IMPORTANCE OF METROLOGY EDUCATION - B&H CASE

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Abstract - The paper deals with education in metrology in diferent countries, importance of metrology education, knowledge transfer, cooperation in education and educational programs. The recently finished master degree program in metrology in B&H is discussed here. The program curriculum was multidisciplinary and it was organized on behalf of support of EU TEMPUS SCM project in cooperation between three universities and under patronage of Ministry of education of the canton.

The main objective of the program was to educate graduates with solid metrological background, both theoretical and practical skills, flexible enough to cope with rapidly moving technologies. The other aim was to educate graduates which will be able to participate in establishing national metrological system in candidate country for EU membership. The program was established in order to fulfil effectively an urgent need for high level manpower capable to support national metrological network and industry. This paper presents a concept of course development, coordination of teaching and laboratories, the current stage of project progress and plans for the future.

Keywords metrology, metrological infrastructure, metrological documents.

1. INTRODUCTION

Science and technology are considered to be essential to the national socioeconomic and industrial development in the years ahead. To enhance the development of these two elements, greater emphasis has to be placed on a more systematic approach to the acquisition and transfers of technology, from both local and international sources, which will lead to research and development activities (R&D) for the creation of innovations and more commercial value adding. This approach also requires the availability of basic infrastructure such as national information database and network, intellectual property protection, especially national metrology system.

The organized metrology activitiees push the boundaries of metrological capability to ever-greater heights, in turn spurred on by advances in science and technology, the demands of industry and the needs of society. That includes delivering benefits to the national economy or quality of life for citizens by working to overcome obstacles. However, there is an increasingly need to rethink definitions of national impact in metrology in a global economy. The present attitude prevails more and more that national boundaries have to be substituted by international legislation in a form of different agreements, standards including bilateral and multilateral cooperation for growing economy and better quality of life.

Measurement community is convinced of the benefits, often considering metrology as the best and unseen foundation on which other empires are constructed. Many new products and processes, new science and technology, indeed new markets and the legislation that governs them, depend on good metrology. Metrology and measurements are intrinsic elements in planning the processes on which they impact, yet often they are not routinely addressed, or at least not in a timely way. Mechanisms by which metrology impacts on the future are between national and global perspectives, and suggest new thrusts for embedding metrology into our economies and lives.

In order for the field of metrology to advance in line with the growth in a particular branch of industry, it is necessary to provide the appropriate personnel, up-to-date standards and measuring equipment. It will be necessary to import sophisticated foreign equipment and specialized experts for metrology. Developing countries must also make an effort to penetrate the domain of fundamental scientific research as it relates to metrology. While it is necessary to use expertise acquired form abroad, it is not usually possible to transfer metrology from the developed countries in a successful manner without the intervention of a domestic scientific and technological basis to ensure the adequate application of such knowledge. Metrology is the science of measurement and accuracy of measurement is achieved through metrology. Metrological capabilities have to provide measurement of physical quantities with the required level of accuracy. The degree of development of metrology in a country also reflects the stages of development in that country's industry.

Metrology professionals can help in increasing productivity and efficiency, they can improve process repeatability by minimizing opportunities for human error, increase internal/external customer satisfaction, achieve and maintain compliance while saving money through advances in computer technologies. Many countries with well established metrology system have metrology training centres, specialized educational institutions and, of course, formal metrology education at technical schools and university level.

Number of educated non-professionals and professionals in metrology depends on many factors. We will mention here some of the best practices. Japan educated trainers in 2006, who came from public sector and private companies. After passing the national examination of environmental certified measurer (of concentration measurement or of noise and vibration) they attended 3-day to 3-month courses.

Widely spread education in metrology is present in South Africa [2], concretely in metrology professionals. Soon after the local African accreditation process began, it was identified that the personnel in these labs required

specific metrology training. The South African experience in this area therefore stretches over more than 25 years and, quite justifiably, those involved believe that the model evolved is fit for purposes and meets the requirements of the vast majority of the needs of the laboratories.

Education and training about the measurement uncertainty was organized widely in many countries during last decade. Before performing the wide education, the teaching personnel had to be educated.

Some of the countries have a policy of metrology education [3]. But the new technology needs highly skilled professionals in metrology.

Establishment of new metrology systems in new independent countries needs special education for the professionals involved in the process. Customers of calibration services have some understanding of calibration, quality standards, regulation laws and the benefits to them or to the society at large. All is matter of some level of education. Education on metrology developed and proposed different methods [4] for university education.

Measurement knowledge transfer is a key factor in metrology impact on modern society, since better measurement is an essential component in promoting innovation, growth and welfare and developed through project iMERA [5]. Knowledge transfer is considered an essential element in a European Metrology Research Programme, since new measurement knowledge, created in research, needs to be transferred to be useful. It is a two-way information exchange between national metrology institutes (NMIs) and metrology stakeholders (universities, practitioners, industry, regulators). A wide variety of knowledge transfer mechanisms have evolved to different degrees in participating countries such as direct research collaboration, with industry, collaborations with regulatory agencies, universities etc metrology clubs, interest groups around specific topics, best practice guides, scientific publications and participation in documentary standards activities. Developing countries, their NMI and universities have to be involved and use the best practice of it.

2. B&H CASE

After the war in Bosnia and Herzegovina (B&H), manufacturing and service companies rapidly began to certificate their quality management systems according to ISO 9000, ISO 14000 and QS 9000 series. Establishing these quality certifications increased their presence, status and opportunities within B&H and international markets.

Due to rapid industrial expansion in the surrounding over the past ten years, the demand for science and technology workforce has been rising very quickly. The supply could not keep pace with the demand. The situation in the Balkan area is not the same as in the other countries, but the increasing demands for the development asks for specialists especially in the areas not educated previously. As a consequence, B&H is faced with a serious problem: the shortage of high-level personnel in metrology, important for high-technology industrial development and fundamental scientific research to ensure the successful transfer of technologies relating to B&H.

There is an urgent need to develop high-level manpower to support the development of the metrological system and industrial development as shown in Figure 1.

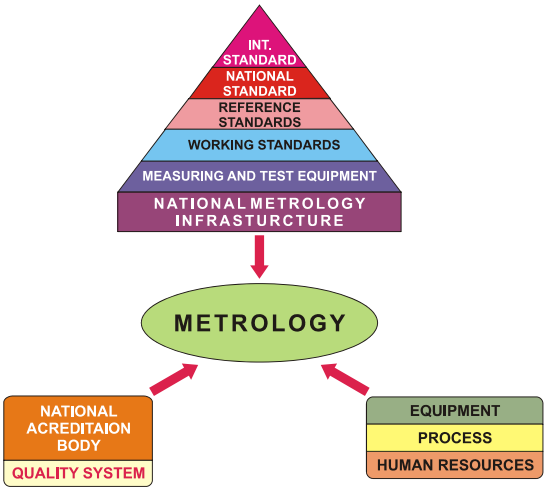

Fig. 1. Requirement for course development.

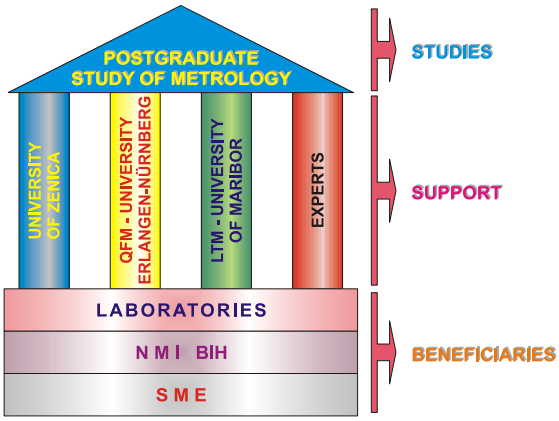

Fig. 2. Consortium of parties interested and involved in metrology.

3. REQUIREMENT AND CONSORTIUM FOR COURSE DEVELOPMENT

At present, Bosnia and Herzegovina can produce only a small number of graduates suitable for metrological development. Courses in measurement sciences and technology have never been offered neither at undergraduate or postgraduate levels in Bosnia and Herzegovina. An advanced program at the postgraduate level had to be initiated to educate the urgently needed manpower. As educational institutions in Bosnia and Herzegovina are generally weak in the area of metrology, a consortium of institutions had to be formed for such a purpose.

On the occasion of EU SCM TEMPUS project, the Master of Engineering degree program in metrology has been established. This unique and first of its kind program has been offered, both in theoretical groundwork and laboratory skills, by the consortium of 3 universities, namely: Chair for Automation and Metrology at the University of Zenica (Bosnia and Herzegovina), Chair for

Metrology and Quality Management at the University of Erlangen (Germany), Department for Production Technologies (Laboratory for Technological Measures) at the University of Maribor (Slovenia), and a number of individual experts from other institutions. The six objectives in organizing the consortium were as follows:

- to produce graduates at the master degree level in industry, and fundamental measurements.
- to promote research and development activities in metrology.
- to strengthen selected University in Zenica in the area of metrology through staff development and R&D funding supports.
- to promote the offer of courses in metrology as electives at the bachelor degree level and master in science and engineering.
- to deliver advanced courses on metrology to practice engineers and scientists.
- to put the groundwork for future Ph.D. program in metrology in Bosnia and Herzegovina.

The budget for the master program was partially supported by EU funds and expenses were covered partially through participation of students.

4. PROFILE OF THE COURSE

The Master of Engineering degree program in Metrology is a two semester master course. It comprises of carefully selected appropriate disciplines in science, engineering and technology. The objectives of the course are:

- to educate graduates having adequate theoretical groundwork and practical skills in metrology to work in a related field.
- to have master degree graduates for various areas in mechanical metrology, to cover all fields like dimensional metrology, computational metrology, vibrations, noise, measurement uncertainty, and calibrations, etc.

The program consists of compulsory courses, covering fundamental skills and knowledge about metrology; general courses, dealing with more specialised and advanced topics; and elective courses, where students were able to choose the course which suits their professional needs. The master thesis is a final task within a program.

TABLE I. Metrology program structure

1. Compulsory courses	- Metrology for research and development - Standardization - Measurement planning and processing of results - Metrology infrastructure
2. General courses	- Measurement uncertainty - Calibration, documentation and laboratory management - Instrumentation
3. Elective courses	- GPS (Geometrical product specifications) - Testing product characteristics - Measurement of process properties
4. Master thesis	

5. PRESENT RESULTS OF THE STUDY

The program was realised between November 2006 and November 2007, except for the master theses. All project activities were supported by project web portal [6]. The course materials are available for download, and a number of international users expressed the interest to use these materials. The presentations were password-protected, and password is available after short registration. Therefore, we were able to track the interest for these materials; we had requests from Brazil, Turkey, Croatia, Albania, Nigeria, Netherlands, etc.

Fig. 3. Project web portal.

Postgraduate students - participants in Metrology course were dedicated to the study, in spite of their full time employment in industry and public services. They attended lectures and made presentations almost four days a week including weekends. Comparing with previous experience with postgraduate students, they earned better results, as shown in table II and in figure 4.

TABLE II. Exam pass rate (results before May 2008).

Semester	Course	No. of students	No. of exams passed	%
I	I.1 Metrology for research and development	48	32	66,7%
	I.2 Metrology infrastructure	48	30	62,5%
	I.3 Standardization	48	30	62,5%
	I.4 Measurement planning and processing of results	48	24	50,0%
II	I.5 Measurement uncertainty	46	40	87,0%
	I.6 Calibration, documentation and laboratory management	46	37	80,4%
	I.7 Instrumentation	46	27	58,7%
	I.8a Testing product characteristics*	13	10	76,9%
	I.8b Measurement of process properties*	22	20	90,9%
	I.8c GPS (Geometrical product specifications)*	11	7	63,6%

* Elective courses

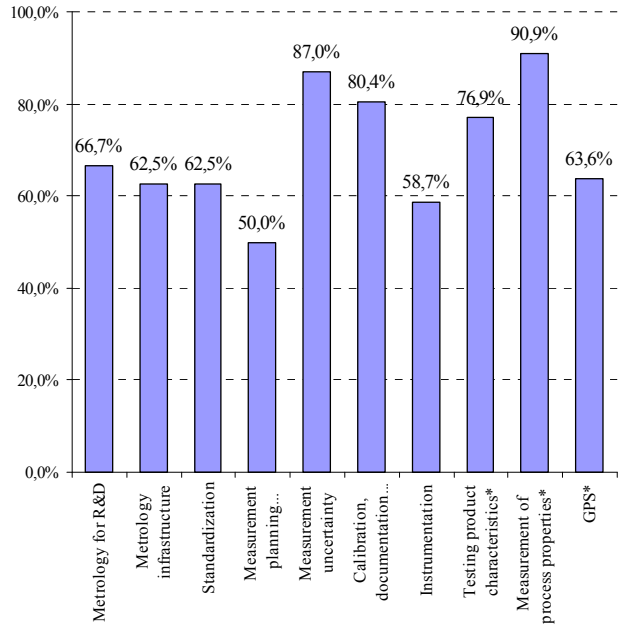

Fig. 4. Exam pass rates.

Table II and figure 4 show the exam pass rate for all courses during this program. Compared to other postgraduate courses in Bosnia and Herzegovina, the pass rate is satisfactory, especially having in mind that most courses were delivered in English, including exams.

Motivation for metrology study was the fact of lack of the specialized engineers, interdisciplinary character of the study and wide employment opportunities in the region. Several of the attendees are currently in a process of doing research for their master theses, defined in various fields of metrology and measurements.

The total of 48 participants enrolled for the program, coming from a variety of companies and institutions: manufacturers, research institutes, universities, trading companies, as well as from the National Metrology Institute. Their educational background was also different: mechanical, electrical and chemical engineering, natural sciences, technology and metallurgy. The students were required to show English language skills, since most courses were delivered in English.

6. CONCLUSIONS

Metrology education is important to developing countries for their economy and for attacking investments. All kinds of metrology education are welcome: for customers, for managers who are responsible for decision making in financing measurement equipment. At the very beginning of establishing national metrology system, educating metrology experts and education of trainers is an important step for reaching metrology educational aims. The results of a master study organized in B&H show that it was an important step in establishing metrology friendly area. The students showed strong interest in metrology studies. Wide cooperation showed excellent results, and knowledge transfer from the European universities is welcome. It got the best form and prepared solid ground for new forms of future cooperation.

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