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How Do Engineering Students Think About the Effects of Robotization of Working Conditions?

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Abstract

Research on the social and labour market impacts of robots increasingly emphasises the role of education in preparing future employees. This paper presents the results of a questionnaire-based survey conducted among engineering students. The survey was conducted using a measurement tool that was on the one hand partly developed in-house and on the other hand partly adapted from the General Attitudes Towards Robots Scale (GAToRS). The students (N = 320) expressed their views on the one hand how are their beliefs influenced by the experiences of robotisation they obtained in their studies or work? On the other hand what are their expectations regarding robotisation in the near future? The results indicate that they consider climate change, the scarcity of natural resources and the availability of fast and safe transport routes to be the factors that will have the greatest impact on human working conditions. The students see the role of expertise in Hungary changing in five years' time, with low-level skills being replaced by the need for specific competences. They believe that robots will create new working conditions and a new working culture that will replace physically demanding, dangerous and boring work. The survey also revealed that female students have stronger reservations and fears about robotisation than their male counterparts.

Keywords

robotisation, workforce, engineering students

1 Introduction

While the first industrial revolution was characterised by mechanisation, the second by mass production and the third by automation, the central theme of the fourth industrial revolution is coordinated networks. Digitisation and data are at the heart of the fourth industrial revolution, in which the computer is considered only a tool. The evolution of the internet and technology is creating a network of people, organisations and technical devices that are constantly connected to each other, enabling companies to create fully customised products for their customers by continuously sharing data from value-creating processes. The cutting-edge techniques and technologies of the fourth industrial revolution are autonomous robots, simulation, horizontal and vertical systems integration, Industrial IoT (Internet of Things, i.e., networked "smart" devices), cybersecurity, cloud-based services, additive manufacturing (3D printing), augmented reality, and big data analytics.

However, the growing demand for industrial robots is raising concerns that robot-based innovation could lead to widespread job losses (Cho and Kim, 2018; Frey and Osborne, 2017; World Economic Forum, 2016).

Feelings of uncertainty about job security and working conditions lower performance, which has been confirmed not only by psychological stress theories but also by empirical research among workers in robotic environments (De Witte et al., 2016; Stankevičiūtė et al., 2021a). Stankevičiūtė et al. (2021b) point out that the existence of "good feelings" about a job is of particular importance for sustainability.

Artificial intelligence, which can operate with less and less human control, raises ethical and legal questions that focus researchers' attention on human perceptions and reactions to robotic autonomy and its different levels (Acemoglu et al, 2018; David, 2015). In the workplace, robots can take on a variety of roles such as assistants or even co-workers. Previous academic studies on the social acceptance of robots have shown that human attitudes are more positive when people perceive robots as devices rather than colleagues (Savela et al., 2018). The difference in thinking

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about the two roles of robots lies in the difference in their situations. Robotic equipment as single-function devices are mostly complementary to human work. However, there is more autonomy in the actions of robot colleagues. The differentiation is based on various strategies and attitudes. Humans adapt to robots while rationalising and predicting robot behaviour (Dennett, 1971; Dennett, 1987; Schellen and Wykowska, 2019). For people who perceive robots as more like equipment, working together is like using any other machine (Marchesi et al., 2019).

Pol and Reveley (2017), who focused their research on the workplace threats to young people, investigated the labour replacement effects of technological change. The impact on future generations is a major uncertainty factor with regards to the introduction of innovations. This unpredictability is one of the sources of anxiety for employees. Citing Radinsky (2015), the authors emphasise that with the advancement of robotics and artificial intelligence, the shadow of unemployment caused by technological progress reappears on the horizon. They quote Stiegler, who believes that there is a "huge transition" in our society (Stiegler, 2015:p.126), as automation transforms jobs. They also support their argument with the ideas by Brynjolfsson and McAfee (2011) and Ford (2015), who advise young people to take part in as much training as possible and acquire new competences in order to be protected from losing their jobs. Pol and Reveley (2017) also argue for the inevitability of technological unemployment and the need for coping strategies. The latter helps members of the younger generation to deal with their fears of previous life situations.

Several papers emphasise the importance of the university harmonising its courses with the expectations of the labour market and assigning a central role to competence development (Hirvonen et al., 2000; Kiss and Varga, 2021; Marin-Garcia et al, 2008).

2 Introduction to the research

The above research points out that it is important to emphasise the formation of students' beliefs in university education in order for the engineers of the future to find the appropriate application of robots and their harmony with the human workforce. The first step in finding methods of attitude formation is to get to know the students' thinking about the topic. It is important to learn about the views of future engineers on the social and regarding its role in the labour market. The aim of this piece of research is – as a university training institution – to get to know the students' beliefs in order to further develop the curriculum in a way that harmonises the needs of the students and the labour market. The research questions were as follows:

1. How are their beliefs influenced by experiences of robotisation obtained in their studies or work?
2. What are their expectations regarding robotisation in the near future?

A total of 320 students participated in the research. The survey was conducted using on the one hand a measurement tool that was partly developed in-house and on the other hand partly adapted from the General Attitudes Towards Robots Scale (GAToRS). The reliability of the questionnaire is indicated by a Cronbach's alpha of 0.727. The time spent on each part of the questionnaire was as follows:

- Background questionnaire: 166.01 sec (Std. Deviation (SD) = 97.107 sec);
- Transversal competences: 247.26 sec (SD = 126.299 sec);
- Robotisation attitude: 220.71 sec (SD = 124.295 sec).

The questionnaires were answered during 03–17 May 2022.

The age distribution of students participating in the research project is shown in Fig. 1 (Mean (M) = 24.41 years; SD = 6.133 years). 75% of them are aged 25 or under, most of them aged 21 (15.3%) and 23 (13.8%). The proportion of those over 27 is 12.8% (48 people).

67.2% of students (215) are men and 32.8% (105) are women; 59.1% (189) are studying on a bachelor training program, 33.1% (106) on a master training program and 7.8% (25) on a doctoral program. Of the undergraduate students, 45 (23.8%) are studying computer science engineering, 25 (13.23%) electrical engineering, 19 (10.05%)

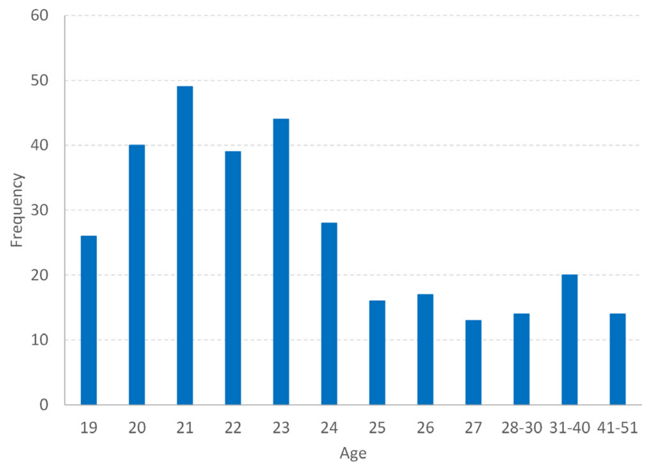

Fig. 1 Age distribution of students participating in the survey

mechanical engineering, 17 (8.99%) chemical or mechatronics engineering, and 15 (7.94%) business administration and management. The distribution of Master's students by academic program shows a very diverse picture. 14 (13.21%) study computer science engineering, 12 (11.32%) mechanical engineering and 9 (8.49%) mechatronics engineering. Of the doctoral students, 5 (20%) are studying at the BME Doctoral School of Computer Sciences, 5 (20%) at the BME Kandó Kálmán Doctoral School and 4 (16%) at the BME Vásárhelyi Pál Doctoral School of Civil Engineering and Earth Sciences.

290 (90.6%) are on full-time programs, while 46 (14.4%) are on self-financed programs. 85.6% of them (274) study with a state scholarship and 14.4% (46) pay for their fees.

3 Perception of future working conditions

The first question asked which factors will affect human working conditions in Hungary in the next 5 years as well as to what extent, taking into account future prospects? The students were asked to rate each environmental factor on a six-point Likert scale (1: not at all, …, 6: significant influence). If they could not tell, they also had an option to select to indicate this. This option was the answer most frequently given for "shifts in global power centers" (20 students) and "fast and safe transport routes" (21 students), while it was the least frequent answer for "technical and technological progress" (2 students) and "climate change" (6 students).

Among the most decisive factors, the respondents cited technical and technological progress (M = 5.29; SD = 1.050), the quality of public education and vocational training (M = 5.06; SD = 1.244) and the lack of a well-trained workforce (M = 4.88; SD = 1.178), while the least influential factors were migration (M = 3.86; SD = 1.494), climate change (M = 3.94; SD = 1.569) and the provision of fast and safe transport routes (M = 4.12; SD = 1.328). The largest variance, and therefore the largest difference in beliefs, is in the perception of the impacts of climate change, natural resources (M = 4.17; SD = 1.527) and migration (Fig. 2).

The relationship between the different influencing factors varies widely. The strongest relationships were found between the following variables (Significance level (p) = 0.01):

- Climate changes – demographic changes (r = 0.393); climate change – migration (correlation coefficient (r) = 0.300); climate change – natural resources (r = 0.388);
- Demographic changes – migration (r = 0.562);
- Well-trained workforce – fast and safe transport routes (r = 0.317); well-trained workforce – quality of public education and vocational training (r = 0.337);
- Natural resources – shifts in global power centers (r = 0.393); natural resources – fast and safe transport routes (r = 0.387);
- Shifts in global power centers – fast and safe transport routes (r = 0.494);
- Fast and safe transport routes – digitalisation of production and transport (r = 0.400).

Taking into account the number of relationships, the most important factors affecting human working conditions, according to the students, are climate change, scarcity of natural resources and the existence of fast and safe transport routes.

Factor analysis was used to group the influencing factors, which was made possible by the corresponding Kaiser–Meyer–Olkin (KMO) criterion factor (0.717)

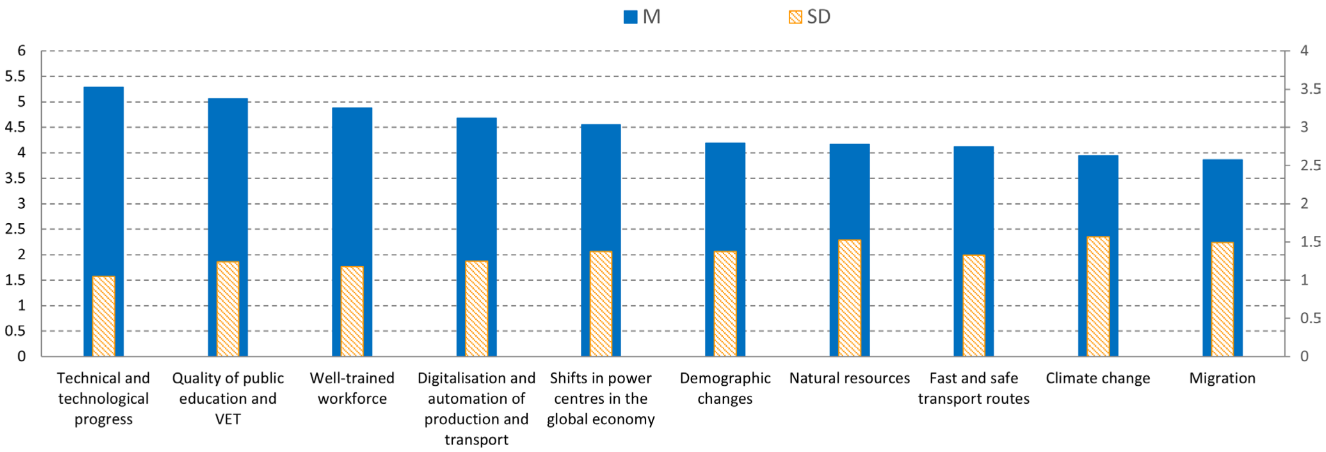

Fig. 2 Perception of factors affecting human working conditions

and Bartlett's test (the Chi-squared test (χ^2) = 563,176; p = 0.000). The main factors influencing human working conditions are those shown in Fig. 3. The 10 influencing factors can be grouped into 4 factors:

- F1: Production and delivery conditions;
- F2: Demographic changes;
- F3: Qualification level of the workforce;
- F4: Technical and technological background.

A cluster analysis of the cases was also performed using the factor variables. Based on the factor variables "qualification level of the workforce" and "technical and technological progress" two clusters emerge. Cluster C1 (N = 140) includes students who think that the qualification level of the workforce has a rather negative impact on working conditions, while the technical and technological background has more of a positive influence, while cluster C2 (statistical population (N) = 131) includes those who think the opposite.

Perceptions of changes in working conditions can also be examined by background variables and there were a number of significant differences.

Women found all indicators to be significantly more of a risk than male students. Women are more fearful in this respect (Table 1).

The only significant difference in the students' place of residence was found for one variable (χ^2 = 12.974; p = 0.005), namely demographic changes: capital city (N = 180; M = 4.26; SD = 1.329), big city – over 50,000 inhabitants (N = 37; M = 4.68; SD = 1.248), small town (N = 61; M = 4.08; SD = 1.429), municipality, village (N = 34; M = 3.50; SD = 1.420). Students living in smaller settlements are less afraid of demographic changes.

Rotated Component Matrix*

Factors affecting working conditions:	**Component 1**	**2**	**3**	**4**
...fast and safe transport routes	0.825	0.055	0.208	0.006
...shifts in global power centres	0.748	0.27	0.058	-0.098
...natural resources	0.664	0.332	-0.182	0.178
...digitalisation and automation of production and transport	0.584	-0.177	0.282	0.354
...demographic changes	0.141	0.84	0.148	-0.002
...migration	0.126	0.791	0.089	-0.096
...climate change	0.133	0.599	-0.16	0.557
...quality of public education and vocational training	-0.04	0.073	0.838	0.071
...qualified workforce	0.33	0.102	0.597	0.088
...technical and technological progress	0.033	-0.076	0.183	*0.866*

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.*

* Rotation converged in 6 iterations.

Fig. 3 Key factors affecting human working conditions

Table 1 Gender perception of factors affecting human working conditions

Factors affecting working conditions	Gender	N	M	SD	χ^2	p
Climate change	Female	105	4.42	1.399	13.878	0.000
	Male	209	3.70	1.599		
Demographic changes	Female	104	4.59	1.228	12.064	0.001
	Male	208	3.99	1.404		
Migration	Female	103	4.33	1.417	14.998	0.000
	Male	208	3.63	1.479		
Natural resources	Female	102	4.72	1.300	18.525	0.000
	Male	209	3.91	1.562		
Shifts in global power centers	Female	98	4.88	1.038	5.253	0.022
	Male	202	4.39	1.489		
Fast and safe transport routes	Female	101	4.38	1.232	4.837	0.028
	Male	198	3.99	1.359		

Students' perceptions of working conditions are similar according to the level of training and the form of funding, with no significant difference according to this background variable.

By type of training, four variables were identified for which there were significant or close to significant differences. Students in the part-time training program are likely to find these factors more challenging because of their greater work and life experience (Table 2).

Based on their experiences of robotisation, it can be concluded that there is no significant difference in students' perceptions. But if the studies focus on the social impact of robotisation, then there is a significant difference. There are four circumstances where students' perceptions of factors affecting working conditions differ significantly or close to significantly. All in all, know-how obtained in this area causes significant differences for those conditions that focus on the readiness of the workforce (Table 3).

Based on robotisation work experience, there were no significant differences in the factors influencing individual working conditions.

The last set of questions of the survey asked how the role of labour market factors will change in Hungary in the next 5 years. Again, the answers had to be marked on a six-point scale: 1 – will decrease radically; …; 6 – will increase radically. The answer "I cannot tell" was also ticked here. Quite a lot of respondents could not rate the last three statements (the role of atypical employment [part-time, non-employment, etc.] – 31 respondents; the economic importance of multinational companies – 40 respondents; the economic role of small businesses – 39 respondents).

Students also had to make assumptions about changes in labour market factors in the near future. Students predicted an increase in the following areas: the role of special expertise (M = 4.96; SD = 1.192), the importance of flexible working hours (M = 4.92; SD = 1.126), the importance of work outside the workplace (M = 4.83; SD = 1.173). Rather, a decrease was predicted for the role of monotonous work (M = 3.06; SD = 1.399), the role of low-skilled work (3.24; SD = 1.432) and the economic role of small businesses (M = 3.43; SD = 1.321) (Fig. 4).

Table 2 Perception of factors affecting human working conditions by type of training

Factors affecting working conditions	Form of training	N	M	SD	χ^2	p
Climate change	Full-time	284	3.88	1.579	3.923	0.048
	Correspondence	30	4.50	1.383		
Demographic changes	Full-time	282	4.14	1.388	3.911	0.048
	Correspondence	30	4.67	1.155		
Migration	Full-time	281	3.81	1.502	3.214	0.073
	Correspondence	30	4.33	1.348		
Digitisation of production and transport	Full-time	282	4.63	1.268	4.419	0.036
	Correspondence	30	5.17	0.874		

Table 3 Factors influencing human working conditions according to what is learned about the social impact of robotisation

Factors affecting working conditions	Learned about the social impact of robotisation	N	M	SD	χ^2	p
Demographic changes	No	240	4.11	1.390	6.409	0.041
	Yes	65	4.35	1.3106		
	Yes, multiple courses	7	5.29	0.756		
Well-trained workforce	No	241	4.90	1.195	7.236	0.027
	Yes	65	4.68	1.133		
	Yes, multiple courses	8	5.63	0.518		
Quality of public education and vocational training	No	240	5.13	1.184	8.485	0.014
	Yes	63	4.68	1.446		
	Yes, multiple courses	9	5.78	0.441		
Digitisation of production and transport	No	240	4.69	1.230	5.843	0.054
	Yes	64	4.53	1.321		
	Yes, multiple courses	8	5.63	0.518		

3.1 Effects of study and work experience on student beliefs of robotics

Changes in working conditions with factor analysis (KMO = 0.679; Bartlett's test: $\chi^2 = 602.090$; $p = 0.000$) were summarised and four main causes and factors were identified (Fig. 5):

- F1: The declining role of low-level expertise;
- F2: Changes in work organisation;
- F3: Growing demand for high-level expertise;
- F4: Changes in the economic environment.

Obviously, these beliefs strongly reflect the fact that the survey was conducted after a period of almost two years of Covid-19, when atypical employment and working conditions had become accepted and common.

The relationship between the variables was characterised by Spearman's correlation coefficient, and a medium-level relationship ($p = 0.01$) was observed between the following labour market factors:

- The role of monotonous work - the role of creative work ($r = -0.470$); the role of monotonous work - the role of low-skilled workforce ($r = 0.473$); the role of monotonous work - the role of high-skilled workforce ($r = -0.321$);
- The role of creative work – the role of low-skilled workforce ($r = -0.348$); the role of creative work – the role of high-skilled workforce ($r = 0.419$); the role of creative work – the role of special expertise ($r = 0.306$);
- The role of low-skilled workforce – the role of high-skilled workforce ($r = -0.514$);
- The role of high-skilled workforce – the role of special expertise ($r = 0.503$);

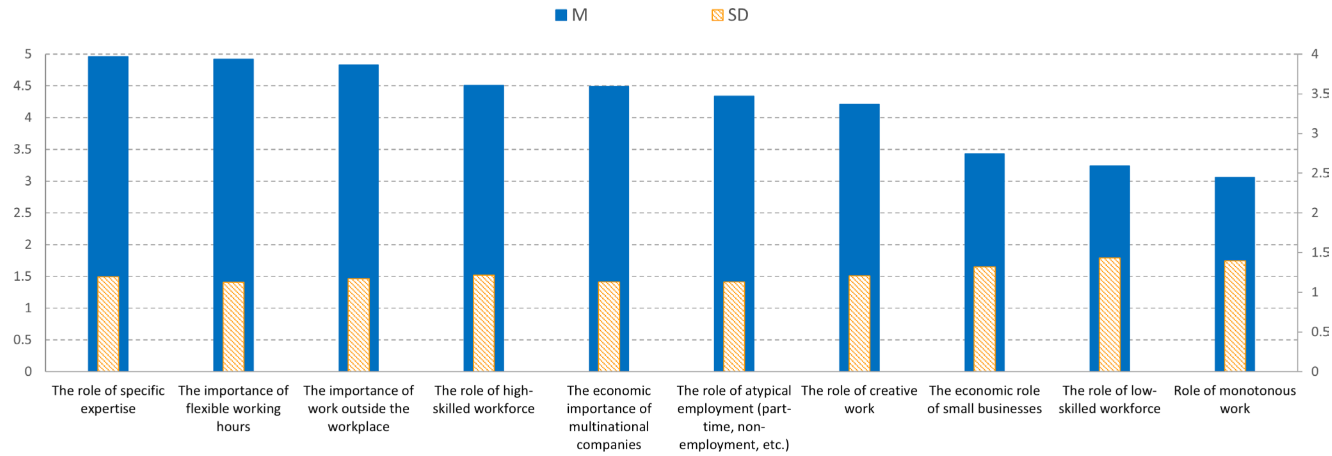

Fig. 4 Changes in labour market factors in the near future

Rotated Component Matrix*				
	Component			
Changing labour market factors in Hungary:	1	2	3	4
...the role of monotonous work	0.845	-0.048	-0.029	0.008
...the role of low-skilled workforce	0.793	-0.066	-0.237	0.053
...the role of creative work	0.52	0.166	0.453	0.286
...the importance of flexible working hours	-0.133	0.825	0.152	0.071
...the role of atypical employment	0.008	0.756	-0.104	0.056
...the role of work outside the workplace	-0.028	0.75	0.121	-0.07
...the role of specific expertise	-0.062	0.76	0.82	0.133
...the role of high-skilled workforce	-0.466	0.007	0.734	0.109
...the economic role of small businesses	0.7	0.065	0.296	0.88
...the economic importance of multinational companies	0.491	0.114	0.471	-0.517

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.*

* Rotation converged in 6 iterations.

Fig. 5 Factors influencing human working conditions according to what is learned about the social impact of robotisation

- The role of work outside the workplace – the importance of flexible working hours ($r = 0.564$); the role of work outside the workplace – the role of atypical employment ($r = 0.326$);
- The importance of flexible working hours – the role of atypical employment ($r = 0.414$).

Therefore, the students see the role of expertise in Hungary changing in five years' time, with low-level skills being replaced by the need for specific competences, while the forms currently considered to be somewhat atypical in the location and timing of work (remote work, home office, flexible working hours, etc.) are gradually becoming typical.

Examining this issue according to background variables, there were significant differences in some cases.

There were four significant differences according to gender of the students (Table 4). Overall, women found the changes more pronounced than male students.

By the type of training, it can be established that part-time and correspondence program students consider significantly or close to significantly that the four labour market factors specified in Table 5 (low-skilled workforce) significantly increase or decrease. These findings are reinforced by the fact that those in part-time training programs already have significant life and work experience.

By the funding method of studies, we found a significant difference in two labour market factors:

- the role of creative work ($\chi^2 = 6.613$; $p = 0.010$): state scholarship (N = 268; M = 4.29; SD = 1.174) vs. self-financed (N = 46; M = 3.74; SD = 1.307);
- the role of a high-skilled workforce ($\chi^2 = 6.006$; $p = 0.014$): state scholarship (N = 270; M = 4.60; SD = 1.142) vs. self-financed (N = 44; M = 4.00; SD = 1.525).

Creative work that requires a high-skilled workforce is considered significantly more significant by students receiving state scholarships than their fee-paying counterparts. The reason for this may be that:

1. self-financed students were placed into this category due to their poorer academic results (11.0% of full-time students are self-financed);
2. a higher proportion of students in part-time training programmes are self-financed (46.7%), so in both cases they probably have to work in addition to pursuing their studies, which implies a more accurate positioning of challenges.

In the studies related to robotisation, no significant difference was found for any of the variables. The same can

Table 4 Gender perceptions of the changing role of labour market factors

The changing role of labour market factors	Gender	N	M	SD	χ^2	p
The role of work outside the workplace	Female	102	5.02	1.235	6.932	0.008
	Male	200	4.74	1.132		
The importance of flexible working hours	Female	102	5.12	1.093	6.142	0.013
	Male	211	4.82	1.132		
The role of atypical employment	Female	94	4.56	1.160	6.357	0.012
	Male	195	4.24	1.106		
The economic role of small businesses	Female	86	3.66	1.252	3.891	0.049
	Male	195	3.32	1.341		

Table 5 Perception of the changing role of labour market factors by training form

The changing role of labour market factors	Form of training	N	M	SD	χ^2	p
The role of creative work	Full-time	284	4.15	1.210	9.548	0.002
	Correspondence	30	4.80	1.031		
The role of low-skilled workforce	Full-time	278	3.29	1.436	5.312	0.021
	Correspondence	28	2.68	1.278		
The role of high-skilled workforce	Full-time	285	4.48	1.218	2.762	0.097
	Correspondence	29	4.83	1.197		
The role of atypical employment	Full-time	260	4.30	1.147	3.141	0.076
	Correspondence	29	4.72	0.922		

be said for the level of training. However, when we asked what they learned about the social impact of robotisation, we found significant differences in three variables. The perception of high-skilled creative expertise has been quite contradictory. Those who did not study this, or those who only studied this in one course thought in a similar way. At the same time, those who had more than one of these courses consider the role of these factors to be significantly more important. This is fine-tuned by the fact that there were only 9 students who had several courses that discussed the social impact of robotisation (Table 6).

Based on robotisation work experience, we found no significant differences in any of the factors.

As described above, students had to imagine how the role of labour market factors is expected to change in 5 years' time. These factors were compared with the competence priorities students expected to see on the labour market in 5 years' time (Fig. 6).

The prognosis of competence needs can be linked to the change in four labour market factors: creative work, high-skilled workforce, flexible working hours, and the economic role of small businesses. Based on these, students predict working conditions where high-skilled professionals are needed, who perform creative work, but the economic role of small businesses and the reduced importance of monotonous work must also be taken into account. For all of these, problem-solving, creativity, critical thinking, judgment and decision-making are the competencies that employees of the future must possess (Table 7).

3.2 Expectations related to robotisation

In the third part of the questionnaire, students' expectations related to robotisation were mapped. The reliability of the questionnaire, i.e., Cronbach's alpha resulted in 0.806.

The students were asked to rate the statements related to the expected role of robotisation in 5 years on a 6-point

Table 6 Perception of the changing role of labour market factors based on what is learned about the social impact of robotisation

The changing role of labour market factors	Learned about the social impact of robotisation	N	M	SD	χ^2	p
	No	241	4.26	1.155		
The role of creative work	Yes	64	3.92	1.349	8.229	0.016
	Yes, multiple courses	9	5.11	1.054		
	No	240	4.52	1.186		
The role of high-skilled workforce	Yes	65	4.32	1.312	13.849	0.001
	Yes, multiple courses	9	5.78	0.441		
	No	243	4.95	1.167		
The role of special expertise	Yes	64	4.88	1.315	8.146	0.017
	Yes, multiple courses	9	5.89	0.333		

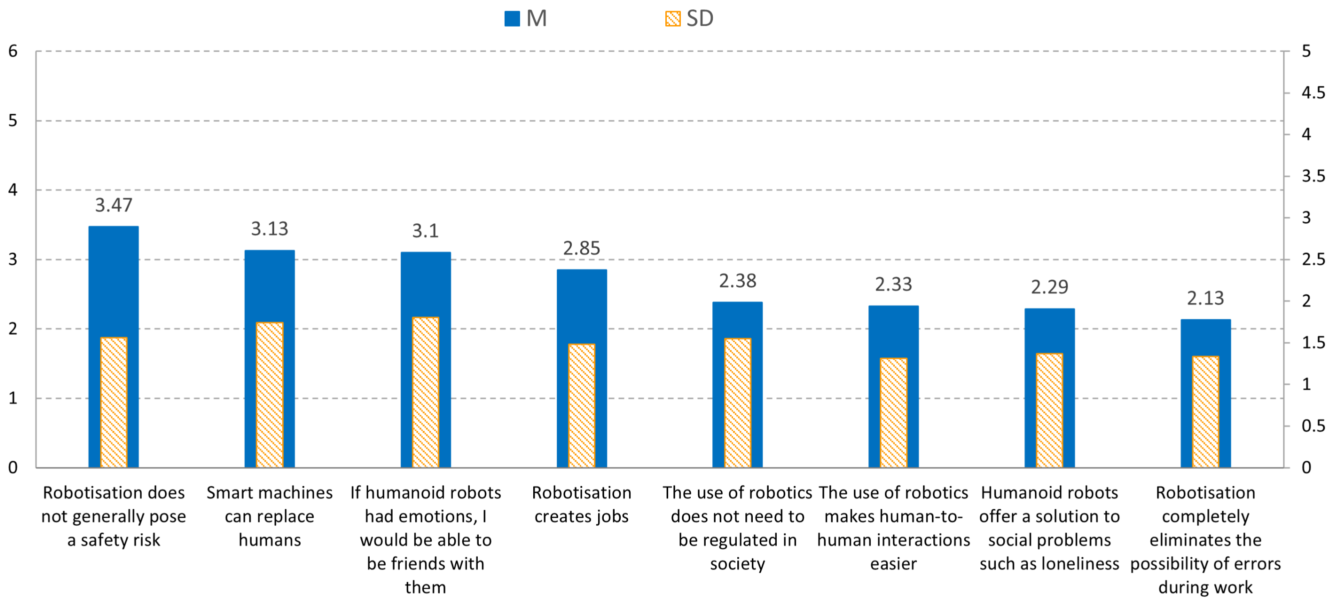

Fig. 6 Descriptive statistical indicators of expectations related to robotisation

Table 7 Perception of the changing role of labour market factors compared to competence needs ($p = 0.01$)

Competence need	Correlation	The changing role of labour market factors
Problem solving	0.245	The role of creative work
	0.218	The role of high-skilled workforce
	−0.218	The role of monotonous work
Creativity	0.357	The role of creative work
	0.220	Flexible working hours
	0.246	The economic role of small businesses
Critical thinking	0.252	The role of creative work
	0.232	High-skilled workforce
Self-confidence	0.237	Flexible working hours
	0.213	The economic role of small businesses
Judgment and decision making	0.246	High-skilled workforce
	0.235	The economic role of small businesses
Commitment to continuous learning	−0.246	The role of monotonous work
	0.244	Creative work
	0.248	The role of high-skilled workforce
Responsibility	0.227	The economic role of small businesses
Load capacity	0.213	The role of monotonous work

Likert scale (1: I strongly disagree; …; 6: I completely agree), but there was also a choice of "Cannot decide". The latter responses were not taken into account in the analysis. This category included 5-6% of the participants in the research. Exceptions were the following statements:

- Robotics contributes to sustainable progress: 10.6%;
- If humanoid robots had emotions, I would be able to be friends with them: 12.2%;
- The use of robotics makes human-to-human interactions easier: 12.5%;
- Developers and companies take into account the needs of their users: 13.1%.

The descriptive statistical indicators belonging to the items of expectations related to robotisation are summarised in Figs. 6 and 7.

Students mostly agreed with the statement that robots will create a new working condition and a new working culture that will replace physically demanding, dangerous and boring work. The last thing they agreed with was that the new form of human-to-machine relationship would completely transform the interpersonal space, that is, it would simplify the relationship between people, solve social problems, exclude the possibility of error, and taking all these into account, it should not be regulated.

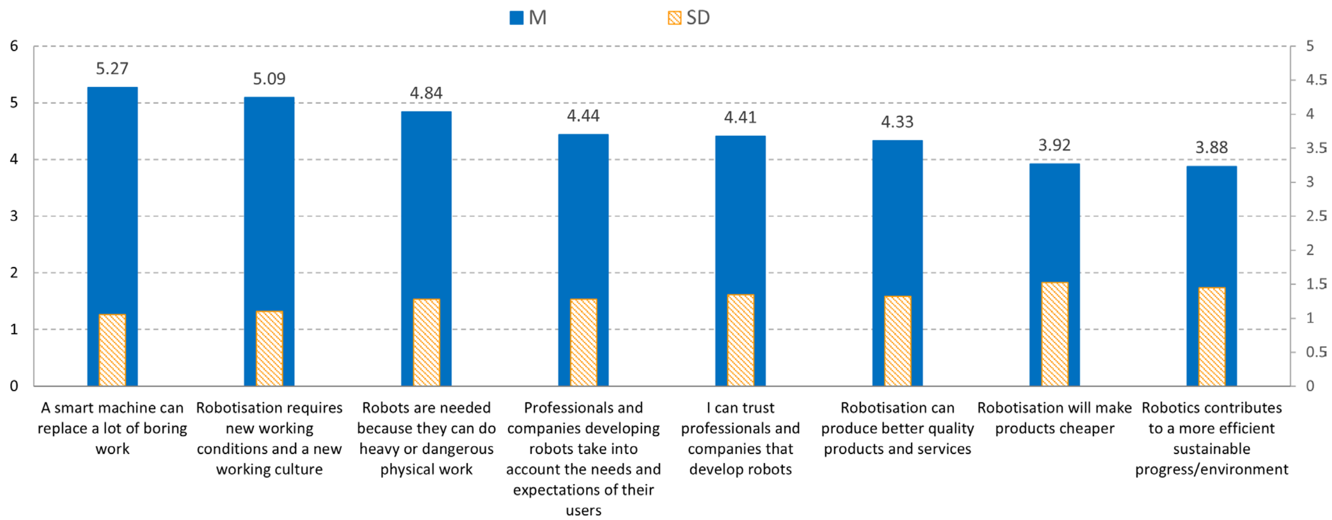

Fig. 7 Descriptive statistical indicators of expectations related to robotisation

We found significant or close to significant differences in several items by gender (Table 8).

Overall, female students have stronger reservations and fears about robotisation. They believe less in its beneficial effect on the economy, social cooperation and human relations. In particular, they think it is more important that regulators should be developed for robotics because they carry safety risks. Male students have fewer reservations, they see the impact of robotics on making human work easier. However, both genders see that robotics creates completely different working conditions and requires a different working culture.

Fewer variables were found to have close to significant differences according to the level of training (Table 9).

Table 8 Gender-based perception of expectations related to robotisation

Expectations related to robotisation	Gender	N	M	SD	χ^2	p
Robotisation requires new working conditions and a new working culture.	Female	103	5.09	0.925	3.549	0.060
	Male	213	4.87	1.270		
Robotisation can produce better quality products and services.	Female	97	4.23	1.339	5.959	0.015
	Male	208	4.48	1.235		
Robotisation creates jobs.	Female	98	2.58	1.406	4.967	0.026
	Male	200	2.92	1.482		
Robotisation does not generally pose a safety risk.	Female	96	2.87	1.468	11.519	0.001
	Male	207	3.50	1.526		
Smart machines can replace humans.	Female	101	2.94	1.657	3.365	0.067
	Male	214	3.40	1.732		
A smart machine can replace a lot of boring work.	Female	104	4.89	1.138	4.110	0.043
	Male	214	5.19	1.129		
If humanoid robots had emotions, I would be able to be friends with them.	Female	93	2.38	1.333	6.107	0.013
	Male	188	3.18	1.787		
The use of robotics does not need to be regulated in society.	Female	94	2.00	1.345	5.410	0.020
	Male	202	2.41	1.543		

Table 9 Perception of expectations related to robotisation according to the level of training

Expectations related to robotisation	Level of training	N	M	SD	χ^2	p
Robots are needed because they can do heavy or dangerous physical work.	Bachelor training program	189	4.98	1.144	6.665	0.036
	Master training program	105	4.39	1.323		
	Doctoral program	25	5.31	1.078		
I can trust professionals and companies that develop robots.	Bachelor training program	183	4.21	1.333	5.808	0.055
	Master training program	103	4.42	1.421		
	Doctoral program	25	4.88	1.147		
Robotisation does not generally pose a safety risk.	Bachelor training program	175	3.40	1.594	6.459	0.040
	Master training program	104	3.10	1.411		
	Doctoral program	24	3.63	1.544		
Robotisation will make products cheaper.	Bachelor training program	177	3.80	1.662	10.531	0.005
	Master training program	101	3.60	1.431		
	Doctoral program	23	4.75	1.000		
Robotisation completely eliminates the possibility of errors during work.	Bachelor training program	189	2.25	1.305	5.376	0.068
	Master training program	105	2.11	1.269		
	Doctoral program	25	2.69	1.352		
Humanoid robots offer a solution to social problems such as loneliness.	Bachelor training program	186	2.31	1.437	5.956	0.051
	Master training program	98	2.58	1.455		
	Doctoral program	24	1.63	0.806		

It is difficult to detect a trend in the significant differences. On the one hand, the lower number of doctoral students and the different ratios of students in various training programs may play a role in this. Therefore, we took a closer look at the students of the bachelor and master training programs. In any case, it can be said that doctoral students agree more with the statement that robotics makes certain working conditions easier and safer, but at the same time they do not believe in the positive role of humanoid robots in solving social problems.

Among students of the bachelor and master training programs, two categories can be identified: professional ("expert") and non-professional students. The former category included mechanical engineers, electrical engineers, IT engineers and mechatronics engineers, while the latter included all other students. We also compared the expectations related to robotisation between these two categories. Among undergraduate students, there was a significant or close to significant difference between students directly related to robotics (professionals) and non-related students (non-professionals) in the majority of the variables. "Professional" students think that the impact of robotics on the world of work is more pronounced and their fears are more moderate than their non-professional counterparts (Table 10).

Among students in the master training program, these significant differences between so-called professionals and non-professionals are already disappearing. There were moderate differences and they were only related to the human aspects of robots (Table 11).

There were only a few significant differences according to the form of training, but in general, it can be said that students participating in part-time training agree less with effects of robotics on making working conditions easier, but at the same time their fears are more pronounced than those in the full-time training program (Table 12).

Table 10 Expectations related to robotisation in the perception according to the type of the bachelor training program

Expectations related to robotisation	Categories in the bachelor training programme	N	M	SD	χ^2	p
Robots are needed because they can do heavy or dangerous physical work.	Professionals	106	5.10	1.179	2.580	0.108
	Non-professionals	107	4.74	1.253		
I can trust professionals and companies that develop robots.	Professionals	104	4.59	1.296	8.024	0.005
	Non-professionals	102	3.98	1.375		
Robotisation requires new working conditions and a new working culture.	Professionals	104	5.03	1.341	3.479	0.062
	Non-professionals	106	4.71	1.195		
Robotisation creates jobs.	Professionals	97	3.02	1.420	10.993	0.001
	Non-professionals	100	2.51	1.427		
Robotisation does not generally pose a safety risk.	Professionals	101	3.85	1.652	8.672	0.003
	Non-professionals	98	3.02	1.375		
Robotisation will make products cheaper.	Professionals	100	4.23	1.521	3.432	0.064
	Non-professionals	101	3.62	1.693		
Professionals and companies developing robots take into account the needs and expectations of their users.	Professionals	93	4.62	1.213	6.664	0.010
	Non-professionals	92	4.06	1.273		
The use of robotics does not need to be regulated in society.	Professionals	100	2.31	1.478	3.594	0.058
	Non-professionals	98	2.22	1.463		
Humanoid robots offer a solution to social problems such as loneliness.	Professionals	103	2.10	1.399	4.014	0.045
	Non-professionals	104	2.46	1.404		

Table 11 Expectations related to robotisation in the perception according to the type of the master training program

Expectations related to robotisation	Categories in the master training program	N	M	SD	χ^2	p
If humanoid robots had emotions, I would be able to be friends with them.	Professionals	37	3.00	1.610	4.215	0.040
	Non-professionals	56	2.81	1.636		
The use of robotics does not need to be regulated in society.	Professionals	41	2.82	1.806	12.113	0.001
	Non-professionals	60	1.97	1.207		
Robotisation completely eliminates the possibility of errors during work.	Professionals	43	1.93	1.274	3.569	0.059
	Non-professionals	65	2.42	1.296		

Table 12 Expectations related to robotisation in the perception according to the form of training

Expectations related to robotisation	Form of training	N	M	SD	χ^2	p
Robots are needed because they can do heavy or dangerous physical work.	Full-time	289	4.88	1.296	6.839	0.009
	Correspondence	30	4.43	1.073		
Robotisation will make products cheaper.	Full-time	273	4.34	1.312	5.913	0.015
	Correspondence	28	4.19	1.415		
Smart machines can replace humans.	Full-time	285	3.11	1.757	7.440	0.006
	Correspondence	30	3.33	1.626		
The use of robotics does not need to be regulated in society.	Full-time	266	2.44	1.580	2.779	0.095
	Correspondence	30	1.90	1.213		

The results were also analysed according to whether the student had learned about robotics, its social effects, and whether they had work experience in this direction. Students with one or more courses on robotisation during their university studies form a more positive attitude towards robotisation, especially in terms of the trust in professionals, services, and in taking into account user needs (Table 13).

As for what they have learned about the social impacts of robotisation, there was a significant difference in only one variable, namely that humanoid robots offer a solution to social problems such as loneliness (χ^2 = 6.185; p = 0.045): they did not have such a course (N = 238; M = 2.21; SD = 1.398), they only had one such course (N = 62; M = 2.60; SD = 1.237), they had multiple such courses (N = 8; M = 2.25; SD = 0.886). The latter number can be considered statistically small, but it can be concluded that what they have learned about the social impacts of robotics gives a more accurate assessment of the expectations of the human aspects of the field of expertise.

Finally, based on students' work experience in robotisation, it can be concluded that those who have such experience, on the one hand, have a much more positive expectation about the impact of robots on improving working conditions, but at the same time, they represent the need for regulating their use at the social level more strongly (Table 14).

By examining the relationship between the variables, it can be concluded that the following variables correlate with each other at least at a medium level (p = 0.01):

- I can trust professionals and companies developing robots – professionals and companies developing robots take into account the needs and expectations of their users (r = 0.462).
- Robotisation can produce better quality products and services – robotisation creates jobs (r = 0.324); Robotisation can produce better quality products and services – professionals and companies developing robots take into account the needs and expectations of their users (r = 0.325).
- Robotisation creates jobs – the use of robotics makes human-to-human interactions easier (r = 0.322); Robotisation creates jobs – robotics contributes to a more efficient sustainable progress/environment (r = 0.309).

Table 13 Expectations related to robotisation based on studies related to robotisation

Expectations related to robotisation	Learned about robotisation	N	M	SD	χ^2	p
I can trust professionals and companies that develop robots.	No	187	4.32	1.308	9.181	0.010
	Yes	87	4.37	1.390		
	Yes, multiple courses	37	4.95	1.332		
Robotisation can produce better quality products and services.	No	182	4.21	1.292	8.588	0.014
	Yes	85	4.36	1.344		
	Yes, multiple courses	38	4.82	1.312		
Robotisation creates jobs.	No	180	2.67	1.429	5.837	0.054
	Yes	84	3.05	1.480		
	Yes, multiple courses	34	3.26	1.657		
Professionals and companies developing robots take into account the needs and expectations of their users.	No	167	4.27	1.333	8.024	0.018
	Yes	77	4.61	1.183		
	Yes, multiple courses	34	4.88	1.066		

Table 14 Expectations related to robotisation based on work experience on the subject

Expectations related to robotisation	Work experience in robotisation	N	M	SD	χ^2	p
I can trust professionals and companies that develop robots.	No	259	4.31	1.368	8.852	0.003
	Yes	52	4.90	1.107		
Robotisation creates jobs.	No	250	2.74	1.425	5.556	0.018
	Yes	48	3.38	1.671		
Smart machines can replace humans.	No	263	3.11	1.768	4.481	0.034
	Yes	52	3.23	1.628		
The use of robotics does not need to be regulated in society.	No	245	2.32	1.560	3.645	0.056
	Yes	51	2.67	1.506		
Robotisation completely eliminates the possibility of errors during work.	No	267	2.18	1.331	3.668	0.055
	Yes	52	1.90	1.361		
Robotics contributes to a more efficient sustainable progress/environment.	No	237	3.81	1.429	4.415	0.036
	Yes	49	4.20	1.500		

- Robotisation does not generally pose a safety risk – robotisation will make products cheaper (r = 0.331).
- Robotisation will make products cheaper – professionals and companies developing robots take into account the needs and expectations of their users (r = 0.312).
- If humanoid robots had emotions, I would be able to be friends with them – the use of robotics does not need to be regulated in society (r = 0.307); if humanoid robots had emotions, I would be able to be friends with them – humanoid robots offer a solution to social problems such as loneliness (r = 0.410).
- The use of robotics makes human-to-human interactions easier – humanoid robots offer a solution to social problems such as loneliness (r = 0.308).

The central element of these relationships is that robotisation creates jobs and the needs of users are taken into account in robotisation developments, that is, job creation and user-friendliness are the most important positive features of robots.

4 Conclusion

Taking into account the future outlook, what factors and to what extent do they think will affect the conditions of human work in Hungary in the next 5 years?

Regarding students' future prospects, they highlighted the following as the most important factors affecting human working conditions: climate change, the scarcity of natural resources and the importance of fast and safe transport routes.

They had different beliefs about the relationship between the qualification level of the workforce and its technical and technological background.

Women feel that the change in working conditions is riskier, they have more fear than men.

Students living in smaller settlements are less afraid of demographic changes.

Students on part-time training programs are likely to find these factors more challenging because of their greater work and life experience.

The perception of the social impacts of robotisation shows a correlation with the students' preparedness and the amount of knowledge.

Regarding changes in labour market factors in the near future, they predicted an increase in the role of special expertise, flexible working hours and work outside the workplace. Conversely, a decrease was predicted for the role of monotonous work, the role of low-skilled work and the economic role of small businesses.

The summary of the research results based on the research questions can be given as follows:

1. How are their beliefs influenced by their experiences of robotisation obtained in their studies or work?
    - The students see the role of expertise in Hungary changing in five years' time, with low-level expertise being replaced by the need for specific competences, while the forms considered to be atypical until the Covid-19 period (remote work, home office, flexible working hours, etc.) will become typical for the location and timing of work.
    - The change in the role of labour market factors was found to be more pronounced by women than by men.
    - The beliefs of students on part-time, correspondence programmes differ significantly in their perception of the changes in labour market factors.

- Creative work that requires a high-skilled workforce is considered significantly more significant by students receiving state scholarships than their fee-paying counterparts.
- The perception of high-skilled creative expertise was controversial. Those who did not study this, or those who only studied this in one course thought in a similar way. At the same time, those who had more than one of these courses consider the role of these factors to be significantly more important.
- They believe that problem-solving, creativity, critical thinking, judgment and decision-making are the competencies that employees of the future must possess.

2. What are their expectations regarding robotisation in the future?
    - Students mostly agreed with the statement that robots will create new working conditions and a new working culture that will replace physically demanding, dangerous and boring work.
    - The last thing they agreed with was that the new form of human-to-machine relationship would completely transform the interpersonal space, that is, it would simplify the relationship between people, solve social problems, exclude the possibility of error, and, taking all these into account, it should not be regulated.
    - Female students have stronger reservations and fears about robotisation. They believe less in its beneficial effect on the economy, social cooperation and human relations. In particular, women consider it more important that regulations should be developed for robotics and that robotics pose safety risks.
    - Male students have fewer reservations about robotisation. They see the impact of robotics making work easier.
    - However, both genders believe that robotics creates completely different working conditions and requires a different working culture.
    - Doctoral students agree more with the statement that robotics makes certain working conditions easier and safer, but at the same time they do not believe in the positive role of humanoid robots in solving social problems.
    - Students participating in part-time training agree less with effects of robotics on making working conditions easier, but at the same time their fears are more pronounced than those in the full-time training programme.
    - Students with one or more courses on robotisation during their university studies form a more positive attitude towards robotisation.
    - Based on students' work experience in robotisation, it can be concluded that those who have such experience, on the one hand, have a much more positive expectation about the impact of robots on improving working conditions, but at the same time, they represent the need for regulating their use at the social level more strongly.

Getting to know the opinions of the students shows that in the training of engineers, it is necessary to develop subjects that focus on the development of the social competences of future engineers in order for them to be able to endure upcoming challenges and changes. In addition, the number of subjects on robotics and its use must be increased. It is necessary to train creative engineers who can face the challenges of robotics in the future.

The generalisability of the research results is hampered by the following two factors: on the one hand, the demarcation of the concepts of artificial intelligence and robotisation, and on the other hand, the homogeneity of the research participants. The sample was represented by students from one university, so the results cannot be applied to all technical higher education institutions.

References

Acemoglu, D., Restrepo, P. (2018) "The Race between Man and Machine: Implications of Technology for Growth, Factor Shares, and Employment", American Economic Review, 108(6), pp. 1488–1542. https://doi.org/10.1257/aer.20160696

Brynjolfsson, E., McAfee, A. (2011) "Race against the Machine: How the Digital Revolution Is Accelerating Innovation, Driving Productivity, and Irreversibly Transforming Employment and the Economy", Digital Frontier Press. ISBN 978-0-9847251-0-6

Cho, J., Kim, J. (2018) "Identifying Factors Reinforcing Robotization: Interactive Forces of Employment, Working Hour and Wage", Sustainability, 10(2), 490. https://doi.org/10.3390/su10020490

David, H. (2015) "Why Are There Still So Many Jobs? The History and Future of Workplace Automation", Journal of Economic Perspectives, 29(3), pp. 3–30. https://doi.org/10.1257/jep.29.3.3

De Witte, H., Pienaar, J., De Cuyper, N. (2016) "Review of 30 Years of Longitudinal Studies on the Association Between Job Insecurity and Health and Well-Being: Is There Causal Evidence?", Australian Psychologist, 51(1), pp. 18–31. https://doi.org/10.1111/ap.12176

Dennett, D. C. (1971) "Intentional systems", The Journal of Philosophy, 68(4), pp. 87–106. https://doi.org/10.2307/2025382

Dennett, D. C. (1987) "The Intentional Stance", MIT Press, Cambridge, MA, USA.

Ford, M. (2015) "Rise of the Robots: Technology and the Threat of a Jobless Future", Basic Books. ISBN 978-0-465-05999-7

Frey, C. B., Osborne, M. A. (2017) "The future of employment: How susceptible are jobs to computerization?", Technological Forecasting and Social Change, 114, pp. 254–280. https://doi.org/10.1016/j.techfore.2016.08.019

Hirvonen, L., Veijalainen, E., Orpana, V. (2000) "The role of a university in the continuous competence development of Master's level engineers", Proceedings of International Conference on Production Research, 19(4), pp. 1–4.

Kiss, É., Varga, G. (2021) "Hazai felsőoktatási és vállalati együttműködések az Ipar 4.0 szempontjából" (Domestic higher education and corporate collaborations from the point of view of Industry 4.0), Educatio, 30(3), pp. 522–531. (in Hungarian) https://doi.org/10.1556/2063.30.2021.3.12

Marchesi, S., Ghiglino, D., Ciardo, F., Perez-Osorio, J., Baykara, E., Wykowska, A. (2019) "Do We Adopt the Intentional Stance Toward Humanoid Robots?", Frontiers in Psychology, 10, 450. https://doi.org/10.3389/fpsyg.2019.00450

Marin-Garcia, J. A., Garcia-Sabater, J. P., Miralles, C., Villalobos, A. R. (2008) "Profile and competences of Spanish industrial engineers in the European Higher Education Area (EHEA)", Journal of Industrial Engineering and Management, 1(2), pp. 269–284. https://doi.org/10.3926/jiem.2008.v1n2.p269-284

Pol, E., Reveley, J. (2017) "Robot Induced Technological Unemployment: Towards a Youth-Focused Coping Strategy", Psychosociological Issues in Human Resource Management, 5(2), pp. 169–186. https://doi.org/10.22381/PIHRM5220177

Radinsky, W. (2015) "Robotics, AI, the Luddite Fallacy and the Future of the Job Market", In: Goertzel, B., Goertzel, T. (eds.) The End of the Beginning: Life, Society and Economy on the Brink of the Singularity, Humanity+ Press, pp. 159–185. ISBN 9780692457665

Savela, N., Turja, T., Oksanen, A. (2018) "Social Acceptance of Robots in Different Occupational Fields: A Systematic Literature Review", International Journal of Social Robotics, 10(4), pp. 493–502. https://doi.org/10.1007/s12369-017-0452-5

Schellen, E., Wykowska, A. (2019) "Intentional Mindset Toward Robots—Open Questions and Methodological Challenges", Frontiers in Robotics and AI, 5, 139. https://doi.org/10.3389/frobt.2018.00139

Stankevičiūtė, Ž., Staniškienė, E., Ramanauskaitė, J. (2021a) "The Impact of Job Insecurity on Organisational Citizenship Behaviour and Task Performance: Evidence from Robotised Furniture Sector Companies", International Journal of Environmental Research and Public Health, 18(2), 515. https://doi.org/10.3390/ijerph18020515

Stankevičiūtė, Ž., Staniškienė, E., Ramanauskaitė, J. (2021b) "The Impact of Job Insecurity on Employee Happiness at Work: A Case of Robotised Production Line Operators in Furniture Industry in Lithuania", Sustainability, 13(3), 1563. https://doi.org/10.3390/su13031563

Stiegler, B. (2015) "Automatic Society 1: The Future of Work – Introduction", La Deleuziana, 1, pp. 121–140.

World Economic Forum (2016) "The Future of Jobs: Employment, Skills and Workforce Strategy for the Fourth Industrial Revolution", [pdf] World Economic Forum, Geneva, Switzerland. Available at: https://www3.weforum.org/docs/WEF_Future_of_Jobs.pdf [Accessed: 25 March 2024]