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Opportunities for the Development of Soft Skills in Engineer Education

Soft skills in higher education

The technological development of the 21st century and the constant changes in the labour market pose new challenges for higher education. Rapid changes lead to a change in attitudes in higher education (Wolhuter, 2020). It is becoming increasingly important for students to acquire up-to-date, theoretically grounded and practical knowledge that will enable them to stand their ground in the world of work and everyday life. Thus, one of the critical goals of higher education is to prepare students for successful work. This can be done by developing hard and soft skills at the same time.

The term complex skill is used for knowledge that can be acquired in school from textbooks. "The development [of hard skills] is well measurable, verifiable, and their evaluation system is in place. The acquisition of these general and professional knowledge and skills determines the rules and routines for students that prescribe what to do and how to act in different situations. Employers can easily gain information about these skills (e.g. qualifications, language skills, numeracy, computer skills)." (Daruka, 2017: 10)

Soft skills are often defined in terms of "those skills, abilities, and personal attributes that can be used within the wide range of working environments that graduates operate in throughout their lives" (Fraser, 2001:1).

Soft skills are classified in various ways in the literature:

- For example, Bennett et al. (1999) identified four main categories: self management, information, others and tasks.
- Gallivan et al. (2004) name six categories: communication, interpersonal, leadership, organization, self-motivation and creativity. According to their research, these appear in 26% of online job advertisements.
- Beard et al. (2007), based on surveying 250 employers, mention 13 different soft skills expected by employers. These include communication, analytical, teamwork, interpersonal and organizational skills, motivation, flexibility and detail orientation. (Kolosai – Bognár, 2007.)
- Chamorro-Premuzic et al. 15 identified a system of soft skills comprising 15 components: "self-management, communicational, interpersonal, team-working skills, the ability to work under pressure, imagination/creativity, critical thinking, willingness to learn, attention to detail, taking responsibility, planning and organizing skills, insight, maturity, professionalism and emotional intelligence." (Chamorro-Premuzic et al., 2010: 223)
- Schulz named the following soft skills: "communication skills, critical and structured thinking, problem-solving skills, creativity, teamwork capability, negotiating skills, self-management, time management, conflict management, cultural awareness, common knowledge, responsibility, etiquette and good manners, courtesy, self-esteem, sociability, integrity/honesty, empathy, work ethic, project management, business management". (Schulz, 2008: 147)

The development of hard skills is prominent in the training program of higher education institutions, but less conscious effort is dedicated to the development of soft skills. However, these two sets of skills are complementary; they are both critical and "their synergy can ensure more effective learning-teaching processes in higher education, thus increasing the efficiency and quality of education" (Daruka, 2017: 10).

In engineering education, a crucial question is the abilities and skills that are important for an engineer in a rapidly changing information society. (Conlon, 2008; Lappalainen, 2009; Williamson et al., 2013). There is a growing demand for flexible, adaptable and communicative engineers (Kolmos, 2006). In addition, employers expect newly-graduated engineers to have professional knowledge and qualities such as problem-solving (Pogatsnik, 2019), openness and creativity, treating people well, and working in a team (Kersánszki – Nádai, 2020).

Engineers must collaborate with other engineers, their employees, marketing and financial professionals, traders, many other corporate employees, and representatives of other companies, foreign partners, and even communicate with users (e.g., when presenting products) (Bajzát, 2010). Soft skills provide the basis for the effective handling of problem situations (Schulz, 2008).

Engineering education focuses primarily on developing professional competencies and technical skills and does not adequately prepare students for the demands of the workplace. For example, Schomburg (2007) draws attention primarily to the lack of social, communicative and personal competencies. Other studies highlight the importance of interpersonal skills concerning engineering work (Direito et al., 2012; Berglund - Heintz, 2014) and emphasize the need to rethink the "traditional pathways" of engineering education because of technical innovations and to develop competencies that meet the expectations of the labour market.

According to the research results of Williamson et al. (2013), the engineers surveyed differ from the research subjects of other occupations in that they have more intrinsic motivation and are more persistent. However, they are less characterized by qualities such as confidence, conscientiousness, emotional stability and optimism.

Other studies (Lappalainen, 2009; Direito et al., 2012) also draw attention to the weaknesses of engineers: they have difficulty in effectively communicating, collaboration, teamwork, project management and lifelong learning.

A survey conducted among students of Linköping University in Sweden pointed out that engineering students had significantly lower levels of empathy than psychology and social worker majors. Differences were also found among engineering students: applied physics students performed worse than engineering informatics students. These results also indicate the need to develop engineering students' empathic skills. (Rasoal et al., 2012)

About the research

Our research among engineering students has also drawn attention to the need to develop soft skills. The research aimed to map the competencies of engineering informatics students and to consider development opportunities.

Our research questions were the following: What are the personality traits of students entering engineering informatics education? How can students' competencies be developed during engineering education?

475 first-year engineering informatics students were surveyed, 9.1%- of whom were female, and 90.9% were male. This ratio is not surprising, as the proportion of women in this field is relatively low.

The average age of respondents was 20.15 years. The youngest student was 18 years old, and the oldest one 35. The majority of surveyed students are from the capital (37.3%). 11.8% of them come from county seats, 33.1% from small towns and 17.9% from villages. 42.74% of students started their studies in the engineering informatics major after graduating from secondary school.

The Hungarian version of the Big Five Questionnaire (BFQ, Caprara et al., 1993) examined students' personalities (Tordai – Holik, 2018a; 2018b). This personality testing tool includes 5 dimensions and 10 subscales, as well as a social desirability scale, which shows how much respondents want to portray themselves in a positive way (Table 1). Students rated 132 items on a 5-point self-assessment scale.

Table 1. *Factors, sub-scales and sample items of BFQ*

Dimension	Sub-scale	Quality
Energy lively, extroverted, captivating	Dynamism	dynamic, active, talkative, enthusiastic
	Dominance	dominant, high self-confidence, confident
Friendliness helpful, understanding, tolerant	Cooperativeness	cooperative, sensitive to the needs of others, empathic
	Politeness	polite, kind, humane, well-meaning, obedient
Conscientiousness responsible, neat, diligent	Scrupulousness	accurate, precise, reliable, orderly, thorough
	Perseverance	persistent, steadfast, able to carry out activities
Emotional Stability balanced, calm, patient	Emotion control	able to master own emotions, cope with anxiety
	Impulse control	able to master own impulses (manage anger and irritability)
Openness creative, imaginative, well-informed	Openness to culture	open to cultural experiences, cultural interest
	Openness to experience	open to new experiences and values, customs and ideas different from own

When examining the reliability of the questionnaire, the Cronbach's alpha was 0.86, which is considered good. Based on the data, the personality characteristics of the interviewed students were outlined (Table 2).

Table 2. *Means and standard deviations (SD) of engineering informatics students on five personality factors and the social desirability scale compared with the Hungarian norm group (N=475)*

	Engineering informatics students Mean (SD)	Hungarian norm group (N=774) Mean (SD)
Energy	74.87 (12.06)	77.51 (11.85)
Friendliness	78.40 (10.09)	82.25 (10.09)
Conscientiousness	81.89 (10.80)	81.34 (11.11)
Emotional stability	73.03 (12.59)	68.60 (15.83)
Openness	79.55 (11.11)	85.52 (6.88)
Social desirability	**34.17 (5.45)**	29.54 (6.88)

Compared to the results obtained during the domestic adaptation of BFQ (Rózsa et al., 2006), we obtained lower scores in the Energy, Friendliness and Openness dimensions, which were close to average in the Conscientiousness and higher in the Emotional Stability dimensions. The surveyed students also scored higher on the Social Desirability Scale, suggesting that they would like to present themselves more favourably.

We interpreted the results both in the high and low zones of each dimension (Table 3).

Table 3. *Distribution of the sample in the low, average and high zones of BFQ dimensions (N=475)*

BFQ Factors	Low	Average	High
Energy	37%	41%	22%
Friendliness	34%	43%	23%
Conscientiousness	23%	44%	33%
Emotional stability	20%	44%	36%
Openness	54%	33%	13%
Social desirability	2%	35%	63%

Converting the raw points to a standardized T-value, the averages achieved on each main scale were classified into low, average and high categories. (T<45: low, 45<=T<=55: average, T>55: high).

The majority of students achieved an average or low value in the Energy Factor. That is, they are less dynamic and communicative, have low self-confidence, are more deliberate, withdrawn and prefer working independently. This dimension suggests weaker social skills.

Regarding the Friendliness factor, they also achieved average or below results, which suggests that they are less characterized by tolerance, empathy, helpfulness and selflessness; therefore, they are presumably less suitable for teamwork and cooperation.

In the Openness dimension, the vast majority scored low, indicating adherence to familiarity, rejection of change and innovation, less original and creative thinking and a lack of interest in the arts and sciences.

However, average or high results were achieved in the dimensions of conscientiousness and emotional stability. This means that they are characterized by reliability, perseverance, accuracy and responsibility, as well as being balanced, calm, and patient. These personality traits are indispensible to engineering work.

Strikingly many respondents achieved a very high score in terms of Social Desirability, which means that they wanted to present a positive image of themselves and meet expectations to a great extent.

Opportunities for the development of soft skills

In technical education, just like in other areas of Hungarian higher education, “traditional”, frontal and knowledge-based teaching is widespread. This form of teaching actually works better in groups with more homogeneous abilities, where the students’ work pace, way of thinking and knowledge are on a similar level.

Its disadvantage is that it cannot take into account the students’ individual abilities and skills. It is not interactive, so it is not suitable for the development of several abilities. However, the labour market demands more and more applicable skills from recent graduates, and students also increasingly demand active and interactive, learner-centred teaching, which enables them to cooperate and use technology (Bates et al., 2017).

In technical education, the psychological order of cognitive processes plays a prominent role: sensation, perception, attention, memory, imagination an thinking. Most of the time in education, however, due to the lack of time, of human resources or of tools, the greatest emphasis is placed on attention (class work) and memory (classroom test) (Rády, 2011).

The development of soft skills also requires the development of students’ self-knowledge (Fűzi – Jármai, 2019), the application of methods by which participants recognize and identify their abilities and characteristics, and then consciously shape them through experiential learning and interactions (Nagy, 2020; Seetha, 2013).

A good basis for personality development is provided by the introduction of various teaching methods and forms of work based on the active participation of the student, which go beyond the content and information transfer of education.

This is what we strive for in our elective courses for engineering students. The Communication course focuses on students’ verbal and non-verbal communication skills. During the practical classes, students perform a number of communication tasks that improve their oral expression skills, vocabulary and presentation techniques. Introductory communication tasks serve the purpose of getting to know each other. Team building tasks help cooperation and conflict management within the group. Tasks that develop communication skills help students in their academic and everyday communication. The topic of communication within the family, school and workplace is of particular interest. Topics such as

communication in the process of job-searching and negotiation techniques are also considered very important by students. The issue of assertive communication is met and practiced with keen interest, too.

The Social Development course provides an insight into some topics of social psychology. It focuses primarily on human nature and social interactions. Self-knowledge, self-esteem and self-awareness play an important role in it. Interpreting one's own and the other person's behaviour, extroversion, introversion, and person perception are also included in the topics. Students are particularly interested in how to make a "good impression" in their environment or what the halo effect is, and during classes, they often express their experiences of stereotyping. Social relationships are also a focus of interest, as the twenties age-group often find it difficult to build and maintain relationships. The exercises in the Social Skills Development course improve students 'self-knowledge in small groups, as well as the social skills that make them more sensitive and open in their social relationships. By improving communication, conflict management and cooperation skills, this course contributes to students' individual well-being and social success.

In our practical classes, different methods are used for the development of soft skills. Debate and discussion within the group provide an excellent opportunity for students to express their thoughts, elaborate their point of view, use arguments and pay attention to their discussion partners.

Situational games are both entertaining and educational, providing an opportunity for students to try themselves in different situations.

Collaborative learning is an excellent opportunity to develop soft skills, as it aims to provide students with an active learning experience. In collaborative learning, the result of learning together is the successful achievement of a common goal. This is achieved through joint activities, which also indirectly develop students' cooperation skills (Benedek – Molnár, 2019).

Cooperative methods can be given an important role to play in higher education, too (Pap-Szigeti, 2007), the application of which also serves the development of soft skills, because these methods are based on student cooperation. The four principles of cooperative learning (Kagan, 2015) – constructive interdependence, individual responsibility, equal participation and parallel interaction – promote the development of soft skills. Research findings point out that the use of cooperative learning techniques and social skills development courses have had a positive effect on co-operation at work and on personal relationships (Smith et al., 2015).

The application of the project method builds on the interest of students and the joint activities of teachers and students. Therefore, it is suitable for the development of cooperation, empathy, conflict management and communication. The project usually focuses on a practical problem, so it provides an excellent opportunity to develop problem-solving skills, too. When this method is applied, the traditional teacher-student relationship also changes (Simonics – Makó, 2016). This is also important because an essential condition for both academic and social integration is the proper cooperation of students and staff members (Engler, 2015). A study by Berglund and Heintz (2014) reported that project-based learning in a real workplace environment develops abilities and skills that facilitate students' employment, such as teamwork, communication, problem solving, and conflict management.

Problem-based learning (PBL) can be particularly effective in engineering education because it confronts students with practical problems, thereby preparing them for creative, critical and analytical thinking.

However, the widespread use of the above methods in higher education also requires the development of the methodological culture of educators. Our research results also confirm that we must strive for high-quality education and the transfer of knowledge that is applicable in the world of work.

Summary

Technological development and labour market expectations pose new challenges for higher education. Competence-development based on labour market needs, the role of practical training and the application of student-centred methods are becoming more and more important. Besides so-called hard skills, the development of soft skills also plays a key role in education.

The results of our research among engineering students have shown that the students surveyed need to be developed in terms of soft skills, especially in the areas of openness, communication and cooperation. The main conclusion of the research is that greater emphasis should be placed on the development of communication skills, social skills, self-knowledge and on the motivation and activation of students. Opportunities should be given to group work, as this form of work provides excellent ground to practice cooperation, adaptation, trust, selflessness, empathy and helpfulness. It is important that students be given assignments in which they can unleash their creativity and teachers should also seek to arouse students' interest in various areas of science. As students achieved a very high score in the field of social desirability, it is necessary to reduce the external control attitude and the desire to meet external expectations and, in doing so, facilitate a shift towards an internal control attitude.

Students' personality development can be facilitated by courses that focus on developing self-knowledge and provide opportunities for student activity and cooperation. Cooperative methods, collaborative learning, the project method and problem-based learning can also play an important role in higher education. The spread of student-centred teaching methods in higher education can be advanced by a change of attitude and the improvement of the methodological culture of teachers.

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