Improving the skills and employability of mechanical engineering students via practical exercise

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ABSTRACT: The main aim of this article is to establish whether the industrial training of mechanical engineering students during the last semester of their studies helps them to gain several professional skills, as well as to find or to adapt to a new job after graduation. In order to reach conclusions regarding these critical issues, a survey was conducted via on-line questionnaires emailed to students of the Department of Mechanical Engineering of the Technological Educational Institute of Western Greece. Students were asked to analyse the contribution of the practical training exercise during their studies to their professional abilities. In order to evaluate and filter the information better, a discussion about mechanical engineering sector in the EU and Greece and a statistical view of companies' perspectives about the required graduate employability skills is required beforehand and, hence, outlined in this article.

BACKGROUND

Employability of graduate students in mechanical engineering in Greece, especially, during the current crisis period, is a main issue. According to employers in the construction industry, employability is associated with three requirements: a good degree, various technological and manufacturing skills and a set of personal attributes. However, there is a concern that traditional education does not provide graduates with the standard employability skills required by the industry. The gap between the education in Greek technological institutes and industrial activity is expected to be bridged via a practical exercise during the last semester of the graduate programme. However, the effectiveness of practical exercise has not been widely investigated yet.

The purpose of this article is to provide empirical evidence on the benefits and barriers of practical exercise from students' perspective. Additionally, the present study aims to explore how the practical exercises in local industry, which are combined on occasion with thesis research, may contribute in increasing the skills and employability of mechanical engineering students. The case study under investigation involves students of the Mechanical Engineering Department of the Technological Educational Institute of Western Greece. The study is based on the feedback from the years 2010 to 2014. During this period, students have been exhorted by teachers to be exposed to heavy industrial environments during their practice exercise.

The process of skills development and progress has been investigated and recorded by supervisors after frequent industrial visits and interviews. The mechanism behind each student's personal improvement has been found to be associated with the gain of skills and knowledge on production processes, as well as action planning and problem-solving during manufacturing in real time. Through the analysis of the interview data, it has been found that the practical exercise motivated students to learn more, to apply theoretical and practical knowledge to solve real engineering problems, to develop effective interpersonal skills and to manage personal commitments. The increase of student's employability after working in production-oriented companies is demonstrated by providing statistical data related to postgraduate unemployment periods.

INTRODUCTION

There is an increasing demand from the industrial sector, and a similar desire by academics, to offer more professional practice skills and experiences to graduates of mechanical engineering programmes. This necessity for more practical training is not only understood and admitted by industry and teachers, but by the candidate engineers as well. Nowadays, competitiveness and technological innovation is driving the requirement for bridging the gap between theory and practice within the engineering curriculum [1]. Within this highly completive environment, students should be exposed for an appropriate period of time to important practical experiences, which simulate the reality of the

engineering profession in order to develop wider skills and attributes, including team-working, communication, leadership, critical thinking and problem-solving. These are commonly known as employability skills [2]. Industrial training is a necessary module of engineering curricula to provide well prepared graduates for industries [3]. An experience within industry practice is necessary for students to obtain employability skills. An introvert faculty distant from industrial reality will miss on significant prospects to adapt the curriculum to meet the industrial needs [4].

In modern times, professional skills are considered extremely important by both the graduates and the employees as well. Most companies request engineering graduates who have gained adequate theoretical knowledge and simultaneously have specific professional skills [5][6]. Industry is seeking graduates who have experience with team-working skills and technical sector-specific skills [7]. On the other hand, there are many complaints about unemployment by graduates because of the lack of such skills [8].

According to Moon, skill is the ability to do something that has been learnt [9]. Consequently, a skill requires some knowledge *that* is combined with some knowledge *how* [9][10]. According to Eraut, professional skills especially, require unique combinations of propositional knowledge, situational knowledge and professional judgment [11]. Inevitably, professional skills may be learned via education techniques combined with practical training and experience [9-11]. In general, skills could be categorised into cognitive skills, which are associated with the theoretical knowledge background and way of thinking, and practical skills, which are related with the applied use of methods, materials and tools.

It becomes evident that the undergraduate curriculum of future engineers should be sufficient to meet the expectations of potential employers and, thus, lead to a successful professional career. Future engineers, among others, will need critical thinking, creativity and communication skills [12]. Moreover, in addition to the technical knowledge that should be gained, students also need to be familiar with the manufacturing processes, project methodologies for design and development, and relevant industrial equipment.

Furthermore, they have to be capable of solving problems, working in an effective manner, which increases productivity, cooperating effectively with groups, managing their time efficiently, understanding ethical and societal issues and, generally, presenting a variety of similar skills. Specifically, companies require more engineering graduates with practical experience in industry. Stronger partnerships between industry and higher education can ensure that the engineering skills, which are necessary within global competitive industry, will be gained [13].

The first objective of the present research, after analysing the attributes of the mechanical engineering sector in Europe [14], is to explore the perceptions of Greek employers concerning the skills, knowledge and characteristics, which help undergraduates/new graduates to be employable [7]. The second and main aim of the present study is to provide evidence of skill enhancement and employability based on the perception of graduate mechanical engineers who have successfully completed a practical exercise in heavy industry mainly in the last phase of their studies.

For this purpose, a special survey has been organised in the Mechanical Engineering Department of the Technological Educational Institute of Western Greece during which questionnaires have been developed to gather information on the performances of engineering graduates on several adopted employability skills. The effect of practical exercise on the students' effort to find a job or to adapt to a new job has been also investigated.

EU MECHANICAL ENGINEERING INDUSTRY

The key data in Table 1 show the major characteristics of the mechanical engineering sector in contrast with the total manufacturing sector [14]. In 2010, mechanical engineering in the EU-27 attained a production value of € 502 billion. This output was achieved by 2.9 million people employed. The breakdown caused by the global financial and economic crisis hit the industry in 2008 and production decreased by more than one fifth, on average, for all EU member states.

Table 1: Key figures for EU-27 in mechanical engineering [14].

Indicator	Sector	Annual average growth rate in %					
		2010		1995-00	2000-05	2005-08	2008-10
Production (in current Prices)	Total Manufacturing	€ bn	5,885	5.3	2.1	6.7	-5.2
	Mechanical Engineering	€ bn	502	4.0	2.3	10.4	-8.4
Gross value added	Total Manufacturing	1,000	1,504.0	2.1	0.0	1.5	-5.2
	Mechanical Engineering	1,000	157.5	2.4	0.3	6.0	-9.3
Employees	Total Manufacturing	1000	30,063	-0.6	-1.3	-0.3	-4.8
	Mechanical Engineering	1000	2,9001	-1.6	-2.2	1.8	-4.8
Productivity (value added per capita and annum)	Total Manufacturing	1000€	50.0	2.7	1.3	1.8	-0.4
	Mechanical Engineering	1000€	54.3	4.0	2.6	4.1	-4.7

Figure 1 provides insight into the recent production cycle concerning generally manufacturing production in contrast with mechanical engineering production [14]. The result due to the 2008 crisis is evident. Despite the strong recovery that appeared recently, the level reached is below the previous peak. However, stronger growth is expected.

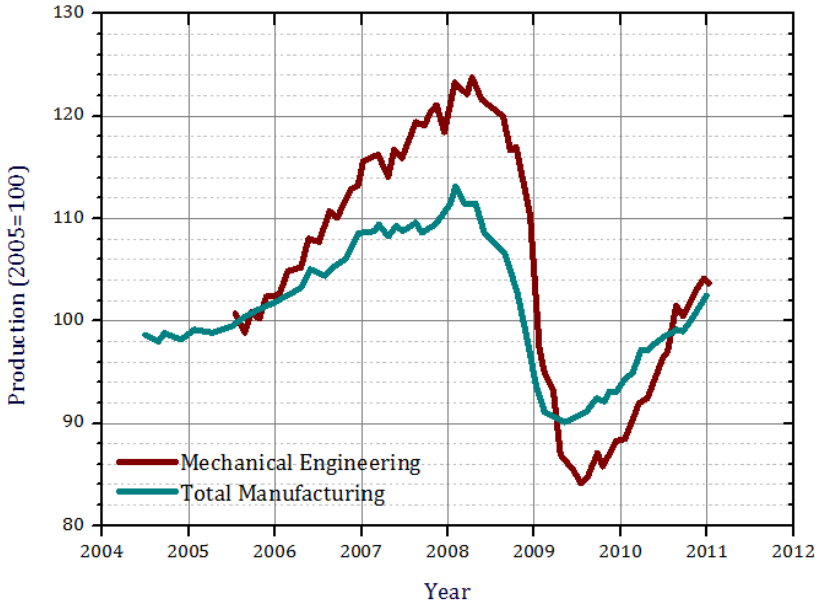

Figure 1: Mechanical engineering's latest business cycle in the EU-27 [14].

A detailed analysis of mechanical engineering by companies according to their size structure is depicted in Table 2 [14]. It is obvious that mechanical engineering companies are larger than other industries. Almost half of them employ more than 250 employees. However, it should be mentioned that in the Greek case, the mechanical engineering companies are medium-sized businesses, which employ between 20 and 49 employees.

Table 2: Distribution of EU mechanical engineering enterprises by size category and average employment [14].

Size category	Total Manufacturing		Mechanical Engineering	
	Employees	Share	Employees	Share
Between 0 and 9 empl.	3273	13,3%	156	6,1%
Between 10 and 19 empl.	2148	8,7%	180	7,1%
Between 20 and 49 empl.	2835	11,5%	287	11,3%
Between 50 and 249 empl.	5980	24,3%	747	29,5%
250 or more empl.	10397	42,2%	1165	46,0%
Total	24633	100%	2535	100%

Figure 2 illustrates the number of engineering graduates in European countries against the employment in mechanical engineering in the same country [14]. Greece is very high in the list with almost nine new engineering graduates per 100 employees in mechanical engineering, while in Germany only two engineering graduates per 100 are finally occupied in mechanical engineering.

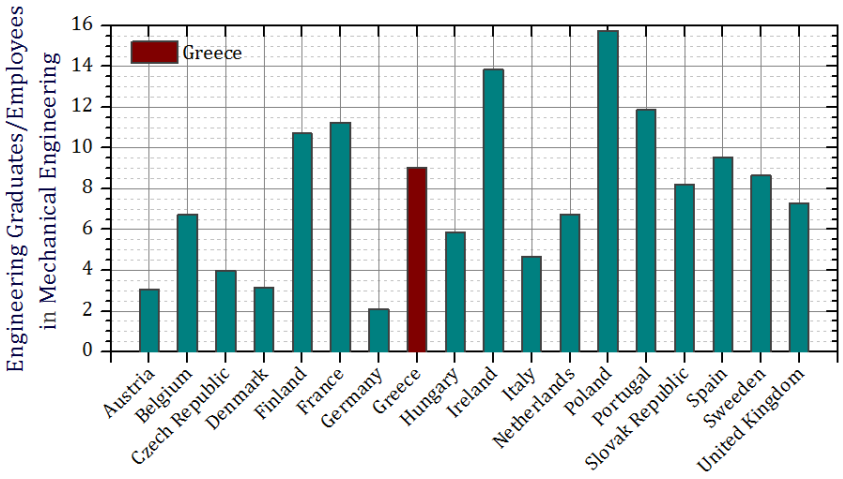

Figure 2: Engineering graduates as a share of employment in mechanical engineering 2000-2007 [14].

Table 3 presents some evidence collected by a survey of eight EU associations related to their perception of the market for specific kinds of employees [14]. Most of the associations shared concerns that there are bottlenecks to fill specific job types in the companies. The associations generally concerned about the availability of engineers and machine operators.

Table 3: Short term demand and supply as perceived by associations [14].

Job type	Labour Sufficiency of supply			
	Sufficient	No need currently	Scarce	Bottleneck
Machine operators			1,2,6,7,8	3,5
Engineers	3,4		2,5,6	1,7
Reseachers/scientists	4		3,6	7
Production control/planning	4	1,2	3,7	5
Other qualified blue collar	3,7		1,8	
Management services, sales	1,2,3,6,7	4		
1: Fachverband Maschinen und Metallwaren Industrie, Austria; 2: European Sectoral Committee Compressors, Pumps, Valves; 3: EUROMOT; 4: Eurovent; 5: VDMA; 6: VDMA-FEM; 7: CECIMO; 8: Federation des Industries Mecanique (FIM)				

Table 4 includes information given by some of the aforementioned associations about which skills would be needed by companies in the future, and by which type of employees [14]. All companies agreed that skilled engineers and technicians will be certainly required.

Table 4: Skills required to a larger extent over the next 3-5 years in different jobs in ME companies [14].

Job type / Skill types needed	Management/ staff	Scientists/ academics	Engineers	Skilled workers
ICT skills	C1	C1,C2	C1,C2	C1
Linguistic skills	C1, C2,C3	C1,C2,C3	C1, C3,E	C1,C3,A
Cultural issues	C1,C2		C1	
Management skills			C1,A,E	
Marketing/sales skills	C1,C2	C1	C1	C1
Communicative skills	C1,C2,E	C1	C1	C1
Technical skills	C1	C1,C2	C1,C2	C1,C2
Legend: C1: Kalfrisa, company producing heat recovery equipment etc.; C2, VanDerLande Industries, company producing baggage handling equipment; C3: Imedexsa, company producing metallic structures (towers); A: VDMA; E: EUROMOT.				

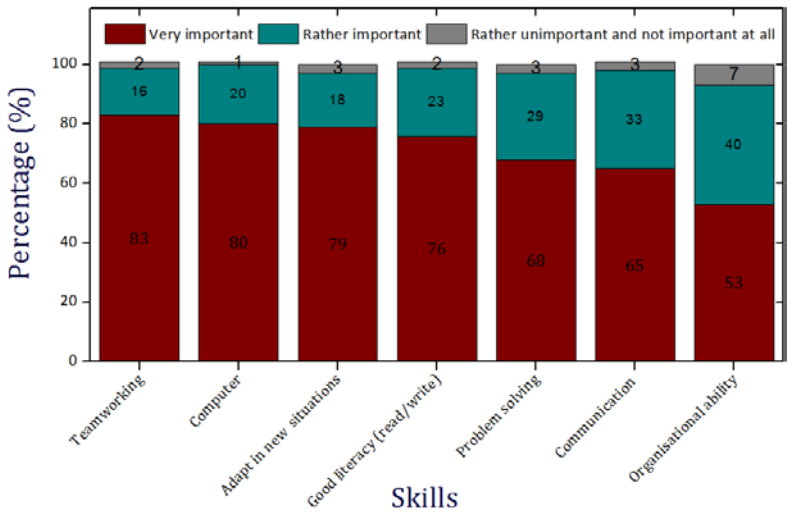

Figure 3: Importance of various skills when recruiting higher education graduates in Greece [7].

In Figure 3, interesting and more focused data is presented which concerns the skills that Greek companies require in order to employ higher education graduates. The companies included in this study are recruited from a variety of educational fields. However, the area most frequently mentioned is related with engineering studies (55% of companies) [7]. The skills that are analysed here are the teamworking ability, computer experience, adaptability, reading and writing, efficiency in problem-solving, communication and organisational aptitude. In Greek reality, and in terms of rating certain skills and capabilities as being *very important*, companies were most likely to highlight the importance of team working (83%), followed by computer literacy (80%), first-class ability in reading/writing (76%), technical skills dependent on the sector under investigation (70%), analytical and problem-solving skills (68%), communication (65%) and finally organisational capability during working (53%).

GRADUATES' PERCEPTION OF THE CONTRIBUTION OF PRACTICAL EXERCISES

Data were collected by distributing questionnaires to recently graduated students of the Department of Mechanical Engineering at the Technological Educational Institute of Western Greece. The surveyed students almost equivalently followed one of the two available course programmes; namely, construction engineering and energy engineering. Their practical exercise took place during the last semester of their studies in workplaces of various profiles, most of them associated with heavy industry and very few with smaller technical companies. The survey explored students' perceptions of the benefits and barriers of the practical exercise. Participation in the survey was voluntary. The questionnaires were filled via a developed on-line application. The data presented below correspond to a sample size over 150 students. Figure 4 depict the skills and abilities that students claim to have gained during their practical exercise.

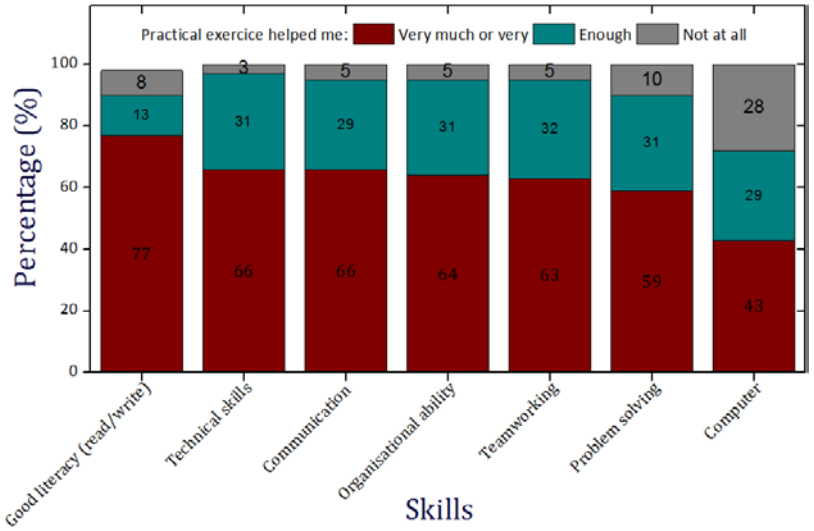

Figure 4: Skills gained due to the practical exercise according to the opinion of mechanical engineering graduates of the Technological Educational Institute of Western Greece.

Seventy per cent of the graduates claimed that during their practical exercise they gained skills concerning reading and writing, technical issues and communication. Almost 60% of them stated that their organisational ability and team working spirit was improved because of their practical training. However, less than 50% of respondents said that they become more efficient in using computer technology. Overall, most of the employers' expectations, explored in the previous paragraph, seem to be fulfilled via the contribution of the practical exercise.

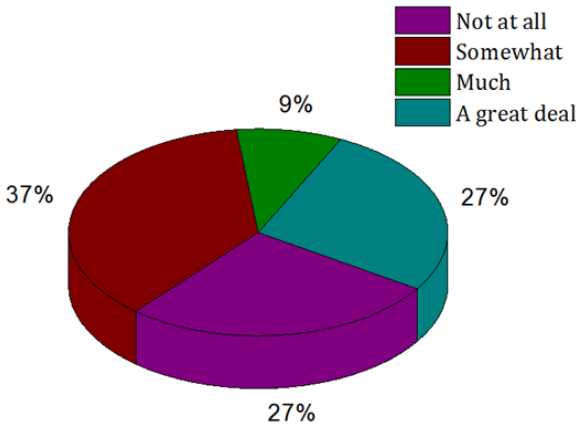

Figure 5: Contribution of the practical exercise to finding a job, according to the opinion of mechanical engineering graduates of the Technological Educational Institute of Western Greece.

Figure 5 illustrates the mechanical engineering graduates' perspective about the contribution of the practical exercise to finding a job. Around 40% believe that the practical exercise was a crucial factor in their effort to become employed. Finally, Figure 6 presents the mechanical engineering graduates' perspective about the contribution of the practical exercise experience within their working environment after graduation. More than 50% of them believe that the practical exercise helped them significantly to adapt to and act in new situations, such as a new workplace environment.

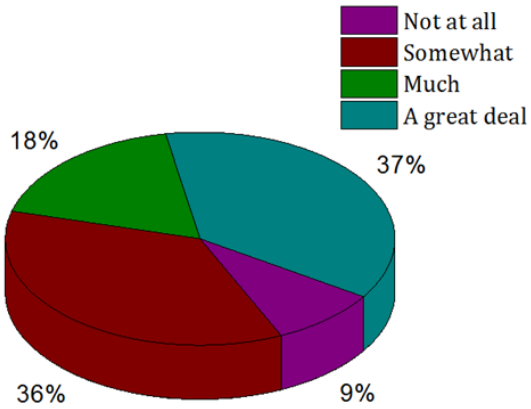

Figure 6: Contribution of the practical exercise to coping with the job already found, according to the opinion of mechanical engineering graduate of the Technological Educational Institute of Western Greece.

At this point, it should be mentioned that after several interviews of students by supervisors during the practical exercise period, some important suggestions were recorded concerning the actions that should be taken to improve the benefits of practical exercise and consequently employability. Many students suggested that the Faculty should include sector specific work placements as an integral part of the study programme, should make the courses more relevant to the needs of employers and that should facilitate relations between graduates and companies.

CONCLUSIONS

No nation can grow, economically or socially, without significant and sustained investments in the knowledge and skills of its people [15]. Greece being in deep crisis for the last few years requires a new generation of engineers appropriately skilled to enforce and support the expected growth. Mechanical engineering field is one of the basic and crucial sectors and should be equipped with the proper manpower.

Inevitably, future mechanical engineers and their engineering expertise will play a significant role in growth in Greece. Therefore, the association between mechanical graduate studies and industrial training will be the key to providing the higher level skills that are required for economic recovery and long term prosperity. In the present work, this necessity for better skilled graduates in the EU and the Greek reality has been investigated and illustrated thoroughly using large scale surveys from the available literature.

A smaller survey conducted in the Department of Mechanical Engineering in the Technological Educational Institute in Western Greece with the help of on-line questionnaires and personal interviews has clearly proved the benefits concerning skills and employability, which may be gained via practical exercise appropriately situated within mechanical engineering course studies.

ACKNOWLEDGEMENTS

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