Co-Created Talent Design towards Industry 4.0 Transformation

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Abstract
Co-creative talent design between universities and industry is often a challenging journey in practice, especially in times of rapid transformations. Bridging knowledge gap from science to innovation and business requires seamless flow between organisations and people in order to create new knowledge, expertise and inspiration. Industry 4.0 transformation calls for even more intense collaboration and dialogue between universities and companies for skills renewal and update.

TAMK's Technology Academy provides a flexible and agile way to co-design and implement mechanical engineering curriculum and to include emerging technology deployment. Topics are selected based on real commercial needs, and the projects are implemented in modern Industry 4.0 innovation infrastructure enabling novel stream of trials and experiments promoting industry driven collaboration and co-creation. This practical approach aims at increased dialogue, university-industry co-creation and enrichment of innovative ideas to foster seed of novel concepts in their path towards real-life solutions and markets.

Technology Academy approach encourages industry and universities jointly to co-create and co-innovate new technologies. The approach takes advantage of university open access infrastructure available as part of the knowledge transfer process and platform to co-create jointly, simultaneously providing understanding of future needs for curriculum development and revisions.

According to interviews, Technology Academy approach provides a practical way to create new added value by bringing together university staff, students and companies. Technology Academy fosters skills and talent creation for the benefit of all stakeholders. Simultaneously, by bringing the universities and companies more closely in continuous dialogue it can boost unexploited innovation ideas with an open entrepreneurial mindset while simultaneously leveraging level of skills and capacities.

Keywords
Co-Creation, Skills, Innovation Capacity, Entrepreneurship, Transformation, Industry 4.0

1 Introduction

1.1 Main problem addressed

Europe faces new challenges in capitalising the opportunities offered by new key emerging technologies related to Industry 4.0. Transformation through Industry 4.0 implies not just purely digitising existing individual products, services or parts of production and manufacturing processes. Firstly, the huge amount of sensor-gathered data must be processed by AI and other advanced technologies to convert the data into useful information. Secondly, this information must be harnessed to extend the partial transformation to systemic level change merging the entireness of manufacturing and production, purchase, sales, maintenance and life cycle services, subcontracting networks, and whole ecosystems including novel business models building on circular economy. Only in this way, Industry 4.0 can leverage the true added value and competitiveness of European industry.

Being able to fully exploit these new technology opportunities requires advanced and transformed digital skills, often marked as ICT specialist skills, and their agile adaption to industry-specific competences, especially to this applies to field of intelligent machine industry. These skills can be also named as Digital Competences 4.0 to reflect the direct dependency on Industry 4.0 (Puurtinen, 2018). In addition to defining the new contextual essence of these skills and competences, it is also obvious that the shortage of adapted digital expertise needs to be addressed rapidly (COM(2016) 0381 final).

Creating favorable circumstances for universities to respond to the future skill needs clearly indicated by the industry is an urgent challenge. Flexible curriculum together with project-based pedagogy proposes a solution. As stated by Krajcik (2008), There is a shift in pedagogy to make science learning meaningful and more focused on learning science by doing science. Project-based, industrial collaboration driven learning approach is also solution for new era Digital Competences 4.0 as referred above.

1.2 Main goal of the paper

As a response to these challenges, Tampere University of Applied Sciences (TAMK) has designed a new Technology Academy approach in its mechanical engineering curriculum. The Technology Academy builds on close collaboration with industrial partners and embeds the needed agility for the skill and competence targets as well as implementing the learning process.

The objectives of the Technology Academy are:

› Quick and agile adaptation of selected emerging technologies in development projects including company collaboration driven by professional interests
› Project management skills in multidisciplinary environment, demonstrating leadership skills together with quality and customer priorisation
› Intrapreneurship and entrepreneurship with creativity and innovation capacity building

In this paper, we focus on co-creative curriculum design, but same concept can also be widened into extension studies, lifelong learning and continuous upgrading of skills and competences.

1.3 Structure of the paper

The structure of this paper is following. In Section 1 Introduction, we present the main features of the problem addressed as well as the main goals and objectives of the present paper. Section 2 Setting the Scene provides the reader with a wider framework to be investigated in this context, presenting the challenges and opportunities offered by the rapid global and regional change of the operational environment. In Section 3, we explain the main features of the novel Technology Academies co-designed and implemented between Tampere University of Applied Sciences and its company partners, with a practically oriented glance on the concrete actions taken in our university. Section 4 Results presents a short overview of qualitative findings illustrating the main benefits and lessons learnt of the approach from the point of view of different stakeholders. Finally, in Section 5 Conclusions and Recommendations, the outcomes of the assessment of the approach so far are concluded. In addition, we point out some risks concerning the approach as well as bring forward a few aspects to be further investigated and evaluated.

2 Setting the Scene

Industry is the backbone of the European economy. As stated by the European Commission, Europe's global competitive advantage in high value-added products and services translates to more than 20% of the EU's total value-added, with industry directly providing 35 million jobs. Competitiveness, prosperity and wellbeing of Europe and its citizens requires a large variety of measures to support the digital and green transformation of EU industry, as reflected and ambitiously targeted in the new EU Industrial Strategy package published in March 2020 (COM(2020) 102 Final) highlighting also the need for quintuple helix collaboration between university, industry, government, public and environment originally introduced by Caryannis (2012).

As also highlighted in the mid-term review on the implementation of the Digital Single Market Strategy, employment of ICT specialists in the EU has grown by around 2 million over the past 10 years. However, for example in 2018, 53% of companies trying to recruit ICT specialists reported difficulties in filling vacancies. [COM(2017) 228 final]. Hence, several practically oriented endeavors launched by the EC such as the European Institutes of Technology (EITs) and the proposed Digital Europe Programme aim to solve the same challenges.

The challenge is, however, not only existing at European level. As emphasised by e.g. the European Committee of Regions, the regional smart specialisation strategies play an important role in supporting the competitive competence level in regional fields of strengths and their future prospects.

The smart specialisation strategy in Tampere Region, Finland, includes four spearheads, namely digitalisation of industry, smart city solutions, circular economy, and services and systems for health and wellbeing (Älykkään erikoistumisen strategia Pirkanmaalla, 2017) Another significant strategy guiding the industrial policy directions at local level in Tampere Region, Tampere City Region Business Strategy launched in November 2019, also underlines the importance of Industry 4.0 in general and the smart manufacturing and technology in particular for the local economy (Tampereen kaupunkiseudun elinkeinostrategia, 2019).

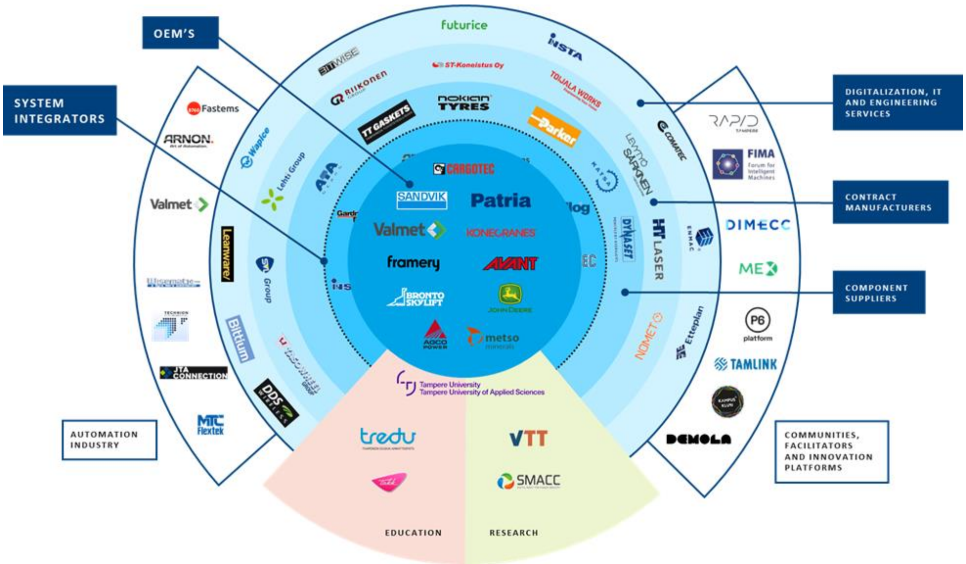


Fig. 1: Intelligent machines & automation ecosystem in Tampere Region (Business Tampere 2020)

Overall, Finland has a stable political and financial climate and investment support is available through Business Finland. Other success factors support the attractiveness of Tampere Region as an investment region (Smart Tampere Programme, 2020). Tampere Region provides favourable and stable investment climate for industrial companies. World-class education and research to support R&D is available enriched by multi-disciplinary research, education and R&D expertise. In this creative industrial driven ecosystem new Tampere University Community (TUNI) offers world-class research and education in different engineering fields. Novel technologies are also integrated in smart city developments projects as demonstrated by the Smart City Lab (SCL) project which is a joint program of the TUNI community in Tampere to create a pool of smart city experts to support Tampere Smart City strategy implementation, including Industry 4.0 implementation. SCL model manages and coordinates knowledge transfer and bridging the gap between research work and real-life solution need, hence from science to innovation and business as described by Puurtinen (2019).

Thus, for universities there exists urgent need for upgrading and updating of skills related to agile, future-oriented adaptation of digital technologies, e.g. digital twins supporting simulations, virtual factory and IoT data exploitation. Hence, the transformation induced by Industry 4.0 is directly reflected in inevitable and rapid curriculum renewal in universities, where essential role is played by co-creative talent design jointly with companies based on openness and constant dialogue. In addition to co-creating new ways of teaching and learning, the companies are equally engaged in continuous and iterative quality assessment procedures assuring that the students and lifelong learners acquire the necessary advanced digital skills needed for the deployment of the key advanced technologies.

3 TAMK Technology Academy Approach

Learning is not dependent of classroom-oriented environment. However, it can be stimulated by proper, well-designed learning environments (platforms), including online environments, combined with guidance and support. Online, hybrid, and blended learning are recent trends in higher education which allow effective pedagogical methods to benefit students, instructors, and universities. Furthermore, as noted by Tucker King (2018), they highlight the importance of journaling for the instructor to reflect, note questions, revisit design decisions, and document solutions for future courses, requiring planning as well as content design and development so that as a result collaborative design and assessment can benefit students, faculty and university. Learning and creation of new competences are also accelerated with idea storms between and inside teams. In these platforms, students are given the possibility to use laboratories openly, share devices, methods and ideas thus enabling learning and encourage for innovations and trials and even exploiting arising business opportunities.

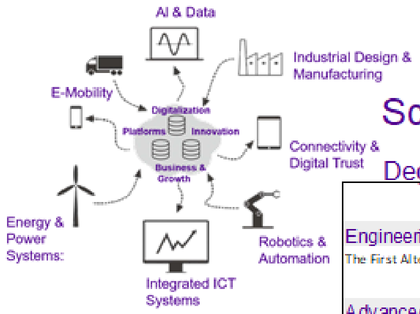
New approach empowers students to take responsibility of their learning, but also requires changes among the university staff, meaning not only renewal in the mindset of teachers and lectures, but also curriculum revisions which have been implemented in Tampere University of Applied Sciences (TAMK). TAMK is a higher education institution focused on promoting innovation. TAMK provides its learning environment and infrastructure for business and entrepreneurial development cooperation to promote commercialization and innovation. In this paper, we will reflect the co-created Technology Academies in TAMK from three different viewpoints:

› Positioning Technology Academies within mechanical engineering curriculum and reflecting them as agile enhancers of IoT and digitalisation skills in the competence development of mechanical engineer students
› Technology Acdemies benefitting TAMK's modern learning environments/infrastructure as a driver of studies towards innovation, entrepreneurial trials and business & start-up skills in real environments and piloting capabilities
› Co-designing and piloting with Industry as an effective enabler and promoter of university-industry collaboration, leading to increased work life skills and competences within all participant groups, namely students, teachers and company employees

These flexible and agile curriculum topic revisions together with emerging technology deployment based on real commercial needs implemented in modern Industry 4.0 innovation infrastructure enable novel stream of trials and experiments promoting industry driven collaboration. Experiences and implementation feedback have been documented by participant interviews.

3.1 Positioning technology academy within mechanical engineering curriculum

TAMK, in the field of mechanical engineering, has formed Technology Academy approach. In these Technology Academies, new Industry 4.0 enabled technologies are applied in student projects implemented in TAMK FieldLab, which is a test and prototyping environment for Industry 4.0 applications. This Technology Academy approach has strong industry collaboration together with professional and economic interests.



School of Industrial Engineering

Degree Programme in Mechanical Engineering

School years	cr	1	2	3	4
Engineering Competences of Study Path					
The First Alternative Project Course in Mechanical Engineering					
Technology Academy, part 1	5			x	
Advanced Competencies of Study Path					
The Second Alternative Project course in Mechanical Engineering					
Technology Academy, part 2	5				x

Fig. 2: Technology Academies in Curricula

Technology Academy project themes are yearly selected based on current industrial trends and industry partner needs. At the moment the selected Technology Academy themes are formed around the following topics:

› Robot Academy: Co-Creation and implementation of projects where applications of robot automation and cobotics, such as robotic and light robot applications, are in focus.

› Drone Academy: Co-creation and implementation of projects where development of drones and their applications are in focus

› Productisation Academy: Co-creation and implementation of projects where digital product development and manufacturing, including Product data and lifecycle management and utilization of Digital Twins are in focus

› Virtual Academy: Co-creation and implementation of projects where virtual reality and augmented reality technologies together with IoT applications are in focus.

More and more collaboration with industry is taking place in the form of project implementation. Previously, this has been typical for final thesis and internships where TAMK has had an established method and offering but it is not enough anymore. Nowadays, an increasing number of enquiries are made by the industry regarding student-based task forces to solve a problem or fulfil a short-term resource gap in product development. And naturally, as is characteristic for this era, with an urgent time schedule.

At the same time, there is a strong need for TAMK to continue the renewal of student project crediting (ECTS) as part of the curriculum design. New approaches and methods are called for on how students can advance their studies while working and connecting with industrial companies, potentially their future employers. Project-based co-design with industry provides this opportunity, especially in the field of specialization within degree program of Mechanical engineering. From the curriculum point of view, these studies are located in the later part of the degree, i.e. duirng 3rd and 4th study year, when a certain specialization level is already reached.

In addition to student gaining a deeper understanding of the technology topic implemented and being able to apply this knowledge in project, learning targets for the participating student is also to learn and understand broadly the main principles, concepts and tools of project activities. As a target, after the completion of Technology Academy courses, the student is able not only to justify and apply his/her learning, but also to critically evaluate his/her own solutions. The students are highly motivated, committed to taking responsibility for his/her own performances and are able to systematically use feedback as a tool for professional growth. In addition, the students can support and guide other fellow students (specialists).

3.2 Benefitting modern learning environments/infrastructure

The Technology Academies utilise TAMK's OpenLab learning environment and open access mindset. OpenLab is TAMK's engineering innovation area & labs supporting knowledge sharing and learning. It focuses on supporting and enabling student's industrial projects, (e.g. intelligent machine projects) and students' collaborative learning workshops, co-innovation and co-creation activities. It is a development platform for research, development and innovation (RDI) projects, innovation camps and hackathons, seminars & workshops and collaboration with companies. It supports technology sharing such as advanced automation solutions, cobotics, additive manufacturing and smart factory related systems and applications. It provides opportunities for studenst to work with megatrends such as industrial internet and digitalization in general. In addition, TAMK's laboratory services in mechanical engineering are provided through the OpenLab platform.

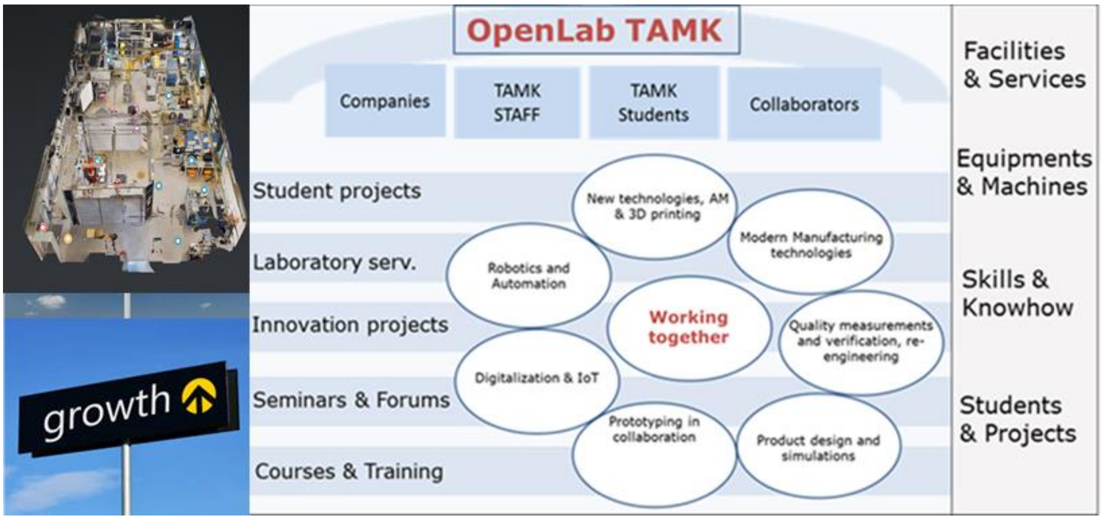


Fig. 3: The TAMK OpenLab

The objectives of TAMK's OpenLab are to promote and enhance work life integration within Tampere Region, support co-operation between educational units and to enhance and enable engineering students' innovation and start-ups, e.g. TAMK students' cooperatives.

TAMK FieldLab as the latest addition and investment of OpenLab learning platform provides an open access to learning environments, tools, and versatile machine environments for collaboration partners, students and staff of TAMK to experience and assess trial cases in Industry 4.0 capable environment. TAMK FieldLab also highly promotes the expansion of Digital Competences 4.0 (Puurtinen, 2018). In this way, TAMK FieldLab responds to the knowledge challenges posed by digital restructuring as well as the opportunities and better utilization of new technologies.

Special attention has been paid to information access solutions and communication capabilities of all equipment investments. TAMK FieldLab activities support TAMK's vision and profiling strategy. Its aim is to strengthen the business cooperation network towards internationalization. TAMK FieldLab conducts research and innovation experiments and pilots to prioritize the needs of the labour market.

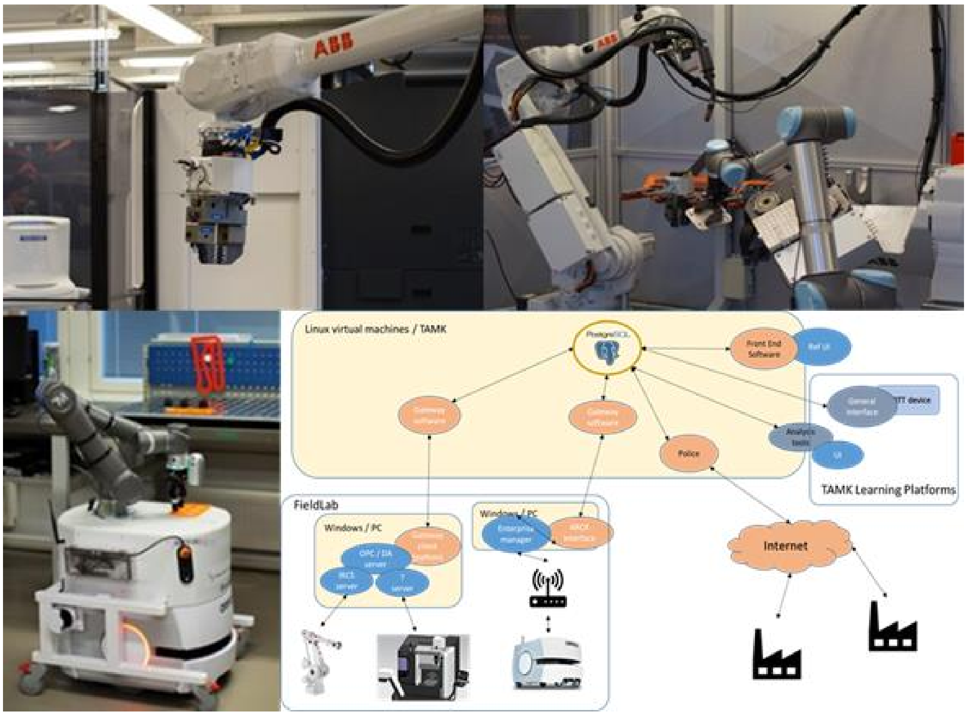


Fig. 4: TAMK FieldLab, Testbed for Industry 4.0 Solutions

Students who participate in Technology Academy courses are empowered to use and independently take full benefit of TAMK's OpenLab learning environment in their Technology Academy studies and during their co-creative project implementation. Learning environment are equipped with selected methods and approaches supporting co-creation driven innovation projects, will enable lifelong learning as well as encourage innovation and experimentation which may eventually lead to new business opportunities.

3.3 Co-designing and piloting with industry

Technology Academy approach has strong industry collaboration together with professional and economic interests. It differs from traditional forming of the industrial needs to internships, final thesis or e.g. student group hackathons in many ways. Firstly, it's not separate student effort formed to projects which only aims to certain pre-defined result, nor is it a competition between student groups or individuals. At its best, it's a co-designed industrial challenge between university, company and students to form a joint learning project which also fulfills requirements set by the standards in curriculum. Secondly, targets of the projects are set and if needed revised together with companies, and the implementation is done in co-creation agreement where project business owner, typically, industrial partner, also assigs needed specialists to join development team. In this way, the Technology Academies expedit the co-creation and learning process of all participants, featuring and concretising Creative Growth Revival process [Puurtinen, 2019].

Technology Academy project themes are yearly selected based on current industrial trends and industry partner needs. Typical starting points are industry partner initiative, especially technology & machinery providers, for collaboration based on their need. Typical topics include looking for help to explore their technology or machinery commercial exploitation. Agreement process is made simple, university offers the organisation and guidance for student groups and needed staff member involvement, industry partner provides the equipment and specialist support & resources. A meaningful and challenging project framework is set and jointly agreed within this co-creative task force.

Fig. 5: Case example ABB robotics; creation of demonstration setup for an exhibition fair

Industry benefits from the effort of the student work and their knowhow (knowledge transfer) supporting further support business innovation while experimenting available resources and creating an easy and reliable recruitment channel. University staff members and students gain competence growth of co-design and new technology related skill development. In addition to developing skills, students will receive one more meeting point to contact with companies and acquire direct opportunities for internships and job opportunities. TAMK gains free access to industry partners' latest equipment and applications as well as their current and future strategic R&D and innovation agendas. In exchange for their investment, the industry partners obtain novel, high quality solutions without time-consuming fully in-house operated expertise resource engagement. Also universities find a natural way of improving their understanding of current and future industrial needs (new technologies, skills, competences). Technology Academies can also work as university's RDI project implementation task force as in case of TAMK's autonomous drone research.

4 Results and Impact

As an implication of successful implementation of the Technology Academy approach, technology adaptation skills together with engineering creativity and innovation have shown great advancement. Along the professional hard engineering skills this approach develops also students' and participating partner specialists' soft skills, team working capabilities and entrepreneurial mindset. Thus, the approach brings novel added value to Academy participating companies and future employers.

Technology Academies were included in official curriculum in 2018 and their implementation is continuing also in study year 2019/2020 and onwards. Qualitative interviews have been carried out in order to find early feedback and improvement suggestions from selected stakeholders and participants of the academy approach. The topics the interviewed were asked to comment were:

› Overall experience working with TAMK Technology Academy approach

› TAMK Technology Academy implementation influenced to university industry collaboration

› Development feedback concerning TAMK Technology Academy approach

Main findings from the interviews can be summarized as follows. Companies have enjoyed working with TAMK's students and are very satisfied with Technology Academy results. They propose to increase the media coverage of this form of industry university collaboration and expect furthermore networking and cooperation in order to increase the number of joint projects.

> *Students have acted very professionally and responsible in our exhibition co-operations. These two worlds have come more closer to each other during this collaboration.' (Interview of ABB staff March 2020)*

> *We'd like to have more visibility in social media, and we think this could be beneficial to both parties. We have had already some discussions about this with Robot Academy fellows. (Interview of ABB staff March 2020)*

Overall, companies were pleased to have affordable access to resources such as expertise, equipment, machinery and the students. Furthermore, they were able to establish an easy and reliable recruitment channel for new work force with up-to-date competences.

Teachers and TAMK aim to improve the competences and learning environments for their students by offering projects for the local industry as well as to increase their research and innovation activities. Technology Academies are seen as an effective and agile way to deepen the university-company collaboration. Simultaneously, they open new project and business opportunities for both. Project topics are easier to be tailored according to the needs and interests of mechanical engineering students, hence increasing their motivation through direct industry collaboration.

> *Academies support and develop student's self-orientation it their studies, and they improve their collaboration and problem-solving skills. Students notice the practical benefits they're achieving and are thus very motivated. This, again, makes 'coaching' of the groups very nice for teacher. (Interview of a TAMK lecturer involved in Technology Academy course impelementation, March 2020)*

> *Project themes and targets are easy to tailor to suit mechanical engineering learning targets and curriculum requirements. (Interview of a TAMK lecturer involved in Technology Academy course implementation, March 2020)*

Based on feedback from teachers, Technology Academies could be better described in the curriculum and marketed more, making it easier for students to join. In addition, continuity between project teams and course implementations, like lessons learned and knowledge transfer should be further advanced and guidance created.

Students involved in Technology Academy envisage getting new knowledge of technology utilisation and an increase of soft skills together with valuable contacts to companies that may be beneficial when students look for internships or job offers. In addition, positive increase in motivation through university-industry collaboration and utilization of real case studies among students can be observed, potentially leading to faster graduation times and better employability.

> *I've liked the experience, and I feel like I've gotten a lot of knowledge from the academy which I wouldn't have gotten otherwise relying only on normal lessons. In addition to learning how to program the robots and how to present the demonstrations at the trade fairs, the Academy has also given me good experience on how to work around projects with a group (vs working alone). (Interview of a TAMK student involved in Technology Academy course impelementation, March 2020)*

> *The collaboration through the Academy has given a little sight on how the company (ABB) works and how the automation industry works. It has also given some potentially valuable contacts in the industry. (Interview of a TAMK student involved in Technology Academy course impelementation, March 2020)*

Students see Technology Academies as a great learning opportunity, and they hope other similar collaborations will emerge as well. The biggest challenge with the concept was seen in effective communication, where more guidance and standardization were proposed.

In summary, topics such as open access learning platforms, pedagogical and coaching methods applied together with curriculum co-creation were brought up in several occasions. The approach enables expanding the networks of teaching staff. Hence, both the project management and networking competences of teachers must be ensured. The authentic learning environments and close collaboration with companies give students the possibility to use their skills and competences in a more diverse way, thus helping them to improve both their employability and professional self-esteem. Facilities with modern technology capability equipment and support offered enable and accelerate students to innovate and create new business opportunities towards companies and consumers. The crucial factor in succeeding to implement the approach is, however, how profoundly the platforms are incorporated in the curriculum.

5 Conclusions

The system-level transformation induced by Industry 4.0 touches upon all operations of companies, not just partially single products and services or production processes. In addition, new business models responding to the future necessities of circular economy and complex regional and even global ecosystems require immense change within companies.

This radical systematic shift must be also reflected in educating the current and future talents. As a result, curricula of traditional degree programmes and lifelong learning actions must be co-created, designed, implemented and assessed in continuous dialogue with industry partners. Only in this way universities can ensure the agility and flexibility of their graduates and lifelong learners updating and upscaling their knowledge and skills. Simultaneously, companies' innovation cultures develop and mature when students function as innovation agents, spreading new tools and methods for innovation. In the meanwhile, constant dialogue between universities and companies is a prerequisite for keeping up with the quicker and quicker speed of transformation, necessitating adoptable and resilient curricula.

TAMK's Technology Academy approach gives one response to these challenges. Technology Academies provide the students with intra- and entrepreneurial mindsets along with the upfront technical and soft skills. The benefits of co-creation, design and implementation are bidirectional, as the companies can increase their innovation capacity while simultaneously getting the urgently needed talented employees with the skills of the future. On the other hand, universities are forced to look outside of their traditional silos with a future oriented perspective, with the final goal to contribute to UN Sustainable Development Goals such as Industry, Innovation and Infrastructure (SDG 9), Economic Growth and Decent Work (SDG 8) and Quality education (SDG 4).

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