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Chemical engineering in technical and technological culture

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Abstract: Modern technologies continuously change humans and their relationship with the environment. They can achieve a lot in the field of chemical engineering, thereby improving and enhancing the quality of human life, but on the other hand, technologies can be used to destroy human lives. Technical and technological culture (hereinafter referred to as TTC) is the entirety of social achievements in the field of technical and technological sciences and their application, as well as of the all knowledge and skills needed to understand the achievements, use them correctly, transfer them to the younger generation and create new values in this field. This paper will present a pilot study aimed to examine the attitudes and beliefs of engineers, Technological (chemical engineering) and Technical faculties, regarding the development of TTC and to determine socio-demographic factors that may influence its development. The research was conducted in Serbia and Croatia. The results indicate that the most important aspects of TTC are: the development of awareness of sustainable development, the impact on environmental protection, *etc*. The respondents recognized the ethical challenges we face today, the need for the education of young engineers and the promotion of TTC in the media and professional public.

Keywords: environmental protection; ethical; attitudes; research; promotion; education.

INTRODUCTION

Engineering practice has been present since the beginning of humankind. The history of chemical engineering traces the historical and technological dev-

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elopment of industry.[1] Today's modern technologies are not only a product of humans but also a prerequisite for their existence; they continuously change the mankind and their relationship to the environment.[2] A chemical engineer is a professional who researches, develops, advises and directs chemical processes at a commercial level.[3] Developing a comprehensive skill set, including technical, professional, and technological expertise, is critical to success in an increasingly competitive global job market.[4] At the turn of the millennium, there was a discrepancy between the trained engineers and the engineers that society needed, while there have been concerns about the ability of future professionals to act socially and to cope with the current global challenges, that are becoming much more complex and multidisciplinary.[1,5] The engineering education is being urged to move towards student-centred teaching.[1] The competency-based curriculum represents a major paradigm shift in the conceptualization of the university education system.[1,6] Professional competencies include three dimensions: knowledge, skills and attitudes.[1] To develop these skills, the global institutions have promoted and adapted teaching strategies aimed at preparing students to work in complex situations.[1] During the engineering education process, it is necessary to develop students' ability to perceive humanity and sociality, to bridge the gap between humanitarian and technical and technological culture, and to eliminate the traditional dehumanization of the engineering-technical education.[7] The challenges for chemical engineers, at local, regional, national and global levels, require graduates to have strong training in technical skills and knowledge, but also in soft skills, and such as communication and teamwork, critical and creative thinking, ethics and sustainability, as well as in social responsibility.[3] In 2019, Serbia and Macedonia held training called Escape Room, aimed to promote student engagement and motivation to master teaching content through playing, improve the communication skills *via* social interaction and fun, and develop creative, critical and logical thinking, self-regulation and a positive attitude towards chemistry lessons.[8] The technological changes and the introduction of new technological concepts lead to the emergence of completely new needs regarding the behaviour and competencies of those who implement production processes.[9] The introduction of technological innovations into everyday life, the readiness to recognize new solutions, the acquisition of the ability to exploit technological products is associated with a personal, organizational, and local culture, and should be analysed as a separate category – technical and technological culture.[10] According to Wyrwicka, technical and technological culture is a system of permanent attitudes and efficiency, which enable the proper use of the existing technological products in order to change the pattern in the quality of life.[10] It is expressed in relatively permanent and positive attitudes towards the phenomena of technology (design and product), in the possession of knowledge, and above all in the ethical behaviour and the attitude of people involved in different technological situations.[10] Technical and technological culture manifests itself in relatively long-term activities and good ethical human attitudes, enabling the correct application of the existing technologies and the development of new ethical solutions aimed at the improvement of the efficiency of life's cooperative processes.[11] If we want to respond to the demands of future technological development, it is important to reinvest in the concept of technical and technological culture. It is also important for engineers, as they are the carriers of technical and technological culture, to ask themselves questions related to the impact of techniques and technology on society and the world we live in.[12] The social demands for greener products, a reduction in greenhouse gas emissions and more sustainable processes have also had an irreversible impact on the chemical industry.[1] The chemical engineering professionals must have the necessary skills and abilities to apply numerical solutions and understand their limitations and difficulties in approach, and also possess critical thinking, *etc*.[1] The role of engineers in the transformation of society is very clear. Engineers, throughout history, have been uniquely suited to provide new solutions to some of the humanity's greatest challenges.[4] At present, the state of engineering has been assessed as critical, with a focus on four areas in particular: the taking over of engineering by unconventional design; the technological takeover of engineering; an awareness of the negative consequences of engineering; and a crisis in the traditionally scientific and engineering image of the world.[13] In this context, technical and technological culture is a valuable aspect of modern and future education and includes the personal qualities that enable a technologically competent solution of any problems in the field of engineering and creative solutions to social and economic issues.[13] The process of introducing technical and technological culture is sometimes very difficult and therefore it is necessary to overcome the inertia of technocratic thinking and a misunderstanding of the importance of the idea of developing technical and technological culture and the personal characteristics and qualities that are important for it.[13] The european engineering education and academic networks in Europe should open up to cooperation with academic, student, industrial and professional partners worldwide and, in addition to lifelong learning, expand the inclusion of non-technical skills without lowering the technical level of the learning process and also improve the cooperation between companies and universities in the field of education.[14] The mission of educators is to contribute not only to building a society of “knowledge” but also a society of “wisdom”.[14]

This paper presents the pilot research on attitudes and beliefs about technical and technological culture, as well as socio-demographic factors that can have an impact on its development (gender, age, education, years of work experience, company size, ownership structure of the company and its activity, as well as satisfaction with the respondent’s material status). The pilot research was conducted on a sample consisting of engineers from the Technical and Technological

Faculties (chemical engineering) in the Republic of Serbia and the Republic of Croatia. Professors/assistants, students and employees in the industry/IT sector/NGO also participated in the research. As part of the pilot research, a questionnaire was constructed to examine attitudes and beliefs about the development of technical and technological culture, which was created on the basis of a list of questions, related to the perception of the development of technical and technological culture (list of survey questions, Wyrwicka), supplemented with the indicators for popularization and the legislation of scientific and technical technological culture and the key competencies of polytechnic engineers.[10,15,16]

METHODOLOGY

Pattern and procedure

A total of 105 respondents participated in the research, the majority of them were male (56.19 %), with a slightly higher number of respondents from Serbia (59.04 %) compared to respondents from Croatia (40.96 %). In relation to the engineering profile, a larger number of respondents were engineers of technical sciences (75.24 %) compared to engineers of technological sciences (chemical engineering) (24.76 %). The largest number of respondents were professors/assistants at faculties (54.29 %), followed by the employees in the economy/industry/IT/NGO (35.24 %), while the smallest number of respondents were students (10.48 %). The majority of respondents, from both countries, attended doctoral academic studies as their educational level (50.00 %). When it comes to differences between countries, and in the context of individual socio-demographic characteristics of the respondents, differences were present only in respect of company size. The respondents from Serbia are mostly employed in large companies (in excess of 250 employees), while respondents from Croatia are more often employed in medium-sized companies (from 50 to 250 employees). The complete socio-demographic characteristics of the sample, for the entire sample, as well as for each country individually, have been presented in Table I.

The data collection was carried out during September and October 2023, within the Republic of Serbia and the Republic of Croatia. The respondents were invited to participate in the research through various communication media (live, by phone, email, *etc.*) and were informed about the goals of the research, prior to filling out the questionnaire. The participation in the research was anonymous and the respondents needed about five minutes to answer the questionnaire. The data collection was carried out through the Google Forms platform.

Instrument

The questionnaire for the assessment of attitudes and beliefs on technical and technological culture (hereinafter: TTC), created for the purposes of this research, includes a total of 31 questions with a 5-point Likert-type response scale (from 1 – completely disagree to 5 – agree completely). The questionnaire items were devised in accordance with the subject of the measuring items, applied during the previous researches (for the use of which we obtained the author's consent), and are directly related to the research problem from this paper, as well as the assessment of several experts from the field.[12,18,19] One question each was associated with the understanding of the meaning of the term TTC, as well as the development of TTC. The remaining questions were grouped into the sets of questions related to education on TTC (3 questions), promotion of TTC (3 questions), legal regulations related to TTC (2 questions), different attitudes and beliefs regarding TTC (18 questions) and cultural factors (3 questions).

TABLE I. Sociodemographic characteristics of the sample

Variable	Category	*N*	Total %	*N*	Serbia %	N	Croatia %	χ^2	*DF*	*p*
Gender	Male	59	56.19	30	48.39	29	67.44	3.74	1	.053
	Female	46	43.81	32	51.61	14	32.56			
Age (years)	20–24	4	3.81	2	3.23	2	4.65	7.43	6	.283
	25–29	11	10.48	5	8.06	6	13.95			
	30–34	20	19.05	10	16.13	10	23.26			
	35–39	12	11.43	9	14.52	3	6.98			
	40–49	38	36.19	27	43.55	11	25.58			
	50–59	15	14.29	6	9.68	9	20.93			
	60 +	5	4.76	3	4.84	2	4.65			
Education	OAS	21	20.00	12	19.35	9	20.93	0.67	2	.714
	MAS	34	32.38	22	35.48	12	27.91			
	DAS	50	47.62	28	45.16	22	51.16			
Professional status	Students	11	10.48	7	11.29	4	9.30	2.17	2	.337
	Prof. and Ass. prof.	57	54.29	30	48.39	27	62.79			
	Employed in industry/IT/NGO	37	35.24	25	40.32	12	27.91			
Engineering profile	Technical	79	75.24	47	75.81	32	74.42	0.02	1	.871
	Technological	26	24.76	15	24.19	11	25.58			
Years of work experience	0–1	3	2.86	2	3.23	1	2.33	7.33	8	.501
	1–5	21	20.00	13	20.97	8	18.60			
	6–10	18	17.14	9	14.52	9	20.93			
	11–15	19	18.10	15	24.19	4	9.30			
	16–20	17	16.19	11	17.74	6	13.95			
	21–25	13	12.38	5	8.06	8	18.60			
	26–30	3	2.86	2	3.23	1	2.33			
	31–35	7	6.67	3	4.84	4	9.30			
	36+	4	3.81	2	3.23	2	4.65			
Company size (number of employees)	Micro (1–10)	4	3.81	3	4.84	1	2.33	14.59	3	.002
	Small (11–50)	15	14.29	8	12.90	7	16.28			
	Medium (51–250)	48	45.71	20	32.26	28	65.12			
	Large (250 +)	38	36.19	31	50.00	7	16.28			
Company activity	Service	78	74.29	50	80.65	28	65.12	3.20	1	.073
	Production	27	25.71	12	19.35	15	34.88			
Ownership structure	Domestic public	70	66.67	39	62.90	31	72.09	6.85	3	.077
	Domestic private	26	24.76	14	22.58	12	27.91			
	Foreign	7	6.67	7	11.29	0	0.00			
	Shared ownership	2	1.90	2	3.23	0	0.00			
Satisfaction with material status	Very dissatisfied	1	0.95	1	1.61	0	0.00	3.69	4	.448
	Dissatisfied	11	10.48	7	11.29	4	9.30			
	Neider sat. nor dissat.	26	24.76	18	29.03	8	18.60			
	Satisfied	55	52.38	28	45.16	27	62.79			
	Very satisfied	12	11.43	8	12.90	4	9.30			

RESULTS AND DISCUSSION

The descriptive statistical analysis was performed using the SPSS program. The descriptive statistics and the correlations between variables have been presented in Tables II and III. Based on the value of the indicators of the shape of the distribution (skewness and kurtosis), we concluded that the distribution of all continuous measures were close to normal distribution. When it comes to correlation coefficients, the results pointed to the conclusion that the correlations were predominantly statistically significant, positive and of low to moderate intensity.

TABLE II. Descriptive statistical indicators; Min – minimum value; Max – maximum value; *AS* – arithmetic mean; *SD* - standard deviation; *Sk* – skewness; *Ku* – kurtosis

Indicator	Min	Max	*AS*	*SD*	*Sk*	*Ku*
Meaning of the term TTC (1)	1	5	3.89	0.93	–0.71	0.43
Development of TTC (2)	1	5	3.63	0.92	–0.24	–0.40
Edukation about TTC (3)	7	15	12.37	1.77	–0.56	0.03
Promotion of TTC (4)	7	15	11.57	1.64	–0.40	0.28
Legal regulations related to TTC (5)	2	10	6.38	1.49	–0.09	0.85
Development of awareness about TTC (6)	41	90	75.32	11.50	–0.85	0.44
Cultural factors (7)	6	15	11.55	2.31	–0.41	–0.44

TABLE III. Correlations between continuous measures; * $p < .05$; ** $p < .01$

Indicator	1	2	3	4	5	6	7
Meaning of the term TTC (1)	1						
Development of TTC (2)	.464**	1					
Edukation about TTC (3)	.648**	.562**	1				
Promotion of TTC (4)	.389**	.517**	.565**	1			
Legal regulations related to TTC (5)	.384**	.223*	.299**	.481**	1		
Development of awareness about TTC (6)	.240*	.211*	.279**	.342**	.123	1	
Cultural factors (7)	.248*	.070	.163	.195*	.089	.273**	1

The association and diffterences in socio-demographic variables, with the understanding of the meaning of the term TTC and the development of TTC, have been presented in Table IV. The satisfaction with material status achieves a statistically significant and positive correlation of low intensity with the question related to the development of TTC. The respondents from Croatia, and respondents/engineers of technical sciences, achieved higher scores than the respondents from Serbia, and the respondents/engineers of technological sciences (chemical engineering), with the respect to understanding the term TTC (Fig. 1). This data shows us that the technological faculties (chemical engineering) in Serbia should implement promotional activities (or education) for students, professors and employees in the economy/IT/NGO, about technical and technological culture, and contribute to its better understanding. The remaining correlations, as well as the differences between the groups, are not statistically significant.

TABLE IV. Association and differences in sociodemographic variables with the understanding of the meaning of the term TTC and the development of TTC. The results from the upper part of the table refer to the results obtained using the Pearson correlation coefficient *r*, while the results from the lower part of the table refer to the results obtained using *t*-test for independent samples/one-way analysis of variance

Variable	Meaning of the term TTC		Development of TTC	
	r/T/F-test	*p*	*r*/T/F-test	*p*
Age, years	.146	.137	.026	0.791
Education	–.181	.064	–.043	0.661
Years of work experience	.160	.103	.054	0.584
Company size	–.068	.491	–.097	0.327
Satisfaction with material status	.091	.358	**.274**	**0.005**
Gender	1.428	.156	–0.870	.386
Company activity	–0.736	.463	–0.248	.805
Country	–2.028	**.045**	–0.853	.396
Engineering profile	2.489	**.014**	1.314	.192
Professional status	0.932	.397	0.603	.549
Ownership structure	1.740	.164	2.622	.055

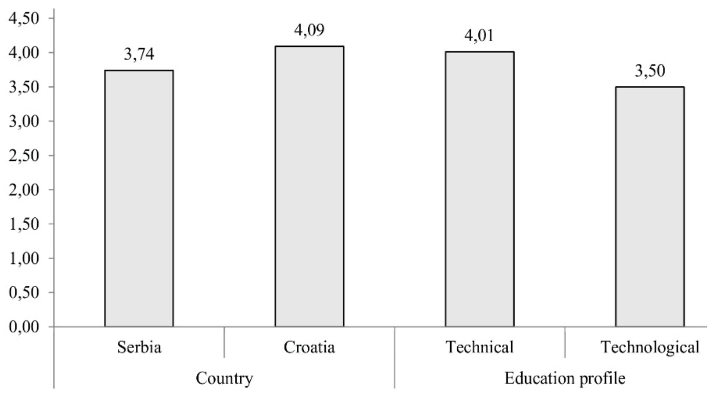

Fig. 1. Differences between countries and educational profiles in the context of understanding the meaning of the term TTC.

The association and the differences in socio-demographic variables with the understanding of the meaning of the term TTC and the development of TTC, especially by country and especially by engineering profile, have been presented in Tables V and VI. When it comes to correlations, there are significant and positive correlations between the satisfaction with material status and the development of TTC in the sub-sample of respondents from Serbia, as well as in the sub--sample of respondents/engineers of technological sciences (chemical engineering). This result indicates that the engineers of technological sciences (chemical engineering) in Serbia, who are more satisfied with their material status, have a more developed TTC in their environment. Age and work experience achieve significant and positive correlations with the meaning of the term TTC, on the sub-sample of respondents/engineers of technical sciences. When it comes to the significance of the differences between the groups, the female respondents achieved higher scores on the understanding of TTC, on the sub-sample of respondents from Croatia, while male respondents from Serbia achieved higher scores from the companies that are jointly owned, compared to the respondents whose companies are from other categories of ownership structure. The remaining correlations and differences between groups are not statistically significant. The significant differences between groups have been presented in Fig. 2.

TABLE V. Association and differences in sociodemographic variables with the understanding of the meaning of the term TTC and the development of TTC, especially by country. The results from the upper part of the table refer to the results obtained using the Pearson correlation coefficient *r*, while the results from the lower part of the table refer to the results obtained using *t*-test for independent samples/one-way analysis of variance

Variable	Meaning of the term TTC				Development of TTC			
	Serbia		Croatia		Serbia		Croatia	
	r/T/F-test	*p*	*r*/T/F-test	*p*	*r*/T/F-test	*p*	*r*/T/F-test	*p*
Age, years	0.226	.077	0.064	.683	–0.005	.967	0.078	.618
Education	–0.185	.149	–0.206	.185	–0.138	.285	0.086	.584
Years of work experience	0.209	.103	0.042	.790	0.004	.973	0.101	.517
Company size	–0.066	.608	0.058	.713	–0.153	.235	0.058	.712
Satisfaction with material status	0.088	.497	0.046	.768	**.311**	**.014**	0.193	.214
Gender	0.928	.357	0.560	.578	0.287	.775	**–2.212**	**.033**
Company activity	–0.656	.515	0.167	.868	–0.671	.511	0.991	.327
Professional status	1.830	.169	0.093	.911	0.001	.999	1.269	.292
Ownership structure	2.189	.099	0.157	.694	**3.104**	**.033**	0.984	.327

The differences by country and engineering profile (technical and technological sciences), in the context of the remaining continuous measures, have been presented in Table VII and Fig. 3. Between the engineering profiles, the only statistically significant differences were identified on the dimensions education on TTC, where the respondents who belong to technical sciences achieve significantly higher scores than the respondents who belong to technological sciences. The remaining differences are not statistically significant, neither when it comes to the differences between countries, nor when it comes to the differences between engineering profiles (engineers of technical sciences and engineers of technological sciences (chemical engineering)).

When it comes to the degree of agreement between the respondents' statements related to attitudes and beliefs about what TTC refers to, the results (arithmetic means) have been presented in Table VIII. The results have been presented for the entire sample of respondents, subsamples by country and subsamples by engineering profile (technical and technological). Regardless of whether it refers to the entire sample of respondents, or about sub-samples with the respect to country and engineering profile, the highest degree of agreement refers to the statements related to the development of the awareness of the environmental and social impact of engineering and technology, the development of the awareness of the impact of engineering and technology on sustainable development, encouraging the development of the awareness about the use of renewable energy sources, encouraging the interest and forming the positive attitudes among young people towards technique and technology, developing a responsible attitude towards work, work tools and one's own environment, and developing technical and information literacy.

TABLE VI. Association and differences in sociodemographic variables with the understanding of the meaning of the term TTC and the development of TTC, especially for engineering profiles (technical and technological). The results from the upper part of the table refer to the results obtained using the Pearson correlation coefficient *r*, while the results from the lower part of the table refer to the results obtained using *t*-test for independent samples/one-way analysis of variance

Variable	Meaning of the term TTC				Development of TTC			
	Serbia		Croatia		Serbia		Croatia	
	r/T/F-test	*p*	*r*/T/F-test	*p*	*r*/T/F-test	*p*	*r*/T/F-test	*p*
Age, years	**.223**	**.049**	0.202	.323	0.128	.262	–0.253	.212
Education	–0.072	.531	–0.373	.061	–0.022	.847	0.082	.691
Years of work experience	0.221	**.050**	0.230	.258	0.169	.136	–0.206	.312
Company size	–0.141	.216	0.030	.884	–0.181	.111	0.178	.384
Satisfaction with material status	–0.013	.913	0.200	.326	0.187	.098	**.528**	**.006**
Gender	0.342	.733	1.209	.238	–1.394	.167	0.111	.913
Company activity	–1.284	.203	1.480	.152	–1.443	.155	–1.357	.187
Professional status	0.286	.752	1.638	.213	0.850	.431	1.766	.196
Ownership structure	1.045	.378	1.153	.294	2.144	.102	0.053	.820

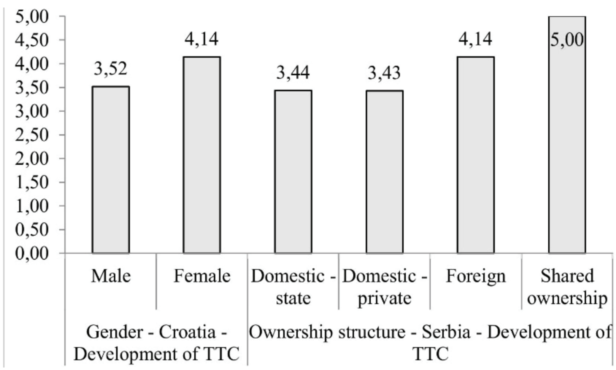

Fig. 2. Differences between TTC development in relation to gender (Croatia) and ownerhip structure (Serbia).

TABLE VII. Differences in relation to the country and engineering profile, and in the context of the remaining continuous measures

Item	Country		Engineering profile	
	t-Test	*p*	*t*-Test	*p*
Education about TTC	–1.932	0.056	2.715	**0.008**
Promotion of TTC	–1.638	0.104	0.118	0.907
Legal regulations related to TTC	–0.614	0.541	0.895	0.373
Development of awareness about TTC	0.067	0.946	0.813	0.418
Cultural factors	0.836	0.405	–0.549	0.584

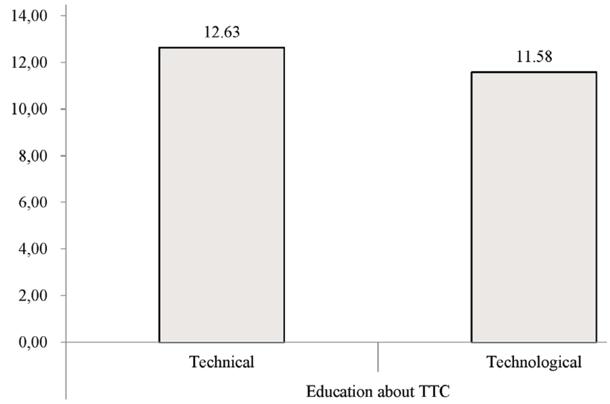

Fig. 3. Distinguishing engineers' profiles based on the cumulative score of three items pertaining to the significance of education about TTC.

TABLE VIII. The degree of agreement of respondents with the statements related to attitudes and beliefs about what TTC refers to

No.	Statement	Total	Technical engineers	Technological engineers	Serbia	Croatia
11.1.	Obeying to the norms for the successful performance of the work process	3.96	4.08	3.62	4.05	3.84
11.2.	Establishment of work procedures	4.11	4.22	3.81	4.10	4.14
11.3.	Creation of quality standards (standardization)	4.16	4.27	3.85	4.08	4.28
11.4.	Unification of the approach to technological problems	3.90	3.86	4.00	3.94	3.84
11.5.	Prevention (anticipating future needs for successful work performance)	3.98	4.08	3.69	4.00	3.95
11.6.	Thriftiness (not spending more than is needed)	3.90	3.90	3.92	3.84	4.00
11.7.	Paying greater attention to work efficiency (economy, rationality...)	4.13	4.19	3.96	4.15	4.12
11.8.	Solidarity in the work environment and cooperation (teamwork)	4.07	4.15	3.81	4.18	3.91

TABLE VIII. Continued

No.	Statement	Total	Technical engineers	Technological engineers	Serbia	Croatia
11.9.	Reliability in people when performing work tasks	3.98	4.08	3.69	4.06	3.86
11.10.	Work discipline	4.01	4.04	3.92	4.02	4.00
11.11.	Commitment to work (involvement in one's work)	3.97	4.04	3.77	4.02	3.91
11.12.	Developing an awareness of the environmental impact of technique and technology (importance of environmental protection)	4.38	4.42	4.27	4.32	4.47
11.13.	Developing an awareness of the social impact of technique and technology (human aspect)	4.42	**4.47**	4.27	4.37	4.49
11.14.	Developing an awareness of the impact of technique and technology on the sustainable development of society	**4.52**	**4.49**	4.62	**4.48**	**4.58**
11.15.	Encouraging the development of awareness about the use of renewable energy sources	4.44	4.35	**4.69**	4.45	4.42
11.16.	Encouraging interest and forming an affirmative attitude, among young people, towards technique and technology	**4.45**	4.37	**4.69**	4.35	**4.58**
11.17.	Developing a responsible attitude towards work, means of work and own environment	4.33	4.29	4.46	4.42	4.21
11.18.	Developing technical and IT literacy	**4.60**	**4.57**	**4.69**	**4.56**	**4.65**

Based on the research conducted in Poland, the author implies that technical and technological culture will be more important in future business environments and that it should be nurtured in every company, through organizational learning and continuous improvement.[10] The development of students' professional competences can be developed through the implementation of technical and technological culture at faculties.[12] The results of the research conducted in Russia indicate that the introduction of content, for the formation of technical and technological culture among students, as future engineers, enables an increase in the level of development of technical and technological cultural indicators.[13] In addition, it ensures the integration of special, professional and technological training that contributes to the formation of a certain technological view of the world, and the mastery of technical and technological culture.[13] The results of the pilot research presented in this paper, which we conducted among the engineers of technological (chemical engineering) and technical faculties in Serbia and Croatia, confirmed that educating young people about technical and technological culture is perceived as very important. The empirical research was conducted in Hungary with the aim of examining the competencies of undergraduate engineering informatics students.[17] Based on the obtained results, optional courses were introduced into the curricula for engineering studies aimed at developing their communication skills and preparing them for the globalized and competitive labour market.[17] This research data has also highlighted the importance of teamwork and cooperation. The lack of required skills for the engineering sectors, which reduces the scope of employment for engineering graduates, is particularly pronounced in India where only 7 % of engineers are suitable for basic engineering jobs.[18] Based on the research results, it has been suggested that the professsional skills, as well as social skills, are equally important for future engineers, and their synergy in higher education can ensure more efficient learning and teaching processes, and improve the quality of education.[17] This is also confirmed by the results of our pilot research, which also stresses the development of technical and information literacy, encouraging interest and forming positive attitudes among young people towards technique and technology. An intervention implemented, as part of an undergraduate course among chemical engineering students at Columbia, led to an increase in the students' perceptions of the development of teamwork and collaborative skills.[4] The approach implemented in Macedonia and Serbia, called Escape Room, based on teamwork, communication, cooperation and problem solving, contributed to the promotion of creativity, critical and logical thinking, a positive attitude towards chemistry and encouraging student engagement and motivation.[8] The project-based learning and the use of educational projects in science are also some of the powerful tools for the promotion, the motivation, and the inspiration of scientific and technical and technological culture.[19] The promotional activities are very important for the development of technical and technological culture, and the results we obtained through the pilot research indicate that technical and technological culture has been insufficiently represented in the media, and that it should be promoted, in particular among experts and engineers. Godin and Gingras present a multidimensional model in which scientific and technical and technological culture is defined as having two dimensions: individual and collective.[15] They discuss how this model can be used to define the indicators of scientific and technical and technological culture, and to understand the role of scientists in the dissemination of scientific and technical and technological culture.[15] They also state that the scientific and the technical and technological culture is related to the promotional and diffusion activities aimed at the general public. Therefore, they point out that the ability to design and present relevant policies, for the executives and the managers in the industry, is the capacity to invest wisely in research; to evaluate and select new technologies and ensure adequate training of employees and the proper maintenance of equipment.[15] The results of this research indicate the importance of developing an awareness of the impact of technique and technology on sustainable development, developing a responsible attitude towards work, work tools and one's own environment, all of which is also a part of a technical and technological culture. A constructivist approach centred on chemical engineering students, applied to modernize the chemical engineering curriculum at the level of the faculty, defines the so-called sensitivities, capacities and competencies (SCC) as a set of attitudes, skills and knowledge necessary for the integral work of an engineer.[3] They were considered from two points of view: general and disciplinary training. At the disciplinary level, the historic traditional pillars of chemical engineering have been preserved using the advantage of academic research, development and innovation (R+D+I), an the expertise required by industry across the university, in addition to the transversal priority areas for modern professional chemical engineering.[3] The pilot research results obtained in this paper have presented the following views: developing an awareness of the ecological and social impact of technique and technology, developing an awareness of the impact of technique and technology on sustainable development, *etc.*

CONCLUSION

Technology is changing the world, and engineers are the ones who create, design, and produce everything in our environment, and that is the reason why their attitudes and beliefs are of importance, because of how the world will look tomorrow depends on them. In this pilot research, we used a questionnaire designed to examine the attitudes and beliefs of the engineers of technical and technological sciences (chemical engineering) about the technical and technological culture, which we believe has been unfairly overshadowed by the innovation and which is of great importance for the future directions of technical and technological development, and the engineers as their creators. The results obtained in this pilot research indicate that our respondents – engineers of technological sciences (chemical engineering) and technical sciences have positive attitudes towards the statements related to technical and technological culture, but state that they do not understand the meaning of the term technical and technological culture, which can be the result of insufficient representation of this topic in the media, as well as the lack of promotional activities among the general and professional public. The greatest misunderstanding of the term technical and technological culture was expressed by the respondents of technological sciences (chemical engineering) from Serbia, which could be significant for thinking about the education of young people, and the organization of promotional activities at faculties and among the general public. Given that our respondents were engineers, all interested parties should be involved in the promotion of technical and technological culture: from universities, government, the private sector, and non-governmental organizations. A better understanding of the meaning of the term technical and technological culture, of the respondents from Croatia, can be linked to the legal regulations and the existence of laws of technical culture in Croatia. It is interesting that, although they express a lack of understanding of the term technical and technological culture, some significant and positive correlations were achieved between the satisfaction with material status, and the development of technical and technological culture in the working environment on the sub-sample of respondents from Serbia, as well as on the sub-sample of respondents/engineers of technological sciences (chemical engineering). It is indicated that the engineers of technological sciences (chemical engineering) in Serbia, who are more satisfied with their material status, have a more developed technical and technological culture in their environment. Based on an analysis of the obtained data, it can be concluded that all respondents agree that young people should be educated about technical and technological culture, that it is important to promote it among scientists and engineers, and that the topic of technological culture should be more represented in the media, and also, the legislation and the law on technical and technological culture should be adopted in Serbia as well. We hope that these results will stimulate thinking and will be followed by the specific actions regarding education and the promotion of the technical and the technological culture, so that all engineers develop positive and ethical attitudes when creating and applying techniques and technologies in the future.

The possible limitations of this pilot research are that the research was done only at the level of two countries, from the same region, so we think that the research should be extended to all the countries that are mentioned in this paper, which possess the technical and the technological culture. Therefore, the number of respondents should be increased in order to obtain more data.

What would be important for further research is to connect with the universities from all over the world, who have devoted the attention to the education of future engineers of technical and technological sciences, as well as to the promotion of technical and technological culture among scientists, experts, engineers and the general public, and the legal regulation of technical and technological culture.

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И З В О Д

ХЕМИЈСКО ИНЖЕЊЕРСТВО У ТЕХНИЧКО-ТЕХНОЛОШКОЈ КУЛТУРИ

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Савремене технологије континуирано мењају човека и његов однос са околином. Оне могу много постићи у области хемијског инжењерства, чиме се побољшава и унапређује квалитет људског живота, али са друге стране, технологије се могу користити и за уништавање људских живота. Техничко-технолошка култура (у даљем тексту ТТК) је свеукупност друштвених достигнућа у области техничко технолошких наука и њихове примене, као и сва знања и вештине потребне за разумевање достигнућа, њихово правилно коришћење, пренос на млађе генерације и стварање нових вредности у овој области. У овом раду ће бити представљено пилот истраживање спроведено у циљу испитивања ставова и уверења инжењера технолошких (хемијско инжењерство) и техничких факултета у погледу развоја ТТК и утврђивања социо-демографских фактора који могу имати утицаја на њен развој. Истраживање је спроведено у Србији и Хрватској. Резултати указују да су важни аспекти ТТК: развој свести о одрживом развоју, утицај на заштиту животне средине, итд. Испитаници су препознали етичке изазове са којима се данас суочавамо, потребу за увођење ТТК у садржај образовања младих инжењера и промоцију ТТК у медијима и стручној јавности.

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