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Engineering

INDUSTRIAL NEEDS FOR MODERN ENGINEERING KNOWLEDGE IN CENTRAL EUROPEAN REGION – SURVEY RESULTS

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ABSTRACT:
IN ORDER TO PROVIDE COMPANIES WITH A COMPETITIVE ADVANTAGE, IT IS NECESSARY TO CONSTANTLY INVEST IN NEW CAPACITIES OF THE STAFF ENGINEERS WHO DEVELOP NEW PRODUCTS, AS WELL AS OF NEW GENERATIONS OF STUDENTS. IN ADDITION TO BASIC ENGINEERING SKILLS, THEY SHOULD ALSO BE PROVIDED WITH SKILLS WHICH WOULD HELP THEM TO DEAL WITH CONTEMPORARY CHALLENGES IN PRODUCT DEVELOPMENT. THE MAIN TRENDS IN THIS RESPECT INCLUDE DEVELOPMENT OF SMART PRODUCTS AND TRANSITION FROM THE PRODUCT AS AN OBJECT OF SALE TO THE PRODUCT AS AN OBJECT TO SUPPORT THE SALE OF A SERVICE. IN THIS PAPER, THE AUTHORS PRESENT RESULTS OF A RESEARCH CARRIED OUT AMONG THE INDUSTRIAL PARTNERS IN CENTRAL EUROPE. THE OBJECTIVE OF THE RESEARCH IS TO IDENTIFY THE DEMAND OF INDUSTRY FOR NEW STAFF, THEIR CAPACITIES AND SKILLS. OUR FINAL AIM IS TO PREPARE AN INTERNATIONAL JOINT STUDY PROGRAM OF THREE UNIVERSITIES.
THE RESULTS HAVE SHOWN THAT COMPANIES IN CENTRAL EUROPE ARE AWARE OF AND FOLLOW GLOBAL TRENDS AND THEY ARE ADAPTING THEIR STAFF ACCORDINGLY. AS THEIR MAIN CHALLENGE, MANUFACTURING COMPANIES PERCEIVE THE GROWING NEED FOR INTERDISCIPLINARY SKILLS AND THE INTRODUCTION OF NEW BUSINESS MODELS THAT BECAME POSSIBLE BY INCREASED SMARTNESS OF PRODUCTS.

KEY WORDS: ENGINEERING SKILLS, ENGINEERING KNOWLEDGE, SMART PRODUCTS, SMART ENGINEERING, SMART PRODUCTION

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INTRODUCTION

Academic partners from the University of Ljubljana, Faculty of Mechanical Engineering (UL-FME), Universities in Zagreb, Faculty of Mechanical Engineering and Naval Architecture (UZ-FMENA), and TU Wien recognized the need for a joint master's degree program, tailored to the needs of industry for engineers with interdisciplinary knowledge that is required for the development of new smart products. To identify the key capacities and skills that industry expects from students, and to identify where the greatest knowledge and skills mismatch occurs, the authors of this paper and their colleagues have reviewed the literature and carried out a research among the industrial partners in the Central European region.

Early results of the literature review have shown that the needs of industry are often different from what students bring from the academic sphere, and that some key skills are under-developed and that there is a gap between how industry and students, respectively, perceive them. It is also of some interest that the results of different studies from different parts of the world are similar and as such, they are not tied only to a specific geographical area.

In an Australian study[6], Nguyen found that "the most essential generic skills and attributes of a modern engineer are technical knowledge, skills and attitudes. The emphasis given to personal and professional attitudes by the industrial sector was interesting and indicates that engineers are not only expected to be technically proficient in the field but also to know how to behave and operate within an organization". On the other hand, May and Strong[7] have found that in Canada, "three of the four skills that students perceive as their strongest points are identified by industry as the greatest weaknesses in engineering education. It is clearly demonstrated by student's perception of having sound professional design skills, contrasted with the evident unfulfilled needs and wants of industry that there is a significant disconnect between stakeholders".

Most studies have also recognized the need to improve communication and organizational skills of engineering students. This is crucial for a rapid integration of individuals into development teams and for successful professional collaboration. For example, Ramadi et al[8] found that "an area where graduates appeared to have substantial deficiencies was the ability to manage time. Additionally, substantial improvements appeared to be needed in engineering graduates' communication skills." In a study, conducted in China, Peng et. al.[9] came to this conclusion: "The curriculum should be expanded to cultivate the competencies of Communication and Coordination as well as Organizational Management. Student collaboration with enterprises and industry engineers should be maintained and further strengthened."; which reflects the findings of Spinks et. al.[10], who argue that "there was also strong support amongst the interviewees for ensuring that

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[6] Nguyen, Duyen Q.; *The Essential Skills and Attributes of an Engineer: A Comparative Study of Academics, Industry Personnel and Engineering Students*, Global J. of Engineering Education, 2(1), p,p. 65-75, 1998

[7] May, Elizabeth; Strong, David S.; *Is Engineering Education Delivering What Industry Requires?*; Proceedings of the Canadian Design Engineering Network (CDEN) Conference, Toronto, Canada, p.p. 24-26, 2006

[8] Ramadi, Eric; Ramadi, Serge; Nasr, Karim; *Engineering graduates' skill sets in the MENA region: a gap analysis of industry expectations and satisfaction*; European Journal of Engineering Education, DOI: 10.1080/03043797.2015.1012707; 2015

[9] Peng, Lijun; Zhang, Shulin; Gu, Jibao; *Evaluating the competency mismatch between Master of Engineering graduates and industry needs in China*, Studies in Higher Education, 41(3), p.p. 445-461, DOI: 10.1080/03075079.2014.942268, 2016

[10] Spinks, Nigel; Silburn, Nicholas L. J.; Birchall, David W.; *Making it all work: the engineering graduate of the future, a UK perspective*, European Journal of Engineering Education, 32(3), p.p. 325-335, DOI: 10.1080/03043790701278573, 2007

undergraduates gained relevant industry experience, including vacation work, prior to graduation.”.

Two of the three partners in the development of the new study program (UL-FME and UZ-FMENA) had already previously recognized the above observations and successfully addressed them a decade ago in a joint European Global Product Realization[11] course of study. Developing a joint master's degree program in cooperation with TU Wien, their objective now is to raise the experience to a new, higher and more comprehensive level.

METHODOLOGY

In this paper we present the main findings of the industrial survey, performed by project partners as a part of intellectual output. The survey was designed for the purposes of preparing a new master study curriculum in order to identify the needs for new engineers in Austria, Croatia and Slovenia.

After the initial research of higher education trends in engineering, preliminary discussion with industrial partners and a comprehensive analysis of existing product development MSc courses, we prepared a set of questions to identify the industrial needs for new knowledge in the field of the development of new, smart products. The survey was created by four question categories: (1) demographic category; (2) three sets of selective (Likert scale) questions and one open question to investigate the field of existing and needed engineering knowledge and expertise; (3) a set of selective questions about product development in the companies; (4) and a set of questions about the position and role of “smartness” of new products in the company’s portfolio.

The questionnaire was put online as an anonymized web-based questionnaire, however, accessible only to the invited respondents. The selection of respondents was among professional profiles who have clear vision of company strategy and direct impact on future R&D trends in companies. These profiles are mostly executive staff and R&D personnel.

In the research, 58 people have participated – 24 from Austrian based companies, 24 from Croatian based companies, 9 from Slovenia, and one from Germany as well. They are from various fields of knowledge and company positions, but mostly from different fields of mechanical engineering (Figure 1).

[11] Žavbi, Roman; Tavčar, Jože; *Preparing undergraduate students for work in virtual product development teams*; Computers & Education: an international journal, ISSN 0360-1315, 44(4), p.p. 357-376, 2005

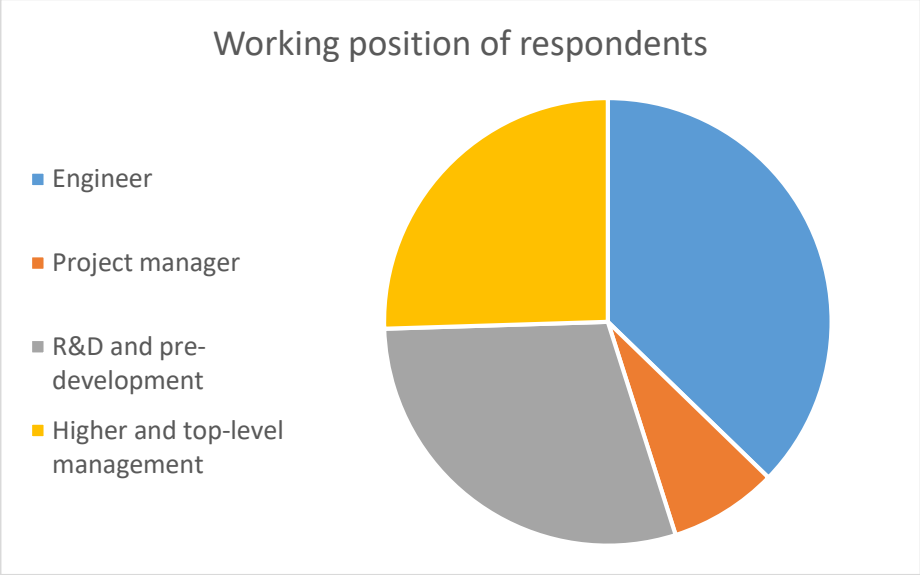

Figure 1: professional positions of respondents

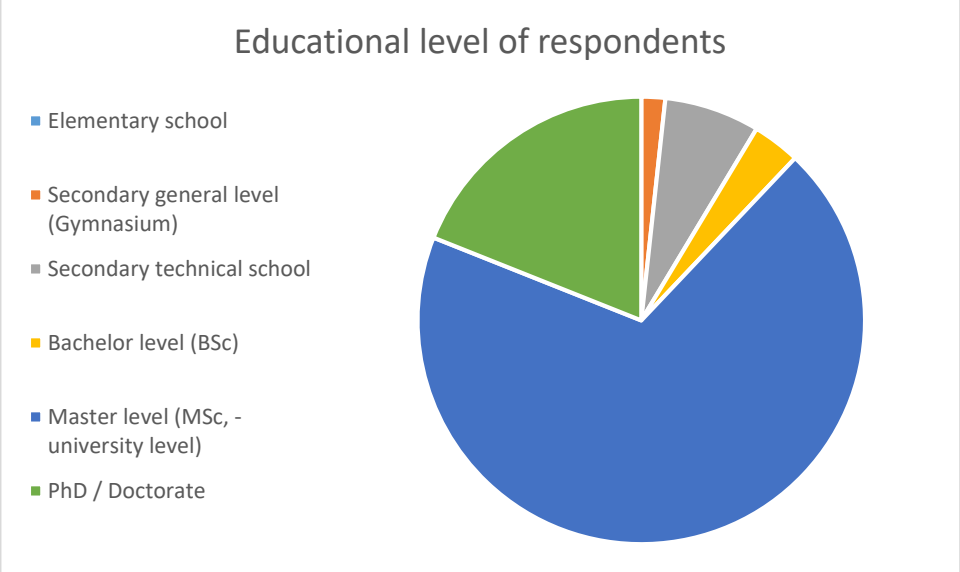

Figure 2: educational level of respondents

The educational level of respondents showed, that more than 88% of respondents are highly educated, having achieved a master's or even PhD level. Almost three quarters of all respondents hold a master's degree, which shows there is a large pool of population that requires the master's level for their job positions. Particularly interesting is also a large number of PhDs, showing the trend and needs for this level of knowledge and experience. We believe that both these shares will only increase in the future.

Unfortunately, the unbalanced gender representation in engineering is reflected also in this survey, where only 6.9% of respondents were female.

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Age distribution chart shows that approximately half of the respondents are within their first decade of working experience in engineering. Since education programs do not change rapidly, it can be concluded that half of the respondents can critically evaluate the knowledge provided by universities at the master's level, while at the same time the younger generations are usually more familiar with new trends and technologies.

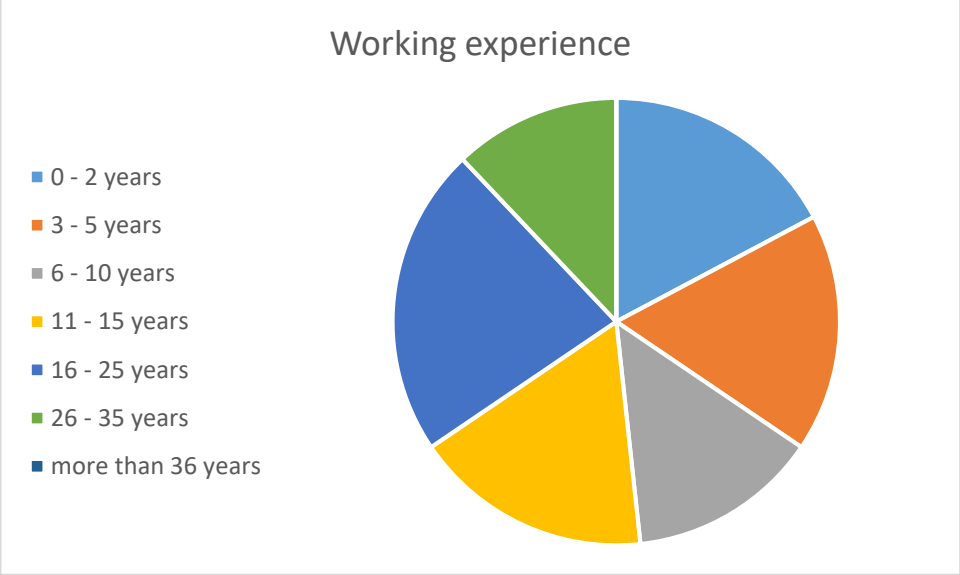

Figure 3: Working experience of respondents

The respondents were asked to answer three thematic sets of questions:

- questions about competences of new master engineers
- questions about the trends in product development process
- and questions about smartness of the products

The answers are presented on the following pages, together with our interpretation of the results.

RESULTS

Competences of newly graduated master's level engineers

The first set of questions asked participants of the survey about their opinion on the quality of the competences of newly graduated engineers in different traditional and emerging engineering skills, as well in some basic transverse skills, e.g. legal basics and business analytics. The selection of subjects mentioned in this survey was based on subjects (and their equivalents) currently being taught at all three universities, subjects that are included in competitive joint master courses around the world and enriched with some topics that are emerging in the field of development of smart and web-based products.

As expected, the traditional knowledge was well represented, especially the knowledge of machine elements and various CAD technologies. Both subjects are usually taught at the bachelor's level, so making a new engineering curriculum would not have a negative effect on the results. There are also some traditional engineering subjects, which should be reorganized or changed as

they do not perform well: material science in particular. This subject usually provides very fundamental knowledge about materials, with a huge emphasis on steel, however the engineers who are dealing with product development need deeper knowledge on the principles of proper material selection and availability and properties of different construction materials.

There was a significant lack of transitive knowledge; therefore, we emphasize improvements in that field – especially by implementing subjects about entrepreneurship, innovation, legal basics, management and business.

The third field of emphasis is new and multidisciplinary knowledge: both of which are only seldom taught at traditional mechanical engineering master courses. This knowledge should cover at least: big data, machine learning, Internet of Things, and cloud base solutions, robotics, electronics, product data management and automation.

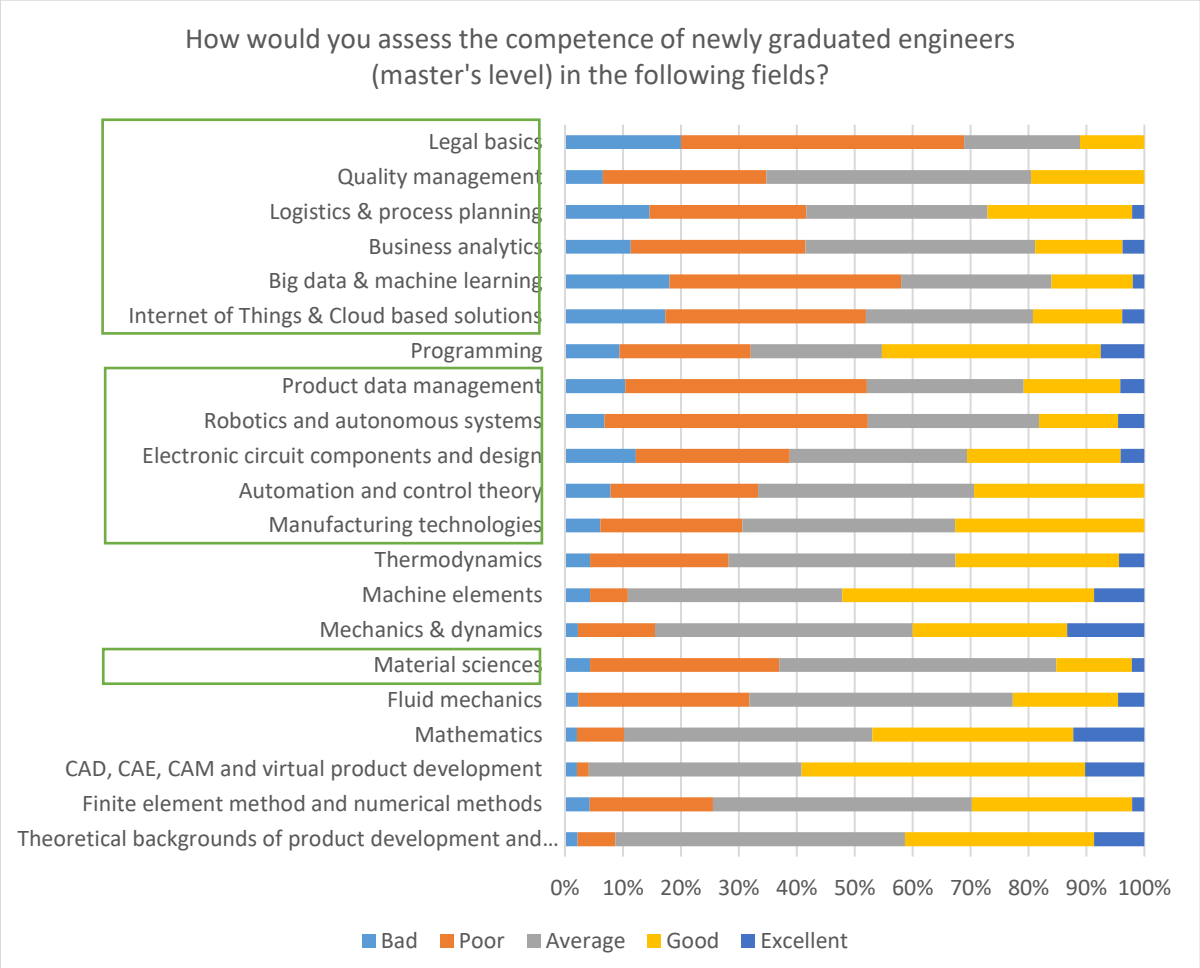

Figure 4: Skills and competences of newly graduated engineers according to industrial perception.

Trends in product development process

The second set of questions investigated how the product development process has changed in the past 10 years. The purpose of this question set is to identify the trends in product development, so the newly developed curriculum would properly address these changes. There are

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two main identified shifts in the product development process: (1) the increased interdisciplinarity of the process; (2) and the shortened development cycle. Both shifts result in needs for outsourcing different sub-tasks and in the need to gather and analyze more data in a shorter time. Successful tools and methods exist to address these changes, however, students usually meet them for the first time only during their first industrial experience. Other research also showed a trend when a product is no longer in the focus of a company's business model and a source of income; instead it is the service the company can provide with these products (i.e. product service systems). The survey showed that less than 50% respondents agree with that, but the share of those who do not agree with this statement is less than 20%. This suggests that engineers are becoming aware of this trend (Figure 5).

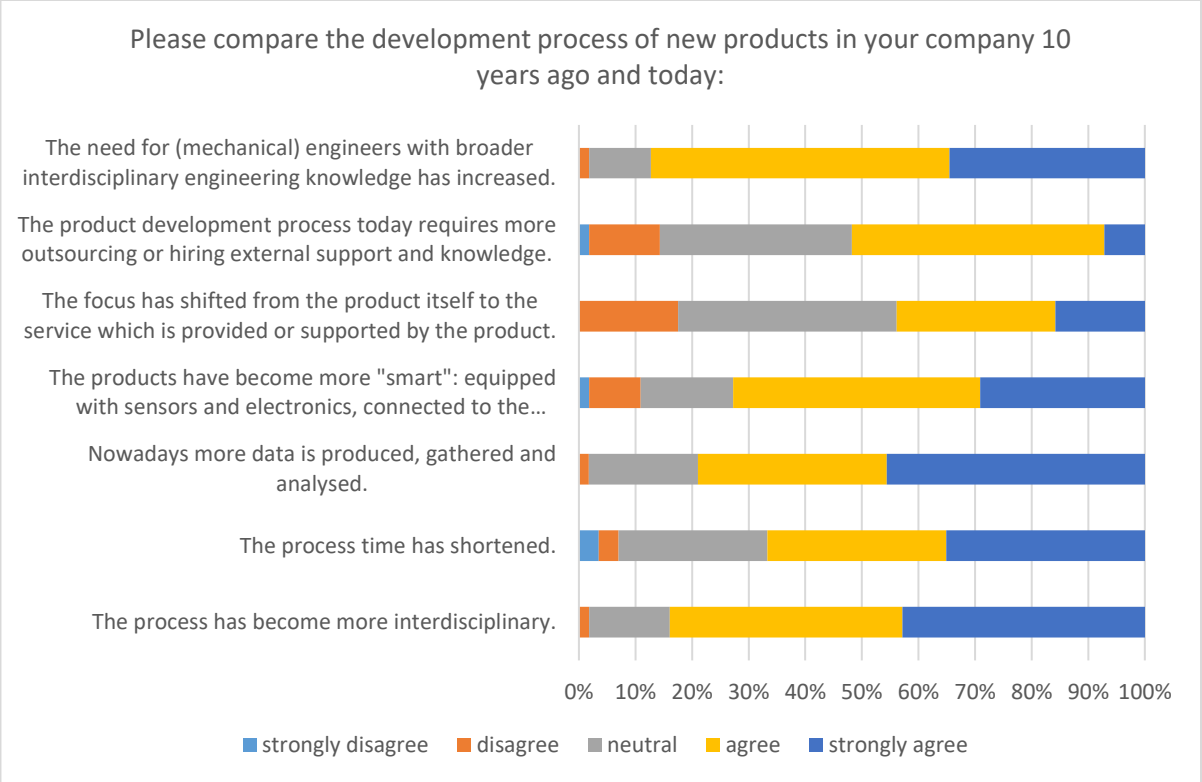

Figure 5: Trends in new product development in the past 10 years.

Smartness of the products

The third set of questions explored how the companies adapt to increasing smartness of the product. The respondents are strongly aware that smart technologies are inevitable for the improvement of their products in the future. Almost 50% strongly agree with the statement, while almost 90% agree or strongly agree that this will be the future. Furthermore, almost 50% of respondents admit that their products already include some level of smart technologies and 60% of respondents say their companies have a strategy to add value to the products by implementing smart technologies.

These results show positive trends in the observed industry. On the other hand, there are some concerns how to implement them. Namely, more that 50% of respondents say the companies

will have to reorganize their development teams and processes, while 40% think this will require also the reorganization of the business model and the organization of the company. The answer that the company does not have capacities to implement smart technologies is of particular concern. Only 20% of respondents think so, while more than 50% think the opposite.

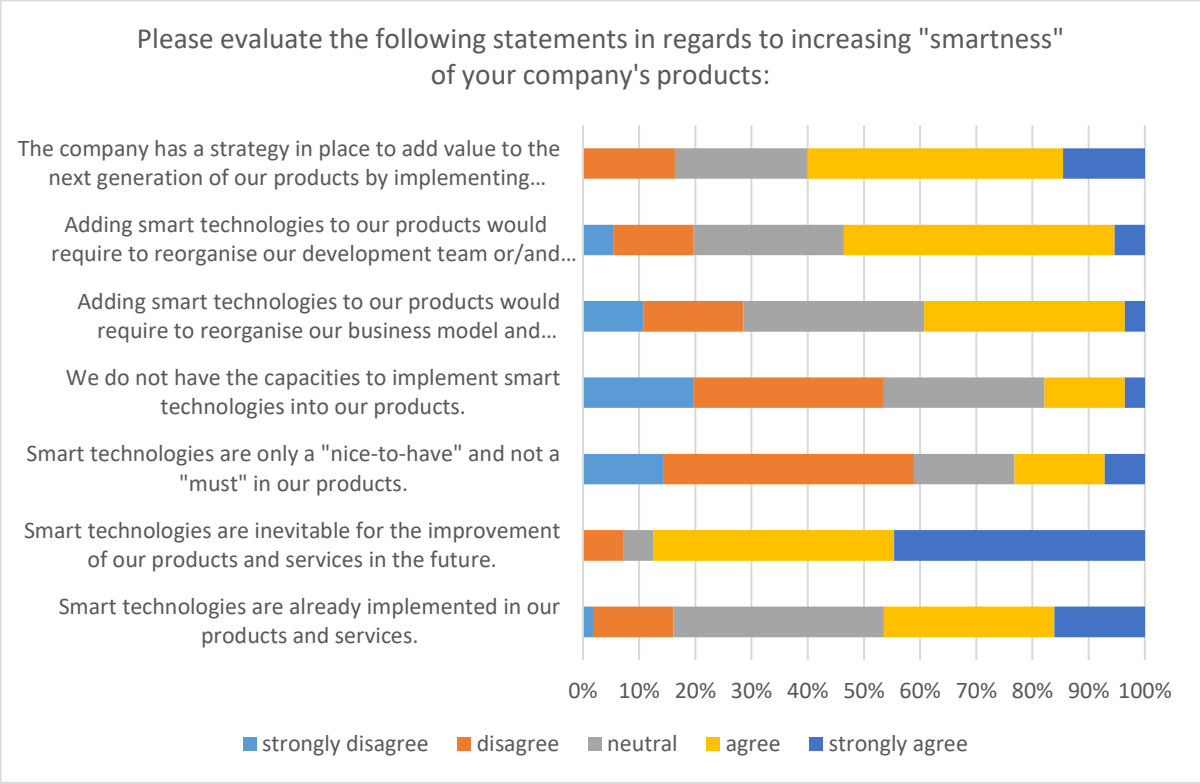

Figure 6: Perception of engineers about the »smartness« of their company's products

CONCLUSION

The paper presented the results of a research, performed by the authors among the industrial partners in Austria, Slovenia, Croatia and Germany. In the research, we tried to identify the skills and competences that industry will need in the next decade when new "smart" content will be increasingly expected from new products.

The results have shown that companies in Central Europe are aware of and follow global trends, and they are adapting their staff accordingly. As their main challenge, companies perceive the growing need for interdisciplinary skills and the introduction of new business models, made possible by smart products. In the future, the authors of this paper intend to produce even more in-depth analyzes in this field, and they are also working on a curriculum that will give young engineering graduates the skills and competences that industry needs in the fight on the competitive global market.

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