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Strengthening Capacities for the Implementation of
Dual Education in BH Higher Education (DUALSCI)

Description and Concept of Specific Dual Higher Education Model for the Professional Undergraduate Study Programme of Computing at the Faculty of Mechanical Engineering, Computing and Electrical Engineering, University of Mostar

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1. Introduction

The history of the Faculty of Mechanical Engineering and Computing in Mostar dates to 1959, founded by the Higher Technical School of Mechanical Engineering. The initial idea for the founding of the school is related to the desire to provide training for mechanical engineering engineers in Mostar and Herzegovina, to establish the core of scientific thought, and to enable the transfer of new knowledge to businessmen and entrepreneurs in this extremely important geographical and economic space.

Guided by these ideas, the school experienced various transformations until it became an independent higher education institution in 1976 within the University of Mostar.

Aware of the fact that the education system is, on the one hand, closely connected to technological development, and, on the other hand, linked with the social changes that are inevitably happening in the world, in the academic year 2002/2003. the faculty has turned a new page of his history. The study programmes of Computing, both University and Professional study programmes, were started, along with an existing study programme of Mechanical Engineering. This also led to the change of the faculty name to the Faculty of Mechanical Engineering and Computing, University of Mostar.

In the year 2017, a study programme of Electrical Engineering has started, which was one of the biggest projects that we have prepared at the Faculty. The idea has been present since 2001, and these days it has become a reality. A laboratory for the electrical engineering courses was opened, with the attendance of numerous participants from the academic community, politics, economy, and colleagues from related technical faculties.

1.1. Professional Undergraduate Study Programme of Computing

The Professional undergraduate study programme of Computing is intended for the acquisition of knowledge in the field of computer science with a focus on the practical application of computers in everyday business. Practical work with databases includes data model, relational approach, work with distributed databases using standard SQL language. Programming includes getting acquainted with the process of creating a program as well as getting acquainted with the practical use of procedures for creating a program. Introduction to language processors, operating systems and computer graphics are an integral part of the curriculum, and multimedia is represented in almost all subjects of this study.

The Professional undergraduate study programme of Computing aims to educate professionals capable of adapting to constant changes in the field of computer science and all fields of technology. Education includes providing the necessary basics in the field of computing and technology in general. The study aims to develop the ability to design,

apply and use computer science and information technology with special emphasis on application in the field of technology.

The proposed study programme is in line with the long-term and short-term goals of the University of Mostar and the Faculty of Mechanical Engineering, Computing and Electrical Engineering.

The curriculum of the Professional undergraduate study programme of Computing, in its structure and content, is generally harmonized with similar studies in Bosnia and Herzegovina and in the European Union.

The curriculum includes obligatory courses that form the core of the study programme. The program also includes the obligation to enrol in elective courses offered in the study programme. Students are given the freedom to choose courses from the list of offered courses.

The Professional undergraduate study programme of Computing lasts six semesters, during which students can earn 180 ECTS credits, which includes passed obligatory and elective courses, as well as the preparation and defence of the final thesis. Upon successful completion of their studies, students acquire the title of Professional Bachelor of Computing.

Upon completion of the study programme, basic theoretical knowledge and practical professional knowledge in the field of computer science are acquired, along with the ability to adopt new knowledge and technologies. The ability to design, implement and maintain medium-complex computer systems that include the integration of software and hardware solutions is acquired. Upon completion of the studies, the preconditions for the continuation of studies within the graduate study are realized, which forms a fully educated expert capable of solving the most complex engineering tasks and participating in scientific research.

A student who completes an professional undergraduate study of computer science can:

- Independently develop smaller software solutions and participate in the development of complex software solutions.
- Consolidate knowledge of the principles of operation of computer hardware, both individual components and their connection to the system.
- Apply theoretical knowledge and practical skills in solving problems in the field of computing.
- Identify the possibilities of applied algorithms and used data structures in software solutions.
- Assess the impact of computer architecture and operating systems on the operation of computers, with the possibility of their installation, application and maintenance.

- Understand the complete software development cycle from planning, through development and testing to maintenance.
- Analyze the principle of operation and components of computer networks.
- Apply the acquired knowledge about the roles and stages of development of information systems.

In addition to all the above, students can:

- Apply basic programming skills.
- Apply security mechanisms to protect computer systems.
- Develop and maintain smaller information systems.
- Apply existing information technologies.
- Build multimedia applications.
- Use developed communication skills.

The Professional Bachelor of Computer Science, in his/her further professional work, will show the following competencies:

- Ability to collect, process and interpret relevant data within the field of computing.
- Ability to work individually and in teams.
- Communicating using language appropriate to professional and non-professional audiences.
- Ability and motivation to engage in lifelong learning and continuous professional development.

2. Implementation of the Dual Higher Education Model

2.1. Basic Assumptions for the Implementation of the Dual Higher Education Model

In the beginning, we will look at the existing legislation described in the Regulations on the Study of the University of Mostar:

Article 8: The professional study lasts three or four years and upon its completion 180 or 240 ECTS credits are acquired, as well as the title of Professional Bachelor or equivalent with an indication of profession or other professional orientation.

Article 25, paragraph (1): Part-time students are studying while working or performing other activity that requires a special program and have the status of a part-time student based on enrolment, which they pay following the decision of the Governing Board at the proposal of the organizational unit.

Article 40, paragraph (1): The workload of students during the academic year is realized through 30 (15 + 15) weeks of classes and 12 (4 + 4 + 4) weeks within which the time required for exam preparation and exams is provided.

Article 40, paragraph (6): The share of practical and/or field teaching is determined by ECTS credits.

Article 40, paragraph (7): One semester of study is evaluated with 30 ECTS credits.

The dual model must include:

- Hours scheduled for classes (lectures and exercises) at higher education institution.
- Hours provided for learning (exam preparation) and exams.
- Hours provided for work in companies/institutions.

Mentors in companies will need to attend and complete the prescribed program in the field of pedagogical education and the acquisition of teacher competencies, to acquire the necessary qualifications for participation in the practical part of teaching within the Dual Model of Higher Education.

2.2. Proposed Dual Model of Professional Undergraduate Study Programme of Computing

The current needs of the economy are primarily reflected in the constant demand and chronic shortage of quality and professional IT engineers. Existing trends point to even more pronounced disparities in the future if decisive action is not taken. The development of Bosnia and Herzegovina in the 21st century will not be possible without highly educated

computer and information staff. Therefore, we decided to offer young people, but also those older who want new knowledge and skills, education in this very interesting area through the professional undergraduate study of computing.

A new curriculum for the professional undergraduate study of computing was adopted in 2019. With these changes, the curriculum has been modernized and improved, and it has removed and identified the identified shortcomings in the previous curriculum, which has been implemented since 2004.

Several key determinants were considered when developing the new curriculum:

- The need to modernize the curriculum by introducing new subjects for areas of new technologies.
- Reduction of the number of general education subjects and at the same time inclusion of the development of practical projects from professional subjects in all semesters, except the final one.
- Providing prerequisites for gaining practical experience in the profession, but also solving specific complex engineering problems through professional practice and the preparation of a diploma thesis.

This curriculum seems very suitable for the implementation of the dual model of education because it involves a large share of practical work in companies. This is reflected both in the timeshare and in the share in the total amount of ECTS credits that the practical work brings.

During the three-year study, students will go through practical forms of learning through active engagement in the company, on projects that will be agreed with the faculty and will relate to professional content that has previously been theoretically covered in classical teaching.

The practical part of teaching, through projects that are performed in all semesters and the final work, which must also have a practical component, is realized by the following courses:

1. Project 1 in the first semester of studies (120 hours – 4 ECTS credits)
2. Project 2 in the second semester of studies (120 hours – 4 ECTS credits)
3. Project 3 in the third semester of studies (120 hours – 4 ECTS credits)
4. Project 4 in the fourth semester of studies (120 hours – 4 ECTS credits)
5. Practice / Project in the fifth semester of studies (450 hours – 15 ECTS credits)
6. Final thesis in the sixth semester of studies (450 hours – 15 ECTS credits)

In this way, during their studies, students in the company spend 1380 hours in professional work on approved projects and achieve 46 ECTS credits.

The Tables below show the lists of subjects by semesters, hours of lectures and exercises, as well as the corresponding number of ECTS for each of them.

Table 1. Course structure in the first semester

Course	L+E	Exam	ECTS
Programming 1	45+30	1	7
Mathematics	45+45	1	7
Digital Electronics	30+30	1	6
Internet and Web Technologies	30+30	1	6
Project 1	0+30*	1	4
Total	150+165	5	30

* hours with mentor in the company

Table 2. Course structure in the second semester

Course	L+E	Exam	ECTS
Programming 2	45+30	1	7
Applied Mathematics	45+30	1	6
Computer Architecture	45+30	1	7
Computer Networks	30+30	1	6
Project 2	0+30*	1	4
Total	165+150	5	30

* hours with mentor in the company

Table 3. Course structure in the third semester

Course	L+E	Exam	ECTS
Object Oriented Programming	30+30	1	7
Algorithms and Data Structures	30+30	1	7
Databases	30+30	,1	7
English Language 1	30+30	1	5
Project 3	0+30*	1	4
Total	120+150	5	30

* hours with mentor in the company

Table 4. Course structure in the fourth semester

Course	L+E	Exam	ECTS
Cloud Computing	30+30	1	7
Operating Systems	30+30	1	7
Development of Web Applications	30+30	1	7
English Language 2	30+30	1	5
Project 4	0+30*	1	4
Total	120+150	5	30

* hours with mentor in the company

Table 5. Course structure in the fifth semester

Course	L+E	Exam	ECTS
Introduction to Information Systems	30+30	1	5
Elective Course 1	30+30	1	5
Elective Course 2	30+30	1	5
Practice / Project	0+90*	1	15
Total	90+180	4	30

* hours with mentor in the company and mentor at the University

Table 6. Course structure in the sixth semester

Course	L+E	Exam	ECTS
Entrepreneurship and Computing	30+30	1	5
Elective Course 3	30+30	1	5
Elective Course 4	30+30	1	5
Final Thesis	0+90*	1	15
Total	90+180	4	30

* hours with mentor in the company and mentor at the University

Table 7. List of elective courses

Course	L+E	Semester	ECTS
Basics of Microcomputers	30+30	5 / 6	5
Multimedia Systems	30+30	5 / 6	5
Telecommunication Systems and Networks	30+30	5 / 6	5
Mobile Communications	30+30	5 / 6	5
Optical Communications	30+30	5 / 6	5
Programming in Java	30+30	5 / 6	5
Scripting Languages	30+30	5 / 6	5
Software Engineering	30+30	5 / 6	5
Practicum in Digital Image Processing	15+45	5 / 6	5

2.3. The Structure of the Practical Part of Teaching

The structure of student workload during the academic year of student work with employers is planned to be based on the proposed variant 4 of the generic model 1. The workload structure for semesters 1-4 is shown in Figure 1 and the workload structure for semesters 5-6 is shown in Figure 2.

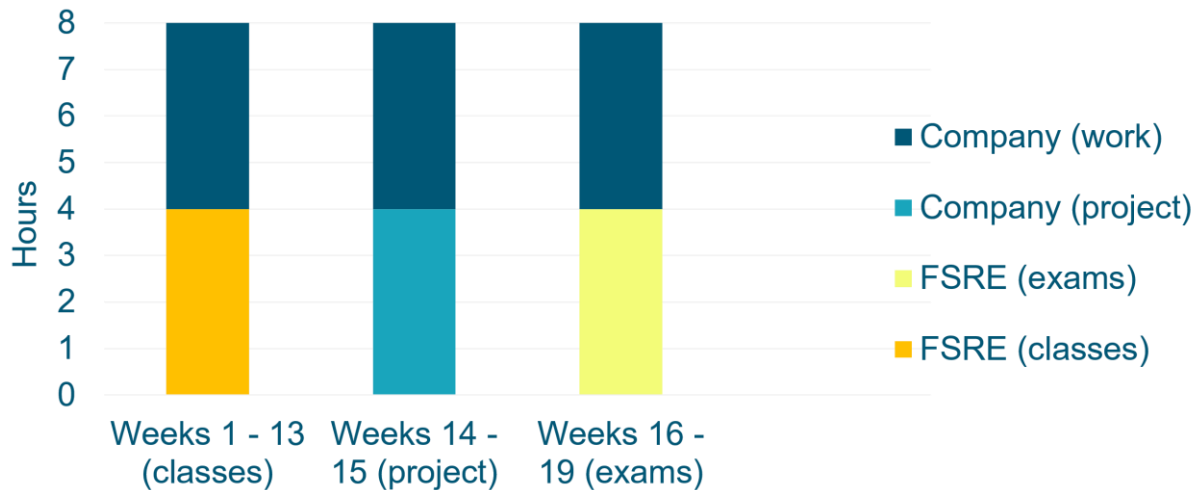


Figure 1. Structure of student workload for semesters 1-4

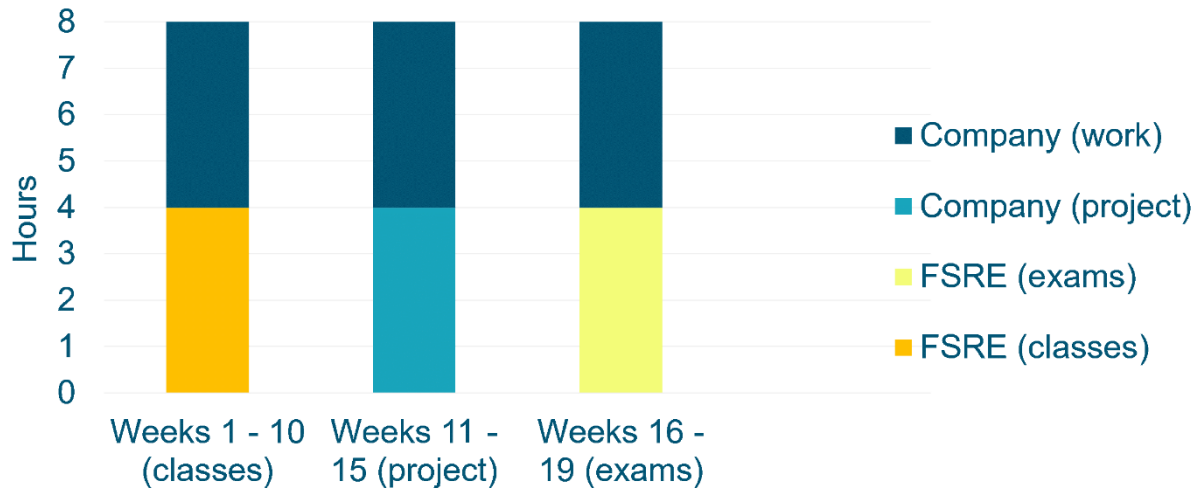


Figure 2. Structure of student workload for semesters 5-6

The structure of the practical part of the teaching is given below.

In semesters 1-4, the practical part of teaching in companies takes place within the courses **Project 1**, **Project 2**, **Project 3** and **Project 4**. As can be seen from the previously shown structure of student workload in semesters 1-4, these courses are held in the final weeks of the semester, after students have listened to other courses in that semester. It is envisaged that the knowledge and skills acquired in the subjects studied in that semester will be applied in these practical courses.

Subjects Project 1-4 involves individual or group work on practical projects proposed by subject teachers, faculty or company. Through project assignments, the student will express the level of adoption of the teaching content of the semester in which the project is performed (Project 1 - Programming 1, Digital Electronics, Internet and Web Technologies, Project 2 - Programming 2, Computer Architecture, Computer Networks, Project 3 - Object Oriented Programming, Algorithms and Data Structures, Databases, Project 4 - Cloud Computing, Operating Systems, Development of Web Applications) and the possibility of applying the acquired knowledge and skills to practical examples.

The goals of these courses are:

- Instruct students in solving practical problems.
- To train students for independent work and group work.
- Introduce students to the correct way of writing technical reports.
- Encourage students' communication skills.

After passing this course, students will know / be able to:

- Combine theoretical knowledge and practical skills in problem solving.
- Use literature, databases and other sources of information.
- Select appropriate methods and procedures for solving practical problems.

- Apply technical knowledge and skills to effectively solve engineering problems.
- Prepare a written report on the results of the work.

These courses carry 4 ECTS credits, which is equivalent to 120 hours of student time, of which 30 hours are spent working with a mentor in the company, and 90 hours for independent work of students on the project task, project report preparation and project presentation. One part of that time will take place in the final weeks of the semester, and the other, proportional part of the time, will take place in the weeks for exam preparation and exams.

In semesters 5-6, the practical part of teaching in companies takes place within the courses **Practice / Project** and **Final Thesis**. As can be seen from the previously shown structure of student workload in semesters 5-6, these courses are held in the final weeks of the semester, after students have listened to other courses in that semester. It is envisaged that the knowledge and skills acquired from all subjects studied throughout the study will be applied in the practical courses Practice / Project and in the Final Thesis, which must necessarily include the practical part.

The goals of these courses are:

- Combining theoretical knowledge and practical skills in solving practical problems.
- Introduction to the organization, work and business of the host institution.
- Solving practical professional problems.
- Inclusion in the labour market.

These courses carry 15 ECTS credits, which is equivalent to 450 hours of student time, of which 90 hours are spent working with a mentor in the company and/or mentor at the University, and 360 hours for independent work of students on the project/final thesis task, project/final thesis report preparation and project/final thesis presentation. One part of that time will take place in the final weeks of the semester, and the other, proportional part of the time, will take place in the weeks for exam preparation and exams.

3. Legal Conditions for the Realisation of Dual Higher Education Model

The University of Mostar has received an expert opinion from the Ministry of Education, Science, Culture and Sports of the Herzegovina-Neretva County, according to which the University, according to the Law on Higher Education, has the autonomy to regulate dual education by an internal act..

Article 102 of the Law states:

Paragraph (1): The sum of 60 ECTS credits corresponds to the average total student engagement in the scope of a 40-hour working week during one school year.

Paragraph (2): The total engagement of students consists of teaching (lectures, exercises, practicums, seminars, etc.), independent work, colloquia, exams, final work, volunteer work in the local community and other forms of engagement.

"Other types of engagement", which are stated in the Law, include learning through work.

Article 94 of the Law states:

Paragraph (1): A higher education institution shall act in accordance with the Administrative Procedure Law when deciding on individual rights and obligations of students, and, in particular, on:

- (a) Enrolment of candidates in the first year of study.
- (b) Enrolment of students in the following year of study.
- (c) The student's right to a diploma.
- (d) The measure of exclusion.
- (e) The obligation to pay the costs of studies.
- (f) Other cases provided by law.

On the basis of the above, there is room for signing a contract between a higher education institution, an organization where learning through work will be conducted and a student who would have the status of part-time student, and for whom **Article 85** of the said Law stipulates that "attend the study program with work or other activity".

The University Rule book on Dual Education will regulate the following:

- Basic terms (dual model, learning through work, employer, mentor with the employer, plan for the realization of learning through work).
- Way of performing and characteristics of the study program according to the dual model.
- Register of employers.
- Structure and content of the curriculum of dual model study program.

- Share and way of realization of learning through work.
- Conditions for conducting learning through work with the employer.
- Manner and conditions for student enrolment.
- Career guidance and counselling.
- Protection of student rights.
- Regulating the relationship between University, employers and students (Dual model agreement and Agreement of learning through work).
- Register of dual model agreement.
- Evaluation and exams in the dual model.
- Material and financial insurance of students.