ENGINEERING JOB SKILLS IN CROATIAN ECONOMY: EMPLOYERS' PERSPECTIVE

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ABSTRACT

Different actors, or stakeholders, are interested and want to participate in discussions and interventions related to the topic of skills as an important outcome of engineering education. In the Croatian context, the entire process is still predominantly internally driven and determined by academic evaluations while the involvement of the alumni and employers as external stakeholders is sporadic and under researched. Since Croatian employers are not sufficiently familiar with the levels and structures of reformed study programs, the main objective of this research was to assess to what extent the current and largely accepted set of engineering skills fit their expectations.

By reviewing available literature, 36 key skills were identified and used in a questionnaire administrated to Croatian employers, resulting in 418 completed and usable responses. Results show that employers find every assessed skill as somewhat/extremely valuable. However, it is found that employers most valued skills related to the wider set of transferable skills with somewhat greater emphases on skills that reflect professionalism and work ethic. In general, it turned out that employers approach transferable skills in terms of their functionality. Mean comparison within subgroups has shown statistically significant differences with regard to respondent's gender. In general, women fit the theorized dimensions more than their male counterparts, perhaps indicating that they understand all skills, and transferable skills in particular, more holistically than men.

Finally, in order to understand the underlying structure of the explored items, exploratory factor analysis was employed, resulting in 8 clear dimensions suggesting engineering "employability skills" in the Croatian context.

KEYWORDS

engineering, skills, learning outcomes, employers

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INTRODUCTION

To say that recent developments in work arrangements and a rapid growth in technological innovation constantly challenge engineering education to transform itself and to meet demands of engineering practice seems urgent in an age of globalization, precarious, flexible work and ubiquity of digital technology. At the same time, it seems like a long and thoroughly discussed theme in the literature concerned with relations between engineering education and practice. Basically, at least from the middle of the twentieth century, literature on engineering education addresses different aspects of tensions between engineering education and engineering practice [1-2]. In general, until the 1980s, this discussion was framed by Fordist models of capitalist accumulation and reproduction with images of engineers as professionals who were supposed to find their area of activity predominantly in industrial settings, and to be equipped with knowledge of engineering science with the addition of some functional information stemming from the field of organizational studies like management, industrial sociology and industrial psychology.

However, since the 1980s, the neoliberal phase in socio-economic developments of industrial capitalist societies, coupled with the rise of information technology and globalisation, influenced the landscape of engineering activities, changing not only the scope of engineering practice beyond industrial settings but also prevalent images of what engineers are as a profession, what they precisely do while working, what their working material and human environment would look like in times to come.

As indicated by several authors [3-4], engineering practice in the manufacturing sector has gone beyond strictly technical engineering roles, while simultaneously expanding towards activities in the service and public sectors. Already in the 1990s, Barley and Orr [5] pointed to the analytical difficulties that arose from blurring boundaries between technical and, for example, accounting work, as represented in the official occupational classifications. While they concentrated primarily on technicians, Barley and Orr offered a developmental contour of technization of work at the societal level: “By technization, we mean to characterize the emergence of work, which is comparatively complex, analytic, and even abstract, because it makes use of tools that generate symbolic representations of physical phenomena and that often mediate between workers and the objects of their work” [5; p.5]. In regard to the expansion of possibilities for engineers to be employed outside the manufacturing settings, the National Academy of Engineering (NAE) clearly indicated the need for an engineering education oriented towards a wide range of career opportunities that include non-engineering jobs [6]. As an example of non-traditional engineering employment area, Beder singled out financial firms where engineers’ problem solving, mathematical and computer skills in the context of financial transactions becoming more complex were recognized as desired [3]. More recently, Krawczyk and Murphy pointed out a similar perspective: “There is no single archetypal engineer or pattern that universally describes what engineers are in the world of 2011. Descriptions of engineers tend to focus on what engineers do rather than on the intrinsic characteristics of what makes someone an engineer. Engineers practice in many diverse disciplines and perform many diverse roles, even within those disciplines. There are also many people who have been educated as engineers but no longer work in engineering roles” [4; p.110].

All these authors, as well as many others [7-10], have considered those changes in terms of skills and competencies engineers need in contemporary circumstances. Sometimes the skills are covered under the umbrella of “employability” [11]; sometimes they are covered through the number of general descriptions that usually include knowledge, intellectual skills, practical skills and transferable skills [4]. In any case, some kind of a common viewpoint and frame are concisely offered through accreditation agencies' recommendations, which generalize the issues of engineering skills and competencies in terms of learning outcomes – a concept that recently became both a dominant and "the principal instrument to describe competency" [12; p.9].

In the process of reforming higher education in Croatia in accordance with the Bologna declaration, the aforementioned recommendations represent an important frame of reference for numerous engineering higher education institutions. Therefore, learning outcomes have become a usual reference for knowledge, competencies and skills in the engineering field, although occasionally constructed in a manner that reflect long established and deeply internalized practices of "problem solving" among Croatian engineers [13] rather than a systematic effort of national engineering associations to foresee the meaning of engineering in the long-term perspective of Croatian social and economic development. This means that the overall engineering field is fragmented with some higher education institutions trying to officially acquire international accreditations, while others strive to follow these recommendations in an informal way, ingeniously phrasing learning outcomes to fit their own needs. The entire process is still predominantly internally driven and determined by academic evaluations, while the involvement of alumni and employers as external stakeholders is sporadic and under researched. For example, it has been already pointed out that Croatian employers are not sufficiently familiar with the levels and structures of reformed study programs [14]. An effort to involve employers was made in the creation of the catalogue of knowledge, skills and competencies for Croatian mechanical engineering study programs [15]. However, results seem to be unreliable since the research procedure has not been presented in sufficient detail, and the sample of employers (46) was relatively small to allow for wider generalisations.

If the learning outcomes approach in the current process of harmonization of Croatian and European higher education system does not cover suggestions from different stakeholders in education, then our primary research objective will be to assess the extent to which the prevailing learning outcomes in engineering study programs in Croatia meet the expectations of employers. In addition, since the learning outcomes approach as a synthesizing instrument for estimating engineering skills and competencies in Croatia is still fragmented and relatively diverse, we have also tried to define the key components of skills and competencies as elaborated in the literature we have found relevant for our study and to estimate to what extent employers consider them important. Finally, the present research examines whether it is possible to determine differences in employers' ratings of skills and competencies by a number of independent variables, such as the employers' field of activity, enterprise size, private or public ownership, engineering professions they employ and by gender of respondents as the single socio-demographic feature selected for the study.

CONCEPTUAL BACKGROUND

Generally, the skill-based approach in engineering has corresponded to a wider educational turn since the 1980s and to educational policy efforts in European countries in order to promote education as the most important generator of economic growth [16]. Still, it is evident that skills and competencies have various definitions, as the perspectives of key stakeholders in academic engineering education (employers, academic institutions, students, engineering associations, and alumni) often express different positions, interests and problems [12]. This process has resulted in formulations of qualifications frameworks as conceptual backgrounds of arising European and national educational architectures oriented toward learning outcomes and skills as the main indicators of quality of education. As fundamentally social and dubious in its character, the very concept of knowledge society in which education crucially affects economic development altogether with the process of developing a framework of qualifications has been widely questioned and criticised as a policy device for wider marketization of education and its adaptation to the needs of profit-oriented external stakeholders, i.e., employers [12, 17-20]. However, almost none of the critics dispute neither the issue of skills and learning outcomes nor the research of employers' perspective on (engineering) education and preferable skills formation as the relevant subject.

Conceptualizations of engineering skills and competencies are usually grouped around several general features. Principally, these features are derived from a list of skills formulated by various organisations, national bodies or quality assurance agencies around the world [11, 21], and are explicitly or implicitly taken into account and thoroughly discussed in the corresponding literature. For example, the Accreditation Board for Engineering and Technology (ABET) EC2000's Criterion 3 [22] specifies 11 student learning skills (or, more precisely, learning outcomes), representing a frame of reference for engineering studies worldwide, including some Croatian engineering faculties. In the context of European engineering higher education, these skills are elaborated by quality assurance institutions, among which some, like *Akkreditierungsagentur für Studiengänge der Ingenieurwissenschaften, der Informatik, der Naturwissenschaften und der Mathematik* (ASIIN), accredit and advise some Croatian and other higher education institutions throughout the whole of Europe. In the case of ABET, proposed outcomes are provided for undergraduate engineering programs, while in the case of the ASIIN, these outcomes are formulated according to research and practice-oriented programs as at least two typical general profiles of engineering studies. Additionally, ASIIN differentiates ideal learning outcomes for Bachelor's and Master's degree as an orientation guideline. Thus, requirements for Master's degree programmes are conceived as a continuation of an initial university degree leading "to the acquisition of advanced analytic-methodical and technical competencies" [23; p.5].

In regard to specific learning outcomes, there is significant similarity among aforementioned and other organisations, national bodies or quality assurance agencies [11, 21]. The same goes for general features into which these outcomes are synthesized. By establishing the broadest perspective possible with regard to the diverse branches of engineering, the National Academy of Engineering (NAE) has considered skills that, in terms of attributes, engineers will need in 2020.

NAE predicted analytical skills as desirable, confirming their lasting value. The next predicted feature has pointed to practical ingenuity as a set of skills that represent the ability to define problems and to find solutions through the use of science. The next set of skills are covered by the term creativity to emphasize the importance of "invention, innovation, thinking outside the box, (and) art" in dealing with the growing "complexity and diversity of the technologies of the 21st century" [6; p.55]. The last two set of skills have involved professionalism and leadership as a way to sum up the so-called transferable skills. These involve abilities to communicate well; to express leadership skills based on the understanding of corresponding principles since the possibilities for engineers to be employed outside manufacturing settings will grow; to act according to high ethical standards; to understand the contemporary social context, which requires flexibility, resilience or agility; and finally to be life-long learners.

The NAE attributes are scenario-based, for they were thought to differentiate several possible upcoming trends in the future. A corresponding scenario-based approach is used by Krawczyk and Murphy [4], who surmised three scenario options. The first involves the possibility of continuation of existing socio-economic order, the second considered radical transformation towards just, peaceful and sustainable world, and the third referred to a kind of possible social, cultural, political and economic regression with the dramatic rise of environmental problems, social injustice, the establishment of firm hierarchical structures, etc. They suggested a related set of composite skills: knowledge skills, intellectual skills, practical skills and general transferable skills. Here, the knowledge skills correspond to NAE's analytical skills and refer to knowledge and understanding of the essentials of engineering science. Intellectual skills correspond to NAE's term, creativity, while practical skills correspond to practical ingenuity as proposed by NAE. Finally, general transferable skills refer to professionalism and leadership as described in NAE publication. As regards a different certainty of scenarios, Krawczyk and Murphy have suggested that all the same skills would be needed; the only difference refers to "problems and projects these skills will be applied against" [4; p.118].

Both approaches use ABET recommendations as a basic conceptual framework. Considering its wide utilisation in creation of instruments for measuring ABET's 11 learning skills, Strauss and Terenzini pointed out that flexibility of interpretation as its main advantage could also be the source of ambiguities "in defining and measuring the skills that students must demonstrate if a program is to meet the intent of the criteria" [24; p.10.927.2]. Their effort to develop psychometrically sound instrument for assessing different stakeholders' viewpoints on engineering higher education learning outcomes has resulted in nine-factor solution representing the main corresponding engineering skills as follows: design and analytical skills, societal and global issues, codes and ethics, experimental skills, communication skills, applying engineering skills, group skills, life-long learning, and applying basic skills.

In other related literature, the skills employers perceived as important are also considered in terms of learning outcomes and personal attributes of graduated engineers. In most of them, it is possible to discern explicitly or implicitly stated that engineering higher education has to be the driving force in improving the competitiveness of national economies. In a way, for a number of these research reports, Drucker's critical observations of the failures of American educational institutions from the 1990s to prepare the students for the world of business can be seen as a common conceptual background [25]. Research reports refer to studies around the world – from the USA, Great Britain to South-East Asia and Australia.

In the Australian context, Hagan has found that 40 % of employers were not satisfied with the level of ITC students' mastery of some generic skills, mostly their business management skills and communication skills [26]. Markes offered systematic literature review on engineering skills that British employers perceive as important in contemporary flexible companies that strive to cope with constant and rapid changes [11]. In a similar way, Prados, Peterson and Lattuca explain the reasons for the key changes that have taken place in the process of revision of ABET recommendations, which put in the foreground the ever-changing needs of engineering practice [27].

Some corresponding research have been conducted in fast-growing economies like India, Malaysia, Sri Lanka, as well as have been concerned with the wider regional scope. As a background assumption, there is, again, the importance of engineers for national economic, technological and infrastructural development in times of constant changes, which force these nations to deal with new challenges [21, 28, 29]. For example, Blom and Saeki have seen the research of employers' perception of important engineering skills as a necessary contribution to balancing educational system within the Indian economy, which during their research was growing over by 8 % annually, including the year of the financial crisis in 2009 [30]. Blom and Saeki stated that the growing need for engineers in relation to the increase in educational institutions resulted in the decrease of the quality of skills employers needed.

Finally, Zaharim et al. have proposed a model of engineering employability skills that intend to provide a framework for Malaysian engineering programmes. Relying on existing researches, different national and international accrediting bodies and frameworks, the authors have also comparatively revised engineering skills and attributes required for engineering graduates worldwide [21].

In sum, all of the aforementioned studies converge toward a relatively close set of engineering skills with more or less attention given to ABET EC2000's Criterion 3 as an important reference. The same goes for the present study – three main sources we have referred to in more detail in the first part of this chapter, namely, NAE report, Krawczyk and Murphy's study and Strauss and Terenzini's nine set skills solution, are altogether derived from or based on ABET's list. Therefore, their sets of skills converge as shown in Table 1.

Table 1. Engineering skills as defined in the selected research.

NAE	Krawczyk and Murphy	Strauss and Terenzini
Analytical skills	Knowledge skills	Applying Basic skills
Ingenuity	Practical skills	Applying Engineering skills Experimental skills
Creativity	Intellectual skills	Design and analytical skills
Professionalism Leadership	General transferable skills	Societal and global issues Codes and ethics Communication skills Group skills Lifelong learning

METHODOLOGY

Working under the assumption that employers aren't keen on participating in studies, in order to secure enough responses, an oversampling of engineer employers has been made using both the register of Croatian's Chamber of Commerce [31] and the archive of the Faculty of Mechanical Engineering and Naval Architecture (FAMENA) [32] "job openings and scholarships" column. As the Chamber of Commerce's archive lists every legal entity in Croatia, a few restrictions had to be implemented in order to reach a, not only sufficient, but also efficient sample.

In order to enter the sample, companies had to be both active and must have delivered the financial report for the year[1] 2015. After this first filter, companies were sorted in descending order to accommodate their total income and number of employees. While their total income was not additionally categorized, companies have been categorized by their number of employees in big (more than 250), medium (50 to 249), small (10 to 49) and micro (1 to 9) entities, with each category yielding no more than 250 subjects per category. These filters have been implemented for each category of the National Classification of Occupation as listed in the People's Newspaper[2] [33], yielding a total of 15 785 contacts. After retaining only unique values (one e-mail per company), the total number of contacts dropped to 7 586. Browsing the archives of FAMENA's aforementioned column back to the beginning of 2012 yielded an additional 27 unique employers.

University of Zagreb's University Computing Centre's (SRCE) Lime Survey service was used to contact all the employers, additionally asking them to snowball the questionnaire to other engineers' employers, which resulted in a total of 8 878 contacts. As expected, the response rate was low, with only 478 participants filling out the questionnaire. After eliminating participants whose responses were incomplete, or who said they did not employ engineers at all, the final number of usable responses dropped to 418.

QUESTIONNAIRE CONSTRUCTION

In constructing the questionnaire, this study tried to cover a widespread theoretical and empirical background of engineer employability research, drawing from a wide body of articles as well as curricula mentioned in the conceptual background [11, 21-23, 24, 28-30, 34-38]. Trying to utilize previous findings as best as possible, all researched and/or recommended skills were taken into account, resulting in 107 unique entries. In order to make sense of such a large number, content analysis was employed. Combining or deleting variables that resemble each other to some degree, consulting mainly the works of Strauss and Terenzini and that of Zaharim et al., while adding a number of variables specific to FAMENA's curriculum, led to a total of 36 skills, grouped in 10 categories to be explored.

The final was a two-part questionnaire, which consisted of general information about the respondent's company and 36 items comprising skills employers could find valuable in engineers, rated on a 5-point scale, ranging from "1 – Not at all important" to "5 – Extremely important". In order to avoid fence-sitting and add clarity to the results, the value of 3 – "could not estimate" – was subsequently eliminated from the analysis. Based on the literature overview as well as their conceptual meaning, the 36 items were divided into 9 + 13 dimensions[3], labelled as Communication skills (3 items), Lifelong learning (3 items), Teamwork (5 items), Experimentation (2 items), Ethics and responsibility (3 items), Professionalism (5 items), Project management (3 items), Specific skills (3 items), and Other (6 items). Most of the mentioned dimensions were retained via dimension reduction procedures.

FINDINGS

DATA ANALYSIS

SPSS 22 software was used to statistically analyse the data. Mean differences (one sample *t*-test, *t*-tests of independent samples, and ANOVA) were tested at $p < 0,05$ significance, with ANOVA employing Bonferroni's test when equal variances were assumed, and Tamhane's T2 test when equal variances were not assumed. Dimension reduction was conducted via exploratory factor analysis(EFA), extracting dimensions based on eigenvalue greater than 1, employing direct oblimin rotation (presuming dimensions were correlated), and excluding missing values by a pair wise method to retain the most number of answers. In order to test scale construction, Cronbach's alpha method was employed.

SAMPLE'S PROFILE

As mentioned in the previous section, a total of 418 respondents/companies participated in the questionnaire, mainly coming from the *private sector* (360), with 56 *government-linked* companies and 2 from NGOs. Based on their size, 88 companies were *micro*, 169 *small*, 104 *medium*, and 57 *big*, with the majority of them coming from economic branches such as *manufacturing* (78), *construction* (70), ICT (46), and *professional, scientific, and technical activities* (33). The majority of these organizations employed engineers as *in-house professionals* (329), 27 *outsourced* them, while 62 of them used a combination of the two. The most sought-after professions were *mechanical engineers* (197), *computer engineers* (63), *construction engineers* (46), and *electrical engineers* (30).

In regard to their position within the organization, most of the respondents were *directors, owners or members of the supervisory board* (223), with the rest being *HR managers or employees* (68), *managers of other departments* (94) or *other* (33); while in regard to their gender, 279 respondents were *male* and 127 respondents were *female*.

Additionally, in order to emphasize the importance of gathered responses, respondents who did not partake in the process of employing engineers in the last five years (69) were excluded from further analysis, resulting in a working sample of 349.

EMPLOYERS' EVALUATION OF EMPLOYABILITY SKILLS

As aforementioned, even though the scale was originally 5 points, after eliminating the middle value, 4 points were retained, namely: "1 – not at all important", "2 – somewhat unimportant", "3 – somewhat important", and "4 – extremely important". Of the 36 items, only one came close to being rated as somewhat unimportant (General knowledge about national and international events – Mean 2.48), while 17 were rated as extremely important, and 18 as somewhat important (Table 2)[4].

Apart from the mean values being extremely positively skewed, what is immediately evident about the data is the overall low standard deviation of scores. Every item has a standard deviation lower than 1, and the 9 highest items sorted by means have an SD lower than 0,5, indicating not only that employers want engineers who "have it all", but that all these skills are treated as equally "extremely important" regardless of the economic branch the organization conducts its business in, its size, the specialists it employs or its governmental/private/NGO ownership. Although all skills are seen as valuable, some domains do seem to be more valuable than others.

Professionalism, which is portrayed as the ability to work under pressure and follow directions while staying motivated, conscientious, and respecting deadlines is found extremely important by employers.

Not only do employers want professional employees; they want them to be extremely good at *problem-solving* as well, which comes as no surprise, with engineers enjoying a reputation of fixers and tinkerers. Such problem-solving skills are theoretically expected to be portrayed by items that measure the importance of the ability to identify and define problems independently, design practical solutions to fix them as well as being capable of approaching the problem from different angles.

In contrast to the extremely favourable attitudes towards problem solving, employers seem to miss its connection with skills linked to *designing experiments* and analysing and interpreting their data (both rated statistically significantly lower than all problem-solving items), or even to the connection of gaining a specialization in a specific field (significantly lower than all problem solving items), as they would rather employ engineers who are "jacks-of-all-trades" than specialists in their specific fields, somehow hinting at their wants of having innovative designs and technologies without wasting time and money on R&D. That cream-of-the-crop approach seems to lead employers' thinking in other dimensions, too.

Although *teamwork* is found extremely valuable, employers favour an ability to work in interdisciplinary teams, as well as the ability to come to optimal solutions in them and understanding one's role statistically higher more than emotion management, empathy and abilities to lead teams. Likewise, *project management* skills are rated only somewhat important with the highest ranked being the ability to write technical documentation, while abilities to think, plan and lead strategically, as well as design quality management systems are rated statistically significantly lower and seem to be less of a concern.

Communication skills are regarded as extremely favourable in terms of abilities to express oneself clearly and to convey engineering ideas and solution to a non-professional public, but the ability to negotiate with others (which, apart from clients, includes employers too), although still positive, is regarded as a significantly less favourable trait.

Two of the three items measuring *ethics and responsibility* are ranked relatively low, with one exception being the ability to follow and implement rules of the profession (rated significantly higher than the other two items from this domain), perhaps because of it being more linked to the concept of professionalism, while the other two might be either considered important or are just socially acceptable responses.

Specific skills are rated moderately high, with the ability to use and implement specific tools, skills and techniques seen as an extremely important skill, while the ability to use advanced computer software (perhaps, linked with the experimenting domain) and the ability to recognize interactions between elements in technical systems (perhaps, linked with the project leading domain) are rated significantly lower.

Finally, the items defining the *Other* domain sank to the bottom of the importance scale, with the exception being the ability to understand a foreign professional language and, somewhat, having had a practical experience during formal education. Apart from the ability to understand advanced mathematics, understanding contemporary political, economic and ecologic problems, having a general knowledge of current national and international events, as well as having an understanding of the global repercussions and significance of engineering solutions, seem to be of little importance to employers. Such low scores, perhaps, accentuate the wants of employers to employ engineers as "doers" and not "thinkers" and shed some additional doubt on the social acceptability quality of ethics and responsibility answers.

In order to further explore possible differences in skill appreciation between employers, *t*-test and ANOVA analyses were conducted based on independent variables such as *respondent's gender*, their *positions* within the organizations, the *specialists* they employ, as well as the *economic field*, and their total *number of employees*.

While the total number of employees, the economic field of the organization, as well as respondents' position within them yielded particularly no interesting findings, with just a few statistically significant differences, respondents do seem to value different skills very differently based on their gender and slightly differently based on the organizations' ownership.

Generally speaking, women tend to value all measured skills more than men, with a mean of 3,5 compared to the 3,3 of their counterparts, and with 26 out of 36 skills being statistically significantly higher, which makes them somewhat harder to impress during the hiring process. What is especially interesting would be their focus on some of the theorized dimensions, where women value all of the items, including the *Communication skills, Experimentation, Ethics,* and *Project management* dimensions, except *Professionalism* and *Problem solving*[5].

Although just a few skills were rated significantly different when compared to the available ownership categories, their domain setup showed an interesting and, perhaps, expected difference between respondents from government-owned and private-owned organizations, with the former valuing items comprising *The Ethics and responsibility* domains significantly higher than the latter. Although not all the items measuring the aforementioned domain were statistically different,[6] there seem to be a notable difference in value (if not in practice) between the two types of ownership, especially if we note that there's a statistical difference in the item "Conscientiousness and ability to implement rules of the profession", too.

Table 2. Mean and standard deviation values of items operationalizing engineer skills (continued on p.11).

Item	N	Mean	SD	Theorized Dimension
Professional and conscientious approach to work tasks	317	3,9	0,349	Professionalism
Willingness for lifelong learning of engineering knowledge, skills and techniques	326	3,8	0,465	Lifelong learning
Motivated approach to work tasks	321	3,8	0,440	Professionalism
Conscientiousness and ability to implement rules of the profession	324	3,7	0,443	Ethics and responsibility
Ability to respect deadlines	318	3,7	0,436	Professionalism
Ability to come to an optimal solution while working with others (engineers and non-engineers alike)	320	3,7	0,503	Teamwork
Ability to independently identify and define problems that need solving	322	3,7	0,499	Problem solving
Understanding and respecting one’s and others’ role in the teamwork	327	3,7	0,493	Teamwork
Ability to find different solutions to existing problems	321	3,7	0,484	Problem solving
Concise and clear communication of ideas to non-engineers (public, clients...)	332	3,6	0,546	Communication skills
An active interest in engineering evolution of technology, knowledge, skills and techniques	322	3,6	0,531	Lifelong learning
Design solution to meet desired needs	322	3,6	0,567	Problem solving
Ability to communicate and express oneself clearly	331	3,6	0,528	Communication skills
Ability to work under pressure (deadlines, downsizings, demanding clients...)	319	3,6	0,583	Professionalism
Ability to choose and use specific engineering tools, skills and techniques	314	3,6	0,570	Specific skills
Ability to work well in interdisciplinary teams	327	3,5	0,610	Teamwork
Ability to follow directions when working on tasks	320	3,5	0,571	Professionalism
Understanding a foreign professional language	312	3,4	0,661	Other
Ability to lead teams	324	3,4	0,641	Teamwork

Table 2. Mean and standard deviation values of items operationalizing engineer skills (continuation from p.10).

Item	N	Mean	SD	Theorized Dimension
Ability to write technical documentation	315	3,4	0,681	Project management
Ability to use advanced computer software	316	3,4	0,661	Specific skills
Ability to negotiate with clients and employers	326	3,4	0,729	Communication skills
Making ethical standards a priority when working on tasks	320	3,3	0,677	Ethics and responsibility
Ability to manage one's and recognizing others' emotions	326	3,3	0,632	Teamwork
Taking into account societal and environmental repercussions when designing engineering solutions	319	3,3	0,647	Ethics and responsibility
Specialization in an engineering field	321	3,3	0,688	Lifelong learning
Ability to think, plan and lead projects strategically	317	3,2	0,661	Project management
Practical experience during formal education	314	3,2	0,783	Other
Ability to recognize interactions between elements in technical systems and processes	311	3,2	0,692	Specific skills
Ability to design and lead experiments in order to test new technical solutions	323	3,1	0,789	Experimentation
Ability to design processes of quality management	314	3,1	0,699	Project management
Ability to analyse and interpret experiment results	323	2,9	0,831	Experimentation
Understanding the global repercussions of engineering solutions	305	2,7	0,780	Other
Advanced understanding of mathematics	305	2,7	0,784	Other
Understanding contemporary (economic, ecological, political...) problems	311	2,6	0,759	Other
General knowledge of national and international events	306	2,5	0,842	Other

DIMENSION REDUCTION

In order to shed some light on the underlying dimensional construct of the questionnaire, an explorative factor analysis was conducted, as explained in the *data analysis* section. After purifying the initial solution and removing items that either saturated too many dimensions, had low Cronbach values or simply didn't make sense considering the solution, 29 items were retained. The final solution resulted in an 8-factor structure, explaining 62 % of the overall variance among the 29 items (Table 3).

All retained items loaded above 0,48 on a single factor and all of the factor scales scored above 0,6 except the domain of communication skills. The final factor solution shows that most of the theorized domains were retained, with the exception of the domains of *Problem-solving*, *Project management*, and *Specific skills*, whose items ended up separating and saturating other factors. Specific skills items, as well as project management items, combined and formed the principal component of this structure, named *Technical and managerial skills*. And while two out of three items from the problem-solving theorized dimension were deleted, one was retained in the *experimentation* domain.

As can be seen in Table 3, the principal component of the factor solution can be traced to abilities that make up day-to-day activities in most of the engineering positions, where employees are tasked with a plethora of jobs, ranging from writing technical documentation to applying specific informational and engineering knowledge to planning, and leading various projects.

Although its items ranked fairly low in terms of importance, the next retained dimension, *Globality of engineering* grouped three items from *Other* dimension, and accounted for 7,6 % of the total variance explained, showing that, although employers do not find these skills particularly important, they do tend to think about them as a part of the engineering skills toolkit.

Unsurprisingly, the two items comprising the theorized *Communication skills* saturated the first confirmed factor through dimension reduction and explained 6,4 % of the total variance. Although its Cronbach alpha does verge on the unacceptance edge, it's fairly clear composition and fairly high percentage of variance explained could mean the scale would just need a few more related items in the questionnaire to achieve far higher values.

The *Teamwork* dimension is also one of the retained theorized dimensions, accounting for 5,4 % of the total variance explained. Although grouping 5 items, items measuring abilities to lead teams, as well as a variant of emotional intelligence, saturate the factor less than items measuring abilities more overtly linked to "productive" teamwork, as if employers did understand their role in teamwork, but, perhaps, underestimated their value in making a team function properly.

Lifelong learning retained all the theorized items, accounting for 5 % of the variance and, while employers seem to value highly a willingness to keep expanding one's knowledge, specializations in specific fields saturate this factor far less.

Professionalism accounted for 4 % of the total variance explained, grouping 4 theorized items, showing that not only do employers value those skills highly (as shown in Table 3) but they find them connected, expecting employees to be able to respect deadlines and work under pressure while being able to keep themselves motivated and in line with given directions.

Ethics and responsibility also retained its initial items, accounting for 4 % of the total variance, showing that employers find both "micro-ethics" (such as putting ethical standards at the foremost place when working, and being conscientious by implementing professional rules) and "macro-ethics" (such as taking into account the societal and environmental repercussions of engineering) as part of an ethical approach in engineering work.

Table 3. Factor structure underlying items operationalizing engineer skills.

Highest Loading Items	Factor Loading	Scale Alpha	Variance explained
1. Technical and managerial skills		0,8	26,0 %
Ability to write technical documentation	0,718		
Ability to design processes of quality management	0,663		
Ability to choose and use specific engineering tools, skills, techniques	0,659		
Ability to use advanced computer software	0,634		
Ability to think, plan and lead projects strategically	0,630		
Ability to recognize interactions between elements in technical systems and processes	0,616		
2. Globality of engineering		0,86	7,6 %
Understanding contemporary (economic, ecological, ...) problems	-0,851		
General knowledge about national and international events	-0,834		
Understanding the global repercussions of engineering solutions	-0,806		
3. Communication skills		0,56	6,4 %
Concise and clear communication of ideas to non-engineers (public, clients...)	0,822		
Ability to communicate and express oneself clearly	0,806		
4. Teamwork		0,68	5,4 %
Understanding and respecting one's and others' role in teamwork	0,723		
Ability to work well in interdisciplinary teams	0,688		
Ability to come to an optimal solution while working with others (engineers and non-engineers alike)	0,597		
Ability to lead teams	0,570		
Ability to manage one's and recognize others' emotions	0,523		
5. Lifelong learning		0,63	4,9 %
Willingness for lifelong learning of engineering knowledge, skills and techniques	-0,781		
An active interest in engineering evolution of technology, knowledge, skills and techniques	-0,754		
Specialization in an engineering field	-0,550		
6. Professionalism		0,71	4,1 %
Ability to respect deadlines	-0,784		
Ability to follow directions when working on tasks	-0,777		
Motivated approach to work tasks	-0,705		
Ability to work under pressure (deadlines, downsizings, demanding clients...)	-0,604		
7. Ethics and responsibility		0,66	4,0 %
Putting ethical standards at the foremost place when working on tasks	-0,757		
Conscientiousness and ability to implement rules of the profession	-0,744		
Taking into account societal and environmental repercussions when designing engineering solutions	-0,697		
8. Experimenting		0,73	3,8 %
Ability to design and lead experiments in order to test new technical solutions	0,883		
Ability to analyse and interpret experiment results	0,820		
Design solution to meet desired needs	0,475		
			62,1 %

Finally, although ranked fairly low on importance, *Experimenting* retained its two theorized items, and grouped one of the mainly deleted *problem-solving* domain. Accounting for 3,8 % of the total variance, this dimension grouped abilities to design and lead experiments as well as analyse and interpret their data. But as mentioned in the previous section, employers do not seem to be all that keen on "wasting time" experimenting, unless it leads to new and practical discoveries, as shown by the third item comprising this domain.

As the component correlation matrix ranged from low (0,03) to moderate (0,3), a second-order analysis was implemented in order to check whether it is possible to treat the final version of the instrument as a unidimensional scale with a Cronbach alpha score of 0,9. Second-order factor analysis yielded 3 factors, while a third-order factor analysis led to only one factor. Such results seem to dismiss the idea of unidimensionality of the scale, so Cronbach alpha scores should be measured at subscale/domain levels.

Finally, it should be noted that a shorter version of this scale, containing 24 items throughout 8 dimensions and explaining 66 % of the total variance can be constructed. But since this is the first kind of explorative factor analysis on a Croatian sample, it was thought best to retain as many items as possible in order to facilitate possible future research.

DISCUSSION

Although most of the items used to estimate skills and learning outcomes of Croatian engineering study programs are relatively highly valued by Croatian employers, some differences in their ratings could be discussed in more detail.

Starting with some of the unexpected results, a relatively lesser importance given to skills of experimentation and the practical experience students acquire during their education seem to be contrary to the image of inventors and tinkerers engineers maintain in society, while a common student's wish to gain more practical experience seems not to be reflected in the needs of future employers. Theory-practice issues have already been discussed in terms of tensions inherent in engineering education, with a possible consequence in the distancing of engineers working in the academic sector from the practice of everyday engineering [39]. As Jamison and Heymann have pointed out "… distance mattered all the more, because teachers and professors now became removed from their original professional location, the engineer in industrial practice, while they successfully created a new profession, the engineering professor, with its own culture and set of norms and values" [39; p.192]. On the other hand, increased educational ascent on experimentation and laboratory work could be considered a visible consequence of the self-imposed direction toward greater scientification, which is believed to be an important vehicle in the recognition of engineers and engineering in general in the society [1-3]. However, based on the results of this study, it seems that the considerable educational efforts towards implementing practical and laboratory work in curricula do not clearly meet Croatian employers' expectations. As related research on a Croatian sample is scarce to non-existent, interpreting results is impossible since theoretical possibilities range from those of Croatian employers considering the issue of practical experience being a regular part of apprenticeship and organisational socialization, to the lack of interest in research, development, and innovation by the Croatian business sector.

Although practical and experimental skills seem to be undervalued in Croatia, this study confirms the findings of previous research about the importance of transferable skills for the engineering profession [4, 6, 24]. Croatian employers seem to concur with their international colleagues, ranking several components of professionalism (the highest ranked, the third and the fifth item), lifelong learning (the second highest ranked item), ethics and responsibility (the fourth top-ranked item) and teamwork (the sixth) as some of the most important skills.

Furthermore, in the referenced literature, soft skills are considered just one part of wider non-technical dimension in engineering education aimed to foster an engineering identity and habitus, which include notions of engineers who are broadly educated, aware of the world around them and who responsibly deliberate their roles in society. In that sense, Krawczyk and Murphy rely on NAE's indications of engineers as "broadly educated, see themselves as global citizens, can lead in business and public service, as well as in research, development and design, are ethical and inclusive of all segments of society" [4]. Therefore, these findings should be taken into account by engineering academic institutions in Croatia, which should lead to a broader range of non-technical classes in their education programs.

However, the importance of professionalism, lifelong learning, ethics and teamwork seem to be valued by employers in somewhat reduced form. For example, it has been shown that employers perceive teamwork as more of a functional than a social situation, i.e., primarily as a more efficient way to attain goals and not so much as a group context in which interaction among the members of the team reflects a culture of mutual respect and understanding. The same "functionality above all" approach goes for communication skills too, where employers do not value negotiation skills as much as other skills pertaining that domain, since an ability to negotiate could imply a need to discuss a range of issues with their employees.

Ethics and responsibility are seen in a similar way. As was mentioned in the previous section, when ethics are linked to professional ethics, they are valued as a top-ranked skill, coming close to the theorized component of professionalism, while, when ethics are linked to environmental and social ethics, they are perceived as significantly less important. Similarly, other non-technical items, such as an understanding of contemporary (economic, ecological and political) problems and general knowledge about national and international events are ranked at the bottom, with employers finding them significantly less important. It should be mentioned that, although employers generally accept engineering skills and learning outcomes designed in accordance with widespread theoretical and empirical background of engineers' employability literature, such functionality might not be shared among other interest groups. In order to encompass broader viewpoints, research on other stakeholders of engineering education (alumni, students, other engineer researchers) should be employed, for education "must be approached as a multifaceted phenomenon, which varies depending on the perspective of the key higher education actors or stakeholders who define them; employers, academics, students and academic and administrative leaders, all of whom potentially assess higher education learning outcome differently." [12].

The present study has also aimed to define the key components underlying skills and competencies analysed. Although all the items were ranked as at least *somewhat important*, in order to shorten the questionnaire, items that either saturated too many dimensions, had low Cronbach values or simply did not make sense considering the solution were deleted. Among the deleted items, those pertaining to the theorized dimension of *problem-solving*, although valued rather highly by employers, were not retained because of their low saturation on different factors. Retained items saturated a solution of 8 dimensions, mostly comparable to previously mentioned research [21, 24], although, in the case of this study, with a stronger emphasis on technical and managerial skills, accounting for 26 % of the explained variance.

Finally, although most of the independent variables analysed resulted in no statistically significant or in slight differences, employers do seem to differ in skill evaluation based on their gender. Generally speaking, women attribute greater value to all skills, both technical and non-technical, than men. Although, when it comes to the issue of recruitment and hiring processes, there is a multitude of studies dealing with gender discrimination and problems women face while trying to get a job, research comparing gender differences in skills evaluation when hiring is unavailable to the best of the authors' knowledge. Since women represent nearly one third of our sample, and are relatively evenly distributed among owners or members of the supervisory boards, among HR managers or employees of such departments and among managers in other departments, the only clue to aforementioned finding could direct this discussion toward a range of research on gender subject in the field of organisations' studies (leadership, homo-social reproduction, organisational diversity with majority-minority aspects, double-higher standard in status and power etc.).

In any case, results from this study indicate that women fit the theorized dimensions more than their male counterparts, perhaps, indicating a more holistic approach to the hiring process. For example, when evaluating the *communication skills* domain, women tend to give far higher scores to the item measuring a skill to negotiate with clients and employers, giving the domain a roundedness not entirely dependent on functionality. Similarly, items pertaining to the *ethics and responsibility* domain are evaluated as far more important by women than they are by men, showing that the former group finds ethics important not only in the workplace but in regard to the environment as well. Additionally, although still rated only "somewhat important", women tend to value experimenting skills higher than men, which is perhaps more in line with the idealistic expectations of engineers. Finally, it should be noted that women evaluated a vast majority of skills as more important than men did, which could lead to a conclusion that future visions of the engineering profession, as postulated by the NAE, includes not only a declarative but instead a real transformation of the profession where women would not be a minority both in engineering practice as well as in high ranked business positions. On the other hand, such higher scores women tend to have compared to men could be a result of their "minority" status in such profession and leading roles. As has been shown in experimental settings [40], minorities (both racial and gender) in a typically male group context (like that of business and engineering) have to constantly legitimate their value through negotiation and/or hard(er) work [41]. In sum, employers' gender differences with regard to the perception of engineering skills are yet to be further explored.

LIMITATIONS

Sampling and response rate problems should be noted as the first limitation of this paper. A scarce and outdated database of Croatian employers, combined with the wide range of economic sectors engineers could find themselves employed, made it extremely difficult to define a universe, and practically impossible to make any sampling aside from convenience sampling. Response rate, although the final number of respondents was sufficient for data analysis, was extremely low, due in part to the high number of respondents contacted.

A second limitation of the paper can be found in the explored skills. Although the instrument was constructed and externally validated, which required consulting a large body of previous research, huge variations in specific skills between various engineering disciplines make it extremely hard to explore such skills, which seems to be a constant problem in all consulted literature. As Strauss and Terenzini [25] mention, trying to develop instruments measuring specific skills in the engineering domain would necessitate a rather lengthy instrument, which is "… a clear illustration of the classic 'depth vs. breadth' trade-offs frequently required in instrument development." Given that the response rate was low even with a rather short instrument, there is a strong possibility that even fewer employers would have engaged in the survey if it was longer.

A third limitation is, once again, linked to the set of skills explored. With every single one of them ranking as either somewhat or extremely important, and with their respective standard deviations being altogether very low (ranging from 0,35 to 0,84), a questionnaire implementing such an evaluation method seems of dubious relevance at best. A better method of evaluation could be found in the means of ranking skills by their relevance, refraining employers from thinking of every skill as extremely important. But seeing as the instrument measured 36 items, such a method would prove to be extremely time-consuming, even if conjoint analysis method would've been implemented. It is important to notice that such high means of skill importance are not specific for this study, but are present in most of the referenced literature and, as such, seem to be a common and recurring "mistake" made by either researchers or employers who seem unable or unwilling to accept (below)average employees.

CONCLUSION

The aim of the presented research was to investigate the extent to which the prevailing learning outcomes in engineering study programs in Croatia meet the expectations of employers and to define the key components of skills and competencies employers consider important. Additionally, the presented research examined whether it is possible to determine differences in employers' ratings of skills and competencies by a number of independent variables. Discussed findings contribute to the recent discussions on engineering skills and competencies as conceptualised in NAE report [6], Krawczyk and Murphy's study [4] and Strauss and Terenzini's nine set skills solution [24]. More precisely, the findings suggest that Croatian employers perceive skills related to professionalism as the most important component among a wider set of transferable skills and significantly more important than other specific technical skills. It turned out that the wider set of transferable skills are seen as the reduced form, mostly through the lenses of their functionality in business and working context. However, further research involving more specified and maybe larger-sized sample could further verify these findings.

With regards to mean comparison within subgroups, the findings suggest the significant gender differences among employers, with women seeing almost all the theorized dimensions as more important than men. We interpreted these differences as indicators, which point to the more holistic approach to skills among women and which correspond to the recent demands of engineering skills in the contemporary world. Still, further research is welcomed in order to verify these findings in more detail.

Finally, exploratory factor analysis resulted in 8 dimensions, describing "employability skills", which explains 62 % of the overall variance among the 29 items. The principal component gathered items marking technical and managerial skills, and explaining more than a quarter of the total variance. Although the retained dimensions are mostly in line with the results of related research, some of them seem to be less recognised by Croatian employers than by their counterparts in other countries. Even though, this research explained almost two thirds of the total variance, further research would be needed to additionally explore other possible dimensions of engineers' employability.

REMARKS

[1]Which was the most recent year when making the sample.

[2]While 21 in total, the category "Extraterritorial organizations" was not included in the sample, as the focus of this research was employability within the Croatian borders.

[3]9 dimensions were conceptually and theoretically clear, and mostly previously confirmed by different studies mentioned in the conceptual background section, while the "+1" was added to further explore some attributes that could not be fitted in one single dimension, and labelled as "other".

[4]Because of the positive skewness of the whole questionnaire, a more extreme approach will be undertaken while interpreting data since it would be of no significant contribution to simply list all the researched skills and write that "Employers value all skills".

[5]"Ability to work under pressure (deadlines, downsizings, demanding clients...)" for the former, and "Design of practical solutions" for the latter.
[6]"Conscientiousness and ability to implement rules of the profession" being the exception.

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