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An analysis of engineering students' knowledge on the topic of occupational health and safety

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Abstract. Occupational health problems often result of poor knowledge of safety requirements and inadequate personnel training, especially considering specific tasks at work. A questionnaire was distributed to university students to respond, in order to analyse their answers and achieve following objectives: (1) to pinpoint the students' knowledge prior to the start of the course; (2) to reveal how many students have had experience with occupational health and safety (OHS) topics before starting the course; (3) to determine whether the knowledge of students with prior experience is greater; (4) to identify the most difficult topics or domains. The obtained results showed that the average test score was 50.2% (n = 151). Students with prior knowledge on OHS (n = 53) did not get higher test scores (p-*value* = 0.12; $\alpha = 0.05$). The objectives of the study were achieved. Further studies considering the efficiency of both teaching and learning are to be conducted.

Key words: OHS, occupational health and safety course, knowledge.

INTRODUCTION

Most occupational health problems are conditioned by poor knowledge of safety requirements and inadequate (personnel) training. To improve the situation several educational institutions (such as universities and vocational education centrums) in Estonia provide courses covering different aspects of occupational health and safety (OHS) in their curricula. Those courses, (targeted mostly to students of the educational institutions itself) are more than necessary, as it is common knowledge that young and new workers experience very high rates of occupational injuries. For example in Europe workers aged 18 to 24 have 50% higher probability to have an occupational accident (Occupational health and safety strategy 2010–2013). This age group of workers is the same wherein our study group is. Usually it is believed that the employees' age is in correlation with occupational injury studies (Breslin & Smith, 2006) have shown that short job tenure is correlated with occupational injury, rather than young age. On the other hand, young people have less work experience, as they are just starting their careers.

To thoroughly understand our motivation to conduct such study in Estonia, a brief overview of the situation in states' approach towards OHS topics is needed. Also an overview of the interest group is given.

Combining the results from the Statistics Estonia's database on Social Life and The Statistical Yearbook of Estonia (2014) data can be obtained considering the number of workers injured in registered occupational accidents during the period of 2005–2013. The Table 1 refers to the aforementioned data. Do note, as it is mentioned in the Statistical Yearbook of Estonia (2014), the data considering the registered accidents at work is underestimated, as not all of the occurring accidents are reported to the Labour Inspectorate. The Statistics Estonia has estimated the number to be almost 2.5 times higher than reported, based on the Labour Force survey.

Table 1. Workers injured in registered accidents at work during 2005–2013

Total of employed people (in thousands)	2005	2006	2007	2008	2009	2010	2011	2012	2013
	615.6	651.7	657.6	656.0	593.9	568.0	603.2	614.8	621.3
	Accidents per 10,000 workers (including fatal accidents)								
Below 24 years of age	10.5	11.1	10.5	11.5	8.6	10.1	11.3	12.5	12.5
Aged 25–34	12.7	12.7	12.7	14.5	11.7	13.2	15.4	16.5	16.8
Aged 35–44	12.1	11.5	11.3	12.1	9.2	11.4	12.8	13.2	11.9
Aged 45–54	12.3	12.6	12.9	13.6	10.9	12.0	11.6	13.5	13.2
Aged 55–64	6.7	7.0	8.1	8.9	7.8	8.7	9.4	10.1	10.9
Above 64 years of age	1.3	1.2	1.2	1.6	1.2	1.2	1.5	1.6	2.0
Total of accidents per 10,000 workers	55.7	56.1	56.6	62.1	49.5	56.6	62.0	67.5	67.3
Total of the accidents reported to the Labor Inspectorate	3,431	3,653	3,723	4,075	2,939	3,215	3,741	4,148	4,180

Schulte et al. (2005) discuss the option that even if young workers have the knowledge on OHS topics, they might not be able to put it into practice, due to their lack of experience, and perhaps even due to the lack of self-confidence to raise safety and health issues with more experienced co-workers or within the workplace.

The necessity for personnel training in enterprises and companies remains, as the Table 1 and Fig. 1 indicate. The OHS related in-service trainings (i.e. the trainings that are enabled to employees during the course of their employment) are seldom if ever offered to employees to attend outside the company's own structure. Järvis et al. (forthcoming 2015) have investigated the employee's possibility to continuously improve their knowledge. The results indicated that 30% of the workers state to have the possibilities, 35% consider to have no possibilities. Approx. 1/10 of the workers were very satisfied with opportunities for both development and gaining knowledge. At the same time 50% of the respondents considered their possibilities 'limited'. The survey consisted of 1,757 participants.

The Ministry of Social Affairs has emitted the 'Occupational health and safety strategy 2010–2013' wherein is shown the synopsis based on The Labour Inspectorate's study results on occupational accidents and risk assessments. It is claimed, that the knowledge of the OHS risks and risk-management is poor, in terms of Estonian employers and employees both. The situation could be aggravated because the primary

training and tutelage in a work-environment or on a position is often implemented by the employer. Järvis et al. (forthcoming 2015) have indicated that 89% of employees claimed to receive OHS related information from their employers or supervisors, 82% of employers claimed the same. Disjointedness and lack of systematic promotion of OHS topics is widespread in Estonia although promotional materials intended for employers are composed and distributed by the state. Too often the high-quality work-environment is not appreciated. As one of the potential causes of the aforementioned problems, it has been referred to the fact, that the OHS topics are not attended to as early as during the studies of basic or general education (Occupational health and safety strategy 2010–2013).

In reality the condition has somewhat improved since 2010, when the strategy for 2010–2013 was ratified. There has been some OHS promotion, such as lectures and courses from Estonian Labour Inspectorate to both employers and working environment specialists. New web-sites have been created and developed for promoting occupational safety, providing additional information on the topic and improving the overall quality of risk assessments.

When communing with employers, their attitude shows unwillingness to understand that some of specific knowledge on OHS can only be learned during the work. Employers expect the trainees or new workers to have good or sufficient knowledge on OHS topics, even on positions which require basic or general education. On a tangential note – studies on the subject have not been conducted yet in Estonia and aforementioned statement is rather an observation than a verified fact. Järvis et al. (forthcoming 2015) have found that the employee's knowledge of OHS topics can seldom be considered good as only 6% of employers and as little as 4% of employees receive their OHS information from specialists. At other times the info is gained from potentially ineligible employer.

As the employers often believe the workers to have more knowledge on OHS topics than employees actually do, the resources to train the worker might be inadequate.

When enabling the training to the employee, the employers will most certainly consider the sufficiency of the training course. But also workers' a priori knowledge must be considered. How to do this?

To be able to consider the topics of in-service trainings and lifelong learning at all, first the qualities of the employee must be considered. As the group of interest of the current study is aged 18–24, the extent of knowledge of the young people taking up their duties is enquired.

In our study this will done by comparing the research results of two groups of students that have not yet participated in any university OHS courses during their studies. One of those groups have no a priori knowledge on the topic, the other group has come into contact with OHS topics during their work in enterprises.

The aim of this study is not to extend the results to generalised population. Rather, the study is conducted to obtain data about the knowledge of a part of population by answering the following questions: (1) to pinpoint the students' knowledge prior to the start of the course; (2) to reveal how many students have had experience with OHS topics before starting the course; (3) to determine whether the knowledge of students with prior experience is greater; (4) to identify the most difficult topics or domains.

The objective is to use the information about student's a priori knowledge to estimate the usefulness of OHS courses in the future.

MATERIALS AND METHODS

To conduct the study a questionnaire was created (from now on referred as the test). The test was then given to Bachelor study students of Tallinn University of Technology to be answered. The test was anonymous; the sample consisted of the volunteers from all the students who had to take the Occupational health course during 2014 spring term. The testing was carried out in the beginning of their first lesson of the course.

The selection consisted of 151 students (114 male, 37 female, aged 19 to 24 from 8 different engineering and technology specialties (Electrical Engineering, Earth Sciences, Geotechnology, Electrical Power Engineering, Thermal Power Engineering, Product Development and Production Engineering, Mechatronics, Chemical and Environmental Technology), of whom 53 had had prior experience in OHS topics due to their employment or practice in an enterprise. Specific information considering the extent of their prior experience was not collected (whether they had attended to any training courses or if they had held e.g. the position of a working environment representative). With the help of the questionnaire we aimed to pinpoint the students' knowledge of the topic in beginning of the course, rather than to compare the results of students with or without a priori knowledge.

The 17 multiple choice questions (MCQ) in the questionnaire (shown in Table 2) were developed specifically for this study and chosen to show student's knowledge on different OHS topics that are also addressed during the course. It should also be noted, that during the course several topics are discussed in great detail. This is due to the fact that during the course the students have to acquire knowledge that will be helpful to them whether they are future employers or employees in different specialities and work environments.

Table 2. The questions used in the 'Educational Diagnostic Test on OHS Topics' questionnaire (some of the questions consisted of several sub-questions)

No	Question	Correct answer	The average score of the question (%)
1.	Choose the correct meaning to each of the CLP Pictograms or safety and health signs*	*1a.* Strong oxidizer *1b.* Is carcinogenic *1c.* Wear eye protection *1d.* Laser radiation	45.5
2.	Which of those hazards can cause Raynaud Syndrome?	Excessive vibration	11.3
3.	Which of those blood pressure values can be considered normal or healthy?	110/75	76.2

Table 2 (continued)

4.	Choose the correct statement to characterize following OHS related occupations and positions*: *4a* working environment representative *4b.* working environment specialist *4c.* ergonomist *4d.* working environment council	*4a.* is a representative elected by employees in occupational health and safety issues *4b.* is an engineer competent in the working environment field (who has received training concerning the topic and whom the employer has authorised to perform occupational health and safety duties). *4c.* evaluates the potential effect of physical and physiological risk factors on workers' health in work environment. *4d.* is a body for co-operation between an employer and the employees' representatives which resolves occupational health and safety issues within the enterprise.	55.6
5.	Which of those relative humidity values can be considered as the optimum for a good work environment?	40–60%	24.5
6.	Which of those can be defined as a chemical hazard? *	*6a.* CO_2 *6b.* Asbestos	78.8
7.	Which of those can be defined as a biological hazard? *	*78a.* Blood *7b.* Staphylococcus	47.7
8.	Which of those can be defined as a physical hazard?*	*8a.* Noise *8b.* Insufficient lighting	54.0
9.	Which of those can be defined as a psychological hazard?*	*9a.* Bulling *9b.* Boring and monotonous work	71.2
10.	What is the maximum value for domestic noise in Estonia, given in dB (A)?	80	23.2
11.	With which physical hazard the term 'glare' agrees with and what does it mean?	Lighting – the term indicates lighting conditions where the light is too strong, even blinding	40.4
12.	Which of those sentences shows the right correlation between 'hazard' and 'risk'?	Risk shows the probability of negative effects caused by a hazard	54.3
13.	Which of those values is considered to be sufficient maintained illuminance for office work?	500 lx	19.9
14.	Lyme's disease is a zoonosis that is carried by which creatures?	Ticks	12.6

Table 2 (continued)

15.	How much can the CO2 levels inside a renovated building exceed the outside levels?	500 ppm	7.3
16.	The question consists of a picture, which shows a worker and his working area. Students need to mark all the named problems in the MCQ that should be attended to improve the conditions. *	*16a.* Display screen is at the right height *16b.* Hand should be bent ~90° from the elbow *16c.* Worker does not need a foot support *16d.* Workers wrists should not rest on the table *16e.* The space between the chair and the back of the worker's knee must be approx. the size of the workers fist.	47.0
17.	The question consists of a picture, which shows a working area. Students need to mark all the named problems in the MCQ that should be attended to improve the conditions. *	*17a.* Workplace may be uncomfortable due to glare due to direct sunlight *17b.* The mould needs to be removed and repelled, to eliminate the risk on workers' health *17c.* Illuminance uniformity the working area is not sufficient *17d.* Air humidity during autumn is too high *17e.* The temperature is fitting throughout the year	59.9

This question consists of several sets of multiple choices, in all of which correct answers occur. The number of sets is indicated in the answers column.

In order to assure the reliability of the questionnaire no open questions were used. Each correct answer gave one point. Scoring was measured by adding up the points and calculated into a scale of 100 percent. The questions were created in accord with several standards (both Estonian and European), Estonian legislation and best practices of OHS.

Do note: (1) the questionnaire was created in Estonian and thereby some of the questions might seem unreasonable, as the terminology in English might describe the essence of some of the phenomenon better than the relevant term in Estonian; (2) each set of answers (from questions 1 to 15, included) also had an option 'I am not aware'; (3) The questions 16 and 17 had different structure than all the other 15 questions (although they were also MCQs), as 16th and 17th question were designed to evaluate the students common sense rather than knowledge of facts.

During the analysis of results, statistical calculations (t-test) were carried out using Microsoft Excel (2013). The significance level was set to 0.05.

RESULTS AND DISCUSSION

The lowest score of the test was 25.7% (20 year old male Electrical power engineering student) and the highest of the test was 80.0% (19 year old male Thermal power engineering student who, according to his own words, did not have prior OHS knowledge). The average test score of all the participants was 48.9% (n = 151).

As it has been referred to earlier, the test had 2 different types of questions.

Therefore Table 3 indicates the scores of the test from different aspects. While comparing the average scores, it is obvious that the 'fact questions' were more difficult to the students than the 'common sense questions'.

Students were asked if they had knowledge on OHS topics prior to the course. 53 students had prior experience in OHS from 1 to 60 months. Students with prior knowledge on OHS did not get higher test scores (*p-value* = 0.13; α = 0.05). Statistically significant difference was not observed while comparing different question (Q 1...15 vs Q 16...17) and experience groups.

Table 3. Results of the test

	Minimum result (in %)	Average result (in %)	Maximum result (in %)	Average standard deviation
Whole test (Questions 1–17)	25.7	48.9	80.0	35.8
1st part of the test (Questions 1–15)	16.0	47.1	80.0	37.3
2nd part of the test (Questions 16–17)	0.0	53.4	100.0	24.5

The average score for students without experience was 46.9% (n = 98). In comparison, the scores of students with at least 6 months of experience in OHS field had results that varied from 28.6% to 65.7%. The average score for the 53 students who claimed to have any prior knowledge was 51.9%.

The average scores of the test (and each question) are shown in Fig. 1.

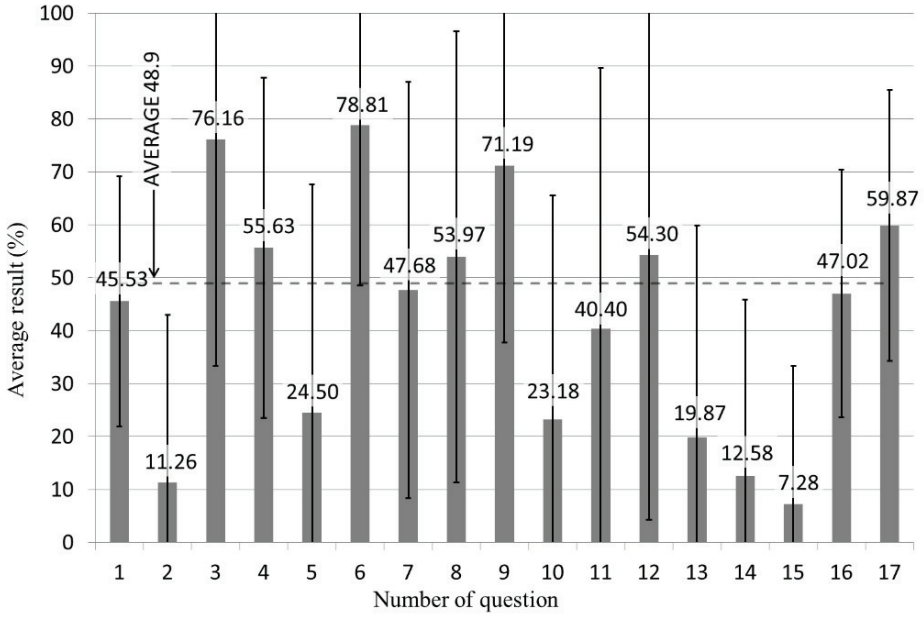

Figure 1. Individual question's average score and error bars (on horizontal axis) and the overall average score (dashed line).

Do note – the questionnaire had its limitations due to the fact that all of the topics of the course were known not to be covered in equal thoroughness; therefore it was undesirable to create a questionnaire that would be too time-consuming for the students to answer.

As Fig. 1 indicates, the students found questions (Q) 2, 5, 10, 13, 14, and 15 difficult. The easiest was the question about chemical hazards (Q6) with the average score of 78.8%. Students found it difficult to answer to questions with specific diseases' names like Raynaud syndrome (Q2) and Lyme's disease (Q14). The study also showed that students are unaware of the working environment normative values on air humidity (Q5), noise (Q10), lighting (Q13) and carbon dioxide (Q15).

From the radar chart (Fig. 2) one can see how students' prior experience with OHS topics (in months) influenced their average score within different sets of questions.

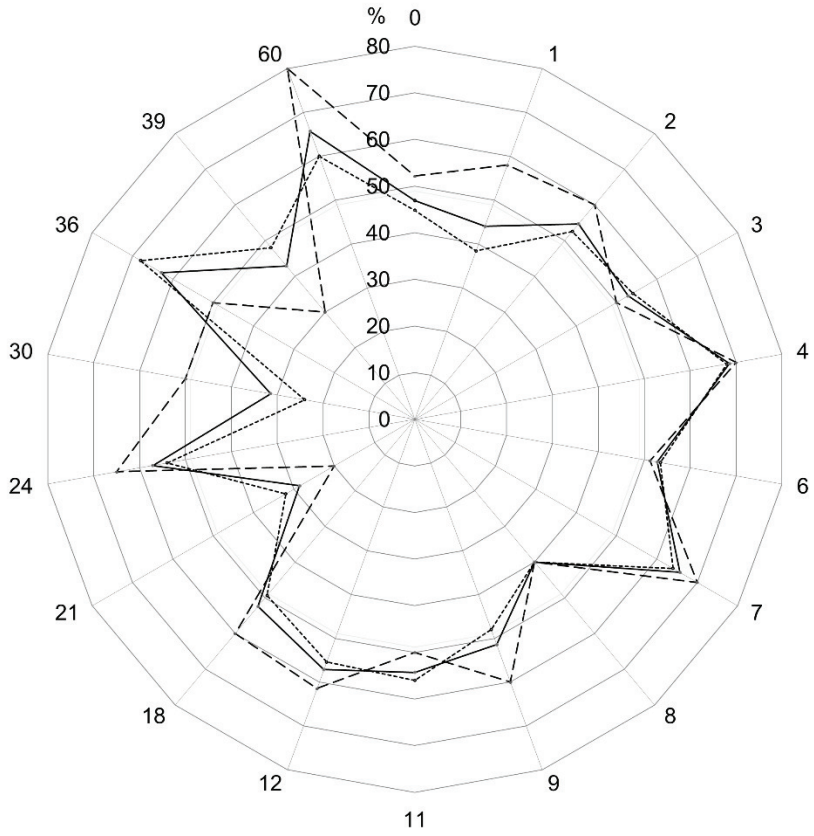

Figure 2. Radar chart showing students' experience in months (outside circle) and students score in % (0–90%). The gray area indicates the overall average and values below average of the test. Average values of the whole test (the questions (Q) 1–17, black line), average values of different parts of the test: Q1–15 (dotted line), Q16–17 (dashed line).

Do note, students did not divide evenly between different experiences categories (there was 98 students without prior knowledge, 30 students with 1–6 months experience and 23 students with experience varying from 6 to 60 months). Fig. 2 indicates that when answering to questions 16 and 17 that do not require factual knowledge students received (regardless of the students' experience) higher score values than to questions 1 to 15. The average score of question 16 suggests that even though all the respondents have personal experience of using a computer workplaces, their own mere experience does not allow them to get higher results when answering the question considering the ergonomics of the workplace. Despite the fact that the question 16 was rather a common sense question than a factual one, students failed to achieve higher results than the overall average of the test. Thus being uninformed of even some of the facts, common sense can lead to misinterpretation of the situation. But their ability to relate to a certain working environment is stronger (question 17), as the results are higher. This could be explained by the fact that question 17 consisted of several physical and biological hazards that are more obviously dangerous or disturbing than working in a wrong posture. Also, it is questionable whether a young and healthy human being who has not practiced 8 hour shifts of sedentary work can relate to the hazards of poor posture.

By the Estonian law the employers are obligated to train and also inform their employees on the subjects of: (1) company's work environment risk assessment; (2) measurement results anterior to the assessment and (3) legal normative values. As the employers are bind to inform the workers on the measurement results and normative values, the topics are also covered in the lectures of the course. Therefore the questions considering the normative values have also been included to the test.

As at least 53 students were working before or during their studies, the test score on the subject of normative values should have been higher. This raises several questions: (1) do employers inform their employees on normative values or do they presume that educational institutions do it instead; (2) how should each worker obtain knowledge on new values, if the normative values change due to developments in hazards control. During the year 2013 Estonian Labour Inspectorate's workers visited and supervised 2,665 companies. Their visits showed that a lot of companies (n = 1,589) failed to instruct their employees (Estonian Labour Inspectorate, 2013). This statistics suggests that OHS courses in higher education are necessary, otherwise young employees would be uninformed of even the most general knowledge considering risks and hazards that can accompany different professions. But employers must admit that as each workplace is different, all specific nuances of a workplace cannot be foreseen and therefore the students cannot be taught to avoid any particular situations in specific environments. During such courses only the fundamentals of risks and hazards can be taught, as well as health-sustaining and constructive attitude towards OHS topics can be created. Young and/or new workers can only learn OHS skills by themselves. This can only be done through their own experience during accomplishing tasks under the supervision of a qualified professional and an expert of OHS, rather than be taught in a lesson.

CONCLUSIONS

The students' knowledge and experience on OHS topics prior to the start of the course were mapped, the most difficult topics and domains were pinpointed. The results show that (1) students with prior experience did not get better test scores and (2) generally students are unaware of normative values on noise, air humidity, carbon dioxide and lighting.

The questionnaire had its limitations due to the fact that all of the topics of the course were not covered in equal thoroughness. Therefore the results might not show each student's definite knowledge.

The exploration is ongoing, as collected data is still being processed and further studies considering the efficiency of both teaching and learning are to be conducted.

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