

1. Form team of 2-3 persons: look around, say “hi”
2. Think about own experience, explain to team
3. Convince your team before proposing an answer

Open discussion, next 2 minutes

- Tell everyone the answer



Q: **Who is responsible** for the **current yield** of higher education?

Vote on best answer

THE BLAME GAME: A SUMMARY

New generation of students, including international, but do we understand them?

New ambition of universities,
but few can select students in the Netherlands

More demands from industry,
but personal skills also matter

Old attitude about the task: the Teacher will just do it!

https://quotablequoteunquote.files.wordpress.com/2008/08/walkingcomputergeek.jpg

THE BLAME GAME: A SUMMARY

New generation of students, including international, but do we understand them?

The main challenge for the future?

Every student counts!
Every student is different!

Mind the Teacher!

https://quotablequoteunquote.files.wordpress.com/2008/08/walkingcomputergeek.jpg

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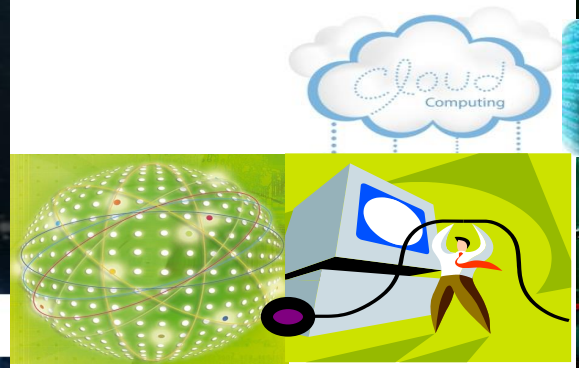
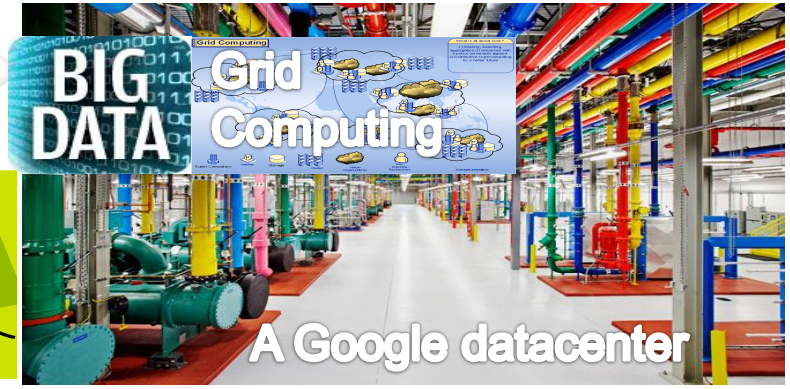
WHAT DOES OUR SOCIETY NEED? THE QUADRUPLE HELIX, ICT-BASED





prosperous society + blooming economy + inventive academia + wise governance

- Enable data access & processing as a fundamental right in Europe (2018: GDPR v.1.0)
- Enable Industry 4.0 and big science (2020: €100 bn., 1 mil. jobs)
- Sustainability, dependability, and privacy, but with energy footprint <5%
- etc. etc. etc.

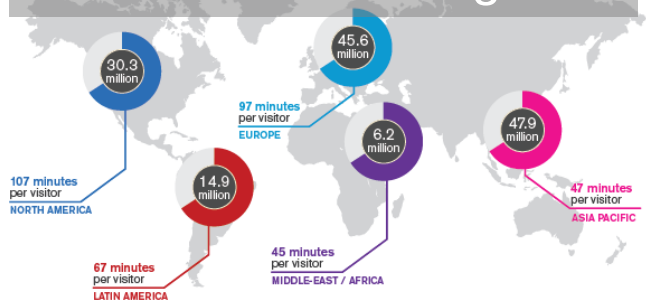
THIS IS THE GOLDEN AGE OF DISTRIBUTED COMPUTER SYSTEMS

Education for Everyone (Online)

Business Services

Big Science

Online Gaming



Daily Life

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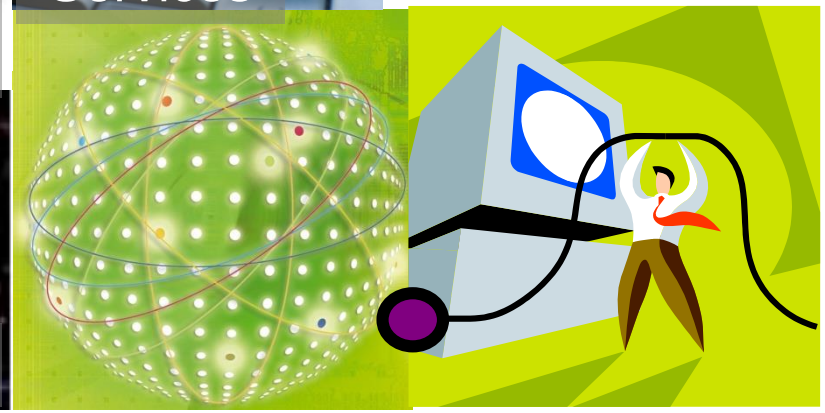
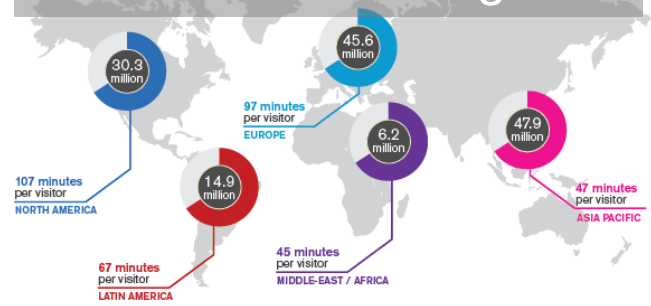


Online Gaming



Daily Life

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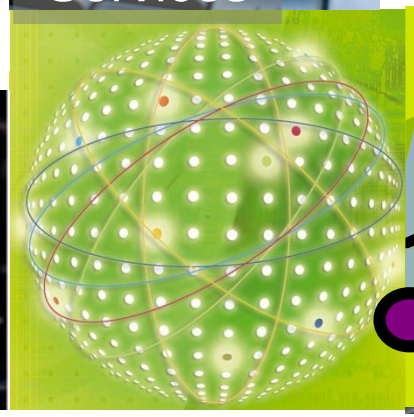

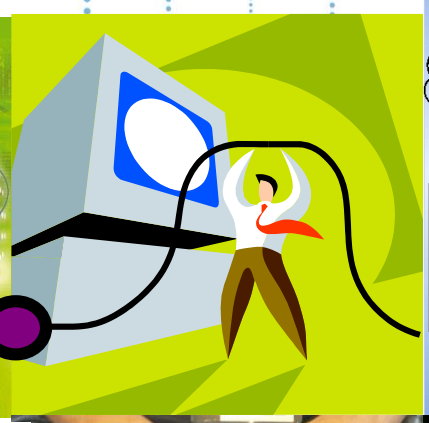

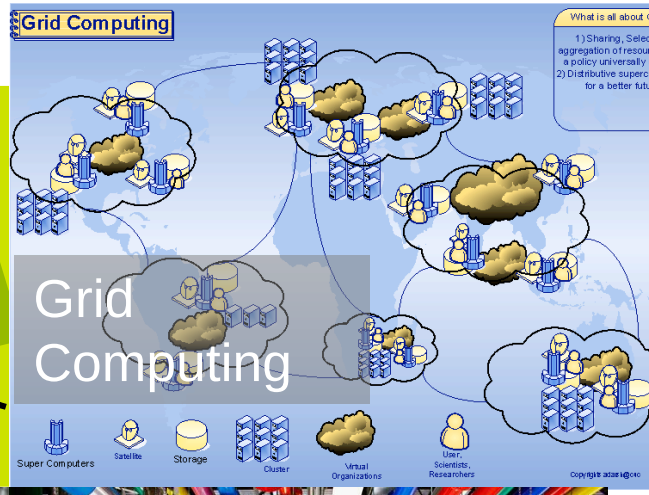

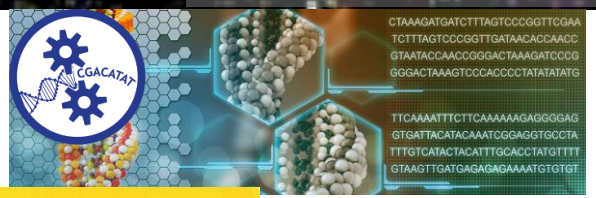

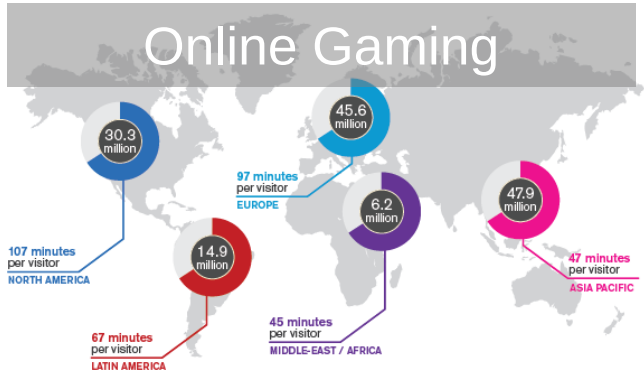

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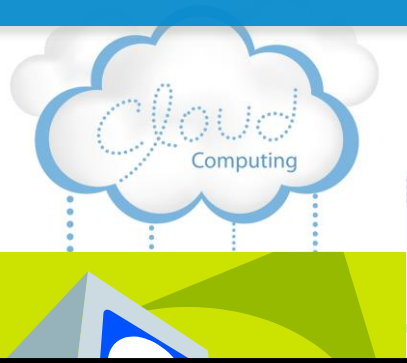
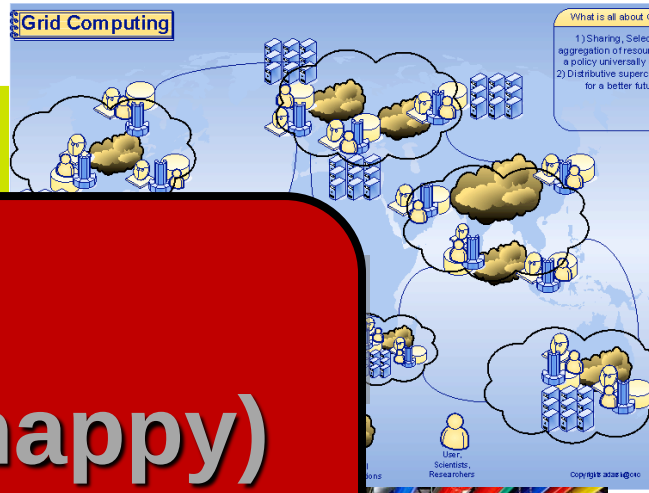
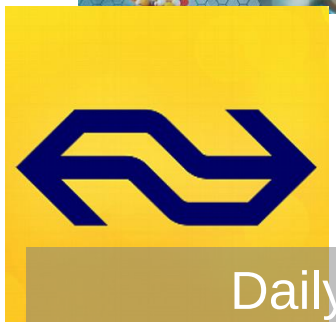
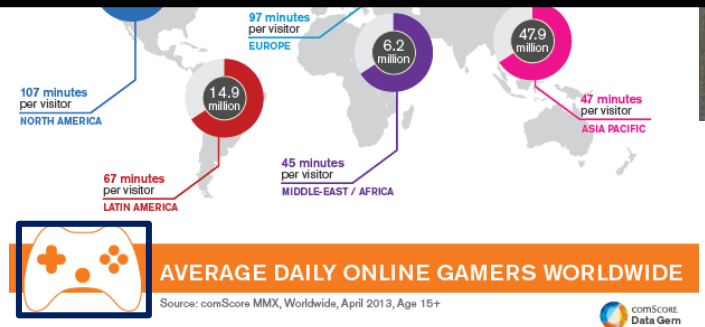




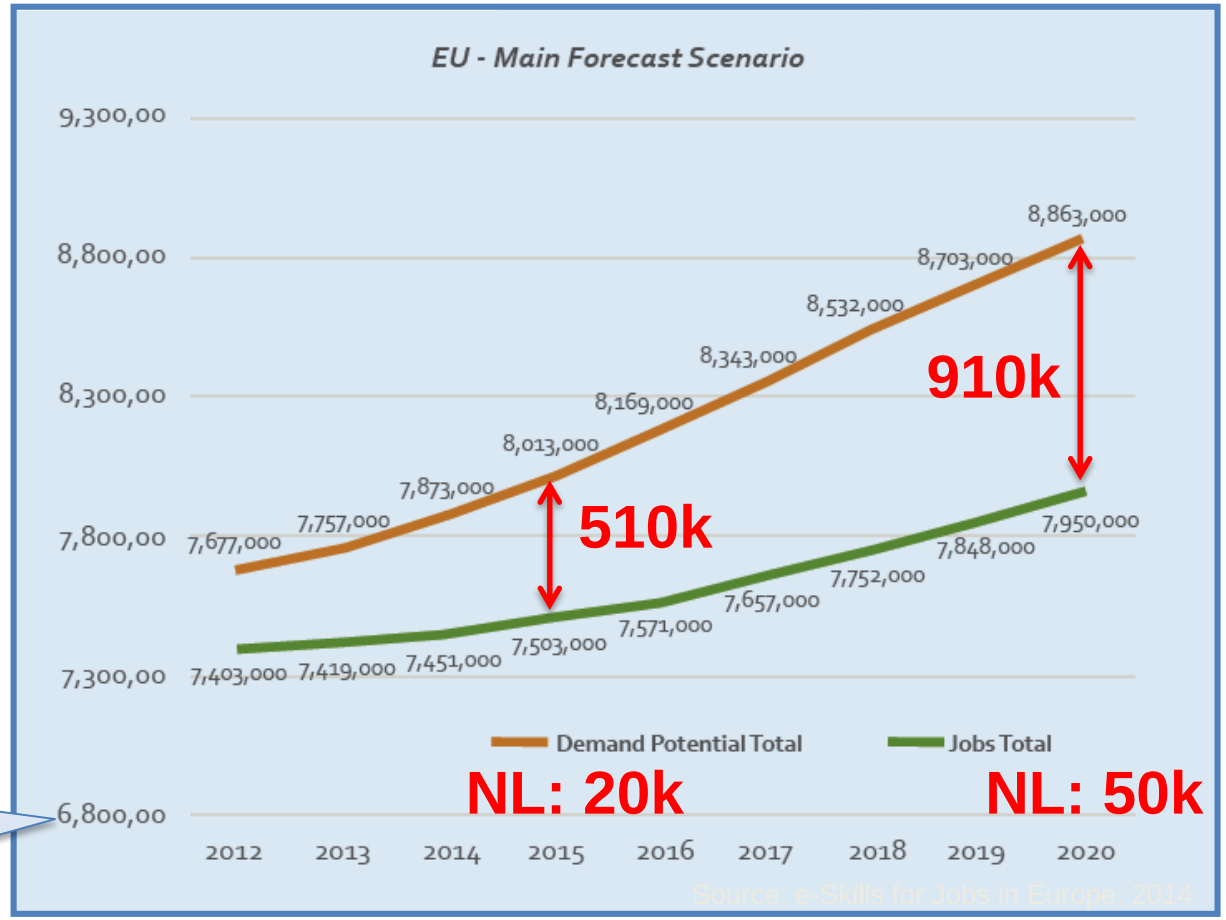
The Problem of
(Unavailable, Unqualified, Unhappy)
Human Resources





Daily Life

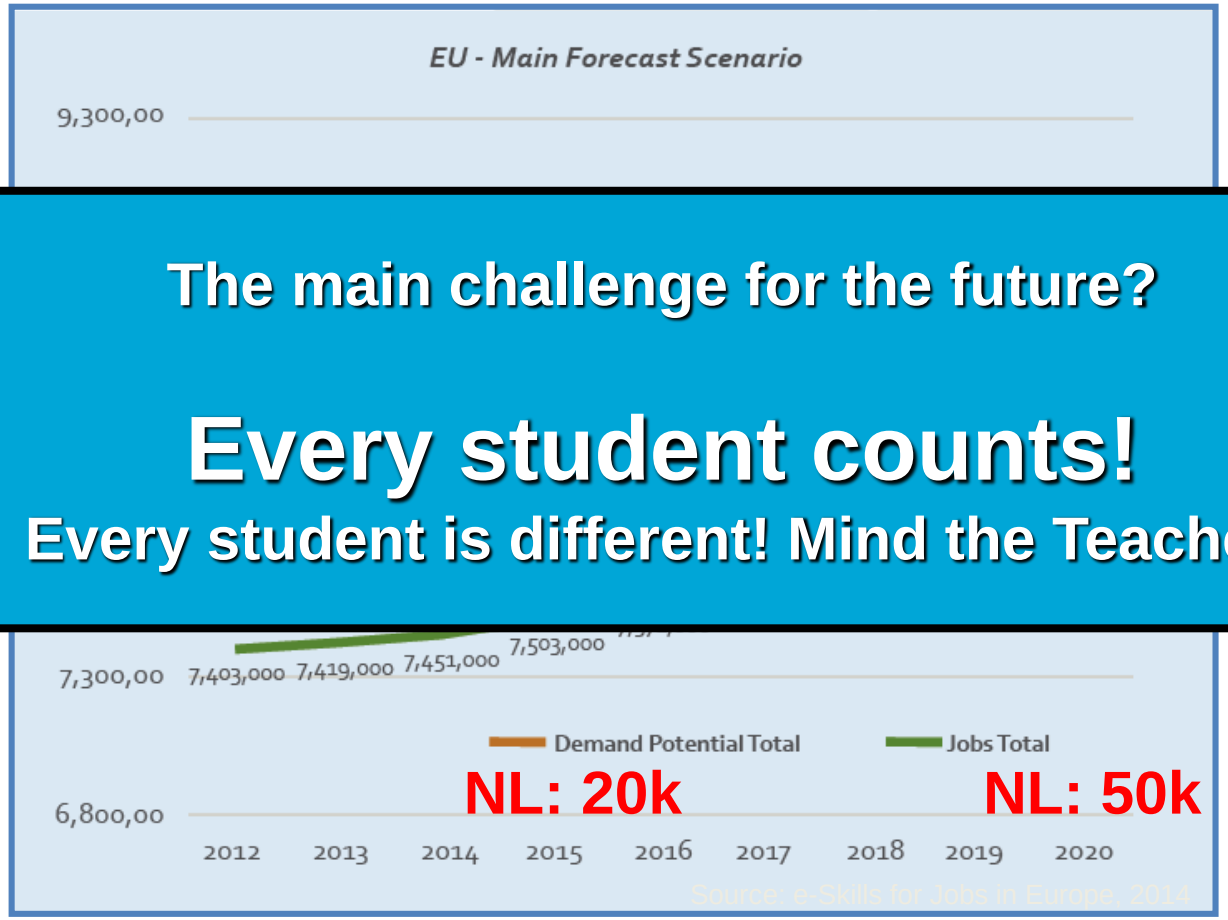
THE WORKFORCE SKILL-GAP IN ICT, EU AND NL



Does not start at 0

Source: Korte et al., e-Skills for Jobs in Europe, EC Report, 2014

THE WORKFORCE SKILL-GAP IN ICT, EU AND NL



The main challenge for the future?

Every student counts!

Every student is different! Mind the Teacher!

Source: Korte et al., e-Skills for Jobs in Europe, EC Report, 2014

On the Future of Higher Education
A Structured Discussion

~40’

~5’ — About Our Team & Massivizing Computer Systems

~10’ — The Golden Age of Massive Systems …Yet We Are in a Crisis

~20’ — An Approach to Higher Education: Darwinian and non-Darwinian

1. Curriculum
2. Didactics
3. Technology
4. Management

~5’ — Take-Home Message

21ST CENTURY NEEDS FOR HIGHER EDUCATION

FROM PRODUCT-DRIVEN TO INFORMATION-/KNOWLEDGE-DRIVEN SOCIETY

1. Students: finding flexibility, fun, self, and a job
2. Society: massivizing and diversifying, behaving ethically
3. Industry: requiring new and more complex skills
4. Academic System: being accountable to stakeholders 1-3

5. Educators: receiving proper recognition, tasks, and time

21ST CENTURY NEEDS FOR MASSIVIZING SYSTEMS

A FRAMEWORK WITH FOUR DIMENSIONS

1. Curriculum: what to teach?
2. Didactics: how to teach?
3. Technology: how to address increasingly higher and more diverse expectations?
4. Management: how to manage the crossroad?

21ST CENTURY NEEDS FOR MASSIVIZING SYSTEMS

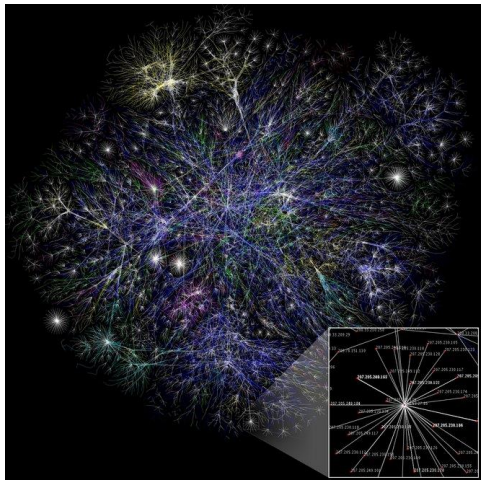
TWO TYPES OF APPROACHES: DARWINIAN AND NON-DARWINIAN

Darwinian

incremental change

Non-Darwinian

paradigmatic shift



21ST CENTURY NEEDS FOR MASSIVIZING SYSTEMS

TWO TYPES OF APPROACHES: DARWINIAN AND NON-DARWINIAN

Darwinian
incremental change

Curriculum	
Content development by small groups	ACM/IEEE Curriculum updates
One BSc course on Comp. Organization	Systems Thinking
One MSc course on Distrib. Sys.	Design Thinking
Didactics	
Flipped classroom	Gamification
Socratic discussion	Young-researcher programmes
Local hackathons	Bootcamps, Global competitions
Technology	
Digitization	Big Data
Informatization	Cloud computing
Automation	Virtual laboratories
Management	
Factory-like (e.g., efficiency measures)	Incentives for educators
Industry-/Academia-only panels	Discussion with all stakeholders

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THIS IS THE GOLDEN AGE OF DISTRIBUTED COMPUTER SYSTEMS

MASSIVIZING COMPUTER SYSTEMS IN A NUTSHELL. THINK ECOSYSTEMS

WHO?	SCIENTISTS, ENGINEERS, DESIGNERS, MANAGERS, ETC.
WHAT? MAIN GOAL	UNDERSTAND AND CONTROL DISTRIBUTED ECOSYSTEMS, TO TURN THEM INTO EFFICIENT, AUTOMATED UTILITIES
HOW? CENTRAL PARADIGM	ECOSYSTEM OPERATION AND CHARACTERISTICS DERIVES NON-TRIVIALLY FROM ITS SYSTEMS AND USERS (RECURSIVELY)
WHICH APPROACH?	MODERN DISTRIBUTED SYSTEMS AND PROBLEM-SOLVING

Iosup et al., Massivizing Computer Systems, ICDCS 2018. [Online]

THE SCIENCE, DESIGN, AND ENGINEERING OF MASSIVIZING

Scheduling
Serverless
Workflows
Portfolio, Auto-scaling*

Dependability
Performance & Failure Analysis*
Space-/Time-Correlation
Availability-On-Demand

New World+
Workload Modeling
Business-Critical
Online Gaming

Ecosystem Navigator+
Performance Variability
Grid*, Cloud, Big Data
Benchmarking*
Longitudinal Studies

Scalability/Elasticity+
Delegated Matchmaking*
BTWorld*, POGGI*, AoS
Auto-Scalers
Heterogeneous Systems

Socially Aware+
Collaborative Downloads*
Groups in Online Gaming
Toxicity Detection*
Interaction Graphs

Education
Social Gamification*

Software Artifacts
Graphalytics, OpenDC

Data Artifacts
Distributed Systems Memex*

Fundamental Problems/Research Lines (+New)
* Award-level work Competitive personal grants

THE SCIENCE, DESIGN, AND ENGINEERING OF MASSIVIZING

THE COMPLEXITY CHALLENGE

<<1% OF BIG DATA
BY MATT TURK (2017)

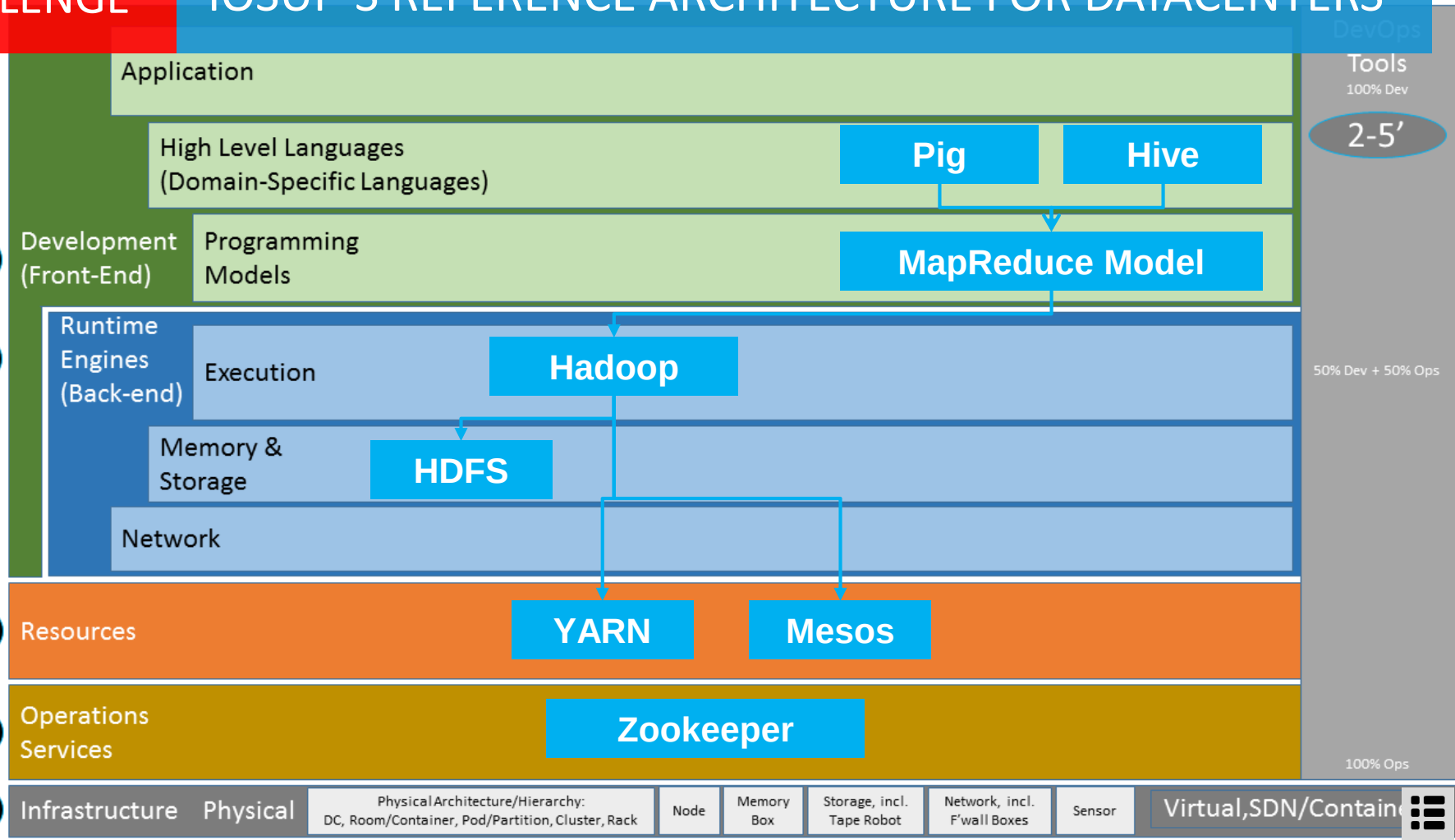
THE SCIENCE, DESIGN, AND ENGINEERING OF MASSIVIZING

THE COMPLEXITY CHALLENGE

Focus on Applications, 5 Core Layers:

5. Development (Front-end)
4. Runtime Engines (Back-end)
3. Resources
2. Operations Services
1. Infrastructure

IOSUP'S REFERENCE ARCHITECTURE FOR DATACENTERS



21ST CENTURY NEEDS FOR MASSIVIZING SYSTEMS

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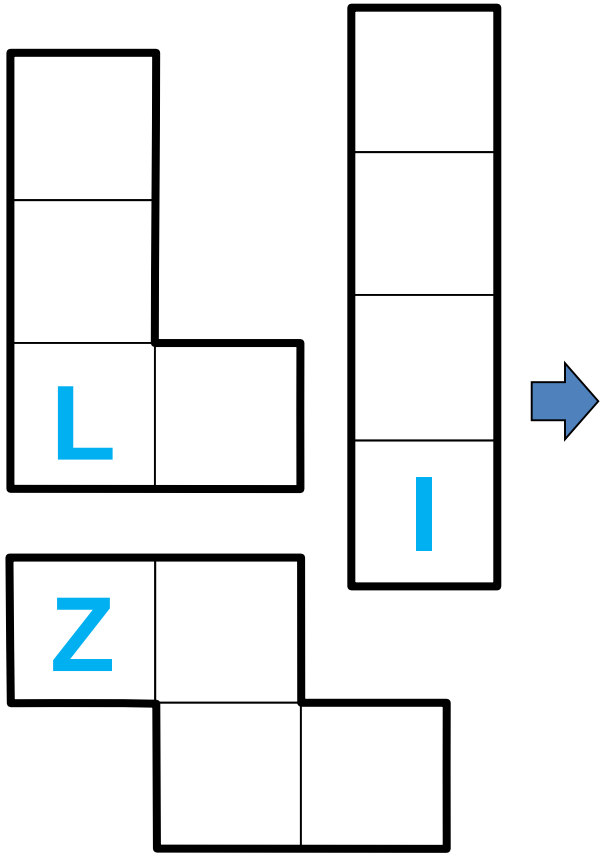
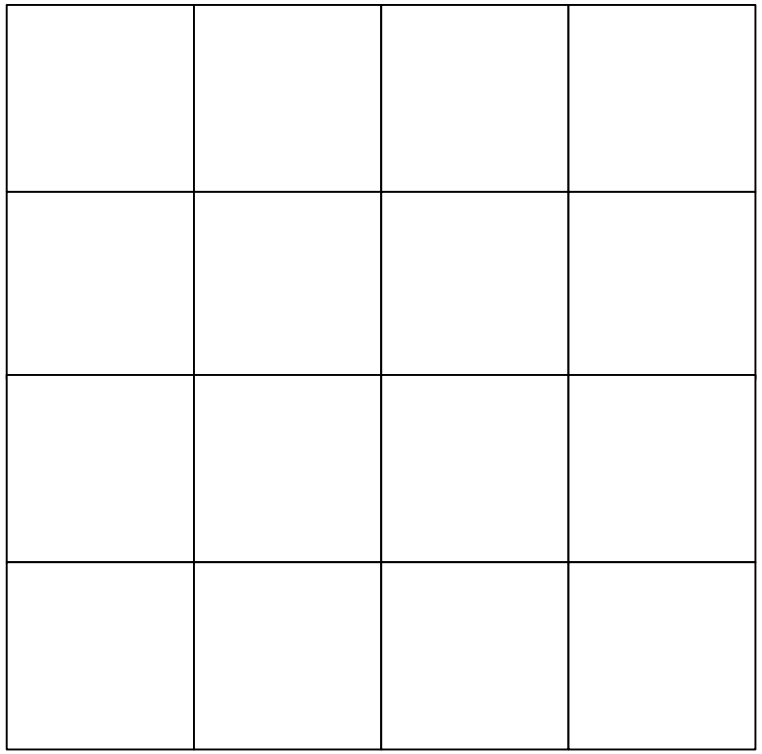
21ST CENTURY NEEDS FOR MASSIVIZING SYSTEMS

DIDACTICS: GAMIFICATION = CHOOSE YOUR OWN PATH OF ADVANCEMENT

Content Unlocked!

2 x





21ST CENTURY NEEDS FOR MASSIVIZING SYSTEMS

DIDACTICS: GAMIFICATION

Gamification = The use of thinking and techniques designed for gaming in non-gaming settings, e.g., in education.

http://goo.gl/V97zSW

What is the intuition behind gamification?

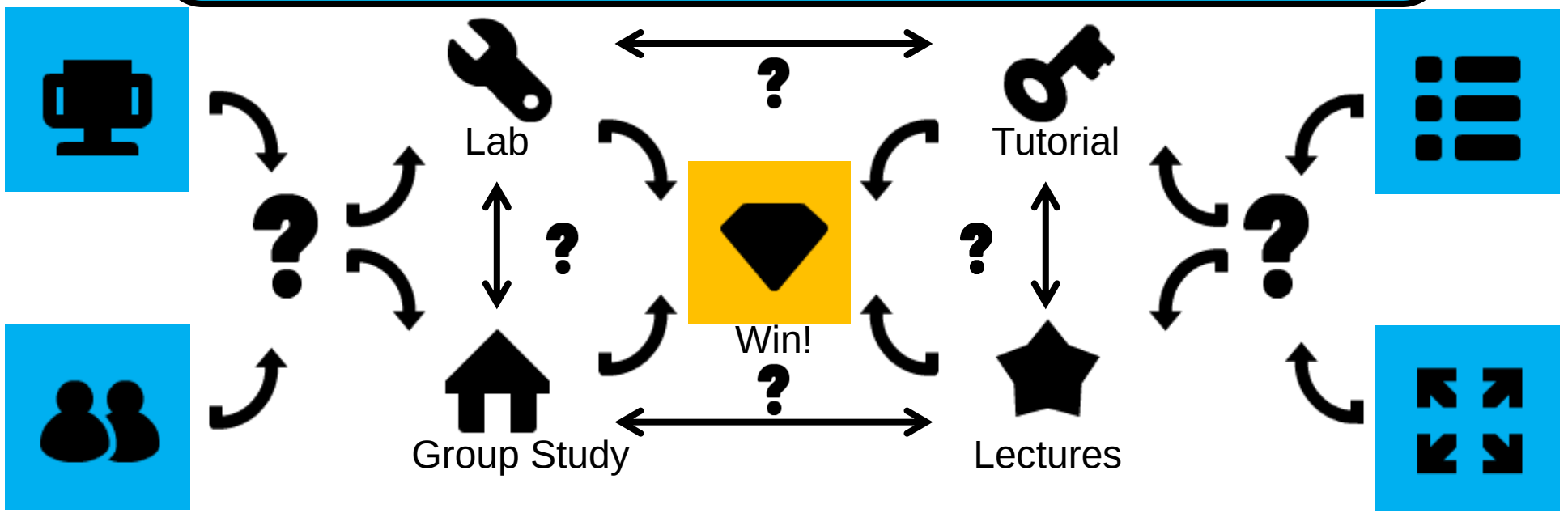
How can gamification be used?

http://goo.gl/ILSNeb

21ST CENTURY NEEDS FOR MASSIVIZING SYSTEMS

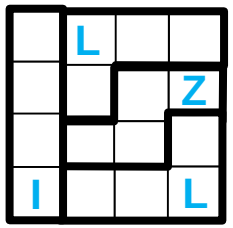
DIDACTICS: GAMIFICATION

Designing a course is like creating a complex puzzle

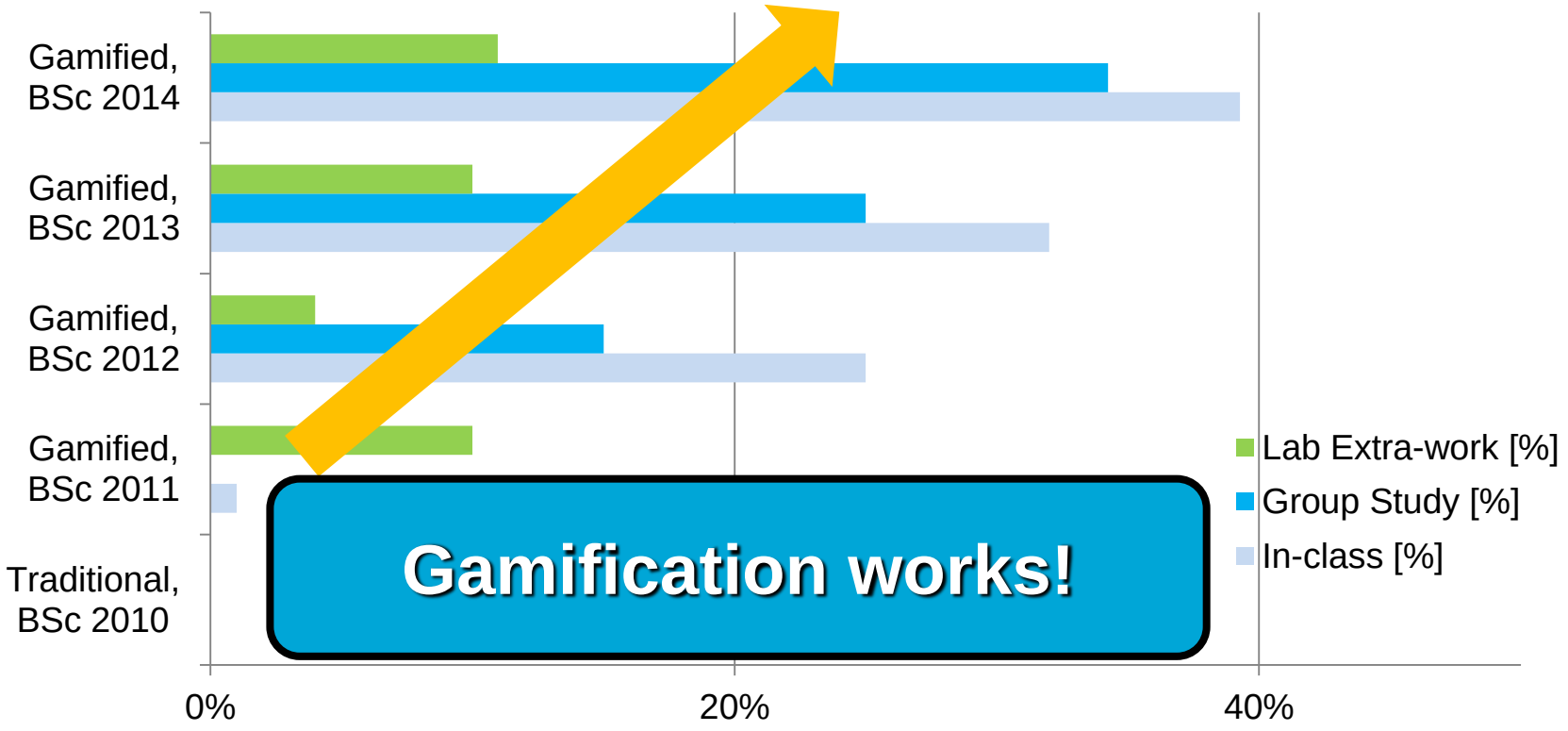


21ST CENTURY NEEDS FOR MASSIVIZING SYSTEMS

DIDACTICS: GAMIFICATION



The Other Path



Extra work due to gamification, relative to traditional [% all students]

21ST CENTURY NEEDS FOR MASSIVIZING SYSTEMS

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21ST CENTURY NEEDS FOR MASSIVIZING SYSTEMS

UNIQUE OPPORTUNITY: WE CAN DRINK OUR OWN CHAMPAGNE

Our (& Your) Prototypes

\+ amazon web services™

We also use IaaS clouds

\+ OpenDC

And simulators

My main research instrument

21ST CENTURY NEEDS FOR MASSIVIZING SYSTEMS

SO WHAT CAN BIG DATA DO IN HIGHER EDUCATION?

As any technology:

1. Improve existing processes, typically through automation
2. Enable new processes, typically by augmenting human abilities

Big Data could help Higher Education to:

"Significantly improve and scale higher education, assisted by digital means and other methods to improve the efficiency and the quality of education, working ethically across different learning cultures, orienting students towards science, industry, governance, and society at large."—
TU Delft pilot-project started by A. Iosup (2015—ongoing)

21ST CENTURY NEEDS FOR MASSIVIZING SYSTEMS

VISION FOR BIG DATA USE IN HIGHER EDUCATION: WHAT IF PROCESSES ARE INFORMED?

The Personal Academic File: Ethical Use of Student Data

- Data access and processing as basic service offered to all students
- Automated tools will inform and suggest course of action

Empowered = Engaged

- Student in control of own progress

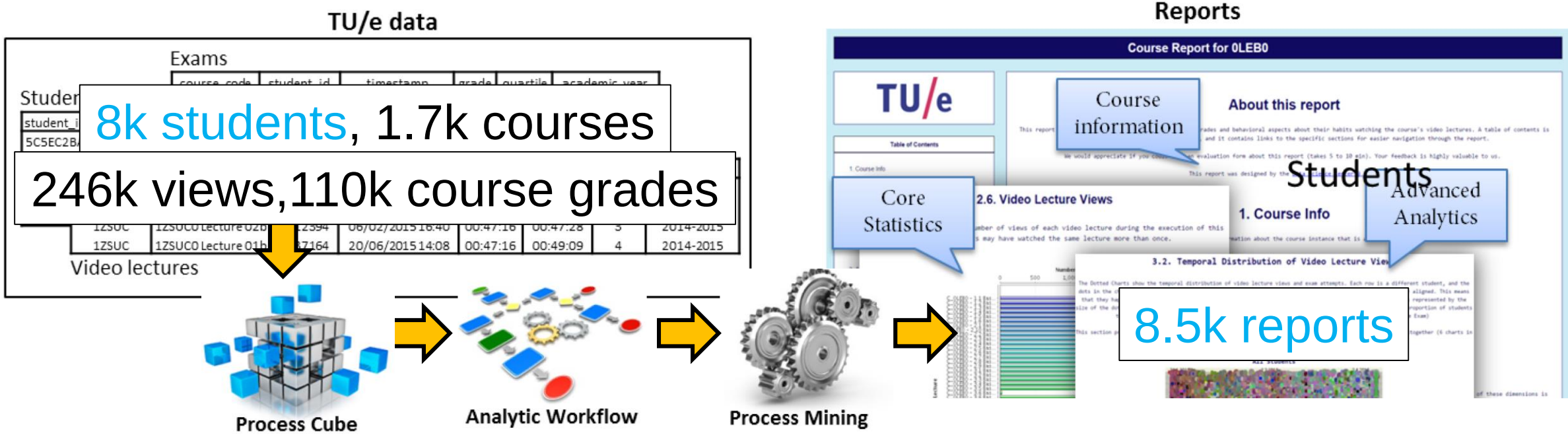
Big Data = Automate + Enable

- Teachers focus on human activities

ICT challenges & Ethical Risks

21ST CENTURY NEEDS FOR MASSIVIZING SYSTEMS

EXAMPLE: PROCESS CUBES AND MINING, ANALYTIC WORKFLOWS AT TU/E, NL



Generic process mining tools Specialized process cube and analytic workflows

Bolt et al. Exploiting Process Cubes, Analytic Workflows and Process Mining for Business Process Reporting: A Case Study in Education. SIMPDA 2015: 33-47

21ST CENTURY NEEDS FOR MASSIVIZING SYSTEMS

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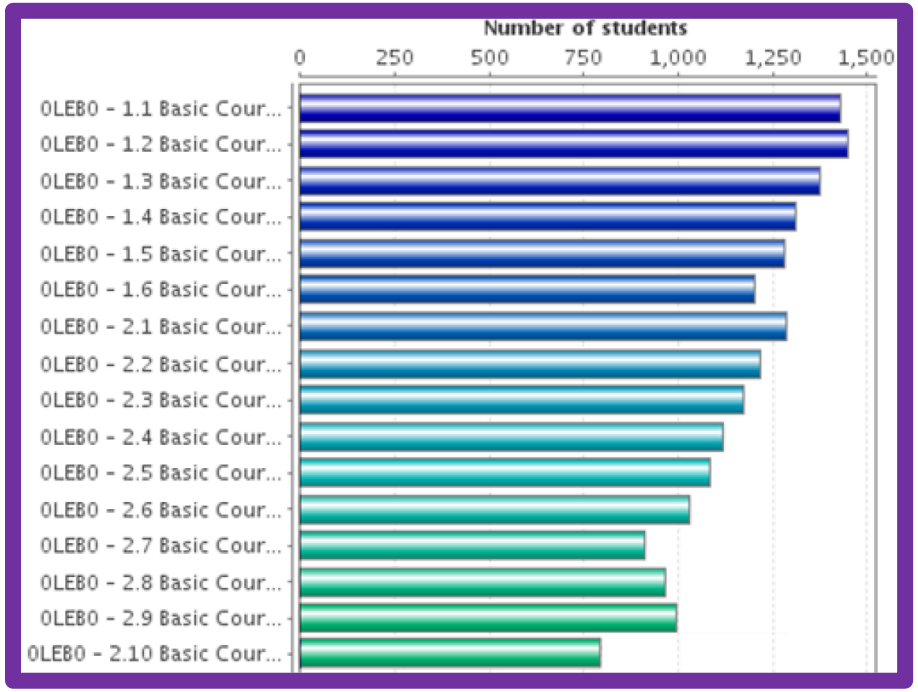
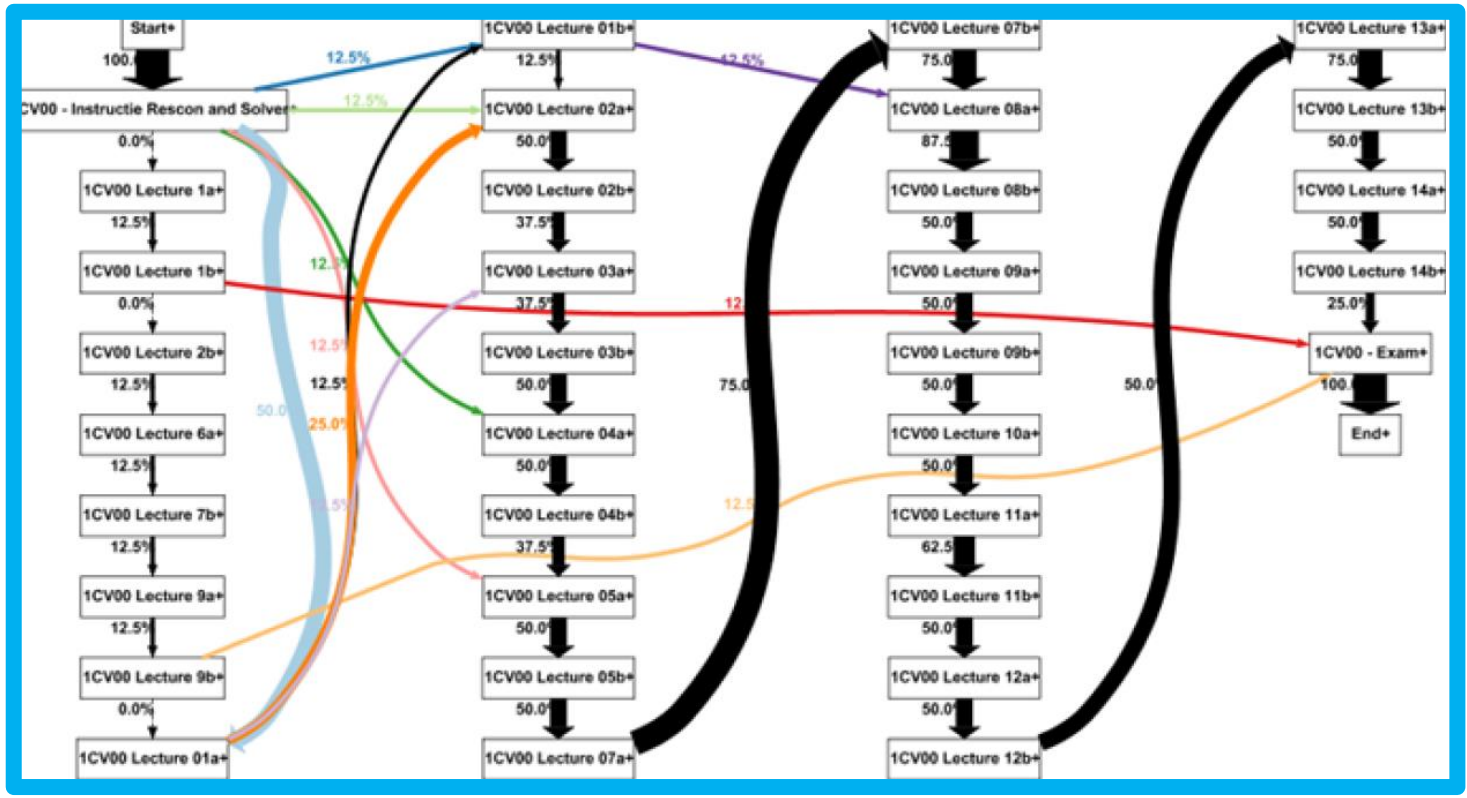


Dropout: data enables analysis



Path of advancement: model vs. actual progress

Bolt et al. SIMPDA 2015

21ST CENTURY NEEDS FOR MASSIVIZING SYSTEMS

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21ST CENTURY NEEDS FOR MASSIVIZING SYSTEMS

MAIN LESSON AFTER 15+ YEARS OF TEACHING? THE TEACHER MATTERS!

Knowledge

- Know the latest greatest fanciest developments in the field
- Students trust knowledge, not slideware

Flexibility

- Mix things that students want to know + have to know
- Students like variety

Adaptability

- Different student types
- Different content types
- Different infrastructure/support/…

Passion and enthusiasm

(preferably contagious)

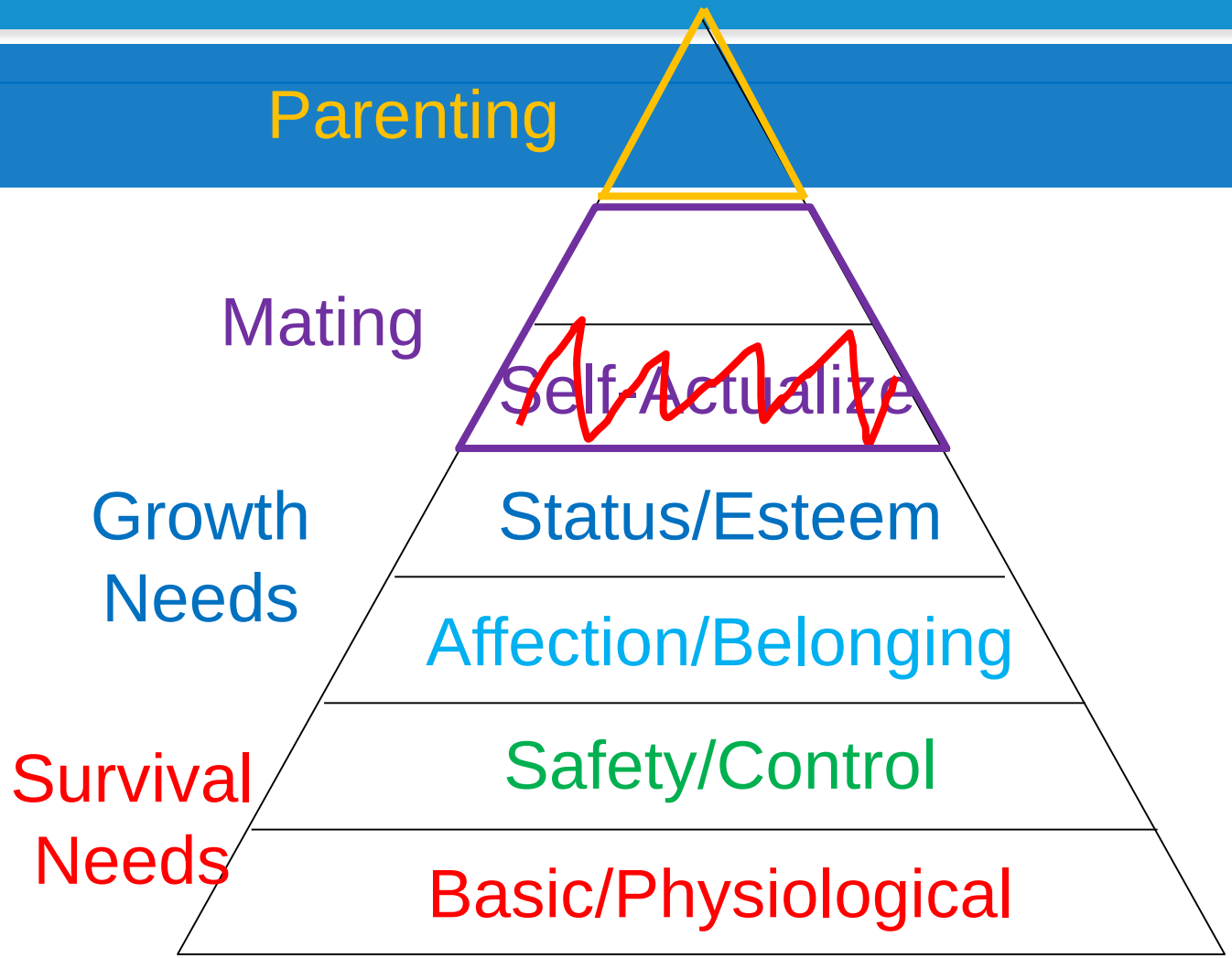
- Students appreciate enthusiasm (even when they don't share it visibly)

After an original idea from Ana Lucia Varbanescu.

21ST CENTURY NEEDS FOR MASSIVIZING SYSTEMS

SO WHAT DO PEOPLE NEED?

Maslow's Hierarchy of Needs* (1943)
+ Kenrick et al.* (2010)



* not scientific, likely invalid
(but still useful for our discussion)

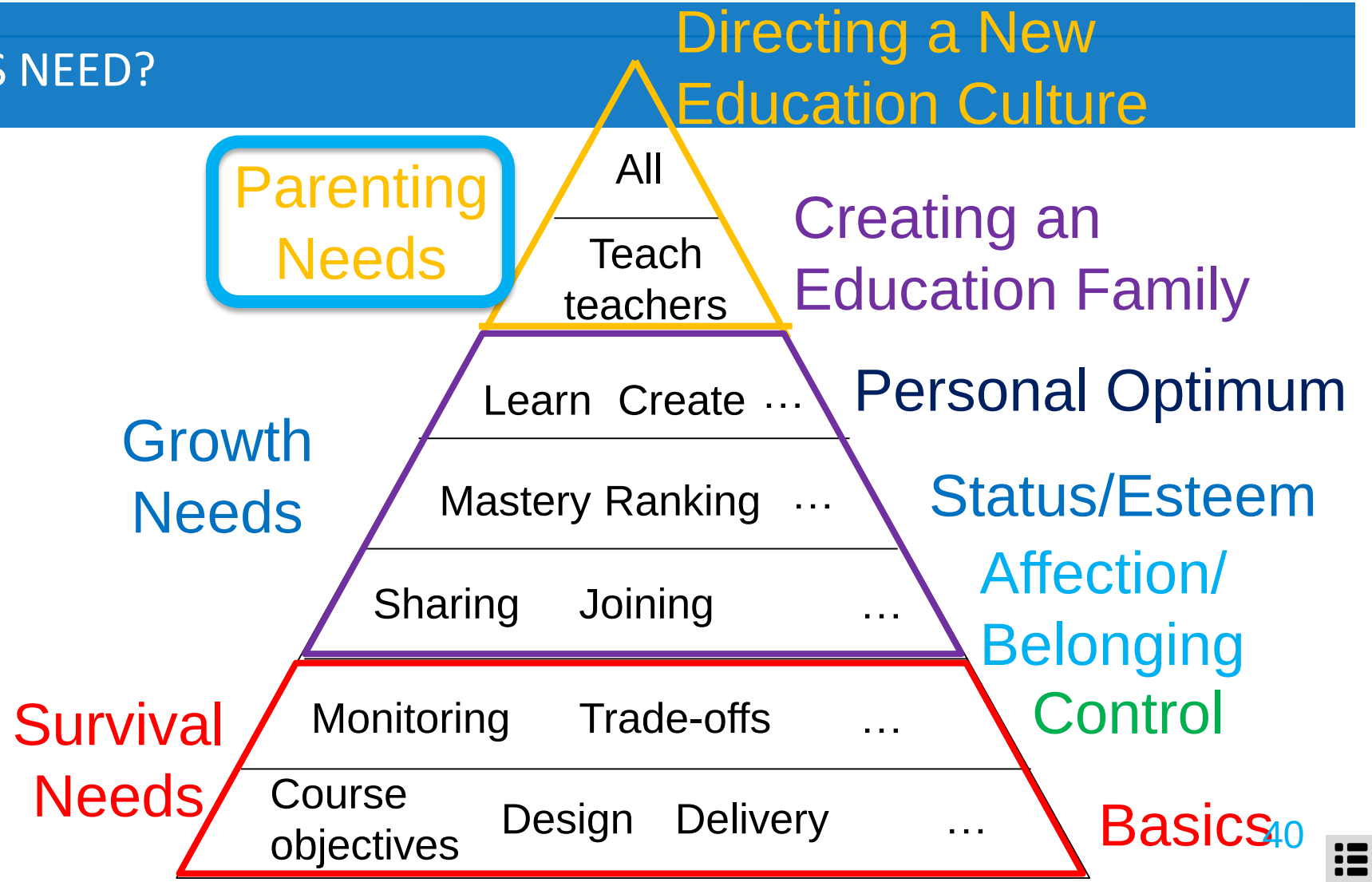
Maslow photo: http://desarrollopersonalefectivo.com/wp-content/uploads/2012/10/abraham-maslow-3.jpg

21ST CENTURY NEEDS FOR MASSIVIZING SYSTEMS

SO WHAT DO TEACHERS NEED?

Iosup's Hierarchy of Needs for Teachers* (2015)

* not scientific



21ST CENTURY NEEDS FOR MASSIVIZING SYSTEMS

SO WHAT DO TEACHERS NEED?

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* not scientific

Parenting Needs

Establish a New Education Culture

- In distributed systems research, 100 citations is a golden standard

But we still need

- EduPar and other ways to disseminate
- The Education Genealogy Project
- Governance for sharing processes
- Tools to advise and collaborate

~40’

On the Future of Higher Education
A Structured Discussion

~5’ — About Our Team & Massivizing Computer Systems

~10’ — The Golden Age of Massive Systems …Yet We Are in a Crisis

~20’ — An Approach to Higher Education: Darwinian and non-Darwinian

1. Curriculum
2. Didactics
3. Technology
4. Management

~5’ — Take-Home Message

ON THE FUTURE OF HIGHER EDUCATION

http://atlarge.science

WHAT DOES EDUPAR-18 CONTRIBUTE?

1. This is the Golden Age of Distributed Systems ...
2. Yet we have a large deficit of skilled people and a crisis in higher ed.
3. Teaching requires Darwinian and non-Darwinian advances

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ON THE FUTURE OF HIGHER EDUCATION

http://atlarge.science

WHAT DOES EDUPAR-18 CONTRIBUTE? LET'S TAKE ONE ARTICLE

1. This is the Golden Age of Distributed Systems ...
2. Yet we have a large deficit of skilled people and a crisis in higher ed.
3. Teaching requires Darwinian and non-Darwinian advances in:
   - Curriculum: 1
   - Didactics:
   - Technology:
   - Management:

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ON THE FUTURE OF HIGHER EDUCATION

http://atlarge.science

WHAT DOES EDUPAR-18 CONTRIBUTE? LET'S TAKE ALL ARTICLES

1. This is the Golden Age of Distributed Systems ...
2. Yet we have a large deficit of skilled people and a crisis in higher ed.
3. Teaching requires Darwinian and non-Darwinian advances in:
   - Curriculum: 3
   - Didactics: 3
   - Technology: 3
   - Management: 0

Homework

Darwinian / non-?

+ Analyze the Posters

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Some articles span multiple categories, were counted multiple times.

ON THE FUTURE OF HIGHER EDUCATION

http://atlarge.science

= DARWINIAN AND NON-DARWINIAN ADVANCES IN CURRICULUM, DIDACTICS, TECHNOLOGY, AND MANAGEMENT

1. This is the Golden Age of Distributed Systems ...
2. Yet we have a large deficit of skilled people and a crisis in higher ed.
3. Teaching requires Darwinian and non-Darwinian advances in:
   - Curriculum: Massivizing Computer Systems means modern DistribSys, etc.
   - Didactics: gamification, etc.
   - Technology: drinking our own champagne, big data, etc.
   - Management: a hierarchy of needs for teachers in higher education

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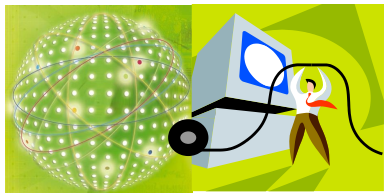
Thank you! Comments, suggestions, questions?

MASSIVIZING COMPUTER SYSTEMS

FURTHER READING ON EDUCATION, MASSIVIZING COMPUTER SYSTEMS

1. Iosup et al. Massivizing Computer Systems. ICDCS 2018 (in print, available online through arxiv.org: http://arxiv.org/abs/1802.05465)
2. van Eyk et al. Serverless is More: From PaaS to Present Cloud Computing. IEEE Internet Computing 2018 (in print)
3. Ilyushkin et al. An Experimental Performance Evaluation of Autoscaling Policies for Complex Workflows. ICPE 2017.
4. Iosup et al. LDBC Graphalytics: A Benchmark for Large-Scale Graph Analysis on Parallel and Distributed Platforms. PVLDB 2016.
5. van Beek et al.: Self-Expressive Management of Business-Critical Workloads in Virtualized Datacenters. IEEE Computer 2015.
6. Ghit et al. Balanced resource allocations across multiple dynamic MapReduce clusters. SIGMETRICS 2014.
7. Iosup and Epema: Grid Computing Workloads. IEEE Internet Computing 2011.
8. Iosup et al.: On the Performance Variability of Production Cloud Services. CCGRID 2011.
9. Iosup et al.: Performance Analysis of Cloud Computing Services for Many-Tasks Scientific Computing. IEEE TPDS 2011.
10. Iosup and Epema. An experience report on using gamification in technical higher education. SIGCSE 2014.

Contact Me or Our Team



Collaboration or discussion about Massivizing Computer Systems:

@Large Research
Massivizing Computer Systems

http://atlarge.science

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WHO AM I?
PROF. DR. IR. ALEXANDRU IOSUP

- Education:
  - Systems Architecture (BSc)
  - Distributed Systems (MSc)
- Research:
  - Massivizing Computer Systems

WHO AM I?
PROF. DR. IR. ALEXANDRU IOSUP

- Education:
  - > Systems Architecture (BSc)
  - > Distributed Systems (MSc)
- Research:
  - > Massivizing Computer Systems

- About me:
  - > Worked in 7 countries, NL since 2004
  - > I like to help… I train people in need
  - > VU University Research Chair
  - > NL ICT Researcher of the Year
  - > NL Higher-Education Teacher of the Year
  - > NL KNAW Royal Young Academy

VU