Co-funded by the Erasmus+ Programme of the European Union

VIRTUAL LEARNING FACTORY TOOLKIT

# Virtual Learning Factory Toolkit

## Output 2

## Summary

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## *Output 2: Virtual Learning Factory – Development of the Curricula*

The aim of this intellectual output (O2) is to create, implement and test the use of the Virtual Learning Factory (VLF) toolkit developed in O1 for the engineering courses, first piloted and tested on Master's curricula in three partner institutes (TalTech, POLIMI and SZTAKI) at the end of the first year of the project. In the following years, VLF toolkit was primarily tested among the students from POLIMI and TalTech. It is mainly due to the COVID-19 effects that the third institute wasn't directly engaged in the testing of the toolkit. However, SZTAKI helped to develop a virtual environment (gamification environment) for the experimenting and testing of digital tools, which was quite demanding and useful for conducting the joint learning labs online (remotely). No new curriculum was developed, but existing curricula' study outputs are improved based on the labor market needs to acquire more and more ICT skills.

The teaching and learning approach adopted is the action-based paradigm, where groups of students address a real manufacturing case taking advantage of the new VLF tools. Moreover, students from different institutes were interacted to address different aspects of the manufacturing problem under study, within a common and integrated perspective. This interaction was operated remotely for a period of about 3 months taking advantage of emails, video-conferencing systems, messaging environment as well as other project management tools, i.e., Trello. It means that learning and testing of the digital tools were practiced in two phases. During the first phase, students worked independently at their home institutes and interact remotely via conference calls. In the second phase, students were involved in the joint learning lab where a complete demonstration of the approach adopted and the use of the tools was provided and discussed together with the supervisors. During the Joint Learning Lab (JLL) students were asked to work together by exchanging information, improving their skills and learning from each other. The students were divided into mixed groups considering the technical skills and the activities they already addressed during the first phase. Each group addressed a specific use-case while adopting the reference workflow and the following main tasks:

a) Formal modelling and defining production (assembly) processes of use-cases by using OntoGui digital tool.
b) Discrete Event Simulation (DES) for performance evaluation by using Java Modelling Tool (JMT). Prepared a procedure for the automatic generation of a DES model using JMT, starting from the model developed with OntoGui for the use-cases.
c) 3D modelling, visualization and animation for products and systems associated to the use-cases. 3D scenes were generated via Unity3D and VEB.js tools and CAD models were created through solid modelling software and open source libraries. The animated output was visualized by means of VR.

This activity facilitates to increase the learning and teaching productivity in education of engineers by establishing an interdisciplinary and intercultural team of students and supervisors from different European universities.

Each year, a cohort of 15 students (5 Master's students from each partner university) took part in this activity, together with at least 2 supervisors (professors) from each partner of the project. During the first year JLL, 5 students from each POLIMI, TalTech and SZTAKI (altogether 15 students) participated. Three supervisors from POLIMI, two from each TalTech, SZTAKI and CNR took part as well. The first JLL was held onsite (with physical attendance) at SZTAKI for a week. However, due to COVID-

19, the second and third JLL were held online via the Microsoft Teams platform. In the second JLL, the same amount of students (altogether 16) were participated, 13 students from POLIMI and 3 from TalTech. Likewise, 17 students took part in the third JLL, 11 from POLIMI and 6 from TalTech. Besides that supervisors (tutors) and evaluators from each partner institute participated and provide support to students. The primary theme addressed during JLLs was the activities in manufacturing. Secondarily, the use of the developed framework and digital tools in different application areas can also be considered. Specifically, health care and services in general are the primary alternative application options.

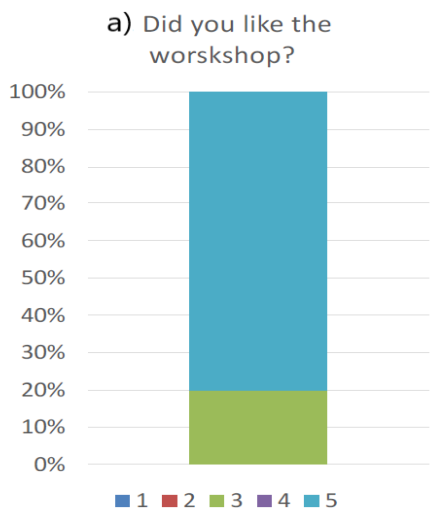
During and immediately after each Joint Learning Lab, the assessment of the tools and the activities was carried out through questionnaires to the students. The collected feedbacks and comments were used to improve the tested digital tools and approaches as well as input requirements of the development of the new digital tools. Herein, we report the results after the first and third joint learning lab.

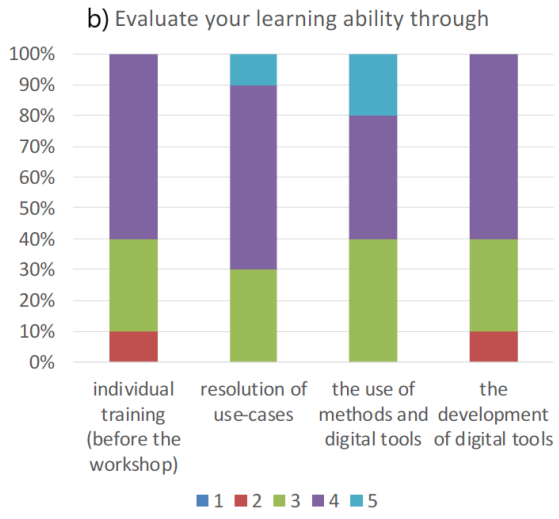
*Students Feedback for onsite (1st) joint learning lab*

The survey consists of questions related to the experience and learning outcome

a) General appreciation for the workshop
b) Learning ability
c) Learning level reached
d) Self-evaluation

The results of the survey are reported in Fig. 1, where the satisfaction of the students is expressed in a 1-5 scale: 1 = Very dissatisfied, 2 = Dissatisfied, 3 = OK, 4 = Satisfied, 5 = Very satisfied.



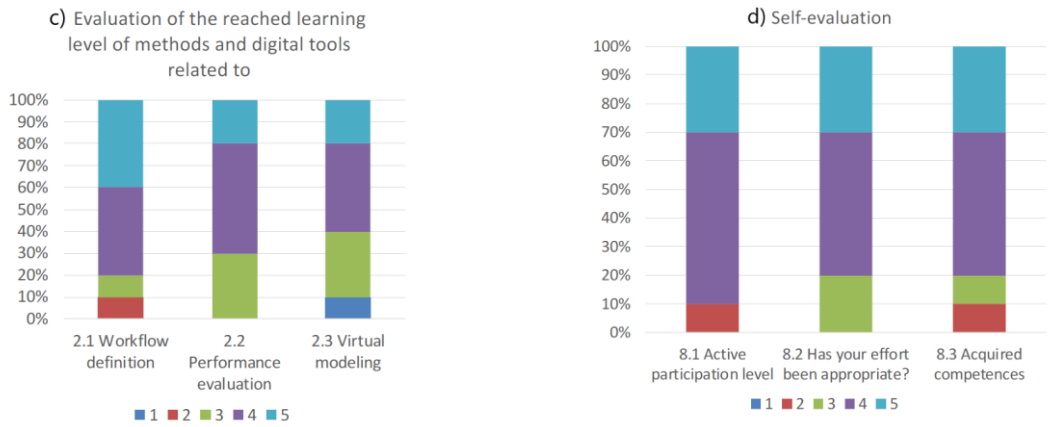



Fig. 1: Graphical representation of students' feedback about the onsite (1st) workshop

Overall, it can be concluded that the student workshop was satisfactory. Students have learned, contributed and tested the digital tools and methods. However, there were few shortcomings like in the learning outcomes of the digital tools used with respect to workflow definition, performance evaluation and virtual modelling. It was also observed that there were some missing competencies related to programming and the integration of digital tools. Moreover, communication and cooperation skills were considered as very necessary aspects in team work.

*Students Feedback for online (3rd) joint learning lab*

The 3rd students' workshop was carried out online and accomplished the planned activities. The feedback of students was collected through a questionnaire, which is based on but not limited to the following elements.

- Ability to learn
- Ability to achieve your goals
- Model production system by a structured approach
- Overall, satisfied with the quality of this learning lab

The results of the online students' workshop are reported in Fig. 2 and were expressed in 1 – 5 scale: 1 = disagree, 2 = somewhat disagree, 3 = Neutral, 4 = somewhat agree, 5 = strongly agree.

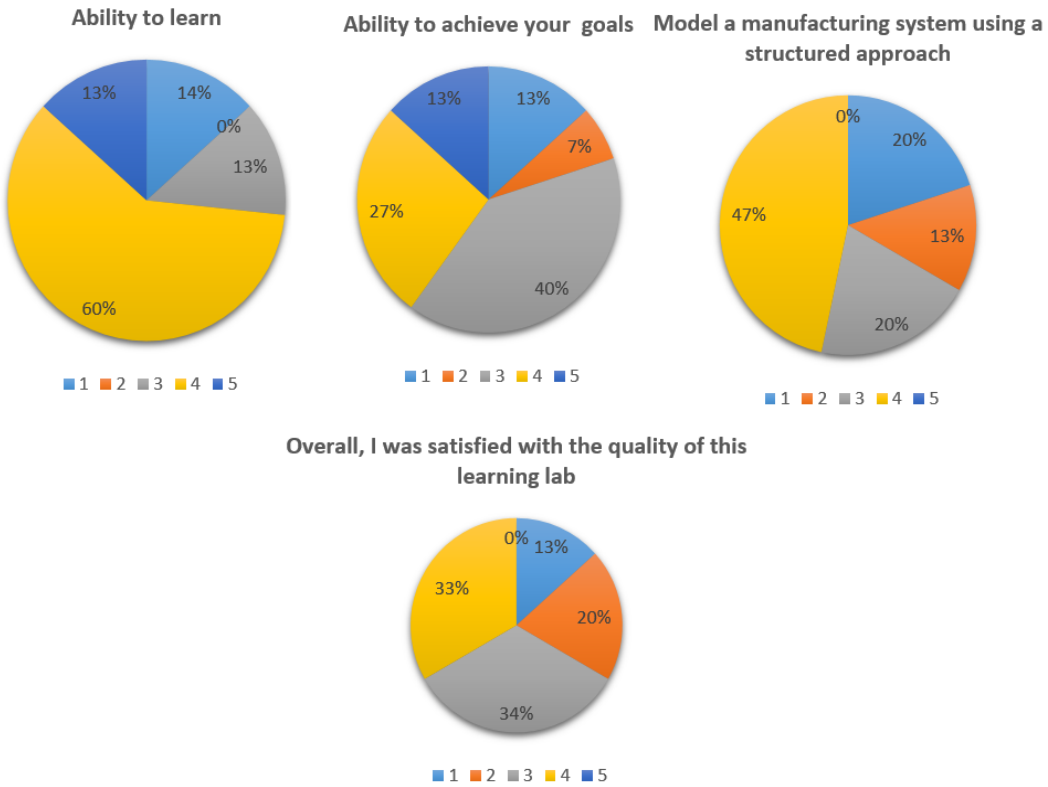



*Fig. 2:* Graphical representation of students' feedback about the online (3rd) workshop

It can be commented that the students have achieved learning objectives related to the use of digital tools for modelling manufacturing systems, with different levels of competence and experienced interesting collaboration among different institutions. However, according to the feedback provided by the students, the online organization of the workshop was a significant barrier to discussion and collaboration, compared to meet in person. Indeed, online meetings were not helpful to start the collaboration among students because of ineffective communication and coordination.

The content of the following existing curricula tend to be improved with the VLF toolkit:

1) Industrial Engineering and Management (TalTech, international curriculum in English) - https://www.ttu.ee/studying/masters/masters_programmes/industrial-engineering-and-management/.

2) Mechanical Engineering (POLIMI, international curriculum in English) - https://www.polimi.it/en/programmes/laurea-magistrale-equivalent-to-master-of-science/

3) Following are the list of courses where the new VLF toolkit was experimented and to be integrated in. For testing and piloting Master's level was chosen as all studies are carried out in English.

1. Production Digitalization course – Industrial Engineering and Management curricula – TalTech
2. Mechanical Engineering curricula - POLIMI

In the future, the VLF toolkit can also be integrated into various Bachelor's degree curricula such as:

- Integrated Engineering curricula – Department of Mechanical and Industrial Engineering, TalTech.

All activities of Output 2 were carried out in 3 phases (Phase 1 in 2019, Phase 2 in 2020 and Phase 3 in 2021), in each phase testing and piloting focuses on a pre-defined element of the new VLF toolkit. In each phase collaboration of trans-national teams was organized in distance (3 months using the labs of each partner university) and then concluded by a 5-days intensive JLL at 1 selected university. The first one was held with physical attendance but the following two were held online due to covid-19 as indicated above.

**Joint Learning Lab Events**

Joint Learning Lab 1: May 26th, 2019 – June 1st, 2019 (physically at SZTAKI, Budapest, Hungary), 15 students participated (TalTech – 5, POLIMI – 5 and SZTAKI – 5).

Joint Learning Lab 2: June 9th, 2020 – June 12th, 2020 (virtually via MS Teams), 16 students participated (TalTech – 3, POLIMI – 13).

Joint Learning Lab 3: May 17th, 2021 – May 21st, 2021 (virtually via MS Teams), 17 students participated (TalTech – 6, POLIMI – 11).