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Documentation of pilots

Digital Manufacturing PD&R, TalTech

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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 **"Product Development and Robotics"** 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 **3rd semester** under the module of **Machine Control**.

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 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/or 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 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 decided to adopt hybrid learning and encouraged the online lectures instead of 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 (project report) as a group work. TalTech 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 TalTech Moodle. Moreover, TalTech 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 scenarios and simulate them, 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 due the to COVID-19, mostly learning/teaching organized online, therefore, 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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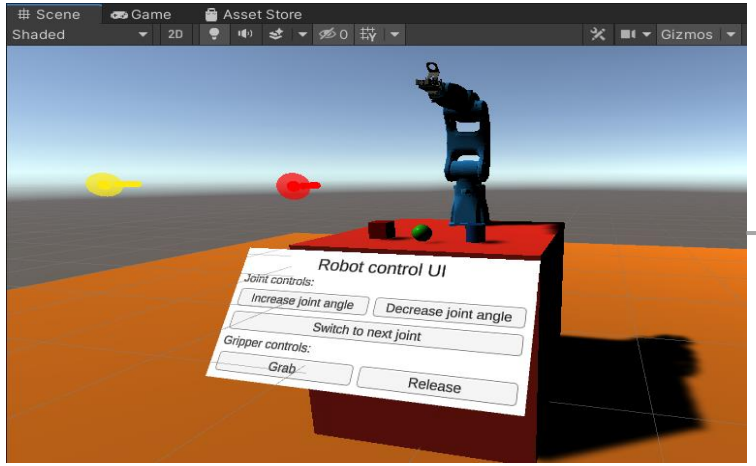
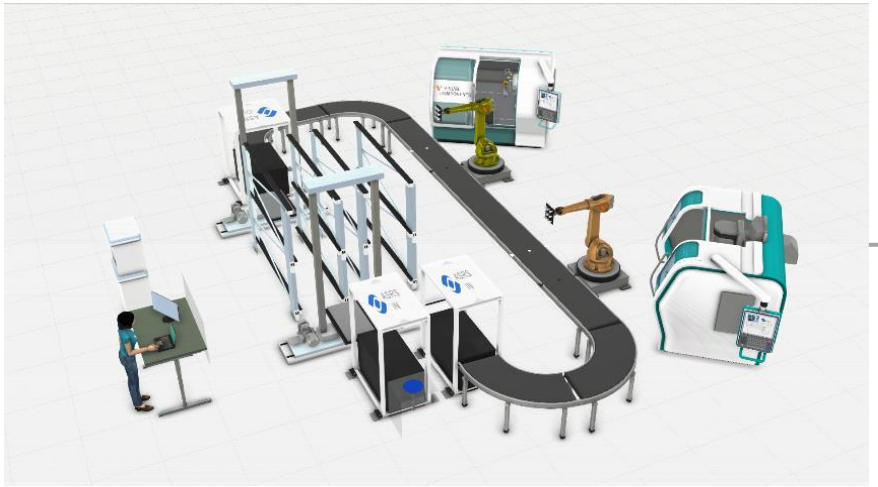
Results and Evaluation

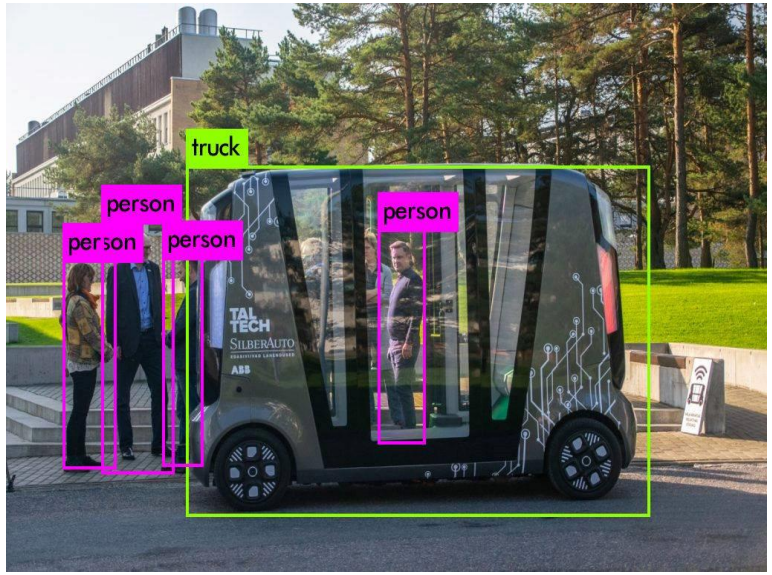


Example of a student's assignment related Virtual Reality (VR)



Example of a student's assignment related to robotic layout configuration and simulation for virtual production environment

Demo center (lab) for hands-on experience of VR related tasks



Example of a student's task related to Machine Vision – object detection

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Results and Evaluation

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

- Students' background
  - Product development and robotics
- Students' expectation and learning needs
  - To get more knowledge about digital manufacturing and Industry 4.0
  - To find some simple and cheap ideas to develop in our company
  - AR/VR basics. Object/person recognition and identification. 3D modelling basics
  - To get new knowledge and have a great team work
  - To learn new fascinating skills to use in the future
  - To see machines working with AR/VR
  - Do have better knowledge about digital technology/Industry 4.0
  - I hope, I can understand everything, I learn
  - Learn how to use new software and in which way the industrial processes are getting more automatized
  - I would like to learn how to implement new computer technologies into industrial manufacturing processes.

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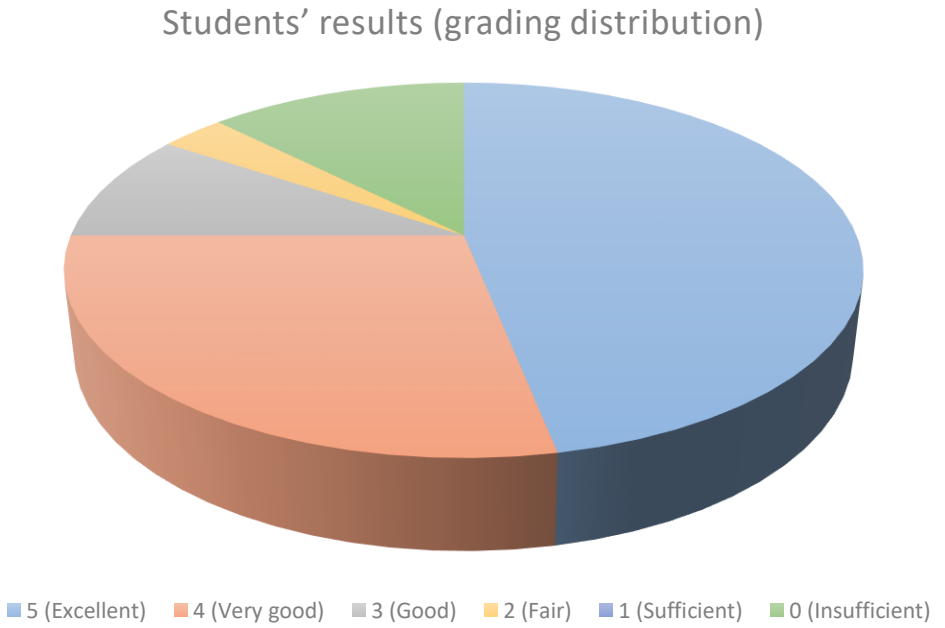
Results and Evaluation

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

- Total number of students participated → 32
- Completed the course successfully → 28
- 87.5% positive results
- 47% with maximum grades



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Results and Evaluation

3. Organization of the course/pilot study

- Feedback after the course by students
- Some comments from students:

a. “The knowledge acquired during this lecture has been really important to enrich the actual basics of Industry 4.0, I have learnt that the word Digital Manufacturing has a really large range of knowledge behind.”

b. “During the course we learned a lot of new things, it was also quite surprising to see, what we can do in manufacturing virtually. It did give us a good experience and overlook of how we can save time and do every detail virtually.”

c. “We were able to try out some technologies related to Industry 4.0, in this process we also learned about the difficulties that can occur during the learning without prior knowledge of IT programming.”

d. “We would like to say that this course and all the homework topics were interesting and useful. We learned a lot of new things and learned how to use several programs.”

e. “My knowledge on Industry 4.0 and digitalization has been enhanced hugely. It has also to be said that I did not have any previous knowledge about it and I have discovered some tools that I find really useful.”

f. “This course was fun. We have learned so many new things and to use new programs. We have done programming, Unity, AI training, robot simulations in Visual components, learned about industry 4.0 and many other things.”

g. “The course gave a good overview of digital manufacturing methods that will be useful in the future. My recommendation is to assign more lessons to machine vision task, as many students who have no IT background had problems to understand.”

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