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APPLICABILITY OF EDUCATION 4.0 IN HIGHER EDUCATION: ENGINEERING STUDENTS' SURVEY

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Abstract

The purpose of the study is to examine how Industry 4.0, and the digital environment, have together created a new situation for companies and universities in terms of soft skills for employability. While companies aim to introduce a new structure, universities try to align with these changes by developing new educational methods, curricula, and models. Many researches are focusing on – rightfully so – Industry 4.0 skills and competences to gain throughout higher education. However, we have shifted our research interest and asked students to what degree their university years added to their knowledge, self-management and skills. 147 engineering and technical manager students' responses from two faculties at Óbuda University, Hungary were analyzed to see their evaluations of the role of the university in the framework of Education 4.0, and their chances in the job market. Quantitative and CHAID analyses were used. Students' responses show significant differences between the two faculties regarding languages, teamwork, self-management and in the different order of the skills seen as most paramount to employability. Engineering students attach greater importance to field-relevant knowledge, while technical manager students find decision-making more useful. The research proved that Education 4.0 is here and Z generation studying at universities prefers problem-based learning, including creativity, analytical, and critical thinking while would like to have good communication skills. Universities need to adapt to these changes and integrate hard as well as soft skills development in tutoring. The importance of technical-IT knowledge is just as important as having interpersonal skills, excellence in problem-solving, so students need to be taught how to analyze problems, engage in scientific debate, or express themselves clearly as previous literature indicated.

Keywords – CHAID analysis, Education 4.0, Industry 4.0, Skills for employability.

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1. Introduction

Since Industry 4.0 has paved the way for artificial intelligence, a much more autonomous supply chain, collaborative work, and the consequent digitization of connected systems, we are now living in a globally linked world characterized by a rapidly changing working environment, robotized manufacturing, and artificial intelligence used by numerous fields. Based on the World Economic Forum Survey, "41% of surveyed companies plan to expand their use of contractors for task-specialized work, only 34% plan to expand their own workforce due to technology integration.” (World Economic Forum, 2020: page 5).

In parallel with COVID-19, fully connected automation systems create a completely new situation for students, universities, and companies as well. Many universities will change their structure and workforce due to the rapid change of new technologies while trying to adhere to these changes and introduce new curricula, methodologies, and structures. Skills gaps remain high, as demand for new job skills is set to change over the next five years. Key competences include critical and analytical thinking, problem-solving and self-management skills, life-long learning, perseverance, and flexibility (Hecklau, Galeitzke, Flachs & Kohl, 2016; Nelson, Martindale, McBrid, Checkland & Hodgson, 2018). Companies estimate that about 40% of employees will need retraining in six months or less, and 94% of business executives say employees are expected to acquire new skills in the workplace to keep up with technological advances and retain their jobs (Manjunath, Shravan & Dechakka, 2019).

This paper includes the analyses of data from 147 student surveys to understand how students evaluate the role of their university education within the framework of Education 4.0 as well as their acquired skills in the changing job market as new graduates. The paper is organized as follows. After the introduction, relevant literature is reviewed. Then after presenting the data and methodology, the results are detailed. Findings are followed by a discussion and finally, the limitations and future research possibilities are given in the conclusion section.

2. Literature Review

The effects of Industry 4.0 cannot be discussed without considering its effects on education, as the primary custodians of professional education for skilled and trained employees are the educational institutions (Paisey & Pasey, 2018). To keep up with technological-industrial advances, universities must change their curricula, and the structure and model of their teaching, and include more practical elements in their courses (Cranfield, Tick, Venter, Blignaut & Renaud, 2021; Fitsilis, Tsoutsa & Gerogiannis, 2018; Valero, 2022). Digital transformation is a more recent academic concept, driven primarily by the COVID-19 pandemic, although it is rooted in previous theories of IT-enabled change (Besson & Rowe, 2012). Recent studies suggest that digital transformation is not only a demand but a process of extensive, systematic change that appears through the integration of various technologies and inherently redefines institutional attitude and identity (Trenerry, Chang, Wang, Suhaila, Lim, Lu et al., 2021). All these changes and the main features and framework have collectively been termed Education 4.0 (Afrianto, 2018). Companies and other industry stakeholders with strong information and technology infrastructures require advanced digital technology knowledge and skills, which are described as 21st century skills (Ghafar, 2020). According to the European Union Digital Competence Framework,

> *“digital competence comprises the following dimensions: (a) information and data literacy that allows people to locate, retrieve, store, manage, and organize digital data, information, and content; (b) communication and collaboration through digital technologies; (c) digital content creation and knowledge about giving the right instructions to a computer system; (d) identity and security management of devices, content, personal data, and privacy protection in digital environments; and (e) the ability to solve conceptual problems and unsettled situations in digital environments”* (Carretero, Vuorikari & Punie, 2018: pages 11-13).

3. Education 4.0

Education 4.0 is a reflection of the Industry 4.0 era (Beke, Horváth & Takacs-Gyorgy, 2020) and refers to a period in which educational paradigms, approaches, curricula, and technologies are changing (Kamaruzaman, Hamid, Mutalib & Rasul, 2019). There is continuously growing demand for personalized and adaptive learning (Tick, 2019), blended learning courses, and practical learning methods (Ciolacu, Tehrani, Binder & Svasta, 2018). Online and later blended learning types of teaching became especially crucial because of the COVID□19 outbreak, which affected every region and most, if not all educational institutions worldwide. Higher education institutions faced a rather challenging situation where they had to make prompt decisions regarding policies, access to the internet and online materials, continuing education, and ongoing evaluation and monitoring (Vlachopoulos, 2020). The pandemic was also a warning signal to have students prepared with Information and Communication Technologies (ICT) and collaborative skills and educate them to remain interested in life-long learning (Hirschi, 2017). This technological-digital shift affects profoundly not only education but future employees and business structures as well: knowledge and talent replace raw materials and capital and become the most competitive assets (Bartram, 2005; Pásztor, 2021). Implementing strategic workforce planning and talent management can give each organization a more agile approach and a new dynamic for progress and development (de Lucas-Ancillo, del Val-Núñez & Gavrila, 2020).

Education 4.0 is considered a new paradigm that reinterprets concepts such as learning, student, teacher, and school according to the needs of Industry 4.0 (Benešová & Tupa, 2017; Tick & Beke, 2021). Harkins (2018) called Education 4.0 an innovation producing process, where concepts like content, technology, teaching, schools, and teacher have been redefined. Based on the OECD recommendations, the main features of Education 4.0 can be summarized as follows (Asian Society/OECD, 2018):

> *"When today's students enter the world of work, they will be working with the world itself. … To be effective participants in this increasingly complex, diverse, and interdependent global economy, students will need to be highly literate and able to analyze situations and solve novel problems in creative ways. They will need to be knowledgeable about issues of global significance in areas such as engineering, business, science, history, politics, and the environment. Students also will need to be comfortable in unfamiliar settings and willing to learn from others… Preparing today's students to live and thrive in this increasingly interdependent world, characterized by international markets, unprecedented migration of peoples, growing economic inequalities, increasing ethnic and religious tensions and violence, and massive changes in the environment will require the transformation of education."* (pp. 10-11)

3.1. Competences in Education 4.0

Gómez, Redondo and López (2018) emphasized the need to orient students to the professional world throughout higher education and educate them so that their skills match with industry demand. They noted that the European business community requires a range of personal attributes in addition to university degrees that would allow graduates to be integrated faster into working environments and cultures. Duarte and Rodriguez (2021) noted that for digital competences in university settings, there are definitions to clarify them. Examples include instant communication, which means interacting with the teachers through digital technologies, and problem-solving, which refers not only to identifying a problem but to proposing solutions as well. Content creation involves editing and creating digital content and class activities that involve engagement with digital skills (Aberšek, 2017; Duarte & Rodriguez, 2021).

Furthermore, Diwan (2017) listed all those competences with which today's students will be able to gain employability and success in their future work. He calls them "future specializations" (Diwan, 2017, para 12). They include financial analysis and technology, business analytics, digital marketing, supply chain and e-commerce related skills (Sánchez-Ramírez, Íñigo-Mendoza, Marcano-Lárez & Romero-García, 2022). Graduates need the ability to understand skills associated with future specializations and to interpret data. Strong, Burkholder, Solberg, Stellmack, Presson and Seitz (2020) surveyed 25,000 students, faculty, staff, and employers across more than 30 countries. Their results showed consistency in critical competences and show many similarities with the present research in terms of industry-needed competences (Hebles, Yániz-Álvarez & Alonso-Dos-Santos, 2022). These include decision-making, communication, problem-solving and analysis, participating in teamwork, and self-management. They concluded that regardless of the job type the critical competences are consistent across industries.

In summary, the basic components of Education 4.0 are highlighted in Figure 1.

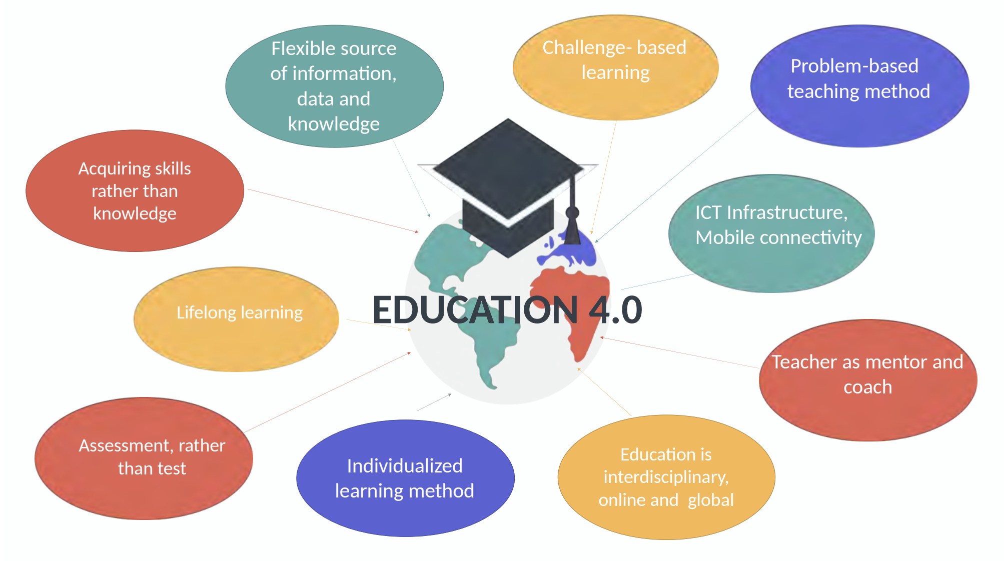

Figure 1. Basics of Education 4.0 (Kozák, Ruzicky, Stefanovic & Schindler, 2018)

3.2. Job Skills for 2050

The World Economic Forum (2020) identified the top 10 job skills for 2050. These 10 skills can be grouped into four categories that include (a) problem-solving, (b) self-management, (c) working with people and (d) technology use and development. These skills within the four groups are presented in Figure 2. The numbers denote the place of the job skills in the ranked list. As Figure 2 presents, four out of the first five skills are problem-solving skills, the sixth top skill is related to working with people and two-two skills are grouped under technology use and development and self-management, respectively.

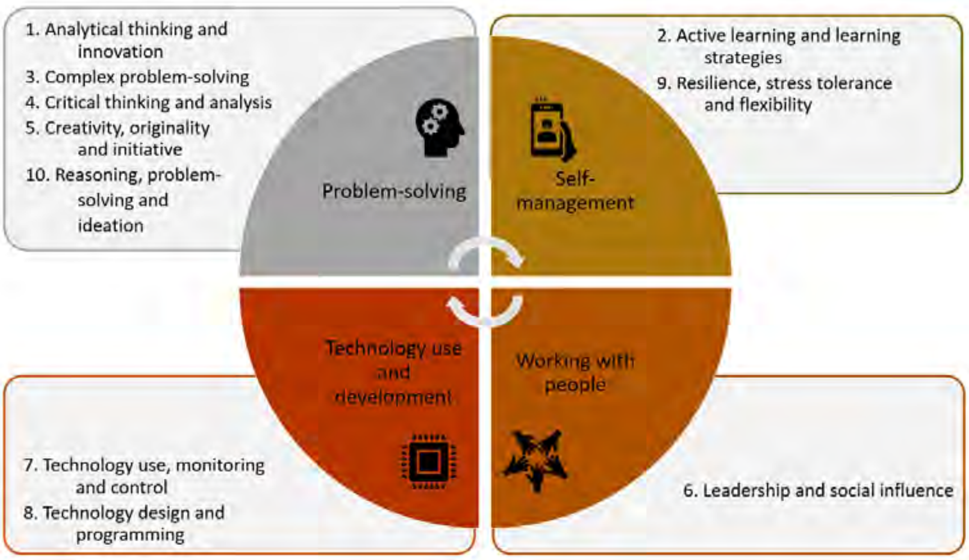

Figure 2. Types of top 10 job skills by the WEF in 2020 (World Economic Forum, 2020)

Szabó and Bartal (2020) found that most Hungarian and Russian students agreed with the top 5 skills based on World Economic Forum research; however, the authors suggested new methods and structure of teaching required to motivate and engage Generation Z students. Consistent with the expected demand, Bonfield, Salter, Longmuir, Benson and Adachi (2020) recommended courses be added to the curriculum, such as Industrial Internet of Things for Advanced Manufacturing, Managing a Smart City with Business Intelligence (data science), Introduction to 3D Printing, Machine Learning, Robotics and

Automation, and Intelligent Sensors, which all belong to the group of skills related to technology use and development.

There are several research studies examining students' perceptions of current skills studying at various faculties (Yelkikalan, Hacioglu, Kiray, Ezilmez, Soylemezoglu, Cetin et al., 2012). Yelikalan et al. in their research have not found any significant differences between students' perception of emotional intelligence apart from sociability. Patrik in their 2020 survey claimed that subtle perception differences among the faculties became apparent when they asked students about active learning possibilities and teaching reform (Patrik, 2020). Kalkan in his 2020 research investigated students' views – studying at different departments – about e-learning readiness as far as computer efficacy and online communication skills are concerned among other skills (Kalkan, 2020). He has concluded that there are differences between faculties as those who have English language skills are more effective users of computer and online communication skills than those without language knowledge (Kalkan, 2020).

Based on the literature reviewed, the concept of Education 4.0 in the light of required industry competences, and the digital competences discussed, the following conceptional framework was developed and is depicted in Figure 3. The basic components and competences in Education 4.0 call for delivering knowledge strongly focusing on specialization while the training of hard as well as soft skills are brought to the focus as well. The four groups of job skills in Figure 2 require active learning leading to practice-oriented education including new forms and new methodologies, for instance, digital online learning or problem-based learning etc. Self-management as well as skills for effective collaboration with people require good communication and networking skills which can be developed through international experience.

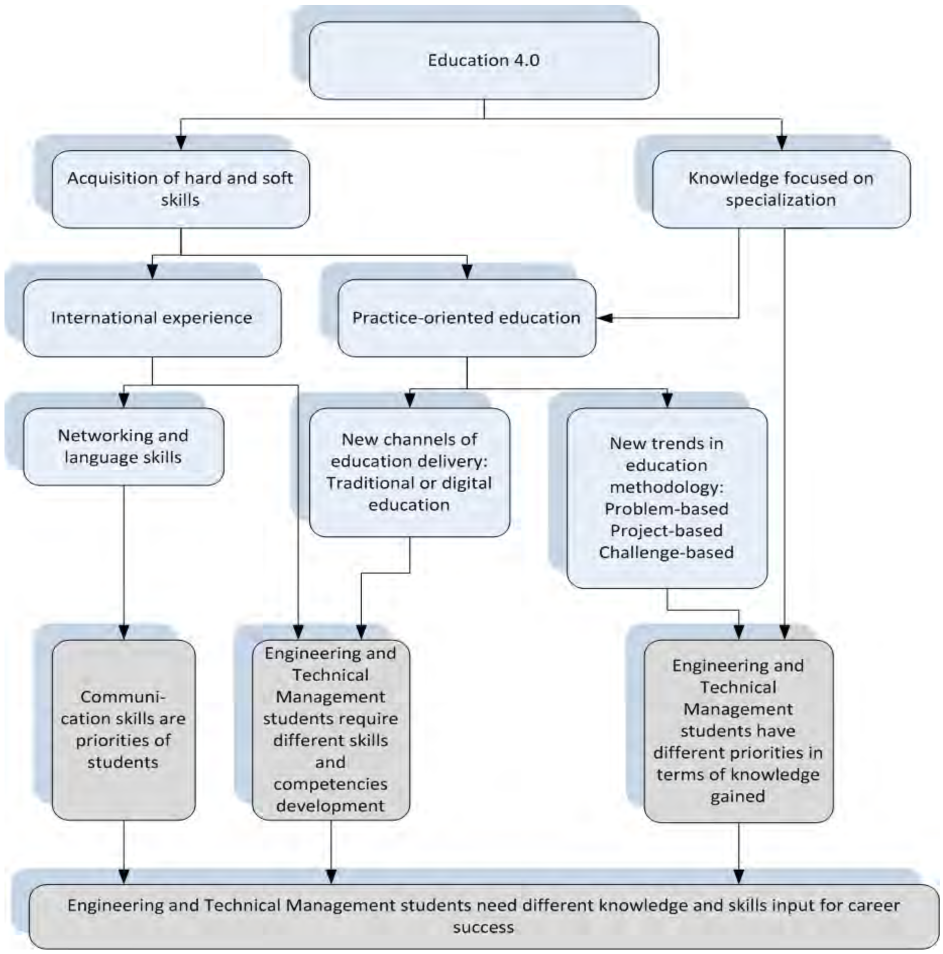

Figure 3. Conceptual framework of the present research

4. Purpose of the Study and Hypotheses

The primary research goal was to shed light on the skills engineering and technical management students at a university in Hungary identified as important for their future careers, which of these skills they regard essential to be taught, trained, and developed at the university and which skills students can improve the most during international studies, and scholarships. Finally, the study aimed to analyze how engineering and technical management students differ in their attitudes to such skills. In our study we refer soft skills as a person's interpersonal, social and communication abilities. Soft skills include teamwork, adaptability, problem-solving, creativity, empathy, conflict resolution. It often can be a deciding factor in hiring especially in careers require interaction with professionals (Teng, Ma, Pahlevan-Sharif & Turner, 2019).

Based on the literature review the following hypotheses were formulated:

H1. Engineering and Technical management students have different priorities regarding necessary soft skills and competences.

H2. Engineering students, opposite to technical management students find different skills important for their future career.

H3. Engineering and technical management students have different expectations from higher educational training.

4.1. Participants

Participant of the research were undergraduate students in their second year of studies registered at a Hungarian University. A purposive, non-probability sampling strategy was applied, and a cross-sectional survey design was employed. The present study is part of a wider scale research project that beyond surveying the digital competences of students needed for employability skills, the competences of lecturers as well as students' expectation of the labor market was also surveyed. Second year university students were the target population, as first year students are new in their higher education studies and have other prioritizes than focusing on employability skills at the beginning of their studies. Third year students, on the other hand, are already employed in large numbers and focus on gaining knowledge for their specialization. Participants' consent to take part in the survey was obtained and 165 students filled in the questionnaire, out of which 147 responses could be analyzed. It must be noted that in this study the primary focus was on the orientation of the students rather than on their gender.

4.2. Procedures

The research was carried out in 2019 and 2021, partly during the lockdown due to the pandemic. A self-administered questionnaire was employed at one faculty via an internet google survey (in Hungarian and English as well). The questionnaire was distributed among students of the two faculties at the participating university in Hungary. At the Engineering faculty, the survey was conducted paper-based in classrooms, where students were given 10-15 minutes to reply. At the Business and Management faculty, an online format was used because of COVID-19 regulation of distant learning and teaching. No special ethical approval was required by the university. Students were invited via email or were asked for their consent to participate in the study. Participants were informed about consent under the European Union Law on the Protection of Personal Data. Anonymity was ensured, and the responses were automatically recorded in an online database or were given directly to the researchers in paper format.

4.3. Instrumentation

The initial survey questions were decided after a literature review process (Aberšek, 2017; Diwan, 2017; Duarte & Rodriguez, 2021; Gómez et al., 2018; Hecklau et al., 2016; Nelson et al., 2018; Strong et al., 2020) and the results of 22 deep interviews with industry representatives in Hungary regarding their views and opinions about needed employability skills and digital competences (Beke & Kelemen-Erdős, 2021). The selection of questions is also supported by the top 10 job skills identified by the World Economic Forum (2020). The survey questions were to explore which skills students considered the most important during their studies, and which ones they thought needed to be trained the most. Therefore, content validity was ensured based on the interviews, a through content analysis, and the top 10 job skills by WEF (2020). The following skills were included in the survey: (1) creativity, (2) technical and IT preparedness, (3) problem solving, (4) learning decision making techniques, (5) analytical thinking and skills, (6) communication skills, (7) participation in teamwork, (8) knowledge gained in relation to specialization, (9) technical and mathematical knowledge, (10) foreign language skills and knowledge, and (11) self-management. Since the research aimed to identify the skills and competences students find important for their future careers, they were invited to pick the three most relevant ones to compare their views with previous findings. Finally, students rated their experiences during their studies abroad. In most of the questions, students were asked to select the three most important aspects.

The researchers surveyed more general skills applicable to numerous positions and industries rather than very field-specific, often unique expertise. This decision was based on the fact, that the authors surveyed two different faculties with diverse orientations.

The following questions were posed to the students:

1. *Skills development:* In your opinion, which skills development are the most important during your university years?

   The response option included all the 11 skills listed previously and students were asked to select the three most important ones that apply to them.

2. *Competences developed through international studies:* Why do you consider the experience gained during your studies abroad to be important?

   Seven, mainly soft skills were listed that students could select from. These options were (1) it improves language skills and communication in a foreign language, (2) it extends networking and networks, (3) it develops adaption skills to international norms, (4) it gets to know foreign culture, mindset, and mentality, (5) it creates a possibility of new research platforms and projects, (6) it gives a new approach to structure and interpreting learning material (7) it is easier to accept otherness. Students were asked to select the three most important ones that apply to them.

3. *Future career options:* In your opinion, what does the employment success of graduates depend on?

   The response options included soft skills as well, which are built into the conceptual framework, therefore the question was analyzed in the study. The response options were: (1) on knowledge gained at the university, (2) on the stable foreign language knowledge (3) on the professional devotion of students, (4) on the excellent network, (5) on the network built during the university years, (6) on individual talents and skills, (7) on the current labor market requirements, out of which the three most important ones were selected by the respondents.

4. *Higher education's contribution:* In your opinion, to what extent has your higher education contributed to the knowledge, experience and self-awareness you have acquired in recent years?

   The response alternatives were seven statements, which are (1) knowledge related to future workplace and job, (2) being able to write and present clearly and precisely, (3) ability to use computers and other information technologies, (4) analyzing quantitative problems, (5) work effectively and efficiently in teams, (6) better understanding of yourself and your own aims and (7) better understanding of the people around you.

The response options ranged from 1=fully to 4=not at all. To check the reliability of the statements measured on the 4-point Likert scale Cronbach's alpha was used. It equaled 0.726, which means high reliability of the question group (Taber, 2018). Deleting any of the items would decrease reliability.

5. Data Analysis

The study used SPSS V25 for quantitative analysis and MS Excel and SPSS V25 were used for data visualization. After descriptive analysis to determine the skills and competences that students find important, contingency analysis using CHI^2 test was conducted to reveal significant differences between the faculties two-sided tests were used.

For confirmative analysis the CHI-squared Automatic Interaction Detector (CHAID) decision tree segmentation and visualization was used to confirm and interpret the significant differences between engineering and technical management students. CHAID is a multivariable recursive classification process that allows a segmentation process in case of categorical data as well. (Dudás, 2018; Hámori, 2001; Kass, 1980; Mai & Tick, 2021). The decision tree, which uses CHI^2 tests for splitting is applied because it provides a visual representation of the questions along which engineering and technical management students' approach to skills for employability significantly differ. The target variable was set to the engineering faculty and all the questions analyzed in the paper were included as independent variables. As there are no restrictions on the measuring scale of the variables and their distribution, which is an advantage of the method, both categorical and numerical data could be loaded. In this research the response options were categorical, or students could rate statements on a Likert scale ranging from 1-4. Splitting in the tree is conducted by CHI^2 tests, the algorithm first unifies the categories that are the least different concerning the selected questions and then splits according to the strength of the faculty. At each level the node highlights which faculty is more dominant, which means the splitting question is more characteristic of the students of that specific faculty. When the algorithm finds an optimal tree depth and no relevant changes would happen in the segments, it terminates. The Exhaustive CHAID method is different from CHAID since non stopping criterion is defined. The splitting variables are used to characterize the different approaches of students to the relevant competences, and their attitudes on what they expect more from higher education – skills, competences, or specialized knowledge. The SPSS program was used for growing the tree.

After the survey, the collected data were cleaned to retain only properly answered papers for further analysis. Out of a total number of 165 responses participants have been excluded based on the following criteria:

1. they did not respond on time;
2. they chose more answers than they were asked to do;
3. they have not responded to all the questions, or have not responded at all.

The analysis of the data focused on the three hypotheses formulated including the foreign language practices and the acknowledged need for students in an international working environment. The following sections present the results of the survey and will discuss the implications and limitations.

5.1. Demographic Profile of the Participants

The participating students are students at the same university; however, they are students of two different faculties, the engineering faculty, and the business and management faculty. Almost two-thirds of the students (65.3%) are enrolled in Mechanical and Safety Engineering degrees while 34.7% of them are Technical Management students. All of them are between 19-22 years old. Of the engineering students, 98% were male 2% female, while at the business faculty, 62.7% of females and 37.3% of males participated in this study. The males are over-represented in the engineering faculty, while the male -female ratio is more balanced in the technical management course. Table 1 describes the characteristics of the participants.

Item	Category	Percentage (%)
Faculty	Engineering (Mechanical and Safety Engineering) Business and Management (Technical Management)	65.3 34.7
Age	19-22	100
Gender		
Engineering faculty	Male Female	98 2
Business and Management faculty	Male Female	37.3 62.7

Table 1. Demographic profile of participating students

6. Results

The section presents the results and findings on the research questions and hypotheses. The questions were first analyzed based on the responses of all the participating students, then the significant differences between the faculties were tested.

6.1. Skill Development for Employability

According to hypothesis 1 engineering and technical management students have different priorities regarding soft skills and competences.

The first question asked students to select the training of which skills they prioritize during their university studies. Figure 4 presents what percentage of students selected the different skills. The top three skills selected by the students were Problem Solving (66.7%), Communication Skills (29.9%) and Knowledge Gained in Relation to Specialization (51.7). Students found Self-Management (8.2%) and Analytical Thinking and Skills (13.6%) to be the least important.

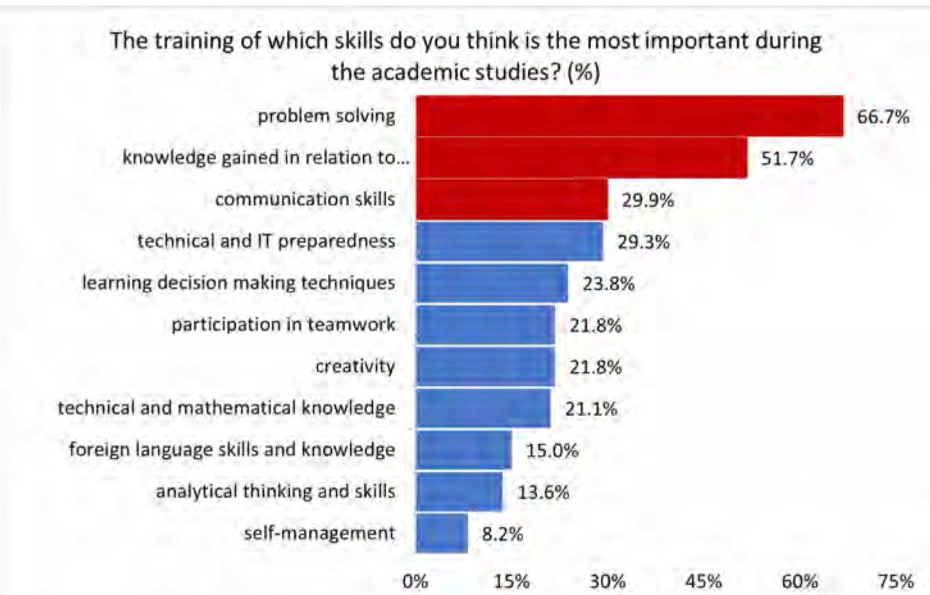

Figure 4. The most important skills during the academic years (% distribution)

Table 2 shows the similarities and differences grouped by the faculties. Skills such as Problem Solving (66.7% at both faculties) and Knowledge Gained in Relation to Specialization (58.3% at Engineering and 39.2% at business and management faculty) were among the top three choices at both faculties. Decision-Making Techniques at business and management faculty (37.3%) and Technical and IT preparedness (30.2%) at engineering faculty came third in student choice. While Communication Skills were among the top three skills to be trained at the university, separately the two groups did not select this specific type of training among the top three ones. It came third for technical management students while Technical and IT preparedness was more important for engineering students.

Communication skills (35.3%) came fourth in the ranking by students at the business faculty while there was a tie for Technical and Mathematical Knowledge and Communication Skills at engineering faculty (27,1%). The least important for students at the engineering faculty was Self-Management (93.8% did not select) and interestingly the fewest number of business management students marked Foreign Language Skills and Knowledge (90.2% did not select) with a tie for Technical and Mathematical Knowledge (90.2% did not select).

The training of which skills do you think is the most important during academic studies?	**Faculty**		
	Engineering	**Business**	**Total**
	(%)	**(%)**	**(%)**
problem solving	**66.7**	**66.7**	**66.7**
knowledge gained in relation to specialization	**58.3**	**39.2**	**51.7**
communication skills	27.1	35.3	**29.9**
technical and IT preparedness	**30.2**	27.5	29.3
learning decision making techniques	16.7	**37.3**	23.8
participation in teamwork	21.9	21.6	21.8
creativity	22.9	19.6	21.8
technical and mathematical knowledge	27.1	9.8	21.1
foreign language skills and knowledge	17.7	9.8	15.0
analytical thinking and skills	9.4	21.6	13.6
self-management	6.3	11.8	8.2

Table 2. Similarities and differences between the faculties

When comparing the preferences of the students from the two faculties it was found that a significant difference was found in specific skills related to their main studies ($CHI^2 = 27.24$, $p = 0.004$) (Table 2).

The four skills that showed a significant difference among the participating students from the two faculties were choices 4, 5, 8 and 9 (see Table 3). Students at the engineering faculty rather selected Knowledge Gained in Relation to Specialization (p=0.027) and Technical and Mathematical Knowledge (p=0.015) while more students at the business faculty chose the options Learning Decision-Making Skills (p=0.005) and Analytical Skills (p=0.04) which can be attributed to the special knowledge students need for their profession. Apart from these skills students find similarly important the training of all the other skills.

The training of which skills do you think is the most important during the academic studies?	**Faculty**	
	Engineering	**Business**
	(%)	**(%)**
4. learning decision making techniques	16.7	37.3*
5. analytical thinking and skills	9.4	21.6*
8. knowledge gained in relation to specialization	58.3*	39.2
9. technical and mathematical knowledge	27.1*	9.8

*: $p < 0.05$.
Tests are adjusted for all pairwise comparisons using the Bonferroni correction.

Table 3. Skills where significant differences were detected between the faculties

6.2. Internationalization to Support Career Success

Special attention is being paid to the internationalization at the faculties of the participating university, whether the experience relays on foreign students studying here with a Hungarian state-funded scholarship – Stipendium Hungaricum – or Hungarian students finishing courses abroad with a European funded scholarship – Erasmus – program. The authors found important to emphasize the training of language skills as a lot of companies' value foreign students arriving from less developed, low or middle-income countries outside the EU studying under the Hungarian state-funded scholarship.

> "This scholarship is considered to be the most prestigious higher education scholarship program of the Hungarian Government that offers a wide range of courses for international students with an excellent academic track records. The scholarship aims to support the internationalization of Hungarian higher education and its constant development, to strengthen the international relations of the academic and research community, and to promote the good reputation and competitiveness of Hungarian higher education throughout the world." (Stipendium Hungaricum, 2022: page 1.)

The response options of the question related to the development of skills and competences abroad. In general, 84.6% of the responding students agreed that studying abroad improves their Language Skills and more than half of the students (53.1%) found Network Building important (Table 4). Furthermore, the development of Adaption Skills to different cultures also overcome factors like Knowing a Foreign Culture, or to Accept Otherness, 45.5% of the students fund it as one of the three most important benefits of foreign studies.

Why do you consider your experiences with Erasmus or Stipendium Hungaricum scholarship important?	**Total n %**	**Engineering %**	**Business %**
improves language skills and communication in a foreign language	**84.6**	85.4	83.0
to extend networking and networks	**53.1**	49.0	61.7
developing adaption skills to international norms	**45.5**	41.7	53.2
get to know foreign culture, mindset, and mentality	43.4	42.7	44.7
possibility of new research platforms and projects	30.1	33.3	23.4
a new approach to structure and interpreting learning material	26.6	34.4*	10.6
it is easier to accept otherness	16.8	14.6	21.3

Significance level for * <0.05.
a. Tests are adjusted for all pairwise comparisons using the Bonferroni correction.

Table 4. Importance of foreign experiences: Erasmus – Stipendium Hungaricum

Comparing the three top factors why students consider foreign studies important, students at both faculties chose the possibility to improve their Foreign Language Skills with similar percentages (85.4% at engineering and 83% at business faculty), however, even though the second most frequent choice was the possibility to Extend Networking only half of the respondents at the engineering faculty selected the option, and over 60% of respondents at the business faculty was in favor of this factor. For engineering students Get to know Foreign Culture, Mindset and Mentality came third in the list while for technical management students developing adaption skills to international norms was more important (Table 4, Figure 5). While students at the engineering faculty regard a new structure as important, students at the business faculty seem to find the Networking and Adaptation to International Norms more important. Joining an International Project is more essential for the engineering students even if it does not show a significant difference than for future technical managers.

Soft skills gained at the two special scholarship programs showed a significant difference between the students of the two faculties (CHI^2=15.545, p=0.03). The significant difference is linked to the learning method and the approach to Structure and Interpreting Learning Material, which is a cognitive skill among soft competences (Table 4). Only 10.6% of the students at the business and management faculty selected the option, while over one-third of the participating students at the engineering faculty voted for it.

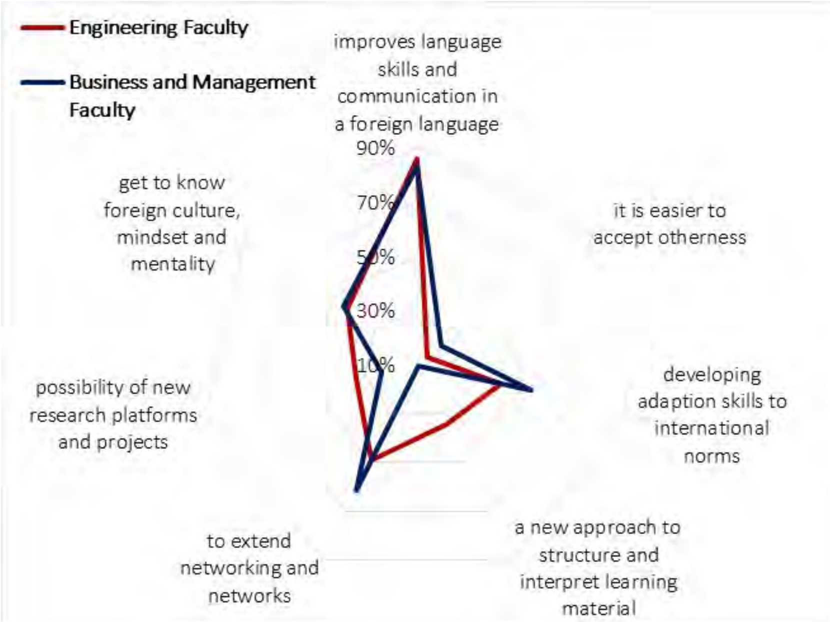

Figure 5. Differences in the top three factors' choices of benefits of foreign studies

The rankings of skills and competences gained through foreign studies by the two faculties also show a strong positive significant rank correlation (Spearman's $\varrho=0.8571$, $p=0.014$), i.e. should students at one faculty ranked a factor ahead then students at the other faculty do so, which is in compliance with the significant difference of approaches to experiences in studying abroad (Figure 6). Figure 6 visually presents where students from the two faculties differ the most. The third and fourth places are interchanged while engineering students find the skill To Easily Accept Otherness the least important as opposed to technical management students placing this skill as number 6. The numbers in Figure 6 denote the order given by engineering students while the colors show where the order is different between the students of the two faculties e.g., number 6 (dark blue, Project Possibilities) by engineering students is placed number 5 by technical management students (orange).

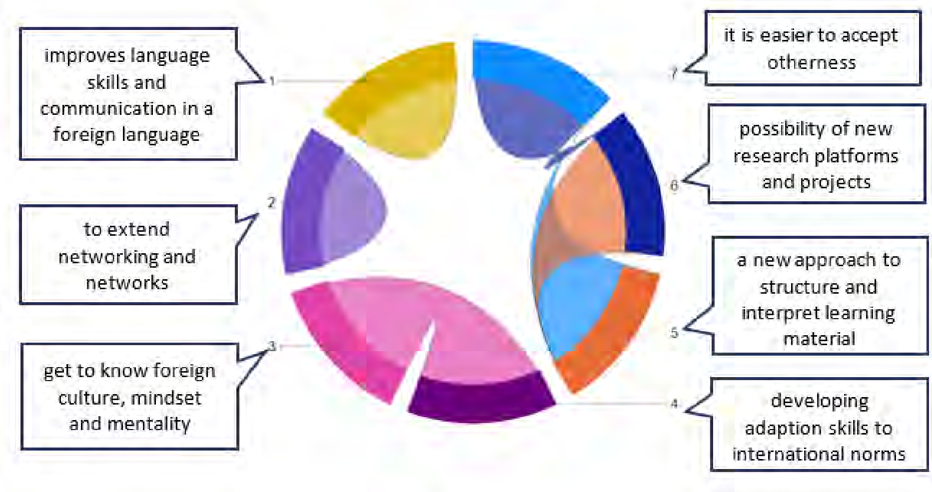

Figure 6. Ranking of skills by both faculties

6.3. Students' Perception of Skills Development for Future Employability

The second hypothesis aims to justify that engineering and technical management student find different skills important for their future career. Based on the responses, students at both faculties judge the labor market success of newly graduates similarly. No significant differences could be detected between the students of the two faculties (CHI^2=8.034 and p=0.330), while the three most important factors were the Individual Talents and Skills (53.1%), the Professional Devotion (51%) and the Excellent Network of students (49.7%) (Table 5). The least important factors according to the students are the Knowledge Gained at the Universities and the Network Built during academic studies. The responses do not say that these factors are not important it only indicates that students do not list these factors among the top three most important ones.

Despite that no significant differences could be detected between the faculties; the order of responses differs in only one statement. According to technical management students the professional devotion of students is only the fifth, while engineering students put this approach as the first most important one (Figure 7).

The labor market success of freshly graduates depend on	Column N %
6 on individual talents and skills	**53.1%**
3 on the professional devotion of students	**51.0%**
4 on the excellent network	**49.7%**
7 on the current labor market requirements	46.9%
2 on the stable foreign language knowledge	41.5%
5 on the network built during the university years	30.6%
1 on knowledge gained at the university	25.9%

Table 5. Factors that influence the career success of newly graduated students

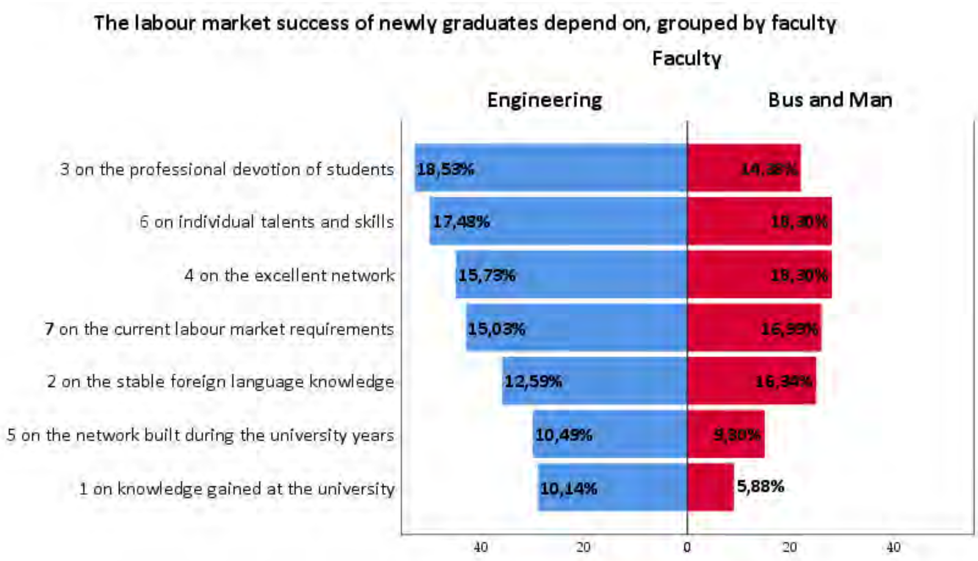

Figure 7. The labor market success dependence

6.4. The Role of Training in Higher Education to Serve Self-Appraisal and Self-Assessment

The third hypothesis is related to students' expectations from higher education concerning their competence development including self-assessment questions on how higher educational studies contribute to someone's knowledge, experiences, and self-awareness to have a successful career after graduation. Figure 8 displays the responses using sentiment analysis. More than half of the respondents agreed that Knowledge Related to Their Future Job (57.82%) and Digital Literacy Skills (55.1%) – the ability to use ICT technologies – contribute fully to their career success together with personal skills – Better Understanding of People Around you (52.38%). On the other hand, skills to be able to Write and Present Clearly and Precisely (39.46%), to Analyze Quantitative Problems (44.9%) and to Work Effectively and Efficiently in Teams (47.62%) were considered a success factor by less than 50% of the respondents. However, these skills can be considered important as over 40% of the students gave a positive response.

Since the proportions of agreement and disagreement are relatively balanced for both the 'hard' and 'soft' skills, it implies that next to professional skills, personal skill development is necessary for engineering as well as technical management students.

Table 6 presents the Mean, Median, Mode and the standard deviation of the responses. No extreme values could be detected, students were not convinced that their education at universities fully contributes to their skills for employability and self-awareness but did not totally deny its contribution. In four cases (question 1, 3 and 7) students feel that their education does rather contribute to their success in skills for employability (Me=2, Mo=2), while in case of question 2, 4, 5 and 6 they voted for the negative sentiment (Me=3 and Mo=3).

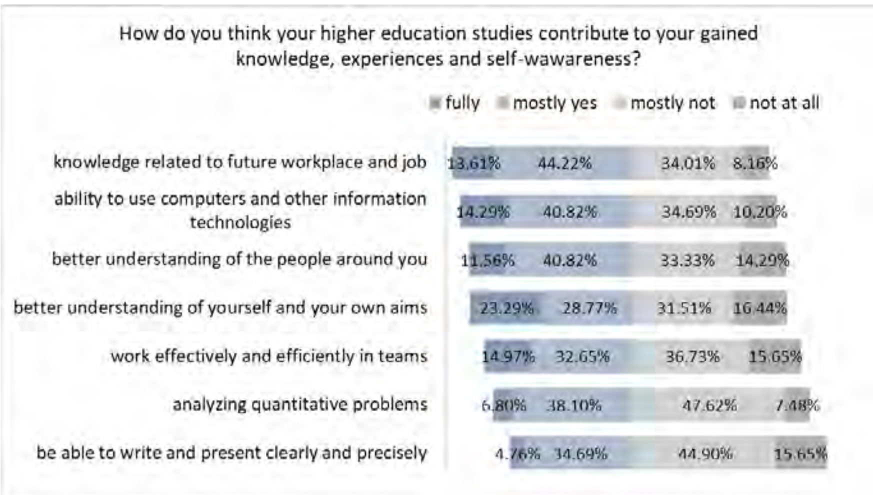

Figure 7. Higher education contributing to future career planning

Skills trained in higher education for self-appraisal and self-assessment	**n**	**Mean**	**Me**	**Mo**	**STD**	**CHI² test value**	**p value**
1. Knowledge related to future workplace and job	147	2.37	2	2	0.820	38.61	**0.000**
2. Be able to write and present clearly and precisely	147	2.71	3	3	0.785	0.645	0.886
3. Ability to use computers and other information technologies	147	2.41	2	2	0.858	5.623	0.131
4. Analyzing quantitative problems	147	2.56	3	3	0.732	9.174	**0.027**
5. Work effectively and efficiently in teams	147	2.53	3	3	0.931	9.524	**0.023**
6. Better understanding of yourself and your own aims	146	2.41	2	3	1.022	12.049	**0.007**
7. Better understanding of the people around you	147	2.50	2	2	0.879	5.567	0.135

Table 6. Descriptive measure of higher educational studies contribution to knowledge, experience, and self-awareness and significant differences between faculties

Based on the percentage distribution of students they are indecisive, as all the three parameters are between 2 and 3, i.e., between 'mostly yes' and 'mostly not'. The question Better Understanding of Yourself and Your Own Aims seems the most controversial, since according to the parameters the question responses show a negative sentiment (Mo=3) (Table 6), however, based on the percentage distribution (52% positive responses) the responses are shifted to the positive sentiment. Nevertheless, this question got the highest number of the most positive responses (23%) (Figure 8).

At first crosschecking, students' opinion significantly differed between the two faculties in the questions with the negative sentiment – see Table 6 CHI^2 test and p values for questions 4 (Analyzing Quantitative Problems), 5 (Work Effectively and Efficiently in Teams) and 6 (Better Understanding of Yourself and Your own Aims) - and the first with the highest ratio of positive responses – Knowledge Related to Future Workplace and Job.

In order to compare the behavior of students of the two faculties further analysis was conducted (Table 7). Out of the seven statements significant differences were traced in the same four questions as above – Professional Knowledge, Analytical Skills, Teamwork and Better Understanding of Oneself and Own Aims. Only in case of question 5 the variances were not equal, however assuming non equal variance the test showed a significant difference.

	Levene's Test for Equality of Variances		t-test for Equality of Means		
Skills for successful career	**F**	**Sig.**	**t**	**df**	**Sig. (2-tailed)**
1. Knowledge related to future workplace and job	0.804	0.371	-4.564	145	**0.000**
2. Be able to write and present clearly and precisely	0.242	0.624	-0.787	145	0.432
3. Ability to use computers and other information technologies	0.303	0.583	-1.662	145	0.099
4. Analyzing quantitative problems	1.895	0.171	-3.054	145	**0.003**
5. Work effectively and efficiently in teams			-2.984	116.5	**0.003**
6. Better understanding of yourself and your own aims	0.003	0.954	-3.443	144	**0.001**
7. Better understanding of the people around you	0.001	0.981	-1.854	145	0.066

Table 7. Significant different opinion of students at the two faculties regarding skills for employability

6.5. Segmenting Factors for Engineering and Technical Management Students

The next step in the comparative analysis was the use of a decision tree to confirm and to reveal the significant differences between the two faculties and to confirm the development of which competences higher educational institutions need to put more emphasis in the future. The competences and expectations of the students that come earlier as splitting points reflect the higher importance of the competence or expectation in training. The categorical variable in this case is the faculty (blue color denotes the engineering faculty and the red color is the business and management faculty) while the independent variables are the question items and statements used in the research. All the statements analyzed above were used as independent variables and the target variable was set to engineering faculty (business and management faculty was set as target variable for a second run and resulted in the same decision tree), with the following criteria: the splitting node significance level was set to α=0.05, the minimum number of cases in the parent node was set to 30 while that of the child note to 10 due to the fact that the number of students from the business and management faculty was 51 and the goal was to gain a decision tree with sufficient depth (Figure 9).

The maximum tree depth was set to 5 to gain as many significant splitting variables as possible. The decision tree grew 3 levels, though, which show the significant factors and define a priority order of significant factors regarding the competences and the students approach to higher education and the value of their degree. Level 0 presents the percentage and the numeric distribution of the students 65.3% engineering and 34.7% technical management students). Then the algorithm selects the most significant items step by step and creates segments in which the distribution of students from the two faculties can be found. It can be concluded that students are split into three groups by the statement Knowledge Related to Future Workplace, then two competences Decision Making techniques and a New Approach to structure and Interpret learning Material with the same impact became the splitting items.

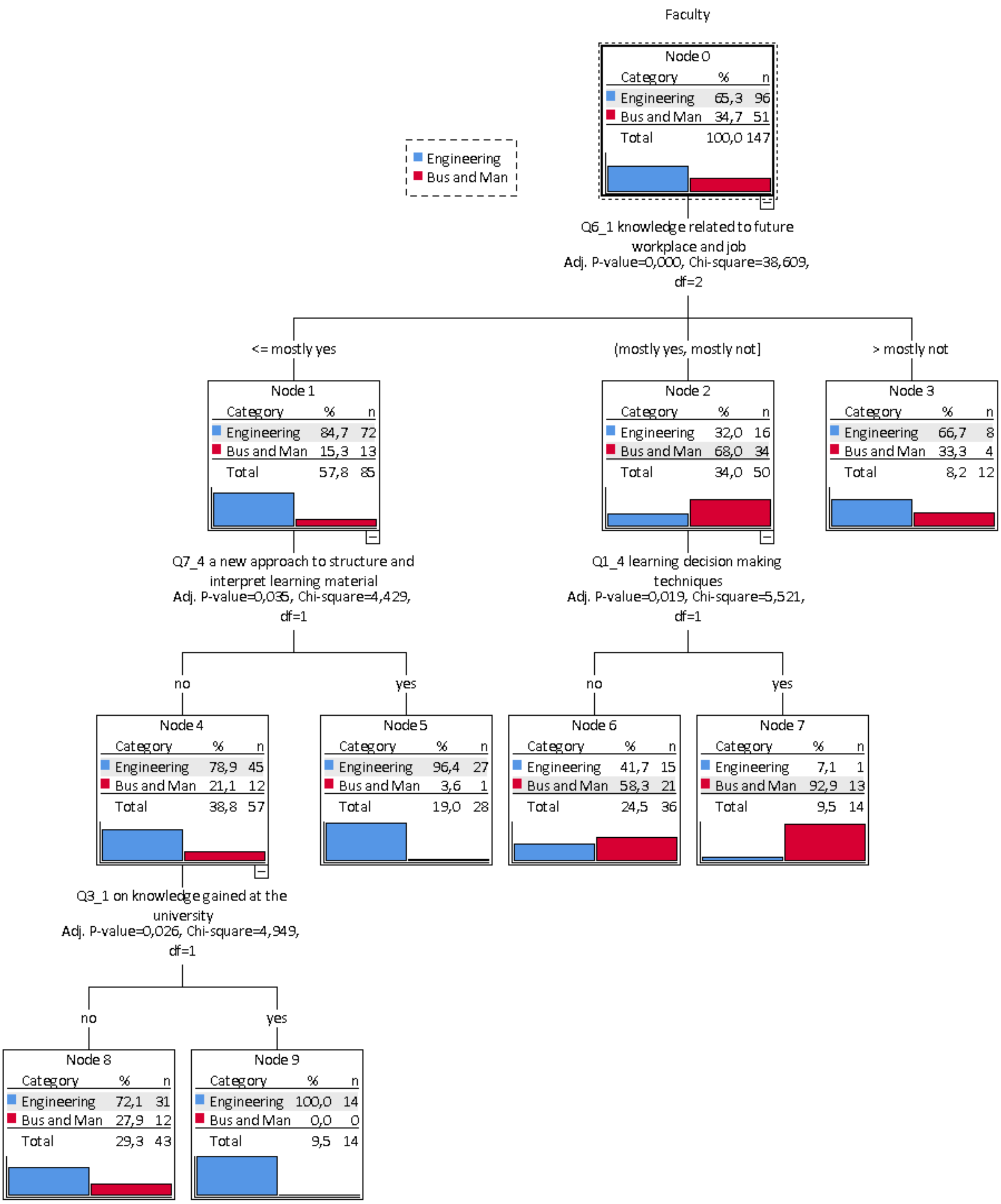

Figure 8. Decision tree to identify separating skills and competences

The level 1 splitting (higher education contributed to Knowledge Related to Future Workplace and Job) put only 16 students of engineering (32%) into the group that is more characteristic to the group of technical management students at the business and management faculty (68%). They are the most indecisive students who answered with 'mostly not' and 'mostly yes' to the statement. Very few students were put into the group who thought that higher education did not contribute to the Knowledge Related to Future Job (8 and 4 students from the engineering and the business and management faculties respectively) while 84.7% of the fully aware students come from the engineering faculty.

These students were further divided by a second choice, namely which requires a New Approach to structure and Interpret Learning Material – a competency gained through studies abroad through which their approach to learning and thinking can change. Both groups are dominated by the engineering students, and those who do not see this opportunity an advantage were further split by knowledge gained at the university. These groups are all assigned to the engineering faculty.

The indecisive student group is assigned to the business and management faculty, those who stand by the importance of the factor are mostly technical management students They are split by the competency Learning Decision making Techniques, resulting in a group voting for the importance of the training of this specific skills (92.9% technical management students), while the 'No' group proved to be more balanced with 41.7% and 58.3% of students from the engineering and business and management faculties, respectively. Considering the method of tree growing, both the CHAID and the EXHAUSTIVE CHAID algorithm resulted in the same decision tree.

Most of the students belonged to the leftmost branch. The exhaustive CHAID algorithm reduces the uncertainty from 34.7% to 15.65% ([12+0]/147=0.0816) by level 4 which is a 26.54% reduction in uncertainty (Table 8).

Table 9 present the leaf information of the decision tree. The 'node' column gives the number of students in the segmented group and the proportion to the total number of students, while the 'Gain' columns gives information on the number of students segmented to the target group by the algorithm and the ratio to the total number of students at the engineering faculty. The 'response' percentages present the proportion of students segmented by the target within the group and finally the 'Index' column is the ratio of the response % and the root target %. The higher the index the impact of the rule leading to that group is larger (Mai & Tick, 2021). With the help of the model the factors could be confirmed that differentiate student expectations regarding competences and skills gained during their academic studies as well as from higher education for future career. The model is 77.6% accurate so there is a 22.4% of misclassification.

Node	Engineering		Bus and Man		Predicted Category	Sig.[a]	df	Split Values
	n	%	n	%				
0	96	65.3	51	34.7	**Engineering**			
1	72	84.7	13	15.3	**Engineering**	0.000	2	<= mostly yes
2	16	32.0	34	68.0	Bus and Man	0.000	2	(mostly yes, mostly not]
3	8	66.7	4	33.3	**Engineering**	0.000	2	> mostly not
4	45	78.9	12	21.1	**Engineering**	0.035	1	no
5	27	96.4	1	3.6	**Engineering**	0.035	1	yes
6	15	41.7	21	58.3	Bus and Man	0.019	1	no
7	1	7.1	13	92.9	Bus and Man	0.019	1	yes
8	31	72.1	12	27.9	**Engineering**	0.026	1	no
9	14	100.0	0	0.0	**Engineering**	0.026	1	yes

Growing Method: EXHAUSTIVE CHAID. Dependent Variable: Faculty. a. Bonferroni adjusted.

Table 8. The representation of the decision tree

Gains for Nodes						
Node	Node		Gain		Response (%)	Index (%)
	n	%	n	%		
9	14	9.5	14	14.6	100.0	153.1
5	28	19.0	27	28.1	96.4	147.7
8	43	29.3	31	32.3	72.1	110.4
3	12	8.2	8	8.3	66.7	102.1
6	36	24.5	15	15.6	41.7	63.8
7	14	9.5	1	1.0	7.1	10.9

Growing Method: EXHAUSTIVE CHAID. Dependent Variable: Faculty.

Table 9. The importance of skills and competences at nodes

7. Discussion

In this section the results of the study are discussed in relation to the study purpose and the findings in the existing literature. The primary objective of the study was to identify which digital competences students find important for their studies and future career and to reveal the significant differences between the students of the engineering and the business and management faculties.

7.1. Integration in the Literature

The role of education in the shaping of the future is undeniable, as academia has greatly contributed to the industry's current revolution and technological innovation (Amry, Ahmad & Lu, 2021). Along with digital transformation, it is also mandatory to have workforce capability building at each level of the industry. Admittedly the type of work varies across different organizations and functions but generally can be said that the workers shift away from hard manual tasks toward to an automated and data-driven technology. Building new skills for this transition is a great challenge for both sides: for the employers as well as for the employees (Collet, Hine & Du Plessis, 2015). Future workers need the proper knowledge and the understanding the use of the digital tools and data, as how to work together in a team and respond to upcoming challenges together (Iordache, Marien & Baelden, 2017). Building 21st century skills can take many forms from retraining or upskilling the present workforce, entering new partnerships, or hiring new, educated workforce with the relevant skills and Industry 4.0 ready capabilities (Coşkun & Gencay, 2019). The question then is not whether higher education is needed, but how it can best assist students in their transition to a paradigm shift and competences can be aligned with it.

The World Economic Forum's research in 2020 listed the 10 top future skills for 2025, as it is shown in Figure 2. Along with the deep interviews conducted with 20 Hungarian companies it can be stated that these inputs and the researchers' findings are in close relation. The industry inputs articulated around the following subjects:

1. Identifying and developing expected competences and build them into future curricula.
2. Promoting more relevant industry-based practice and real industrial based challenges for students, depending on their chosen fields of studies.
3. Globalization leads all students to international experiences, so speaking a foreign language make them able to participate in projects – as team members – became highly important.
4. Focusing on open yet professional communication encompassed with social skills – such as critical thinking, problem solving, care for others – allow our students to collaborate adeptly in their future workplaces whether in virtual environment or in real time and place.

The present research led to similar conclusions and the research results well underpin the conceptual framework developed for the research. The question then is not whether higher education is needed, but how it can best assist students in their transition to a paradigm shift and how competences can be aligned with it.

Three hypotheses have been formulated to investigate how students' opinion differ as far as soft skills concerned – although their studies related to technical skills development – from two faculties at the Óbuda University.

H1. Engineering and Technical management students have different priorities considering soft skills and competences.

While both groups agreed upon that the most important skill is Problem Solving, the second and third places were Knowledge Gained in Relation to Specialization and Technical and Mathematical Knowledge by the engineering students while technical management students ranked Learning Decision Making Techniques and Analytical Thinking and Skills for the second and third places. Similarly, Coskun states, that there is a must for engineering education to adapt to the vision of Industry 4.0 (Coşkun & Gencay, 2019).

Consequently, the first hypothesis is accepted and justified by the significant differences identified. As far as communication and foreign language skills are concerned, both groups think to learn a foreign language is the most important for foreign studies, however while technical management students rank Network Building the second place, engineering students see it as an Opportunity to join a Project or Research Platform or possibly team. As Lavalle, Schuma, Pucher, Forkel and Kauper (2017) states, new didactic methods need to be implemented, eLearning plays a crucial role in the development of Industry 4.0 and a paradigm shift is necessary also in the cultural approach of people. Both groups of students believe that foreign studies as part of their international experience contribute to some specific skill development. Pásztor (2021) in her study also reveals the importance of cultural exposure and networking through mobility programs.

H2. Engineering students, opposite to technical management students find different skills important for their future career.

The answers given by the students – including engineer and management students – show that (Table 5) that more than half of them believe that their success in the future will depend mainly on their Individual Abilities and Talents, while the second place in the overall list is Professional Devotion. This was indicated by half of the respondents. Nearly half of the students surveyed chose an Excellent Relationship System as a determining factor for their career in their future workplaces. Surprisingly, the Dependence on Current Labor Market Expectations is only in the fourth place. Benesova in her study is examining the situation of changing workplaces and reveals how they are affected by digitalization (Benešová & Tupa, 2017). More than a quarter of students chose the Knowledge they Acquired at University as a factor in their future careers. Amry et al (2021) in their study put an emphasis on the new challenges of the universities to meet the required skills of Industry 4.0. No significant differences could be detected between the students of the two faculties, meaning that hypothesis is not accepted. However, the skills are important for the students of the two faculties.

H3. Engineering and technical management students have different expectations from higher educational training.

The results about the knowledge gained at higher education have revealed that more than half of the students from both faculties agreed that Knowledge Related to Their Future Job (58%) and Digital Literacy Skills (56%) – meaning the ability to use ICT technologies – are the two most important factors contributing to their gained knowledge during their higher education years. As for personal skills development 53% of them have chosen Better Understanding of People Around you to contribute to their career successes. As Aberšek (2017) also points out the utmost importance of digital literacy and soft skills for Industry 4.0 employability in his research. They also value as an important soft skill to Work Effectively and Efficiently in Teams (48%), while to Analyze Quantitative Problems (45%) came the fourth place. On the other hand, the skill to be able to Write and Present Clearly and Precisely was considered a success factor only by 40% of the respondents. Students' opinion significantly differed between the two faculties in the questions with the negative sentiment, namely Analyzing Quantitative Problems, Work Effectively and Efficiently in Teams and Better Understanding of Yourself and Your own Aims and in case of the question with positive sentiment, i.e., Knowledge Related to Future Workplace and Job. Since the proportions of agreement and disagreement are relatively balanced for both the 'hard' and 'soft' skills, and for skills for employability, it implies that next to work related cognitive skills, soft skill development is necessary for engineering as well as technical management students. It complies with the findings of Motyl, Baronio, Uberti, Speranza and Filippi (2017). Kamaruzaman et al. (2019) warn that the present skills of engineering students should be replaced early on for future employability. As a result, hypothesis three can be partly accepted as some aspect significant difference could be detected but in other questions students from both faculties agreed.

7.2. Limitations of the Study

The research, however, has its own limitations. Due to the non-probabilistic method of data collection and the relatively low number of students included no further generalization can be done no general conclusions can be drawn. The research should be repeated in a larger sample with additional faculties to explore a greater relationship between subjects, teachers' capabilities, and skill development. Furthermore, the third party, namely industry 4.0 players need to be more involved in developing standardized questionnaire, as questions were partly based on the results of qualitative research with Industry 4.0 players but were developed based on secondary research results. It must also be noted that no previous research has been conducted at the two chosen faculties at the university observed which is greatly reduces a possible comparison or confirmation of the results.

7.3. Implications for Future Research, Theory and Practice

Education 4.0 has also brought together competences under a single umbrella that older systems managed completely separately, like technological knowledge and human or soft skills. According to our survey, the combination of these two groups of competences is today the most desirable skills in the labor market (Chaka, 2020). The importance of Technical-IT knowledge is just as important as having someone with interpersonal skills, excellence in problem solving, or creative thinking (Nelson et al., 2018). Consequently, beyond the basic science of education, future students – as our survey shows – need to be taught how to analyze problems, engage in scientific debate, or express themselves clearly in writing and verbally.

Further quantitative research should be conducted or in-depth interviews to clarify the reasons behind the differences of students' choices as far as skills concerned. It would also give us better understanding about curricula and didactic method if we ask students about their expectations for their academic studies (Gawrycka, Kujawska & Tomczak, 2020). By conducting wider research, surveying more students would also give us deeper comprehension what students consider an optimal teacher-student relationship, what would they change in their studies' structure and to what extent would they need stationary versus online education.

In the future the researchers plan to extend the group of participants to further engineering and business management students as well as to other faculties and universities. Further investigation is planned to include participants from Industry 4.0 in questionnaire design.

8. Conclusion

The research proved that Education 4.0 is here and Z generation studying at universities prefer problem-based learning, including creativity, analytical and critical thinking, would like to have good communication skills, wish to work in team while they need to improve on self-management that is they need to develop on learning strategies and flexibility. Engineering students, in addition, need more technical and IT related skills as well.

Industry 4.0 and digitalization are rapidly and radically changing the job market, which means that different skills and competences are required from freshly graduates. Consequently, universities will also need radically to change their practices. As the worldwide pandemic changed the channel of education delivery, not only means but the methodology and the competences to develop should be reconsidered.

The research conducted partly confirmed that skills and competences that are among the top 10 job skills listed by the World Economic Forum are also of high importance of university students, however, while engineering students prefer ICT skills to develop, new approach and structure to interpret learning material encompass with foreign experiences, they wish to focus on knowledge related to their future job. On the other hand, technical management students rather focus on decision-making skills together with foreign language skills and wish to extent their network by Erasmus mobility.

Universities need to adapt to these strength and weaknesses of students and change their curricula to integrate hard as well as soft skills development in tutoring. Respectively universities also must promote multidisciplinary research and project collaborations to bring different academic fields and talents together, which might lead to a more dynamic working and production environment with optimized technology and structural processes.

Declaration of Conflicting Interests

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