STANDARDIZATION IN ENGINEERING CURRICULUM

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ABSTRACT

The role of standards in a global market in XXI century is unquestionable. However, the standardization is rarely seen as a separate topic in engineering academic programs at all higher education levels (undergraduate, graduate, postgraduate). Although international organizations for standardization, such as ISO or IEEE strive to introduce this topic in education worldwide, it is not common to see subjects called "Standardization", "Standards", "Technical regulations", etc. in a curriculum. This paper gives critical review about standardization-related courses at universities, and proposes the curriculum for a study course "Standardization". It also presents the results of a survey performed at three technical faculties in order to estimate the need for such a course.

Keywords: Standardization, Engineering Education, Quality Infrastructure

1. INTRODUCTION

Standards are technical specifications defining requirements for products, production processes, services or test-methods. These specifications are voluntary. They are developed by industry and market actors following some basic principles such as consensus, openness, transparency and non-discrimination. Standards ensure interoperability and safety, reduce costs and facilitate companies' integration in the value chain and trade [1].

Although typical everyday conversation is full of mentioning standards, quality, certification, accreditation, it is not common to see all of these topics in a curricula. Quality management already found its way into engineering study programs, but one part of quality infrastructure – standardization, still needs to be recognized as an important topic for modern engineers. The similar situation is with other topics, such as accounting, legal issues, and other themes which are non-typical for engineers. However, in a business practice, engineers are often required to have significant knowledge about many non-engineering problems. One of the topics which is not strictly related to typical engineering courses such as mechanics, mathematics, computer science, materials science, and which is considered to be a part of engineering set of skills is standardization. Most engineering students have never encountered an industrial standard within their academic courses.

University of Zenica used to have course "Standardization" at the postgraduate level, but after Bologna reforms, this course was discontinued. During a process of innovating curricula at the University of Zenica, we performed a short analysis in order to check whether it is justifiable to introduce a new course. We analysed the similar academic programs at the other universities, and we tested students to check whether they already have necessary skills and knowledge about standardization. Finally, we prepared a syllabus for the new course.

2. LITERATURE REVIEW

Only a few books about standardization is available on the market. Brenner and Spivak in [2] presented an introductory text on the development and use of standards that define similarity. Their book explains the economic advantages of creating and using similarity standards to increase the size of served markets and to decrease the cost of manufacture. The main focus of this book is on North American standardization, there is also a discussion of the value and importance of worldwide standardized manufacturing and the international standardization organizations associated with similarity standards.

The book [3] by Schneiderman covers the development of new technical standards, how these standards are typically triggered, and how they are submitted to standards development organizations for review and evaluation. This book also features an extensive chapter on standard essential patents -- the sharing of intellectual property.

The book [4] edited by Greenstein and Stango summarizes opinions of leading researchers in the field about open questions: Do markets choose efficient standards? How do standards organizations affect the development of standards? And finally, what constitutes appropriate public policy toward standards?

Murphy and Yates in [5] explore the International Organization for Standardization's (ISO) role as a facilitator of essential economic infrastructure and the implication of ISO techniques for a much wider realm of global governance. Through detailing the initial rationale behind the ISO and a systematic discussion of how this low profile organization has developed, they provide a comprehensive survey of the ISO as a powerful force on the way commerce is conducted in a changing and increasingly globalized world.

An interesting textbook was written by late Edina Tanović, former deputy director of the Bosnian Standardization Institute [6]. Her idea was to provide the Western Balkan universities with a material that summarizes the essential aspects of standardization. It was the pioneer step towards introducing the new, standardization-related courses at university level.

Kowalenko outlines the importance of integrating technical standards into academic programs within IEEE's fields of interest [7]. She refers to a position paper prepared by IEEE, which emphasizes the need to incorporate standards in engineering programs. She proposes that students should be acquainted with the idea of standards and provide them with some preparation, even only at the level of general awareness. Students should not be left with the erroneous impression that they will design new products and algorithms in an environment free of constraints, compatibility requirements, and regulations.

It is important to keep the generality of the course, to avoid the simple enumeration and dull classifications, but to help students to develop skills of understanding, using and developing standards, and use them in practice. De Vries in [8] proposes the basic learning module in standardization. He proposes to start a module with examples of standards, first simple, then business-to-business examples, followed by generalization topics: advantages, definitions, decision-making in standardization, types of standards, and the standardization process. After that, he proposes the topics on formal (national) standardization, and how it fits into regional and international frameworks, then development and implementation of standards, and finally the New approach by EU, which exploits the standardization in a most efficient way. The final, advanced topics should include relations between innovation and standardization, economic aspects, and intellectual property rights.

The same author presented the experiences from a Dutch university [9], which was the pioneer in introducing standardization management in academic curricula, at all three levels: bachelor, master and PhD level.

Laporte, April and Bencherif in [10] presented an example on how standardization can be incorporated in an undergraduate software engineering program. They emphasized the high

price of ISO standards, which are unavailable to students. This also confirms the previously mentioned statement that standardization should be presented in a generalized way.
Krechmer focused on the training needed by technical experts and explored the type of academic coursework and training that technical experts need in the field of standards and standardization [11]. His paper argues that academic courses would be better to focus on teaching the theoretical rules that underlie standards and use specific standardization examples for demonstration that the rules function as proposed. The author argues that studying the science of standards is an academic endeavour while creating standards is a practiced skill.
Choi and de Vries in [12] collected empirical data from 118 educational programs about standardization from 21 countries. They determined the way standardization education programs are segmented and implemented in different contexts. The findings are consolidated into a framework for standardization education. The framework presents an applicable combination of target groups (who), appropriate learning objectives (why), probable program operators (where), prospective contents modules (what), and preferred teaching methods (how). This framework may contribute to planning and implementing more inclusive standardization education programs.

3. STANDARDIZATION IN ACADEMIC PROGRAMS

An interesting free e-learning module is developed by 4 Asian and 2 European universities and now offered by the Helmut Schmidt University Hamburg, Germany, freely available on internet page *http://www.standardization.de/index.php/standardisation-72.html*. The lectures are structured in modules and are based on the contents of the textbook including the history and principles of standardisation. However, the lecture series offers a number of additional features, including multiple-choice tests, FAQs, keywords and a glossary. The e-learning modules have a multimedia-based interactive design and subject matter covering the latest topics in the field of standardisation within companies and markets.
A 2003 European survey on standardization education [13] showed that very little effort was done in Europe related to standardization training and Education. Although standardization is above all an issue of business more than a technical issue, Business Schools are not in general involved in any curriculum or session in a curriculum on this matter. Courses with some standardization focus identified in this survey include IT Security, Quality Engineering and Software Engineering.
A course on Strategic Standardization was offered jointly by the School of Law and the School of Engineering at Catholic University Washington, DC from 1999 to 2001 [11]. Only 18 students attended the course, and it was then discontinued. In a US engineering school survey performed in 2004 by the Center for Global Standards Analysis, the major findings were that standards education is not a priority issue among schools of engineering in the United States and that Engineering schools in the United States do yet not accept the critical nature of standards in the new global economy [11].
The Science and Technology Foresight Center identified 28 different universities with current standardization courses in Japan [11]. These courses are focused on technical students and include lecturers from local standardization organizations.
At two universities in the Netherlands which teach a standardization course, each course attracts between 10 and 30 students per year [11]. The professor teaching the courses notes the difficulty in attracting students to a course in standardization.
EU's European Commission catalogue of academic institutions involved in research and training related to standardization in 2006 suggests the following:

- The focus of most of these academic courses is on standardization in a specific functional area, industry or market segment.

- Academic standardization courses on specific standardization areas such as: metrology, IT security, safety standards, software engineering or quality have little in common.
- Even considering the academic courses, most standardization training is done by the hundreds of existing individual standardization organizations.
- The Korean courses success appears to be due to its focus on engineering students and inclusion in technical curriculums [11].

4. STUDENT SURVEY

In order to check the level of knowledge about standardization, the survey was performed at three faculties in Bosnia and Herzegovina. The survey was performed in a form of questionnaire with multiple-choice questions, and it was given to 37 students: 11 students from the 2nd year of Civil Engineering department at the University of Zenica (Bachelor level), 7 students from the 4th year of the Faculty of Forestry at the University of Sarajevo (Master level) and 19 students from the 2nd year of Production business department at the University of Zenica (Bachelor level). None of these students had courses about standardization, therefore they were not expected to have other than general knowledge about this topic.

4.1. Survey questions and grading system

The survey consisted of 15 questions, with 4 offered answers for each question. Students were informed that each question can have one or more correct answers, and that every incorrect answer will be considered as a negative point. The maximum number of correct answers was 20. The figure 1 shows the part of the questionnaire.

ANKETA O STANDARDIZACIJI

Ova anketa je dio istraživanja o potrebi izučavanja standardizacije i tehničkih propisa u visokom obrazovanju na tehničkim fakultetima u BiH. Molim Vas da na postavljena pitanja odgovorite samostalno, jer za pogrešne odgovore nećete biti kažnjeni niti za tačne odgovore nagrađeni :) Odgovore dajete zaokruživanjem slova u tabeli za koja mislite da daju tačne odgovore. Hvala.

Sta je standard? a) Zakonom propisani skup pravila b) Izmjereni nivo zadovoljstva kupca c) Tehnički propis kojim se propisuju obavezne karakteristike nekog proizvoda d) Dokument donesen konsenzusom i odobren od priznatog tijela, koji sadrži pravila, smjernice ili karakteristike aktivnosti i koji ima za cilj postizanje optimalnog stepena uređenosti u datom kontekstu.	a	b	c	d
Ko kreira i proglašava međunarodne standarde koji važe u cijelom svijetu? a) Ujedinjene nacije b) Niko, takvi standardi ne postoje, postoje samo nacionalni standardi c) Svjetska banka d) ISO (International Organization for Standardization)	a	b	c	d
Ko kreira i proglašava standarde koji važe u EU? a) Vijeće Evrope c) CEN (European Committee for Standardization) b) Evropski parlament d) CENELEC (EU Committee for Electrotechnical Standardization)	a	b	c	d

Figure 1. A part of questionnaire used in this survey

The questionnaire had the following questions:

- What is the standard?
- Who creates and declares the international standards applicable in the whole world?
- Who creates and declares standards applicable in the EU?
- Who creates and declares standards applicable in Bosnia and Herzegovina (B&H)?
- Which is the symbol of national standards in B&H?
- Are the standards are mandatory for all users?
- By which methods international standards are adopted in B&H?
- Can B&H create their own national standard which is not valid in other countries?

- What is certification?
- What is accreditation?
- Can a private company be accredited for some methods of measuring or testing?
- What is the CE mark on the product?
- Is the accreditation issued in B&H valid outside the national borders?
- Which of the following is a violation of intellectual property?
- In which institution in B&H a product or idea can be patented?

4.2. Survey results

The answers are summarized in figure 2. The average result was 14% of correct answers, which is below the minimum of 50%. It is understandable, since students had no chance to be introduced to these topics in the previous studying. However, the questions were rather elementary, and the results show that there is a need for such a course.

The additional question was given to determine the students' interest for this course: "If course Standardization is in the list of optional subjects, would you choose it?" The answers are presented in figure 3. Half of the students are willing to take the course, while one third would choose it depending on who the lecturer is. This shows that elective courses are often chosen according to personal preferences rather than real needs of the student.

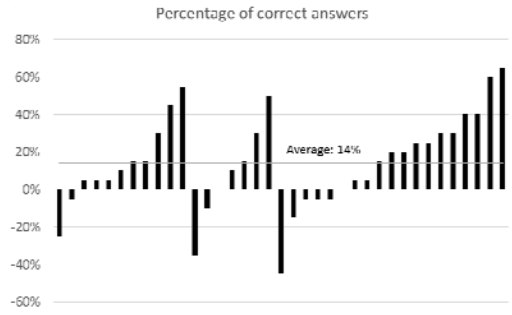

Figure 2. Summary questionnaire results

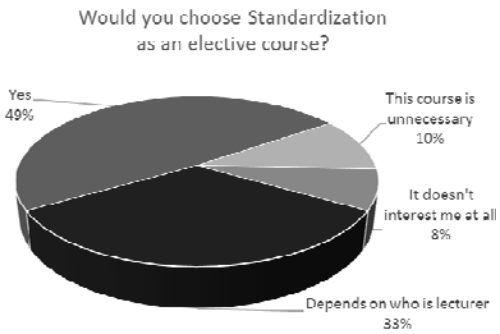

Figure 3. The interest of students for the course Standardization

5. PROPOSED CURRICULUM

The table 1 shows the content for the course Standardization at the Polytechnic faculty in Zenica. The course was developed for the study program "Production engineering", 2nd cycle (Master level).

Table 1. Curriculum for study program "Production engineering" at the University of Zenica

Semester: VII	**Status: Core**	**Hours per week**		**ECTS credit value: 5,5**
		Lectures: 2	**Exercises: 2**	
Subject aims	To introduce students to the basic concepts of technical standardization, accreditation and certification of systems, processes and products, to process of adopting standards and technical regulations, and to the national and international quality infrastructure			
Competences (Learning outcomes)	On successful completion of this subject student will be able to: • Use national and international standards and technical regulations • Know and understand the process of adoption and modification of standards • Demonstrate conformity of the product with the standards and directives • Apply the acquired knowledge to check the conformity of products			

Indicative syllabus content: Introduction, terms and definitions. Basics of standards and standardization. Modern standardization. International, regional and national standardization organizations. Classification and labelling of standards. Development of new standards. Standards and technical regulations. New and Global Approach. Product compliance and CE marking. Testing, surveillance, inspection, auditing, certification and accreditation. Quality infrastructure. Standardization and innovation. Standardization and intellectual property protection.		
Learning delivery: Lectures are delivered with the use of multimedia resources, active learning technology and with active participation of students. Exercises are performed as auditory. On exercises, students go through the procedure of adoption of the standard by methods of proclaiming, covers and translation. Students also have to prepare seminar paper on the verification of compliance with technical regulations and standards of a specific product.		
Assessment Rationale: The assessment is based on three periodic written assessment during the semester, preparation and defence of the seminar paper, and final written exam. Students independently prepare the seminar on selected topic, in the form of written survey and public presentation with discussion.		
Assessment Criteria:		
Activity on lectures (periodic testing)	Seminar paper	Final exam
30%	30%	40%

6. CONCLUSIONS

The standardization should be included in engineering curricula, at least as an elective course. When introducing new courses, in addition to other criteria, surveys like this should be performed in order to test the need for the course, the need for particular topics, and the students' interest.

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