

New University Curricula of Geodesy and Geoinformatics in Croatia

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SUMMARY

During the past year, the Faculty of Geodesy of the University of Zagreb had done a fundamental reform of all its educational programs: from the undergraduate, graduate and postgraduate doctoral studies to the completely new postgraduate specialist studies. The paper describes the new Bachelor and Masters curricula in Geodesy and Geoinformatics at the University of Zagreb, Faculty of Geodesy. These curricula were approved and the Bachelor studies started in 2005/06, and will be followed by the Masters studies.

Furthermore, in 2006, we prepared new postgraduate studies curricula. Postgraduate studies will be offered at two levels, accordingly leading to two types of degrees: Specialization (Spec.) and Doctor of Philosophy (PhD). Both degrees require course studies, as well as dissertation work. Theoretically, it will take one-year full-time studies (60 credits) to obtain the Spec. degree and three years (180 credits) for the PhD degree.

The paper ends with some remarks describing the first experiences of the Bologna process application at the Faculty of Geodesy, University of Zagreb. The authors conclude that this new way of education requires different approach from all participants. Professors are to be engaged more and are more responsible, but also a more thorough, more responsible and more serious approach of students to new instruction requirements is expected. This reform is going to completely succeed only by fulfilment of tasks of all participants.

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1. INTRODUCTION

Croatia has a rather long tradition of higher education. The textbook written by Martin Sabolović *Exercitationes Gaeodeticae*, printed in 1775, brings evidence in this respect. The first diplomas that young graduates were presented certifying that they passed all necessary exams to acquire academic degree and authorizations to act as surveyors were handed in 1811. The students who have graduated from the today's Faculty of Geodesy, University of Zagreb are highly acknowledged experts in Croatia and abroad.

Graduate engineers of geodesy have never had any difficulties in getting employed, and the present situation in the work market indicates that each of 40 annually graduating engineers finds adequate job immediately. Private firms and the public sector grant scholarships and stimulate students in other ways in order to provide high-quality experts for themselves.

Scientific work and its connection with the teaching process have influenced the introduction of new cognitions into the teaching activity. In the periods shorter than 10 years, the Faculty of Geodesy has made more significant changes of this curriculum. In this context, this change makes a logical continuation being supplemented with the adaptation of the studies to the Bologna Declaration processes.

The previous curriculum changes at the Faculty of Geodesy have mostly been influenced by the university curricula from Central and Western Europe where the role of surveyors in the society is similar (Austria, Germany, Switzerland...). Thus, this curriculum can also be compared with the curricula at TU Graz, ETH Zurich and TU Delft.

The curriculum change that introduced significant alteration in teaching processes was carried out in 1978. The next new curriculum was adopted in 1985, and the last more important change of the curriculum happened in 1994 with smaller changes carried out in 2001.

Public institutions and the private sector are interested in the initiation of such new curricula (State Geodetic Administration, Croatian Geodetic Institute, Hydrographic Institute of the Republic of Croatia, Croatian Chamber of Architects and Civil Engineers). The cooperation will be realized through the participation of skilled professionals in the teaching process, but also in the practical training of students in these institutions.

2. NEW STUDY PROGRAMS

Before coming to the new curricula, it was necessary to make a decision concerning the new

title of study programs and define new educational profiles for bachelors and masters. Also, conversations were made with representatives of geodetic profession from all parts of the Republic of Croatia, as well as with representatives of other faculties from the field of technical sciences.

2.1 New Title of Study Programs

Scientific work and its connection with the educational process have affected the consistent introduction of new concepts in education. In periods of less than 10 years, the Faculty of Geodesy has significantly altered its curricula. Due to increasing application of new technologies, the study title itself was also changed, from *Geodesy* to *Geodesy and Geoinformatics*, which is also going to help change the image and increase the affirmation of the profession. In that context, this change is just a logical continuation, which is supplemented by adapting the study to the Bologna Process. It should be noted that certain phases of reform were introduced to the wider geodetic public at meetings organized at the end of 2004 by the administration of the Faculty of Geodesy. The discussion involved geodesists from the Parliament, the Government, the State Geodetic Administration, the Croatian Geodetic Institute, the Croatian Geodetic Society, the Geodesy Engineers' Class of the Croatian Chamber of Architects and Civil Engineers, geodetic companies and other relevant institutions. The participants unanimously supported the process of changes in high geodetic education.

In this way, as the first move in the comprehensive reform, the Faculty Council made a decision that undergraduate, graduate and postgraduate studies, titled *Geodesy and Geoinformatics Studies* are going to be held at the Faculty of Geodesy.

2.2 Undergraduate Studies

The new undergraduate studies last three years, that is six semesters, and a student obtains 60 ECTS points for each academic year in which he or she meets all regulated conditions. By finishing the undergraduate studies, one acquires 180 points and the title of *bachelor or baccalaureus of geodesy and geoinformatics*, and competences for executing all works of today's geodesists, with a lower level of responsibility than graduates, that is masters. The undergraduate studies ends with a final exam for those students who do not wish to continue to study.

At least 27 ECTS points or 15% out of 180 ECTS points have to come from optional subjects.

After graduating from the undergraduate studies, one becomes competent in solving professional jobs in the following activities:

- Determination of the Earth's size and shape and measurement of all data necessary for defining the size, position, shape and contours of an part of the Earth, and their changes.

- Placement and positioning of objects in space and time, and other engineering works on, above or under the Earth's surface.
- Production and updating of plans, maps and other documents.
- Gathering and application of spatial data using close range methods, and aerial and satellite survey.
- Determining the position of public and private land boundaries, including national and international borders, and recording the land in adequate registers.
- Maintenance of geoinformation systems (GIS), and gathering and storing data in these systems.
- Visualisation and communication by means of maps and mobile digital devices.
- Assessment of values and real estate management, either urban or rural area, land or buildings.
- Familiarity with geospatial services for various user groups.

While performing the above-mentioned activities, surveyors/geoinformation collaborators take relevant legal, economic and social viewpoints into consideration that affect every single geodetic project.

A bachelor of geodesy and geoinformation can be:

- A geodetic surveyor
- A GIS-collaborator
- A cadastral surveyor
- A collaborator in photogrammetry
- A collaborator in cartography
- A collaborator in hydrography.

Reform of education at the undergraduate study of geodesy has been an unbroken process ever since the old curriculum was adopted in 1994. In accordance with new legal regulations, it was still necessary to make a radical change, one with more than just a formal character. Therefore, at the beginning of 2005 the professors of the Faculty of Geodesy of the University of Zagreb decided to produce a *body of knowledge*, that is a list of knowledge and skills every student needs to acquire after each year of study. After that – rather than use the earlier usual approach in which the professors would choose what to teach their students – contents of particular subjects were determined according to the body of knowledge. The subjects were named in the second phase, and the professors were determined at the end. The proposed undergraduate and graduate program was reviewed nationally and internationally and the Faculty of Geodesy got a positive opinion from the National Committee for Higher Education and a concession from the Ministry of Science, Education and Sport of the Republic of Croatia.

The basic elements of the reform are: introducing law and management into the profession, considerable reduction of the number of classes of some traditional subjects at the Faculty, introducing numerous new professional subjects related to the informatics, a field with increasing importance. In order to successfully execute the new curriculum, of importance are

decisions by the Faculty Council, according to which the professors are required to prepare their lectures for the new subjects in digital form and make them available to students via web-pages.

2.3 Graduate Studies

The new graduate studies at the Faculty of Geodesy will last two years, that is four semesters, and a student will obtain 60 ECTS points for each academic year in which he or she meets all regulated conditions. The graduate studies ends by producing a diploma thesis and a diploma exam. By finishing the graduate studies, one acquires 120 points and the title of *master of geodesy and geoinformatics*.

At least 24 ECTS points or 20% out of 120 ECTS points have to come from optional subjects.

The graduate studies at the Faculty of Geodesy are carried out in two subject-oriented fields: *Geodesy* and *Geoinformatics*. New contents have been introduced to the new graduate studies, according to the body of knowledge.

After graduating from the *Geodesy and Geoinformatics* graduate studies, the following competences in solving professional and scientific problems are acquired:

- Determination of the size and shape of the Earth and measuring all the data necessary to define the size, position, shape and contours of any part of the Earth and their more significant changes.
- Placement and position determination of objects in space, monitoring the position of natural and man-made objects in space and time, and other engineering works on, above or under the Earth's surface.
- Development, testing and calibrating of geodetic instruments and sensors.
- Designing, production and updating of plans, maps and other documents.
- Gathering and application of spatial data using close-range, aerial and satellite survey methods, and automation of these processes.
- Determination of public and private land boundaries, including national and international borders, and recording the land in adequate registers.
- Designing, establishing and updating geoinformation systems (GIS), and gathering, storing, analysing, managing and distributing data.
- Analysing, interpreting, and integrating spatial objects and phenomena, and their visualisation and communication by means of maps and mobile digital devices.
- Studying natural and social environments, survey of land and sea resources, application of data in planning the development of urban, rural and regional areas.
- Planning, development and renewal of real estates, and value assessment and real estate management, either urban or rural areas, land or buildings.
- Planning, measurement and management of buildings, including cost assessment.
- Development of geospatial services adapted to various user groups.

In performing the above-mentioned activities, masters of geodesy and geoinformation take relevant legal, economic, ecological and social viewpoints affecting each single geodetic project.

A master of geodesy and geoinformation can be:

- A licensed engineer of geodesy
- A geoinformation operator
- A GIS-analyst
- A head of geodetic/geoinformation project
- A supervisor of geodetic/geoinformation project
- A spatial information manager
- A cartographer
- A photogrammetrist
- A real estate assessor
- A cadastre planner
- A hydrographer
- A geodetic supervisor
- A court appointed expert for geodetic jobs
- A geodetic entrepreneur

A master of geodesy and geoinformatics is an expert with university qualification and technical experience to:

Determine, present and measure the position of portions of land, three-dimensional objects, fields and trajectory on a scientific basis;

Gather and evaluate land information and geoinformation, and to apply this information for the purpose of planning and managing the land, sea and structures, as well as the objects on them;

Encourage the improvement and development of the above stated activities.

2.4 Postgraduate Specialist Studies

After the undergraduate and graduate geodesy and geoinformatics studies were designed, a reform of postgraduate studies began in autumn of 2005.

The fundamental goal of postgraduate specialist study, which last one year, is to enable the advancement of knowledge from a field of profession to those former students of geodesy who obtained their diplomas some time ago.

Rapid development of survey and information technologies in the last fifteen years resulted in an increasing obsolescence of knowledge obtained by graduate engineers of geodesy during the old graduate studies program. A radical change of the undergraduate and graduate curriculum, implemented at the Faculty of Geodesy in academic year 2005/06, has significantly altered the profile of former graduate engineer of geodesy. Therefore, every professional from practice needs to supplement his or her knowledge from new areas, which

is offered by the proposed specialist studies. Four areas in which future students would enrol were conceived, but the final proposal consisted of following three topics:

- Introduction of new official geodetic datums and map projections in the Republic of Croatia
- New instruments and methods of geodetic survey
- Geoinformation systems – practical applications

The postgraduate specialist program of geodesy and geoinformatics should also be considered a component of the lifelong education system, especially in those areas where transfer of scientific and professional knowledge is enabled, as well as high-quality research and professional improvement.

2.5 Postgraduate Doctoral Studies

Two-degree postgraduate studies were held earlier at the Faculty of Geodesy of the University of Zagreb: graduate engineers of geodesy usually first obtained the title master of science (MSc) at the postgraduate studies, and after that the title of doctor of science (PhD) at the doctoral studies. The new system envisages a one-degree doctoral study in duration of three years. Rather than passing numerous exams as a prerequisite for production of evaluated papers (master or doctoral), the new doctoral studies are connected exclusively to scientific work and research on scientific projects carried out at the Faculty of Geodesy of the University of Zagreb.

The postgraduate scientific studies of *Geodesy and Geoinformatics* are organised and executed as studies for obtaining the academic degree of doctor of technical sciences. By finishing the postgraduate scientific studies of *Geodesy and Geoinformatics*, one obtains the title of doctor of technical sciences (Dr.), in the field of Geodesy. Instruction at the postgraduate studies of *Geodesy and Geoinformatics* for obtaining the academic degree of doctor of technical sciences lasts six semesters and is carried out during the period of three years.

The doctoral program at the Faculty of Geodesy is going to be developed exclusively within the frame of scientific projects financed by the Ministry of Sciences, Education and Sport of the Republic of Croatia, or within reviewed scientific projects financed by other relevant international institutions (European Commission, National Scientific Foundation USA) under requirement that the suggested duration of a project is at least three years. Special stimulation is going to be employed to exchange students with prominent European and foreign universities.

After graduating from the studies, students acquire the following competences:

- Superior familiarity with the literature and unsolved problems in the scientific field of geodesy

- Independent proposal and conducting of research projects, publishing and presenting the results to other scientists
- Ability to exchange one's own scientific concepts and opinions with other experts, colleagues and students
- Critical attitude towards one's own research, as well as to research work of others, and the ability to accept criticism as the encouragement for further work.

Organization of studies during *full-time* work.

The candidates employed at the University or in other public scientific institutions are obliged to regularly participate in all obligatory activities connected with the studies according to the recommendations of their tutors. Every six months the candidates have to deliver a report about the work at doctoral studies to the Committee for Science of the Faculty of Geodesy.

Organization of studies during *part-time* work.

The students who are not employed at the University or in public scientific institutions are obliged to attend lectures, seminars and exercises in obligatory and optional subjects. They are obliged to participate in other activities within the frame of their possibilities, and at least once a month they need to deliver a report about their work at doctoral studies to the Committee for Science of the Faculty of Geodesy.

During postgraduate doctoral studies and before defending one's doctoral dissertation, a candidate is obliged to publish at least one original scientific paper independently or as the first author in co-authorship in an internationally reviewed scientific journal. The paper must be directly connected with the theme of doctoral dissertation. He/she is also obliged to present the results of the doctoral dissertation in at least one international conference abroad. Finally, a candidate is obliged to complete the doctoral dissertation independently.

For the proposed programs of postgraduate doctoral studies and the postgraduate specialist studies, the Faculty of Geodesy got a guarantee from the Senate of the University of Zagreb, which is, according to the decision by the authorized Ministry, enough to start the studies. The review process of the proposed postgraduate studies is still in progress.

3. FIRST EXPERIENCES OF THE BOLOGNA PROCESS APPLICATION

Already in the first semester of applying the new curricula in the undergraduate studies of geodesy and geoinformatics it is possible to perceive certain positive and negative phenomena related to the Bologna Process and other circumstances the Faculty had no effect on. The effect of accompanying regulations, especially the new high education financing system in the form of *lump-sum* is going to become evident in months and years to come.

According to the undergraduate and graduate study curricula of *Geodesy and Geoinformatics*, the optimal number of students able to enrol with respect to space, equipment and the staff number is 150.

The first semester of the academic year 2005/06 featured the first education according to the new undergraduate study program of *Geodesy and Geoinformatics*, adapted to the Bologna Process. However, one should take into consideration that this semester is not going to be representative by its results, since the number of students enrolled in the first academic year was almost twice (224) the number of students enrolled in the academic year 2004/05 (115 students). This was because the enrolment quota was increased (from 115 to 135 students), the possibility of enrolment according to the special laws (26 students), and the fact that students who failed the 1st year were directed to studying according to the new Bologna Process (63 students). It was impossible to execute parallel education for the first year students by old and new program. The great number of students made difficult the execution of continuous student's knowledge evaluation, and mentor work with smaller groups of students of students was made completely impossible due to lack of professors and assistants.

One could expect better results if some mentioned problems were fully or at least partially solved: too many students, not enough professors and collaborators, lack of adequate number of larger lecture rooms, computer rooms and laboratories.

Also, it should be enabled, as soon as possible, the possibility to continually evaluate a student's knowledge via exams and homeworks, which would lead to partial or complete release from having to attend the final exam. In order to successfully evaluate the Bologna Process, we also envisage quality control via university and student questionnaires, professor evaluations, etc. All requirements necessary for getting a signature or partial or complete release from having to attend the final exam should be defined at the beginning of a semester. Furthermore, all lectures, exercises, tasks and other have to be available to students, and e-learning is to be applied as much as possible in instruction. When all of that is done, the Bologna Process will show all its values.

One of the largest unknowns in applying the Bologna Process is the financing of study programs, that is faculties. Until now the financing of faculties was done according to the number of students, or to the number of education staff. In the future, programs are going to be financed, while the faculties are going to have a great deal of autonomy.

According to the first research, the new programs make the studies 30% more expensive. Since the Ministry of Science, Education and Sport of the Republic of Croatia has not allotted the required resources for covering material expenses of studying at the right time in the past, it is not known how it is going to work out in the future.

The new financing is known as *lump sum*. The expression can be explained as *lump payment of study program* or *financing in previously determined amount*. The new financing system looks quite sophisticated and the *lump sum* model is the topic of the TEMPUS project *Finances Management at Croatian Universities*, which includes the universities of Split, Osijek, Rijeka, Udine, Vienna and Heidelberg.

For the mentioned financial activities, it is necessary to have *transparency of the procedure and to motivate faculties for obtaining their own resources*. The financier of the study programs should be the University (up to now it was the Ministry of Science, Education and Sport of the Republic of Croatia), and the new model is supposed to start being applied from January 1, 2006. Because the subjects in the process of financing were unready, the start of the model functioning was unofficially delayed, but according to the newest decisions, it is going to be applied gradually during 2006 and be completed in 2007.

4. CONCLUSIONS

Education according to the Bologna Process represents a fundamental reform of high education process in the Republic of Croatia. The goal of the reform is to make studying more successful, and that would mean to make the number of highly educated people in Croatia greater.

Besides institutions concerned with education, many issues rise for employers in both public and private sectors. In less than three years, a part of the first generation of bachelors is going to finish their education and will be looking for work. What is the position of a bachelor of geodesy and geoinformatics on the market of jobs? We hope that by presenting the profile and program of bachelors we enabled insight into expected knowledge of future personnel.

This new way of education requires different approach from all participants. Professors are to be engaged more and are more responsible, but also a more thorough, more responsible and more serious approach of students to new instruction requirements is expected. It is also necessary to secure work with smaller groups of students, a larger number of professors and collaborators, enough lecture rooms, computer rooms and laboratories, and adequate equipment and instruments.

This reform is going to completely succeed only by fulfilment of tasks of all participants. During the past year, the Faculty of Geodesy of the University of Zagreb had done a fundamental reform of all its educational programs: from the undergraduate, graduate and postgraduate doctoral studies to the completely new postgraduate specialist studies. We hope that this made possible high-quality and lifelong education of geodesists and geoinformation professionals in the Republic of Croatia.

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BIOGRAPHICAL NOTES

Miljenko Lapaine was born in Zagreb in 1952. He studied mathematics and graduated from the Faculty of Science, University of Zagreb, in the field of theoretical mathematics in 1976. He finished the postgraduate studies of geodesy, the field of cartography in 1991 at the Faculty of Geodesy in Zagreb by defending his Master thesis *A Modern Approach to Map Projections*. He obtained his PhD at the same Faculty in 1996 with a dissertation *Mapping in the Theory of Map Projections*. He has been a full professor since 2003. He published more than 550 papers, several textbooks and monographs. He is a full member of the Croatian Academy of Engineering, a founder and a vice-president of the Croatian Cartographic Society and the chief editor of the *Cartography and Geoinformation* journal.

Zdravko Kapović was born in Opuzen in 1948. He graduated from the Faculty of Geodesy, University of Zagreb in 1974. He received his Master's degree in 1984, and his PhD in 1993 in the field of Engineering Geodesy. He has been a full professor since 2002. His subjects are Engineering Geodesy, Movements and Deformations, Organization of Geodetic Works and Geodesy in Environment Protection. He published about 70 papers. He led scientific-professional expertises of geodetic surveys in testing and evaluation of constructions for more than 500 objects. His scientific-professional activities include geodetic works in civil engineering, measurement of movements and deformations of objects, and geodesy in environment protection. He has been the dean of the Faculty of Geodesy in two mandates: 2003-2005 and 2005-2007. He was the president of the Croatian Geodetic Society from 1996 to 2004.

Stanislav Frangeš graduated from the Faculty of Geodesy, University of Zagreb in 1984, obtained his Master's degree in 1993 by defending his Master's thesis *Differentiation of Objects on Maps with Area Symbols*, and his PhD by defending his doctoral thesis *Map Graphics in Digital Cartography*. His subjects are Geodetic Drawing, General Cartography, Topographic Mapping, Thematic Mapping, Map Reproduction and Map Visualisation. He published several course materials and about 20 cartographic representations. He was awarded for excellence in cartography at the International Cartographic Exhibition in Ottawa in 1999. He was the head of the Institute for Cartography and the chief editor of *Geodetski list*. He is the vice-dean for education at the Faculty of Geodesy, University of Zagreb.

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