Safety knowledge for professional engineers and students: A global scheme of education

Giagloglou, E.
PhD student
University of Kragujevac
Kragujevac, Serbia

Djapan, I.
PhD student
University of Kragujevac
Kragujevac, Serbia

Mijovic, P.
PhD student
University of Kragujevac
Kragujevac, Serbia

Tsiafis, C.
PhD student
University of Kragujevac
Kragujevac, Serbia

Macuzic, I.
Ass. Prof.
University of Kragujevac
Kragujevac, Serbia

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INTRODUCTION

Serbia is aligning to the EU requirements in order to become a member state of the Union. One of the most emergent and representative sectors in which these changes apply, is the one of Occupational Health and Safety (OHS). Moreover, during the recent years many big international industrial companies have been established on the Serbian territory, introducing new technology and new occupational standards. All these technological and regulative novelties impose an actual need of improved and up to date occupational safety knowledge and practice.

Albeit the different educational backgrounds of professionals into OHS, still, the engineer remains one of the most important. An engineer's professional importance in OHS sector can be proved by various recommendations and suggestions, either in legal documents, such as the "Code of Quality for European Chartered Engineers" [1] issued by European Council of Engineers Chambers (ECEC), adopted by the 7th GAM in Ljubljana (20th Nov. 2010), or, alternatively by agencies and alliances, such as Accreditation Board for Engineering and Technology (ABET, criterion 3c 2012-2013) [2] and International Engineering Alliance (IEA, 2009) [3]. Therefore, Engineering Schools of highest education institutes, include in their basic curriculum OHS related courses. Arezes and Swuste [4] have shown that the majority of the academic courses related to OHS in Europe was organised by engineering Schools and Bryan [5] already since 1999 had stated the need of OHS courses into every engineering classroom, during and after the formal education experience.

The School of engineering at the University of Kragujevac, one of the most industrialized areas of the Republic of Serbia, was among the pioneers in adopting OHS aspects, within courses of undergraduate education. Because of the demanding regulative novelties, this role has been expanded to both undergraduate and postgraduate specific curricula, as well as into new educational tasks revolting to all interested OHS stakeholders.

1 GENERAL

1.1 Safety education: Overview of the current needs

From the industrial point of view, a young academic safety engineer should be well trained in latest safety methodologies practiced on real industrial projects, while a technical safety mind-set of a safety engineer is formed on the basis of combined profound safety education and intensive training (Jürgen, 2013) [6].

From a practical point of view and in terms of OHS sector, the School of engineering should solve problems like:

• Complete lack of knowledge during the undergraduate levels; the majority of students have never had a course of OHS during their previous academic career.

• Knowledge gaps in issues emerging by contemporary demands; this can be a usual problem of people working in the OHS sector, who albeit their acquired experience, must continuously become informed about the new regulations and adjust their skills according to the new, updated demands.

• Training focused on real industrial problems. Real problems usually differ from the engineering laboratory applications, and hence, students who aim at a specific curriculum in OHS should remain in close collaboration with industry.

In order to provide appropriate safety knowledge and to succeed in the three aforementioned aspects, the school of engineering should not limit its educational tasks strictly within the academic framework, but expand them towards broader applications and activities.

To this effect, the faculty of engineering at Kragujevac, has chosen to install three lines of safety education:

• Undergraduate and postgraduate courses during the former academic curriculum, as well as doctoral research studies specifically focused on industrial safety.

• Education specifically addressed to OHS professionals, provided within the framework of Lifelong learning.

• Collaboration with industry regarding real problems application. In this way, students are offered the opportunity to apply their knowledge to real cases.

2 MATERIALS AND METHODS

2.1 Undergraduate and postgraduate education

Safety related courses offered by the engineering School at the University of Kragujevac on undergraduate and postgraduate levels, are presented in *Table 1*.

Among three engineering curricula only one, the one of Urban Engineering offers a non-compulsory course on Safety, whilst only one master course at the faculty of mechanical engineering offers one course related to Safety.

It is obvious that the limited courses in this field cannot cover the OHS necessary knowledge which is required for future professionals.

Until recently, the encompassment of appropriate OHS chapters in different engineering courses, was presented as the only solution. However, the Lifelong learning framework gave the opportunity to potentially bridge the gap of OHS knowledge between academia and professionals involved in OHS sector.

Table 1: Safety related courses in Pre and post graduate education

Department	Under-graduation	Post-graduation
Mechanical engineering	None	Safety engineering and risk management
Urban engineering	Safety	None
Automotive engineering	None	None

2.2 Lifelong learning

Lifelong learning (LLL) programmes should generally be more flexible than traditional academic courses so as to cover the emerging needs of the labour market. In addition, these courses cannot be compulsory, as one main focus of these programmes are learners with a certain professional background, also probably involved in relevant activities. Many authors have documented possible difficulties in order to implement appropriately LLL. For Thijssen and Vernooij [7], demand learning, in the frame of LLL, is when the learners are able to regulate their own learning processes and ensure integrated knowledge in their working tasks. The innovation process is complex, and breaking through boundaries requires that the individual shall oversee the change [7].

In the particular case of OHS, Daniel Lo (2012) [8] states that training should be revolted to both, workers and managers. This is not, however, representative of the actual situation. When it comes to the need for OHS training, organizations seem to send the conflicting message that employees on the ground are the only ones who need it.

In order to cover the personal needs of knowledge and improve learners' professional skills, OHS courses -under the LLL framework- are offered in a scheme of 5 thematic areas divided into basic and advanced level as presented in *Table 2*.

The broad field of OHS knowledge becomes more demanding in terms of educational courses, due to the diverse educational backgrounds of adults. The University of Kragujevac, considered these possible diversities among adult learners, and proceeded into forming and initiating an adequate number of courses. Personal needs and skills were taken into consideration. Nonetheless, in order to facilitate the process of adult education, educators should additionally take into account specific principles (*Table* 3). Such an approach has been supported by Knowles, who defined the different aspects needed in the process of facilitation as *principles or pillars of andragogy* respectively [9] [10].

Table 2: Lifelong learning OHS courses

Thematic Areas	**OHS Management Systems**	**Risk Assessment**	**OHS in High Risk Sectors**	**OHS in High Risk Sectors, human-centred**	**OHS through Advanced Technologies**
			BASIC LEVEL		
Title		Basic of risk assessment	Machines and tools safety	Noise and vibration on workplaces	
Title		Risk assessment for variable working environment	Electrical safety	Protective equipment & Lock Out – Tag Out protection systems	
Title			Transportation and forklifts safety	Health Aspect of work in SMEs	
Title			Microclimatic conditions and lighting on workplaces	Stress at workplace	
			OHS in	Ergonomics and	

			construction	musculoskeletal disorder	
Title			Chemical hazards		
			ADVANCED LEVEL		
Title	OHS management system OHSAS 18001 requirements	Advanced techniques for risk assessment		Global and specific safety and health risks in construction	Information systems in OHS
Title	Integration of the OHS system with other management systems	Risk and safety management systems		Mobile working equipment safety	OHS through automation and modernization of production equipment
	CE marking				Modern protection and safeguarding devices and systems
Title					Advanced technical diagnostic methods in hazard identification

Table 3: Principles of adult learning

Adults have accumulated a foundation of life **experiences** and knowledge.
Adults are autonomous and **self-directed**.
Adults are **goal-orientated**, relevancy-orientated and **practical**.
Relevancy-orientated

2.3 Industrial training

During the 1960s and 70s, many psychologists, sociologists and educators believed in the experience acquired through learning, a process which does not impose any reduction or substitution of the theoretical lectures. Rather, it functions as an additional aspect [11].

In the particular case of the Engineering School of the University of Kragujevac, students can acquire such practical experience in two different ways. First, during their education, they can be involved into case specific real industrial issues. Second, upon completion of their courses, they are offered the possibility of enrolment in industrial internship programmes. Internship or practice during the formal studies are established respectively, on the basis of mutual exchange of knowledge, necessary for affronting real engineering and occupational problems. In this way, students are encouraged to put in practice research ideas, that can be immediately implemented in the field of industry. Both aspects of practice provide to the engineers the possibility of applying their knowledge into real cases of industrial safety problems. The practical approach, apart from the development of critical thought, promotes connections with other professionals in the field. Moreover, students as interns become prepared for employment, gain direct workplace experience, can directly observe interactions of engineers with

other professional groups and the functioning and organisation of business and companies. During their internships they are also encouraged to develop additional technical, interpersonal and communication skills. More particularly, they can have access to specific management areas, specific managements systems, OHS methods as well as training focused on appropriate software. Furthermore, the students who are in contact with big international companies established on the Serbian territory, have the possibility to acquire international working experience, based on foreign language communication, mainly English but also Italian, Greek and German, depending on the company. Along with the communication skills, the multinational working environment gives the opportunity to the students to broaden their professional perspective and to become easily adapted to the new demands. In the particular case of Serbian reality, the connection with international companies and the possibility of communicating in foreign languages is something more than an opportunity of an internship or practice; it is a way of modernization of the country.

There is no better teacher than experience that can allow students to enhance their formal learning curve and, in most cases, that curve turns up when industrial training is implemented [12].

3 RESULTS

3.1 LLL programme

At the end of each course we asked the participants to compile anonymously an evaluation sheet. We aimed at investigating how learners evaluate the efficiency of the courses, something that would permit a subsequent improvement of these syllabuses during the second year. The questions addressed tapped the competency of the instructors, the relevancy of the subject according to their area of interest, the evaluation of the OHS lessons through LLL, as well as the quality of the prepared material. Learners had the opportunity to evaluate all the courses, by responding to the specific questions on the basis of rating, with 1 as index of minimum satisfaction up to 5 as index of maximum. The statistical analysis of the evaluation sheets of the first year, revealed the average, minimum and the maximum score of all the modules. *Figure 1* presents the scores of the first year and *Figure 2* presents the scores of the second year.

The evaluation of the LLL programme by the learners demonstrated an overall positive acceptance for the provided courses. It was apparent, however, that further improvement would be expected. For purposes of amelioration, during the second year, new methods have been introduced: the participants who had successfully completed the courses, gave lectures about their experiences as learners and on how the knowledge gained assisted them to improve the OHS in their working place.

Professionals from international companies were also invited, as well as professors from foreign academic institutes. Weekly seminars were realized and thus, second year learners had the opportunity to enrich their learning experiences. Finally, we redistributed the questionnaires after the aforementioned course adjustments, and the average rate was increased by 0.38.

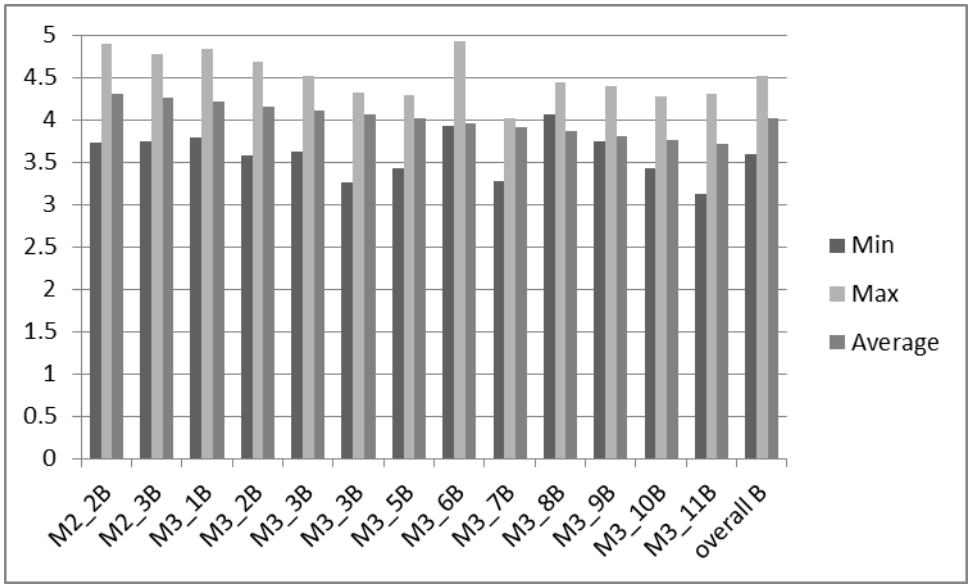

Fig. 1. Evaluation of the 1st year courses.

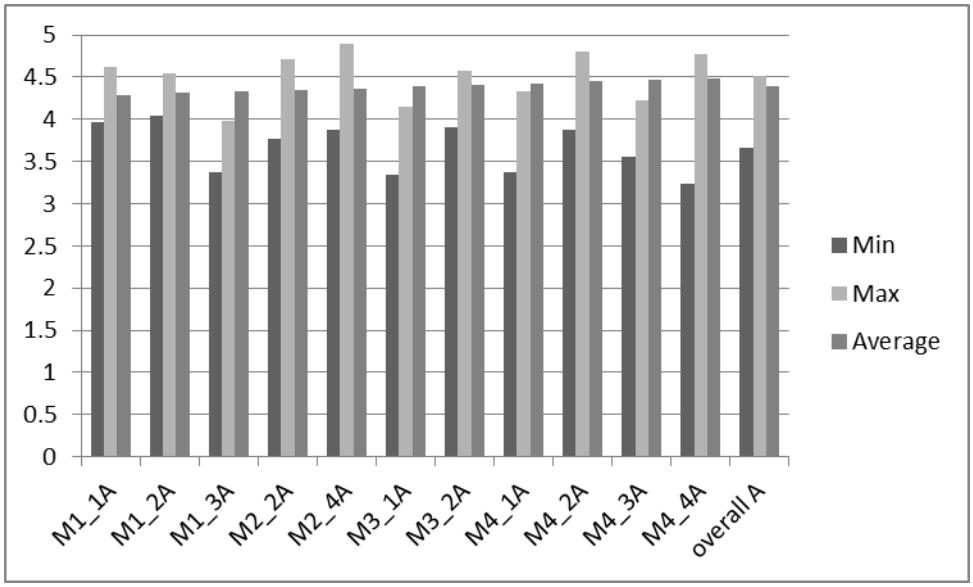

Fig. 2. Evaluation of the 2nd year courses.

3.2 The results of training

We aimed at measuring the efficiency of the industrial training program and for this purpose we used as index the percentage of students who were hired the following year after the completion of their programme. The results are presented in Table 4.

Table 4: Principles of adult learning

	Company A	Company B	Company C	Company D
Number of interns	10	5	5	9
Months of interns each	6	12	12	5
Number of contracts after the programme	8	4	3	8
Percentage of contracts	80%	90%	60%	89%

4 DISCUSSION

There is a European concern about process safety competence decrease, as shown by a relevant discussion in the European Congress on Chemical Engineering in Berlin (ECCE-8, 2011) [14], where several speakers presented similar concerns from other European Countries [13].

Although many of the classical teaching techniques can be applied also to adults, adult learning literature indicates that adult teaching should be approached in different ways [9] [10] [12] [14], implying also different teaching methodologies and approaches. The OHS knowledge is a rather broad field, continuously updated, since always new standards and demands are presented. A possible lack of knowledge, difficulties of OHS teaching, combined with the particularities of adult learners, make the OHS knowledge a specific case of education which cannot be merely covered by the classical academic lectures. The academia and foremost the engineering schools have the main role to

educate the future safety engineers. The academic staff should be flexible enough to adapt to the new demands. While most of the courses offered under LLL framework may cover vocational needs, in terms of OHS, the need to learn and to become adapted is quite demanding and crucial, not only for facilitating the working tasks, but also for ensuring safety which is an intrinsic human need.
The university of Kragujevac has installed three lines of education in order to facilitate the stakeholders and engineers with the new requirements. The academic courses, LLL and industrial training possibilities have been thoroughly investigated and furthermore have been orientated versus a more demanding knowledge of OHS. The whole educational approach can be summarized as in *Figure 1*.

5 CONCLUSION

The Ministry of Labour and Social Affairs - Labour Inspectorate, in cooperation with the Health and Safety at Work and the Department of International Cooperation European Integration and Projects, prepared the project: *Improvement of the safety and health at work in the Republic of Serbia*. This work focuses on the implementation of EU standards, in the field of OHS in the Republic of Serbia. The donor of the project is the Ministry of Foreign Affairs of the Kingdom of Norway (European Social Chapter). Within the framework of this project, and mainly under the Article 3 is stated: *The right to safe and healthy working conditions*. Furthermore, regulative changes shall take place and all stakeholders according to the new regulations should be informed and up to date to with the new requirements. This project shows the importance of the OHS up to date and the alignment of the Serbian regulations with the EU.
Other similar studies have shown the importance and the difficulty to evolve OHS even in countries where this sector was quite developed e.g. in Japan [16] and Australia [17].
While OHS becomes more and more demanding in terms of new needs, technology and knowledge, and all people are directly or indirectly involved into OHS, there is still lack of specialised OHS knowledge or lack of newest OHS regulative demands. We presented a 3 lines educational approach in order to cover lack of knowledge and update the OHS professionals. We believe that more safety related courses should be installed in every engineering Department and if possible to introduce OHS courses even to other educational institutions.
More precisely, concerning the engineering Schools, we hold that if they want to form competitive engineers in terms of OHS demands they should expand the educational activities beyond the academic curriculum.

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