

Internationalisation of PhD education in metrology

Ljupco Arsov, Marija Cundeve-Blajer

*Ss. Cyril and Methodius University, Faculty of Electrical Engineering
and Information Technologies-Skopje, R. Macedonia
e-mail: ljarsov@feit.ukim.edu.mk; mcundeve@feit.ukim.edu.mk*

The paper deals with the internationalization of the PhD education in the area of metrology. The foundation and goals of an international PhD study program in metrology as a model for internationalization of the PhD education are presented. An international consortium of twelve universities, seven EU universities and five South-Eastern European universities participated in the creation of the joint PhD studies in metrology. The specifics and achievements of the novel joint PhD study program are displayed in detail in the paper. The international impact and sustainability of the joint PhD program in metrology are further discussed. Such joint PhD studies are necessary which contributes to the internationalization of the PhD education and enhancement of the international scientific and technological cooperation.

Keywords: PhD education, internationalization, metrology

Introduction

The processes initiated by the Bologna Declaration form (1999) for internationalization and more intensive cooperation in the higher education through opening of the national systems of higher education, exchange of academic staff and students, give opportunities for more intensive regional cooperation in the engineering education. Considering the PhD education, these processes are not only possibility, but also a necessity because of the demanded highest level of academic staff and research facilities.

The metrology is international and inherited in all the scientific and engineering fields. It is present at the universities in the South-Eastern European region: Ss. Cyril & Methodius University-Skopje, South-Eastern European University-Tetovo (R. Macedonia), University of Zagreb, University of Split (R. Croatia), and University of Prishtina (R. Kosovo). At these universities, knowledge in the field of metrology is gained at the accredited study programmes at the first and the second cycle of studies according to the European Credit Transfer System (ECTS) and in line with the Bologna principles. However, in the frame of these existing study programmes there is no significant international academic exchange yet.

Following the process of realization of higher education according to the Bologna Declaration with three cycles of studies (graduate, master and doctoral studies), there was a need of organization of the third cycle of studies in the multidisciplinary field of metrology. The mutual interest of the above mentioned universities was expressed in the initiative for creation and realization of joint third cycle study program-doctoral studies in metrology, which will be based on international academic cooperation. In the frame of the TEMPUS IV program, this initiative has been accepted by the European Commission and the Education, Audiovisual and Cultural Executive Agency (EACEA), which finances the realization of the project 158599-TEMPUS-MK-TEMPUS-JPCR „Creation of the Third Cycle of Studies-Doctoral Studies in Metrology“. In the creation of the joint

third cycle study program the following EU universities participate: University of Pavia-Italy, Braunschweig University of Technology-Germany, Czech Technical University in Prague, Graz University of Technology-Austria, University of Zaragoza-Spain, University of Gavle-Sweden, Superior School of Metrology in Douai-France, as well as the Bureau of Metrology of R. Macedonia. The current experience and results in the realization of the EU TEMPUS programs have shown that the joint projects have significantly contributed to enhancement of the higher education and creation of preconditions for internationalization of the higher education.

Goals of the joint international PhD study program in metrology

The metrology is one of the main factors in the development of the industrial production, technical cooperation and trade among the countries. In the region of South-Eastern Europe the development of metrology is still behind the needs of the industry, trade and society. In the countries which jointly create the study program for doctoral studies in metrology, the metrological infrastructure and especially the national metrological institutes have lack of highly educated staff which would be the carriers of the further development. Beside the countries which develop the joint study program (R. Macedonia, R. Croatia and R. Kosovo), i. e. the universities Ss. Cyril and Methodius-Skopje, University of Zagreb-R. Croatia, University of Split-R. Croatia, University of Prishtina-R. Kosovo, South-Eastern European University in Tetovo-R. Macedonia, there is also lack of staff in the field of metrology in the other Balkan countries (Greece, Bulgaria, Bosnia and Herzegovina, Montenegro, Albania etc.).

By taking into account that metrology is a science inherited in all the technical disciplines and activities, the candidates which will accomplish the doctoral studies will have wide opportunities for application of their knowledge through activities in numerous fields by solving of problems in the industry, health and food sector, environmental protection, energy, transportation and trade sector. In such a way, the conditions for development of the metrological infrastructure for the above mentioned areas would be created.

The wider goals of joint PhD education were posed as:

- Enhancement of the quality and relevance of the higher education in metrology in the South-Eastern European (SEE) region (Macedonia, Croatia and Kosovo)
- Building of the capacities of the SEE universities for international cooperation and for permanent modernization
- Orientation of the SEE universities to offer high quality education in metrology for the necessary industrial development and international economic co-operation
- To intensify the international co-operation of the academic staff.

The specific objectives are:

- Harmonization of the studies in metrology in three cycle degree system according to Bologna process
- Development of new courses and modernization of the existing
- Upgrading of laboratories for practical training to PhD students in metrology
- Establishment of joint PhD study program in metrology among the SEE universities
- International transfer of knowledge and experience in the area of metrology.

Activities for establishing an international joint PhD study program

The establishment of the joint study program in metrology was realized through a set of joint activities of the SEE universities, such as:

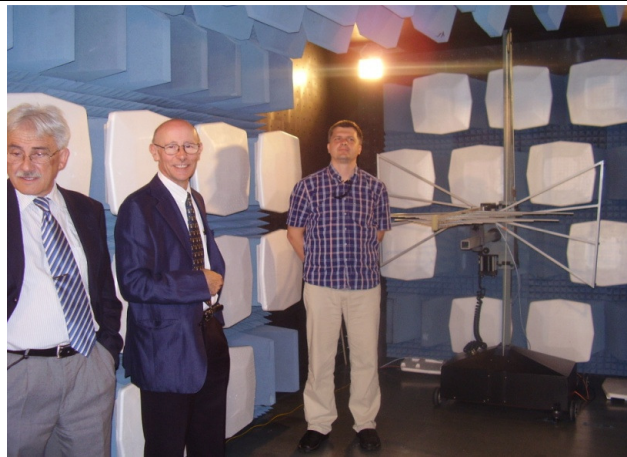
1. Elaboration of new regulation on third cycle of PhD studies in metrology harmonized with the Bologna principles
2. Elaboration and adoption of joint study programme for the PhD studies in metrology
3. Creation and maintenance of web-page of the PhD studies in metrology (www.tempus-metrology.ukim.edu.mk)
4. Promotion of the PhD studies in metrology
5. Development of the content and teaching materials of the new and modernized courses for PhD studies in metrology
6. Joint acquisition of laboratory equipment
7. Elaboration of an agreement for joint PhD study program among the SEE universities
8. Training of academic staff of the SEE universities by the EU universities through study visits, workshops and invited lectures
9. Enrolment of PhD students at the study programme of metrology and students exchange
10. Dissemination of the results and experience from the creation of joint PhD study program
11. Insurance of sustainability of the PhD study program.

These activities were jointly realized. In Photos 1 and 2 the joint study visit to the laboratories of the Czech Technical University in Prague and the University of Zaragoza-Spain are shown, respectively.

PHOTO 1. JOINT STUDY VISIT OF THE SEE ACADEMIC STAFF TO THE LABORATORIES OF THE CZECH TECHNICAL UNIVERSITY IN PRAGUE



PHOTO 2. JOINT STUDY VISIT OF THE SEE ACADEMIC STAFF TO THE LABORATORIES OF THE UNIVERSITY OF ZARAGOZA-SPAIN



Description of the joint international PhD studies in metrology

The joint PhD study program in metrology consists of four pillars:

- ICT in metrology
- Instrumentation, industrial metrology and quality science
- Metrology for life and society
- Scientific metrology.

The pillars are covering the most challenging areas in contemporary metrology. Each of these pillars comprises several courses given in Table 1.

TABLE 1. JOINT PHD STUDY PROGRAM IN METROLOGY

Pillars	ICT in Metrology	Instrumentation, Industrial Metrology and Quality Science	Metrology for life and society	Scientific Metrology
Courses	1. Data acquisition and data processing 2. Sensors and sensor networks 3. Applicative software for metrology 4. Modeling and numerical methods in metrology 5. Knowledge discovery and data mining	1. Signal conditioning 2. Complex monitoring and control systems 3. Metrology for energy 4. RF Measurements and metrology in telecommunications 5. Diagnostics, NDT and quality control	1. Metrology for life sciences-environmental monitoring 2. Metrology for chemistry, biochemistry and food quality and safety 3. Electromagnetic fields, electrical safety and EMC 4. Sensor systems for biomedical measurements and medicine	1. Quantum metrology and nanometrology 2. Primary standards, precise measurements and calibration 3. Metrology of mechanical quantities

The courses in Table 1 are lectured by at least two professors: one from the SEE universities and one from the EU universities. The students choose four of these elective courses for their curriculum and choose a supervisor from the SEE universities and a co-supervisor from the EU universities for the PhD research.

The program is realized by sharing of the academic staff resources, laboratories facilities as well as through common pool of students.

The international student mobility is one of the emphasized components in the realization of the joint PhD program in metrology. The mobility is implemented through joint lectures and workshops, PhD student conferences and presentations as well as study visits for accomplishment of the PhD research. This concept of realization of the joint PhD program implies not only educational cooperation, but also scientific bonding through joint research projects and exchange of researchers.

The results of the joint PhD study program in metrology in first line will be creation of high-qualified professionals and researchers, competitive for the international labor market, with the following general competences:

- Capability of research and development of solutions
- Capability of documenting the scientific researches
- Capability of working in interdisciplinary and international scientific research teams
- Capability of analysis of scientific and expertise problems
- Capability of application of the knowledge into praxis
- Capability of application of scientific research procedures and methods
- Possibility of systematization of knowledge
- Capability of generation of new ideas and solutions
- Knowledge of scientific ethics
- Capability of international transfer of knowledge and presentation of scientific research results.

The specific competences of the doctors of science would be:

- Expert knowledge in the areas studied through the courses of the study program
- Management of scientific researches in the field
- Design of new products and technologies
- Management and design of engineering processes
- Capability of management of the functions in a company and their integration
- Capability of generation of innovation approaches
- Solving practical problems by using scientific methods and procedures
- Activities in consulting services connected to design and engineering of products/processes
- Capability of relating theoretical knowledge and its practical application in studied areas of the engineering processes in the companies
- Capability of application of research methods in praxis.

By accomplishment of the doctoral studies in metrology, the doctors of sciences in the field of metrology will be capable for the following job positions at national and international level:

- Academic staff in higher education institutions

- Researchers in research centers
- Researchers in R&D centers in the industry
- Researchers and managers in the metrological infrastructure and the national metrology institutes.

International impact and sustainability of the joint PhD studies in metrology

The establishment of the joint PhD study program in metrology and its joint realization by the SEE and the EU universities has the potential to contribute to enhancement of the whole scientific, technical and cultural cooperation among these countries. The up-to-date experience shows that the results of this cooperation such as upgrading the level of the academic staff, upgrading the laboratories' facilities or enhancement of exchange of knowledge, is not limited only to the PhD studies. It broadens also positive influence on the undergraduate and the master level studies and generally on the scientific work. These influences are achieved through international mobilities of the academic staff as well as through inclusion of professors from different universities, professionals from the national metrology institutes, from the metrological infrastructure as well as from the industry. The invited lectures and international workshops in metrology are widely open to all the interested institutions and professionals. In such a way the network of the five SEE universities and seven EU universities is extended to the other universities and institutions in the region, but also wider in Europe.

The work in the realization of the international joint PhD study program developed a common language among the participants in the project, initiation and launching of novel joint ideas for further international scientific cooperation. For example, the existing network extended with 15 more universities in Europe has jointly applied for a new European project in metrology under the title "Metrology in Academic Study and Research Exchange".

All of this is a guarantee of the sustainability of the established joint PhD study program in metrology, as well as for further increase of the international impact and contribution to the international cooperation.

Conclusion

The paper presented the internationalization of the PhD education in metrology through establishment of a joint PhD study program. The specifics, achievements and contribution to the internationalization of the higher education by the novel joint PhD study program were presented.

The educational cooperation through realization of joint study programs, such as presented in the paper, has potential to strengthen the international scientific and technical cooperation.

The jointly educated staff is a link for realization and further development of international educational, scientific and technical cooperation, as well as the cultural and political relations among the countries.

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