New Education Perspectives – How to Profile Experts for a Digital Economy Era

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University of Belgrade

Facts & Figures

- More than **200** years of tradition
- **100 000+** students
- **342** study programs
- **64** study programs in English and French
- **31** Faculties
- **11** Research Institutes + **12** Centers
- University Library with **3 500 000** volumes
- One of the **most influential** in the whole Balkans region

Faculty of Organizational Sciences - FON

FON is accredited and matched for the fields:

- INFORMATION SYSTEMS AND TECHNOLOGIES
- MANAGEMENT AND ORGANIZATION

EQANIE

ISO 9001 BUREAU VERITAS Certification

ASIIN

INTERNATIONAL ACCREDITATION

50	6000+	26	170+	19
YEARS OF TRADITION	STUDENTS	STUDY PROGRAMS	FACULTY STAFF MEMBERS	DEPARTMENTS

FON – Applications for Enrolment

2301

Bachelor studies

For 980 places

More than

1000

Master studies

For 660 *places*

FON – Research and Development Hub

RNDHubFOS
RESEARCH AND DEVELOPMENT HUB
FACULTY OF ORGANIZATIONAL SCIENCES

- Represents the place where students and mentors meet in order to share knowledge and skills through research and development projects of the faculty with partner organizations
- Venture an Idea - Route2Launch program, initiated in 2022: mentorship program for students' startups

Research Interests

- **Mision**
  - To be ready and responsible for solving complex System Engineering problems by applying highly formalized approaches and abstraction

- **Two main research directions**
  - **Information / Software system development, Domain Specific Modeling and Languages**
  - **Business Inteligence, Data Warehouse, Data Mining, Data Science**

Research Efforts

- **Information / Software system development, Domain Specific Modeling and Languages**
  - Understanding meta-meta paradigms and models
  - Creating meta-models and languages in various domains
  - Software development methods, techniques and tools
  - Model transformations and software generation
  - Applications in IS, MDSD, and Industry 4.0 domains
- **Business Intelligence, Data Warehouse, Data Mining, Data Science**
  - Performing quantitative data analyses in various domains
  - Understanding Mathematics and Formal Approaches
  - Understanding all the required BI and SE technologies
  - Contributions in Educational Data Mining and Health Care Systems

IIS*Case Toolset

- "Ideal" methods and techniques to develop Information Systems (ISs) are still far from obvious
  - Despite the constant growth of information technologies, as well as
  - Their enriching ISs with novel capabilities
- There are various approaches that may be applied to improve the process of IS development
- Our focus is on the usage of **Model Driven (MD) approaches** and **Domain Specific Languages (DSLs)**
- We have created an approach and Model Driven Software Development (MDSD) tool
  - that provides IS modeling and prototype generation

IIS*Case Toolset

- **Integrated Information Systems CASE Tool Set (IIS*Case)**
  - Conceptual modeling of db schemas, transaction programs, and business applications of an IS
  - Automated design of relational db subschemas in 3NF
  - With special care about several types of constraints
  - Automated integration of subschemas into a unified db schema in 3NF
  - With special care about check and extended check constraints
  - Automated generation of SQL/DDL code for various DBMSs
  - Conceptual design of common user-interface (UI) models
  - Automated generation of software application prototypes
  - Support for Reverse Engineering and Reengineering

IIS*Case Toolset

- **Approach and MDSD tool - Form Type Concept**
  - A model of a user document in an application domain
  - usually, corresponds to a screen or report form of the IS transaction program
  - A specification at the schema abstraction level
  - strict structuring rules are defined
  - A tree structure of component types with attributes and constraints
    - like an XML Schema specification
  - Used by a designer to specify
    - display properties of a transaction program form
    - behavior (allowed operations) of a transaction program
    - initial sets of attributes and database (db) schema constraints

MDSD in Industry 4.0

- **AnyMap Tool**
  - An approach and a framework for the easy integration of technical spaces
    - that heavily relies on DSMLs and MDE
    - Developed in collaboration with University of Leipzig, Software and System Integration Group
    - An application domain: integration of devices and information systems
- **Multi-Level Production Process Modeling Language (MultiProLan)**
  - A DSML for production process modeling in the era of Industry 4.0
    - process models independent of a production system
    - automatic generation of executable resource instructions, contributing to the production flexibility
    - automatic generation and update of the manufacturing documentation
    - creation and management of numerous product and process variations

Data Science Research Efforts

- **Comparing Data Sets Using Graphs**
- **Applications in Educational Data Mining**
  - Analysis of students' performance in regard with seat selection stability and gender at the programing courses
  - A model for identification of performance indicators and quantitative analysis of Serbian academic institutions ERASMUS KA2 / Project PESHES
  - Simultaneous multiple program representations in early education
- **Applications in Health Care Systems**
  - Discovering a predictive model of Early Childhood Caries (ECC)
- **Applications in Agriculture**
  - Humidity level prediction in soil in the irrigation systems

Recent Research Efforts

- **Applications in Educational Data Mining**
  - Dynamic assessment and evaluation of learning outcomes, and
  - Development of an educational recommender system for a generation and reconfiguration of different learning trajectories
- **Applications in Agriculture**
  - Development of a prediction system for effective plant sowing and harvesting scenarios in agriculture
- **Applications in Big Data Analytics**
  - Development of a model for the evaluation of big data analytics maturity of companies, and
  - Development of a recommender system for the improvement of big data analytics capabilities of companies

Agenda

- Motivation
- Findings
- New Education Perspectives
- Final Notes

Motivation – Business Perspective

- **Current state of data and knowledge management in modern business**
  - Acquisition and recording of enormous amounts of data
  - Practically, **exponential growth of the amount** of collected data
  - 15 petabytes of new information is generated every day
    - eight times more than the combined information in all the libraries in the U.S.
    - about 80% of the data generated everyday is textual and unstructured data
      - Ref: [Chiang, 2012]
  - We are facing with the **Age of Big Data**

Motivation – Business Perspective

- **Current state of data and knowledge management in modern business**
  - Data are a great **value** in support of reaching the business goals
  - **Big Data is the next frontier** for innovation, competition, and productivity
    - Ref: [McKinsey 2011]
  - There is **a clear recognition of needs for generating corporate knowledge** from data showed by company management in well-matured companies
    - by means of quantitative, analytical methods
    - so as to be effectively used for decision process and company management

Motivation – Business Perspective

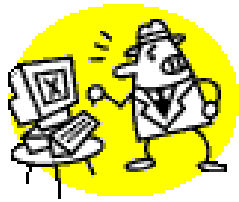
- **Current state of data and knowledge management in modern business**
  - There is a clear recognition of **significant, but unexploited worth** ingrained in stored data
  - Data operationally **used in a short time frame**, and then archived
  - Tremendous amounts of data are available, while **many institutions fail to make efficient use** of the huge amount of data available, or look for patterns
    - Simply because the **business appetite** for doing so **didn't exist**
      - Ref: [Tulasi 2013], [Gartner 2011]
    - The main obstacle to use advanced data analytics is the **lack of understanding** how to apply it
      - Survey presented in Ref: [ADA 2019]

Motivation – Business Perspective

- **A great discrepancy problem: business needs vs. IT capabilities**
  - Significant needs for generation of corporate knowledge from data, on one hand side
  - Inability of modern software products to effectively address these needs, on the other hand side
    - despite that huge amounts of data already exist
    - modern IT tools provide excellent technical capabilities
- **A new form of Software Crisis**
  - **Never ended and present even for decades!**
- We can call such phenomenon a **Big Data Crisis**

Motivation – Business Perspective

- **Main Causes of Big Data Crisis**
  - **(A) Unsatisfactory level of organization maturity** regarding the capacities for
    - information management and corporate knowledge management
    - business processes and institutionalization
    - quality management
  - **(B)** Unsatisfactory level of accumulated **knowledge in a problem domain**
  - **(C)** Unsatisfactory level of accumulated **knowledge in a domain of computer science, software engineering, and data science**
    - for development and formal specification of models for software products
    - aimed at generation of company knowledge and decision support



Motivation – Business Perspective

- **Addressing Big Data Crisis Causes**

- **Strategic and long-life task**
  - Effective by simultaneous addressing all its significant causes

- Addressing (B) and (C) causes is an important endeavor related to the **formal academic education**

Motivation – Business Perspective

- **Addressing Big Data Crisis Causes**
- Endeavor related to the **formal academic education**
- Strong motivators to raise the level of
  - **Interdisciplinarity and multidisciplinarity in profiling students' knowledge**
  - **Abstraction and formalization skills**
  - **Quantification, metrics, and analytical skills**
  - **Specification, implementation, and integration skills**
  - **Management, communication, and soft skills**
  - **Problem domain skills**
    - Ref: [Luković 2020]

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Academic education for Data Science

- **Always hot issues in CSI&SE**
  - Computing, Computer Science (CS) &
  - Informatics (I) &
  - Software Engineering (SE)
- In what extent is it:
  - "self-contained", interdisciplinary oriented, or applied?
- What is a level of overlapping with other disciplines?
- How to constitute high quality study programs
  - to meet the balance between two extremes
  - to satisfy current and future needs of industry

Academic education for Data Science

- What are the industry **needs** today / in future?
- **A common property of**
  - Well-developed IT HR market
  - Under-developed / developing IT HR market

As a rule, it seems that **interdisciplinary oriented professionals** are always welcomed and **better positioned**!

Academic education for Data Science

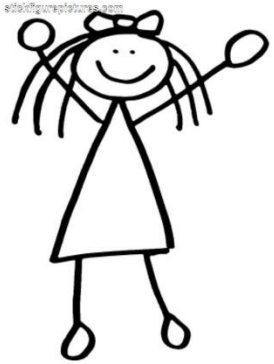
- What are the industry **needs** today / in future?
- **Significant changes at the technology-related job market**
  - over recent years
  - mainly due to technological advances
  - pushed industry toward new demands for skilled professionals
- **A gap between industry needs and professional profiles**
  - available in the job market
  - difficulties to find employees who meet the required profile
  - resulting in financial loss
  - extra training expenses
    - Ref: [Goulart 2021]

Academic education for Data Science

- Absence of almost any high education strategy leads to:
- ⇒ Total leaving the academy to the operational market laws
- ⇒ **Paradox**
  - We incline to **creating more "self-contained"** courses, and consequently almost "pure" professionals
  - the culture of interdisciplinary orientation is usually poorly developed
    - interdisciplinary education is **most likely in experiment phase**
    - no consensus **how to evaluate the outcome** of interdisciplinary education
      - Ref: [Yao 2019]
- However, **interdisciplinary oriented professionals are better** positioned
    - the culture of interdisciplinary orientation is to be nurtured from "early ages“

Academic education for Data Science

- **One more paradox experienced**
  - Many students and even lecturers believe that IT employers will give a job, project or money to CSI&SE professionals for the following reasons:
    - **They require high-educated or well-skilled HR**
      - for example, because "we are particularly good programmers, or software engineers"
    - "We can resolve them a problem that they currently have"
  - However, the reality is **far from such believe**
    - the employers search for those professionals that can **recognize and address** exactly their **complex requirements** or **wishes**
    - they need a complete, "packed", and optimized solution
      - as fast as possible, as cheap as possible
      - without any care if you are a perfect mathematician, programmer or economist



Academic education for Data Science

- **Traditional taxonomy of education and research areas**
  - In some countries (e.g. in Serbia)
  - Very rigid
  - Commonly applied in the academic accreditation process

  - **Science and mathematics**
  - **Engineering and technology**
  - **Social science and humanities**
  - **Medicine**

Academic education for Data Science

- **Current state of CSI&SE**
  - In general, three categories of CSI&SE study programs, as a support for data science
  - **Specific CSI&SE programs**
    - At faculties of CSI&SE or (electrical) engineering
  - **Programs in Mathematics / Applied Mathematics (AM)**
    - At faculties of sciences
  - **Programs in Economics, Business Administration and Management (EBAM)**
    - Business informatics at faculties of economics, management or business administration

Academic education for Data Science

- **Current state of CSI&SE**
  - **Three typical patterns of students' behavior**
    - come from longtime experiences collected in lecturing in the area of CSI&SE, from programs of all the three types

- **Behavioral patterns of „not joinable worlds“**
  - **(A) CSI&SE students**
  - **(B) AM students**
  - **(C) EBAM students**

Academic education for Digital Economy

- **The same patterns are general - not just for Data Science**
  - **Digital Transformation (DT)** - a movement to **Digital Economy (DE)**
  - **Driven by changes** in
    - **Business models**
    - **Culture**
    - **Behavior of individuals**
    - **How technology is driving and driven by these changes**
  - It is much more driven by the first three factors, supported by IT
    - as it has been driven by advancements in technologies themselves

Strategy, Not a Technology, Drives Digital Transformation

- Ref: [Kane 2015]

Academic education for Digital Economy

- **Open questions**
  - In such circumstances, **who will maintain the "interfaces"** between various disciplines?
  - Therefore, we need to systematically educate **interdisciplinary oriented professionals**
    - capable of creating interconnections between various disciplines
    - with a satisfactory deep level of knowledge of details
- Can high education in CSI&SE address this issue successfully?
  - **Personal view (2013):** the best chances are for such orientation
    - both in the areas of **business and organization systems** and **scientific computations**

Academic education for Digital Economy

- Can high education in CSI&SE address this issue successfully?
- **ChatGPT (2024):**
  - Education in CSI&SE can be **closely related to digital manager skills** in several ways
    - **Strong technical foundation** and **problem-solving mindset** are crucial for effective digital management
    - By aligning the **technical expertise** from CSI&SE education with the **strategic and operational skills** required for digital management, professionals can effectively lead DT initiatives and drive organizational success in the digital age
  - By evolving the classical education approaches in CSI&SE
    - Ability to better prepare graduates for the **multifaceted role** of digital managers in modern companies
    - Equipping them with **business acumen**, and **leadership skills** required to drive DT and innovation

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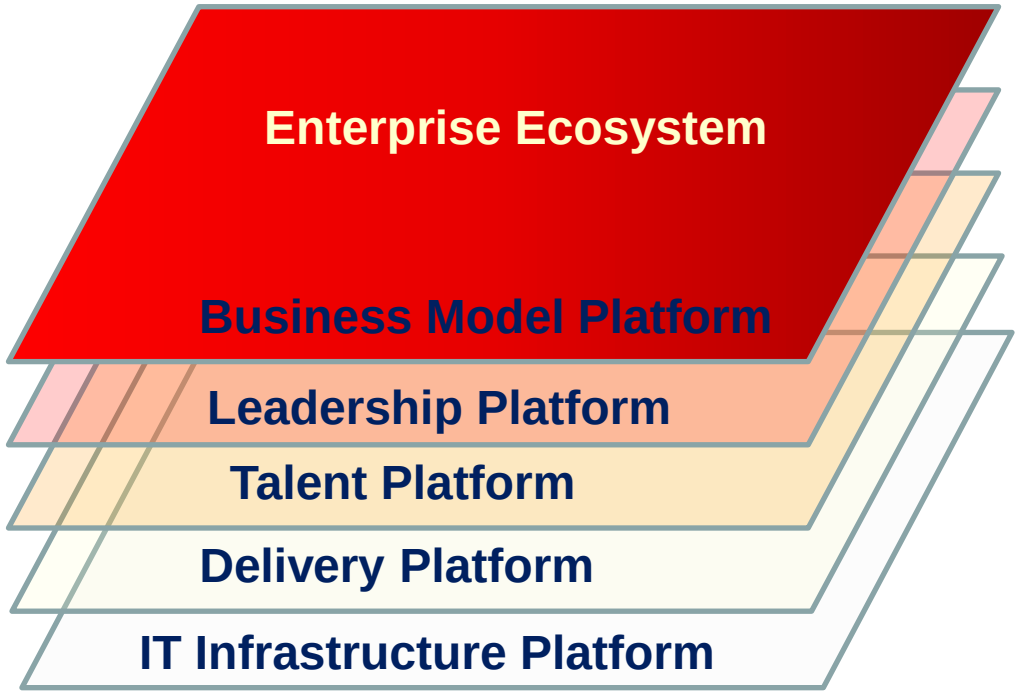
New Education Perspectives for DE

- **Movement to DE by deployment of DT principles**
  - Creates a power for organization **(disruptive)** transformations
  - Scaling from digital experiments and pilots to digital best practices
  - Development of **new digital platforms** – strong requirement
    - Ref: [Kočović 2019]



New Education Perspectives for DE

- **Development of new digital platforms**
  - **Strong demands for DE experts** of a new profile
  - Capable of **high-quality support** of the DT process
  - Workforce skills – **the most difficult barrier** for building organizational capabilities for DT
    - Ref: [Synergy 2019]
- Academic Education **should be subjected to the DT** process
  - To come to the **strategic** goals
    - necessary to support movement to DE and effective production of Digital Managers
  - Overcome **Digital Talent Gap**
  - **Transformations** to come the new digital 5-layered platform
  - **Adjusted priorities** of academic education and training of teachers
    - Ref: [Azoev 2019]

New Education Perspectives for DE

- **Academic Education**
  - **The first-class entity** for profiling DE experts – **Digital Managers**
  - It should be combined with additional ways of education
    - short courses, trainings of various forms, company schools / universities
  - Priority: **Integration of university and corporate education**
    - corporate universities provide ultra-modern, but not systematic enough and fundamental education
    - classical universities are still far from modern society education and new teaching technologies
  - Priority: Universities become **drivers of DT** of society and economy
    - universities, their technology parks, and business incubators together with teachers are to contribute to the development of (youth) startups
      - [Kovalev 2018]

Curricula Transformation Approaches

- **Starting with a CSI&SE curriculum**
  - produce highly technically proficient digital managers
  - who can bridge the gap between technology and business
- **Starting with an EBAM curriculum**
  - produce managers with strong strategic and operational skills
  - who can understand and leverage technology
- **Hybrid or Integrated approach**
  - Create a curriculum from scratch
  - Unify existing CSI&SE, EBAM, and possibly AM curricula
- Outputs:
  - interdisciplinary programs, joint, double, or dual degrees
  - collaborative courses

Curricula Transformation Requirements

- **General requirements to the transformed CSI&SE curriculum**
  - **Interdisciplinary Curriculum**
    - Traditional CSI&SE programs **focus heavily on engineering and tech subjects**
    - Integration with business management, digital marketing, and leadership courses
    - Integration with mathematics (algebra, discrete math, probability theory) and statistics
    - **More holistic** educational experience
    - Engineering and CSI&SE
      - the fields where interdisciplinary and multidisciplinary **education has room to grow**
      - Ref: [Nambisan 2017], [Heikkinen 2018]
  - **Project-Based Learning**
    - Not only theoretical knowledge and isolated coding projects
    - Real-world **project-based learning**
    - Work on multidisciplinary teams, **simulating the collaborative environment**
      - Ref: [Helle 2006]

Curricula Transformation Requirements

- **General requirements to the transformed CSI&SE curriculum**
  - **Soft (Non-Cognitive, Metaskills) Skills Development**
    - Focus not on technical skills only
    - Incorporating soft **skills training**, such as communication, teamwork, leadership
    - Emphasizing effective communication, conflict resolution, team management
  - Skills for DT era
    - Entrepreneurial vision, creative ability, holistic vision, focus on collaboration
    - Ethics and social responsibility
    - Codes and programming
      - Ref: [Goulart 2021], [Robles 2012], [Keegan 2001]
  - **Industry Partnerships and Internships**
    - Strengthen **partnerships with tech companies and startups**
    - Internships, co-op programs, collaborative projects
    - Experience and networking opportunities

Curricula Transformation Requirements

- **General requirements to the transformed CSI&SE curriculum**
  - **Continuous Learning and Adaptation**
    - Not just fixed curriculum with a static set of courses
    - Culture of **continuous learning** and **adaptability to the team-work**
    - Flexibility in offering **elective courses** on emerging technologies
    - Providing access to **online resources**
    - Encouraging **participation in workshops and conferences**
  - **Entrepreneurship and Innovation**
    - Courses on entrepreneurship, innovation management, and startup ecosystems
    - Inspire students to **think creatively and rationally**, and take risks
    - Allowing staying ahead of digital trends and **implementing cutting-edge solutions**

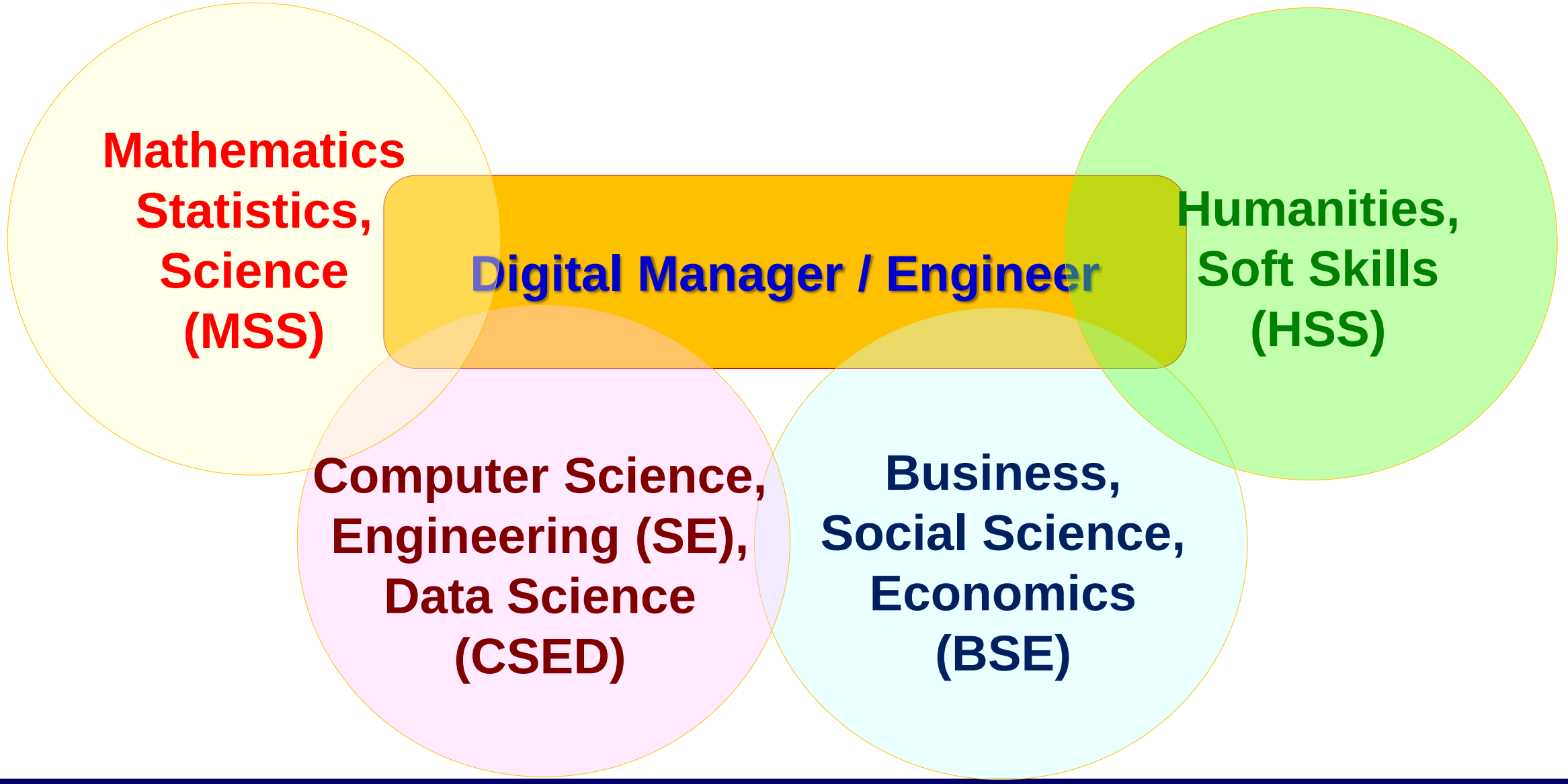
Curricula Transformation Requirements

- **General requirements to the transformed CSI&SE curriculum**
  - **Analytical Thinking and Data-Driven Decision Making**
    - Not only coverage of data structures and algorithms with limited application to business contexts
    - **Advanced courses** in data analytics, machine learning, business intelligence, decision theory, operational research, optimization methods, stochastic processes
    - Emphasizing applications in **strategic decision-making**
  - **User Experience (UX) and Design Thinking**
    - Integrate UX design, HCI, visualization methods, and design thinking courses
    - Emphasize the **user-centric product development**

Curricula Transformation Requirements

- **General requirements to the transformed CSI&SE curriculum**
  - **Cybersecurity and Compliance**
    - Foster cybersecurity education and culture
    - Include topics on regulatory compliance, risk management, and ethical considerations in digital management
      - Ref: [McCrohan 2010]
  - **Mentorship and Networking**
    - Mentorship programs to connect students with industry professionals and alumni
    - Provide a guidance and career advice

Curricula General Structure Areas



Curricula General Structure

- **Body of Knowledge – General Categories**
  - a not necessarily complete list of offered knowledge
  - **Computer Science, (Software) Engineering, Data Science**
    - All core CSI&SE disciplines
    - Algorithms, Computational Intelligence and Machine Learning, HCI, Software Engineering, Information Systems, DevOps, Cyber Security
    - UX and Requirements Engineering, System Engineering, Decision Engineering
    - Formal Methods, Domain Specific Modeling and Languages, Model-Driven Engineering, Conceptual Modeling, System Thinking
  - **(Applied) Mathematics, Statistics, Science**
    - Calculus, (Linear) Algebra, Discrete Mathematics, Graph Theory, Combinatorics, Logic, Probability and Statistics, Stochastic Processes, Operational Research, Optimization Methods, Data Series Processing
    - Physics or relevant science disciplines for a problem domain

Curricula General Structure

- **Body of Knowledge – General Categories**
  - a not necessarily complete list of offered knowledge
  - **Business, Social Science, Economics**
    - Domain knowledge and Customer Experience (CX)
    - Focus areas across physical and social sciences
    - (Quantitative) Finance, Financial Engineering, Marketing, Fundamentals of Economics
    - Organization Design, Management, Strategic Thinking
  - **Humanities, Soft Skills**
    - Communication, Critical thinking, Adaptability, Problem-solving, Leadership, Creativity, Innovation

      - Ref: [Synergy 2019], [Capgemini 2013]

Overcoming Digital Talent Gap

- Recognized skills of Digital Manager / Digital Engineer
  - Analytics, Big data
  - Digital strategy, Financial Modeling
  - Digital marketing
  - Security, privacy, risk, compliance
  - Smart product development
  - Software development
  - Web/mobile development
- **Critical skills gaps** for DT identified
  - Ref: [Synergy 2019]

Soft Skills in Overcoming Digital Talent Gap

- **Altro-centric leadership**
  - An other-centered leadership style, adaptive leadership
  - Mandatory to support DT as a disruptive process
- Increasingly important soft skills
  - empathy, humility, integrity and compassion, integrity, creativity
  - human–ethical sense of judgement to AI's data-driven information and judgments
  - **Managers' focus on**
    - coaching, motivating and empowering employees
  - **Engineers' focus on**
    - algorithmic management practice, particularly supported by AI and GAI methods
    - handle quantifiable managerial tasks and quantitative performance evaluation
      - Ref: [Henderikx 2022]

Soft Skills in Overcoming Digital Talent Gap

- Majority of executives consider **soft skills increasingly** important
- There are studies suggesting that **both soft and hard skills** are needed
- **Key leadership skills**
  - communication skills, language knowledge, organizational skills
  - subject-specific knowledge
  - digital literacy, self-reflection
- **Executives are to be**
  - emphatic, open-minded, flexible, motivated, and stress tolerant
    - Ref: [Klus 2020], [Klus 2021]

Soft Skills in Overcoming Digital Talent Gap

- **Behavioral leadership skills**
  - motivational skills, team-building skills, and emotional intelligence
  - remain **core abilities** of managers
    - Ref: [Kluz 2016], [Henderikx 2022]
- **Digital Intelligence (DI)**
  - All employees, including managers, **should develop DI** as an ability to
    - learn digital technologies
    - deal with digital technologies appropriately
    - read, decode and manipulate digital information
    - acquire and apply new knowledge and skills connected to digital technologies to
      - address insights and openness
      - improve operational efficiency and outcomes
      - Ref: [Boughzala 2020], [Henderikx 2022]

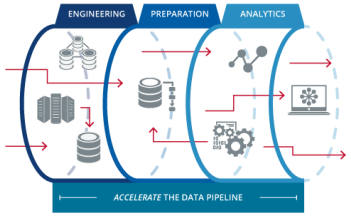
CIO Skills in Overcoming Digital Talent Gap

- CIOs gain new roles in DT process
  - Ref: [Kočović 2019]

Past	Future
Focus on IT outcomes	Focus on business outcomes
Sequencing of operations	Creating collaborative agenda
Support	Overcoming the unconquerable
Costs control	Developing of the income plan
Process Reingeneering	Data utilization
Outsourcing	Design of business
Focus on functions	Focus on platforms
Searching for parity	Searching for differentiation
In the scope of IT sector	Everywhere in the organization
Focus on IT risks	Focus on business risks

Digital Manager / Engineer Roles

- Some possible **‘LEGO’ business roles** of interest
  - Digital Product Manager
  - Digital Business & Finance Manager
  - Digital Sales & Marketing Manager
  - Digital UX / CX Engineer
  - Digital Operations Engineer
  - Business Analyst
  - ML Engineer, Data Scientist, Data Analyst
  - System (Design) Engineer
  - Data Engineer
  - Cyber Security Engineer
  - DevOps Engineer, Software Engineer



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Final Notes

- Addressing Big Data Crisis Causes and challenges of DT
  - **Strategic and long-life task**
- Facing the era of Digital Economy requires
  - A new profile of **Digital Manager / Digital Engineer**
  - Significantly **transformed formal, academic** education
- A **new and more effective** form of academic education is
  - **inline with the DT** principles
  - with clearly defined **education (business) strategy**
  - well combined with high quality **alternative forms** of education
  - evident **multidisciplinary / interdisciplinary** orientation
  - implemented through **highly flexible education** models and curricula structures

Final Notes

- **Highly flexible education** models and curricula structures
  - Support of **all four curricula areas: MSS, CSED, BSE, HSS**
    - In a designed % of share in the whole structure
    - At all study levels (including B.Sc., M.Sc., Ph.D. studies)
    - % of share **may vary slightly**
      - **customized** to the general roles of **Digital Manager** and **Digital Engineer**
  - Curricula **areas are mandatory** rather than sole courses
    - Very few mandatory courses, e.g. max. 1 per each semester
    - Selection of a great no. of courses in each of the four mandatory areas
    - Students are forced to select courses from each of the mandatory areas
      - in a designed extent
    - Students are rather free what courses to select from each mandatory area

Final Notes

- **Highly flexible education** models and curricula structures
  - Classification of courses according to **the level of rigor** and prerequisites
    - Basic, Intermediate, Advanced
    - Prerequisites for each intermediate and advanced courses are clearly defined
      - with no sharp requirements
    - Students are forced to select courses of all three levels, in a designed extent
  - ‘**Default’ profiling of students**
    - By the **Matrix Business Roles / Curricula Areas**
    - The matrix cells are organized in various ways
      - recommended numbers (or %s) of basic, intermediate, and advanced courses in the area
      - recommended individual courses appropriate to a business role
      - recommended %s of share of each of the four curricula areas
  - **Proactive mentorship of students** in their profiling

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End of Presentation

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