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Documentation of pilots

Digital Manufacturing, TalTech

Spring, 2020

Integrated Engineering Curricula

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Introduction

This document contain the documentation of Digital Manufacturing Course, conducted in spring 2020 at TalTech. The document contains a description of the settings and the motivation of the case, as well as an overview of the key performance indicators (KPIs) for the pilot. The execution and documentation of pilots are part of larger process, named Educational Framework, aimed at transforming educational programmes for future Industry 4.0 capabilities. The case/pilot is chosen based on two initial analysis, respectively focused at industry and the institution. For further information regarding the overall process, please see the document 'Educational Framework'.

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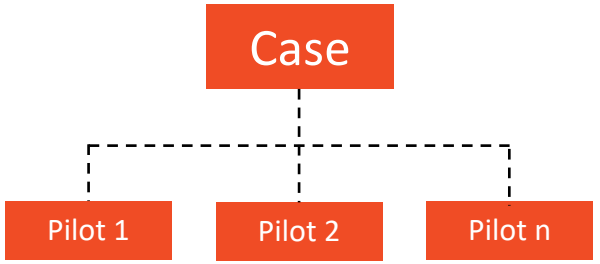

Fig. 1. The figure shows the relationship between the two terms: *case* and *pilot*.

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Description of the pilot (summary)

This pilot represents a course named: Digital Manufacturing that is taught at the educational programme of “Integrated Engineering” in TALTECH. Students from design, manufacturing, ICT and logistics (EQF level 5), and secondary school graduates can enrol into this educational programme. The education is at EQF level 6 (bachelor’s degree) with a total study load of 180 ECTS in the nominal study period of six semesters (3 years). This pilot is a 6 ECTS course, taught during the fourth semester under the module of Information Technology.

In this pilot, our aim is to develop the knowledge and skills for the applications of digital manufacturing principles that can be useful in the enterprises. The topics covered during the course are: Industry 4.0 trends and future technologies, Introduction to Virtual Reality (VR) and Augmented Reality (AR), cyber security in digitalization, understanding of automated production systems and layout creation in the virtual environment, digital Manufacturing tools to support robotic process simulation, and Machine Vision: recognition of technological objects. The pilot includes three hours class per week that combines 1.5 hour lecture and 1.5 exercises. Lecturers start with theory part and support with case studies and best practices on digital manufacturing.

The success criterion of the pilot is to enhance the interdisciplinary knowledge regarding digital and smart manufacturing, as this field is still relatively new and multidisciplinary itself. The competencies among the manufacturing students should still be expanded, with topics that they were not familiar with beforehand, while also bridging the knowledge gaps between the other fields.

The need to enrich the interdisciplinary knowledge was concluded from the industrial analysis, which pointed towards interdisciplinary knowledge as a necessity, where multidisciplinary is the enabler of implementing integrated systems rather than isolated stand-alone solutions. Furthermore, the digital mind-set of the manufacturing students can expand by the integration between manufacturing systems and ICT tools.

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Description of the pilot (summary)

The course, Digital Manufacturing, is based on the following learning goals from the curriculum:

Knowledge:

- Applied theory and methods for the applications of digital manufacturing principles and industry 4.0 trends, concerning the enterprise organization and systems, and the ability to reflect up on the business implications.
- Develop knowledge of the practical and theoretical contents during a group/project work.

Skills:

- Use tools and methods to identify and analyze the implications of technological issues regarding manufacturing and logistics, and to investigate the integration of product, process and information systems.

Competencies:

- Handle innovative, complex and practical-oriented problem solutions for production and applications of technology in an industrial setting.
- Identify own learning needs and develop knowledge skills and competences in their own discipline as well as interdisciplinary.

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KPIs and how they are measured

Based on the aim of pilot, three focus areas are identified and consider to be viable, through KPIs. The three focus areas are: 1) The student's ability to identify new learning needs related to digital manufacturing, 2) the student's ability to integrate the use of digital manufacturing tools into their project, and 3) Organization of the course/pilot study.

Identified KPIs and methods for measuring

1. The student's ability to identify new learning needs related to digital manufacturing

   At the start the course, the students are asked to identify their own learning needs and expectation in writing. The students own identified learning needs are afterwards compared to the results of a project report (prepared by students) at the end of the course.

2. The students' ability to integrate the use of digital manufacturing tools into their project

   During an evaluation after the course, the students' ability to integrate the digital manufacturing tools in the production process development is evaluated by the lecture and an examiner with experience from industry.

3. Organization of the course/pilot study

   Through a mandatory institutional evaluation after the semester, the students are asked to evaluate, how the course is organized and how it can be improved in future.

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Implementation of the Educational Framework

Educational activity sketch

The course is consist of 16 lectures, a lecture per week. Almost each lecture rely on a computer-based classroom, where the students will have to gain knowledge by using course relevant software applications, and the lecture will be targeting discussion, hands-on experience of digital tools and supervision.

In the first lecture, the lecturer introduces the content of the course, including the tasks. Furthermore, the self-study for all lectures will be presented, consisting of reading materials and videos material.

In the remaining lectures, the students are expected to have prepared for lecture, and the task of the day will be presented. The task will show a detail of the specific digital manufacturing tool and technique, and part of the assignment is to describe how these sub-tasks can be applied to their project.

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Implementation of the Educational Framework

Relation to Authentic Task Design

The educational framework is implemented through a case with an ill-defined output, which the students must integrate into the course project report. The course takes place over the 16 weeks, which lets the students investigate the problem field for several different perspectives and describe and implement relevant course material into their semester projects.

Groups formed by the students solve the task, concerning both personalities (tested by the Insights profile tool) and based on their backgrounds. The case topic is the use of studied digital manufacturing tools and techniques to solve the task and compile a report. Students will gain the opportunity to implement their domain-specific knowledge into the project report.

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Implementation of the Educational Framework

Elements

The learning process is iterative, as the students will get an overview in the first lecture, and the knowledge will be expanded in each lecture in the same topics.

Blended learning and computer-based class – the students will receive learning content online through a TalTech Moodle environment so that they can have access to the study material during the class. This gives room for more insightful feedback.

Supervision and feedback – The reflection will be facilitated through feedback, both in class and online TalTech Moodle platform or by TalTech SIS – Study Information System.

Simulation with context – The students will meet the context either physically, or through TalTech Moodle environment, or in the computer-based class.

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Results and Evaluation

The pilot was executed as per plan. However, there were some changes in terms of organization due to the COVID-19, as our university premises was closed for the regular physical studies. We turn to online lectures and exercises via MS Teams, students responded the change effectively and adopted the online environment quickly. The course included the topics of Introduction to Industry 4.0 and related technologies, Introduction to VR/AR, 3D layout configuration and simulation, Machine vision – recognition of technological object. Each topic associated with a online quiz or a practical assignment (solve a case study – authentic task), students need to do the assignments with the help of a particular software application. Hence, there is a learning of a software application and task to perform in that application. Finally, students combined and linked their all assignments and prepared a report as a group work. Moodle (e-learning) platform was used to for sharing the study material and assignments. The submission of assignment and quizzes attempt were also organized via moodle. Moreover, moodle use to communicate the grading and feedback to the student works which was convenient and instant for both teacher and students.

Students able to learned: how to create a digital environment for virtual reality, how to configure a robotic cell layout for production scenario and simulate it, how to use machine vision application for objects detection. Furthermore, they able to gain the knowledge of application and importance of Industry 4.0 and related technologies and how it can impact the business of a company in future. Computer lab and FMS & robotic demo centre (flipped classroom environment) were used to carried out these learning activities. But after the lockdown due to COVID-19, the students provided the software application license key and other sources for the access of required applications to complete their assignments.

Students showed positive intend to learn different digital tools, taught during the course and able to relate those tools for industrial application. Also students actively participated in the learning of digital tools that were used for the organization of the course.

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Results and Evaluation

1. Identified learning needs related to digital manufacturing course at the beginning

- Students' background
  - Integrated Engineering, Robotics, Mechanical Engineering
- Students' expectation and learning needs
  - I expect to have more practice than lectures and something connected to robotics
  - To know more about digital technology
  - Learning VR and AI
  - Engineering mind
  - Learn practical things or learn how to use some software etc. hands-on learning.
  - A better understand of digital and manufacturing application
  - I would like to gain some practical knowledge in Digitalisation and Automation
  - Learn how to develop digital system in manufacturing
  - Everything that teachers teach
  - How to make games

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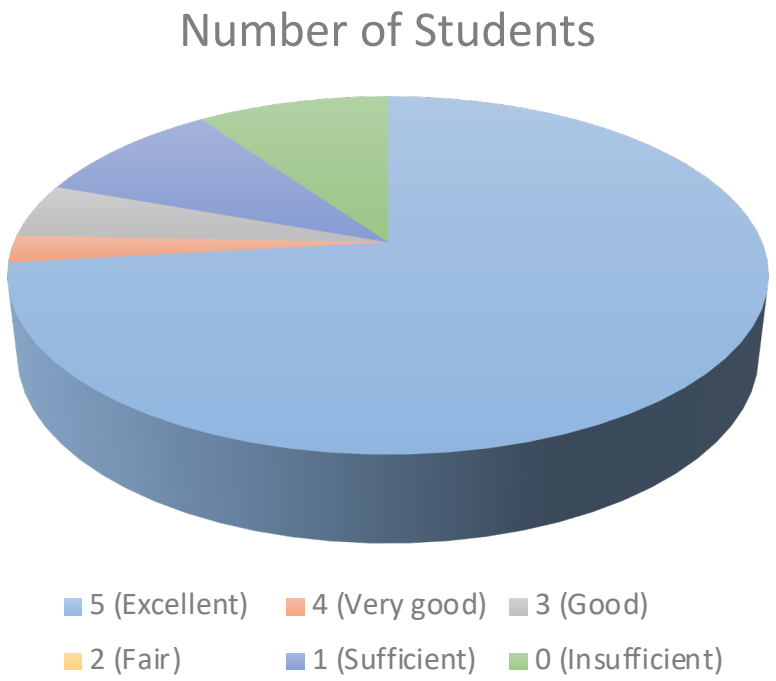
Results and Evaluation

2. Students' ability to integrate the use of digital manufacturing tools into their project

- Total number of students participated → 41
- Completed the course successfully → 33
- 80% positive results
- 73% with maximum grades



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Results and Evaluation

3. Organization of the course/pilot study

- Mandatory feedback after the course by students (Still on going)
- Some comments from students:

a. “I was able to achieve all the goals of this course and more. It exposed me to what integrated engineering is truly about which is the integration of modern technologies into modern day engineering.”

b. “I am highly impressed with the learning outcome of this course. However, more practices should be organized for visual component and machine vision learning. The videos sent to students on visual components simulation and yolo machine vision task was quite useful; I will recommend more videos of such be introduced.”

c. “In general, I liked this course as it gives experience in software programs.”

d. “Overall, all of the home assignments were useful due to the fact that they were related to very specific places of implementation of technologies.”

e. “Due to the COVID-19 situation, actually visiting the company was not possible this time. If available, it would benefit more to understand real world industry issues and approach.”

f. “I can honestly say that this course shows the sense of Integrated Engineering program, because it connects engineering and digitalization.”

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