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University of
Belgrade



**Implementation of Dual Education in Higher Education of
Serbia**

Kraljice Marije 16, 11120 Belgrade 35, Republic of Serbia

email: nzrnic@mas.bg.ac.rs



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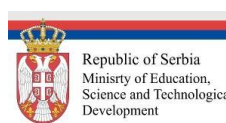
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REVIEW OF MASTER ACADEMIC STUDIES - INDUSTRY 4.0 AT THE UNIVERSITY OF BELGRADE - FACULTY OF MECHANICAL ENGINEERING

(created by Nis Cluster of Advanced Technologies)

contacts:

Prof. Dr.-Ing. Nenad Zrnić, tel: +381-63-287-193

Dr.-Ing. Žarko Mišković, , +381-64-18-32-989

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Abstract	This document represents the concept of specific DHEM developed at UB and represents a basis for the presentation of this DHEM to interested companies.
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Analysis of the contents and the relevance of the covered courses

The content of the MAS Industry 4.0 curriculum keeps up with the contemporary trends in the field of industrial production and it includes the multidisciplinary education of engineers. Courses that comprise the content of the curriculum represent relevant areas that are applied in practice in leading high-tech companies.

The representation of the courses that are currently relevant in Industry 4.0 allow students to obtain complete education – both in the field of information technologies and the contemporary industrial production.

MAS Industry 4.0 represents a modern concept of education of industry experts, which consists of the so-called „smart“factories. The main characteristic of the program MAS Industry 4.0 is its multidisciplinary, because it represents a combination of the most recent knowledge in the area of production engineering and informatics. The content and essence of this program is reflected in the new approach to the production process, which involves networking smart digital devices with the products, machines, tools, robots and humans.

In addition to the elements prescribed by the law regulating higher education, and the accreditation standards, the dual model study program MAS Industry 4.0 contains the description and scope of work-based learning, which is expressed in hours and ECTS credits. The proportion of credits gained through knowledge, through work and on the exam, corresponds to the workload of students in learning, work-based learning and in class.

The content of the courses studied at master academic studies Industry 4.0 is broad, covering a large number of areas that provide opportunities for students to acquire theoretical knowledge during these studies.

One of the courses is *Algorithms and Data Structures* that aims to acquire basic knowledge about data structures, fundamental algorithms, algorithm construction analysis and strategies. By studying this course, students have the opportunity to acquire basic knowledge about data structures, construction strategies and algorithm analysis, and the acquired knowledge can be applied in solving new problems.

Then, by studying the course *Virtual Reality*, students have the opportunity to get acquainted with the basic principles of computer graphics, elementary and complex transformations of objects in computer space. Then, they have the opportunity to develop basic and advanced models of ready-made software solutions with the aim of controlling graphic objects in 2D and 3D models conceived on computer platforms. The aim of this course is to enable students to

apply the acquired knowledge in scientific, technical and engineering applications of virtual reality, to design engineering software based on computer graphics and to integrate knowledge in the field of physicality of video games.

The course *Digital Factory and Intelligent Maintenance* aims to bring students closer to the logic of transforming the way products are designed and produced through digital production and design (DM&D – transition from "paper" processes to digital processes in industry. Also, the aim of this course is to acquaint students with: - the differences caused by technological innovation within Industry 4.0, in production planning, maintenance, facility design (layout), internal transport and material movement, inventory management, as well as what a digitally connected company is, in terms of business process optimization and the concept of product life-cycle management. After completing the course, students can understand what DM&D is and how it affects careers, practice and processes in companies, as well as the role of technology in Industry 4.0. Students will obtain the basic knowledge about digitally connected company and get acquainted with the available tools, technologies and techniques that may be applied in planning production, maintenance, facility design, internal transport and material movement and inventory management.

The aim of the course *Digital Measurement Systems* is to obtain theoretical and practical knowledge in the area of metrological systems – digital measurement systems required for the concept of digital quality and planning inspection in the context of Industry 4.0. After successfully completing this course, students will be able to: recognize, improve the existing and develop new protocols in communication between the virtual and realistic measurement machine; automatically generate the measurement protocol and reduce the measurement preparation period; develop new engineering ontology for the purpose of classifying the reuse and sharing knowledge in a certain domain, with the use of an optimal set of information based on Big Data and Analytics; apply the methods of intelligent inspection planning based on the techniques of artificial intelligence (GA and AC) and simulate the measurement process in virtual environment.

Furthermore, studying the course *Exquisition of Data* aims at numerical and mathematical ability of students to analyze each measurement, projection and writing program for the analysis of measurement, comparison of numerical data processing analysis and program analysis and application of PHP and JAVA SCRIPT. The result of studying this course is for students to be able to independently and professionally perform the given measurement and determine the requested or pre-required quantities, to analyze the quantities mathematically, numerically and statistically, and then to graphically and logically prepare for further analysis, and to design a

software, using PHP and/or JAVA SCRIPT, for performing data processing, which is mathematically determined in advance.

The aim of the course *Industrial Internet of Things and Cyber Security* is for students to acquire the knowledge and the skills required for the development of a reliable and safe industrial internet of things, projecting management systems distributed to smart devices (cyber physical systems) and safe, reliable and secure implementation of industrial internet. After the successful completion of this course, students are able to use a variety of computer networks in the industrial environment, to design and implement industrial system control systems distributed to smart devices, to verify smart device network performance, and to understand reliability and security issues.

Data Research aims to provide students with general knowledge about data research methods and possibilities of their application, and upon the completion of the course, students are acquainted with the basic methods of data research and trained for their practical application.

Studying the course *Cyber Physical Systems* should ensure that students acquire knowledge and skills in the design and implementation of cyber and physical systems through experience in the co-design of mechanical and control subsystems. Upon successful completion of this course, students will be able to design cyber physical systems by adding communication and computing abilities to mechanical devices, to implement smart and conventional sensors and actuators in various systems, design dedicated control systems based on microcontrollers and to understand the basic principles of motion control and implement management by creating movement in different tasks.

The aim of the course *Machine Learning* is to provide students with dual model studies with the basic models and algorithms of machine learning, key elements of their design and evaluation techniques. The outcome of this course is for students to be acquainted with the basic existing techniques of machine learning and the circumstances in which they should be applied, then understand how the decisions made in the process of algorithm design affect the behavior of the algorithm and to be able to assess the quality of such models.

Attending the course *Business Intelligence and Business Analytics* students will be acquainted with business intelligence as computer support for making management decisions. The emphasis is on theoretical and conceptual basis of business intelligence, as well as the commercial tools and techniques available for efficient support in making decisions. Also, the aim of the course is to acquaint the students with the concepts, basics and tools of business analytics, with a special emphasis on the application and examples of analytics in the real environment. After the

successful completion of this course, the students should be able to show knowledge of key principles and techniques of business intelligence and business analytics, to identify adequate tools/techniques of business intelligence and analytics for different business problems, to recognize and differentiate among situations in which it is possible to successfully apply the various techniques for data analysis and knowledge research, to show knowledge and understanding of different algorithms and quantitative techniques suitable for data analysis and knowledge research in a wide range of applications, as well as to make decisions based on data for optimizing the business process in accordance with the results of data analysis and the interpretation of the obtained results and to use practical knowledge and skills in the development and use of contemporary applicative software solutions for supporting business decision making.

During the realization of Practice (1 and 2) in the premises of the company that support the introduction of dual model studies, students obtain practical experience in the application of knowledge acquired at master studies courses in the real industrial/business environment; then, they acquire experience how to connect the obtained knowledge from various courses and integrate them into solving practical problems, to recognize the ways of organization and functioning of environments in which obtained knowledge will be applied in their future professional careers, to recognize and critically consider the organization models and trends of business information in the real business system, to recognize the basic processes in the design, production, maintenance, inventory management, quality assurance and occupational health and safety, in the context of future professional competencies, and finally, they will make personal contacts that they can use during their studies or starting employment.

The final part of MAS Industry 4.0 is the defense of the master thesis, whereby the thesis implies the implementation of research and preparation. The aim of writing the master thesis is the application of engineering knowledge, techniques and skills for identifying, formulating and solving the set engineering task, understanding the principle of product design and equipment and the environment required for their production, system, component or process design within the real limits, such as the economic, ecological, social, ethical, health and safety application of computer and statistical models, simulations and information technologies for analysis and synthesis of technological systems and the application of standard examination and measurement and the overview of results.

Good relationship between practical and theoretical classes

The advantage of the study program MAS Industry 4.0 is reflected in the greater dominance of practical classes, as opposed to the traditional study programs. Work-based learning at

employers, where the number of hours increasing from semester to semester, enables students to practically apply the obtained theoretical knowledge, but also to get to know the real work in the company during their studies. The connection of theoretical and practical knowledge is crucial in this case for complete acquisition of knowledge, which is covered through a simultaneous realization of practical and theoretical classes.

Every student studying according to the dual model will get an academic mentor when enrolling the studies. In addition to the academic mentor, every student will get a mentor from the employer. Then, as agreed with his/her academic mentor and the mentor from the employer, a study plan is defined within the first month from enrollment for every student separately, the one that is suitable for the dual model. Mentors have monthly meetings (or more than once per month if necessary) in order to make decisions about the work tasks for students, and reporting on the work and studying of students is performed every semester.

MAS Industry 4.0 lasts for two years, i.e. four semesters and they are valued with 120 ECTS. The total workload of students during the two-year study program MAS Industry 4.0 is 1005-1125 hours of active classes and 920-992 hours of work-based learning, depending on the elected courses and other forms of classes performed by the employer. Every employer is provided with guidelines for proceeding with students, based on which students are assigned with industrial mentors who will, together with the academic mentor, form a development plan for students and quantified indicators of his/her improvement based on which the student will be graded.

Within the standard study program, according to the accreditation, both the practice and the master thesis of 435 hours will be carried out at the employer, whereby the activities of students will be monitored in close cooperation between the employer's mentor and the master thesis mentor, while other forms of classes will be performed in the academic institution.

Adjusted dynamics of performance and the schedule of courses per years

At the beginning of the realization of the study program, students will get acquainted with the basic production systems, management and organization of the enterprise, as well as other courses enabling the student to get an insight into the functioning of one production organization. Getting acquainted with the current technological trends, such as robotics and artificial intelligence, machine learning, computer intelligence, students obtain the knowledge on current technological trends in the world, whereby they can connect their acquired theoretical knowledge with the later active work at the employer, but also with the experiences of other leading technological companies. The advantage of the study program is in the large number of elective courses, enabling students to focus in accordance with their interests.

The structure of the study program MAS Industry 4.0 contains 9 obligatory and 6 elective courses, 2 of which are professional practice during the third and fourth semesters, writing and defense of the master thesis at the end. The obligatory and elective courses have 6 ECTS, Practice part 1 – 6 ECTS, Practice part 2 – 9 ECTS, and activities connected to the Master thesis have 15 ECTS.

The aim of the master thesis is for the student to apply the obtained engineering knowledge and skills in order to be able to participate more efficiently in the identification and solution of a certain engineering task, then to efficiently participate in system, component or process design, within the real limitations, such as economic, ecological, health and safety, as well as to apply the computer and statistical methods and information technology for the analysis and synthesis of technological systems and to perform the overview of results.

The specificity of the program MAS Industry 4.0 is the professional practice, which will be performed during the second year of studies in two parts. The first part of the practice will be performed during the entire third semester (dynamics is as follows: one day per week with the total duration of 15 days), while the second part of practice will be performed in the fourth semester (the dynamics are as follows: the total duration of 40 working days). After the realization of practice, the defense of the master thesis is performed. 37 teachers and teaching associates work at the program MAS Industry 4.0, 6 of which are from abroad and 12 from the business sector.

Work-based learning in the first semester is represented by 24 hours, in the second semester by 72-96 hours, while in the third semester by 120-168 hours, and the fourth semester by 576-600 hours, it can be noted that the time spent on work-based learning is successively increased from semester to semester, whereby the possibility for the student to obtain theoretical knowledge acquired at the higher education institution is used and extended through work-based learning at the employer, with the realization of the synergetic effect of active classes and work at the employer's.

Expressed participation of companies – practical knowledge obtained by students that is to be used in work immediately upon the completion of studies

The program MAS Industry 4.0 combines traditional methods of learning in class with the work in companies and innovative processes, where students are involved in the regular work of the company and research projects. A great number of companies available for the realization of practical classes show how large the deficiency of their education staff is in the area of Industry 4.0. The annual quota of students being 35, and the number of companies ready to participate in providing practical classes 18, the ratio indicating 2 students per 1 company shows that practical

classes are covered entirely if all companies are ready to train 2 students the most. The provision of practical classes is covered at the highest level.

The fact that the benefits of introducing dual studies is great is evidenced by the fact of interest and willingness of a large number of companies participating in this process, through providing the possibility of realizing practice of students MAS Industry 4.0.

Among companies that are going to participate in the realization of professional training of students for work after completing studies is SAP University Competence Center that will, in cooperation with the company SAP SE, host and maintain SAP software and higher education institutions and other public education institutions will provide access to these systems. The exclusive purpose of SAP University Competence Center is enabling research, education and training for students, internal trainings for professors/lecturers and the preparation of scientific projects (diploma theses, master theses, doctoral dissertations, seminar papers, etc.) using SAP software.

Furthermore, the company Siemens Mobility doo Cerovac that has also taken part in the realization of the dual model studies, by providing the possibility of obtaining scholarships for master studies students (especially the profiles related to the design, production, control, examination and maintenance of rail vehicles, primarily from the Department for Rail Vehicles. The company is willing to employ students after completing their master studies in accordance with their needs, as well as to provide active participation of students on the current project for the purpose of obtaining practical knowledge and getting acquainted with new technologies and systems in the production of rail vehicles.

The company NPS d.o.o. participates in the realization of dual model studies, whereby the subject of cooperation is focused on organization and execution of teaching activities, professional practice, courses and other forms of education covering the area of business operations of this company, as well as leading and participating in the product development, monitoring, and adjusting the technological parameters of the operation of facilities, performing different types of laboratory and industrial research, design of various studies and projects, participating in the design of scientific, educational and professional projects and organizing professional conferences, announcements, papers and other publications.

The company Metalac ad has also recognized the significance of master studies Industry 4.0, indicating the readiness for the organization of student practice in their facilities, as well as the organization and realization of the teaching activities, professional practice, courses and other forms of education. The company is willing to participate and lead the product development, to

monitor and set the technological parameters of facility operation, as well as to participate in the conduct of various laboratories and industrial research and the preparation of project studies, belonging to the fields covered by the company activity.

The company NIS a.d. Novi Sad is one of the interested companies for the realization of dual model studies. This company will work with the faculty to transfer knowledge and technologies to students studying according to this model and to the professional improvement and exchange of knowledge and experience in areas of interest. The intention of NIS is to provide the realization of professional practice of students, in accordance with the needs of the company and the current policy and the dynamics of the valid program of corporate professional practice, the realization of field visits to the company, consultations of students with professionals from the company in creating final, master and other papers, as well as to provide participation of professionals from the company as visiting lecturers at the faculty, in the exchange of knowledge, for the topics of common interest.

Furthermore, the company Milinović Industries Group doo has also taken part in the realization of dual model studies, by providing the possibility of scholarships for master studies students (primarily the ones from the Department for Rail Vehicles), by employing these students upon the completion of their studies in accordance with the needs of the company, as well as involving students on current projects for obtaining practical knowledge and getting acquainted with the new technologies and systems in the production of rail vehicles.

The company Sloboda will contribute to the realization of the dual model studies by providing joint work with the faculty in solving the production, professional and other problems in organizing students' practice in the premises of the company, as well as the organization of the teaching activities, professional practice, courses and other models of education, as well as training company associates and teachers from the faculty.

Nelt Co d.o.o. is one more company to join the implementation of dual studies, ready to contribute to the realization of the dual studies objectives through its activities, by organizing professional practice for the enrolled students, for obtaining practical knowledge and skills for performing jobs in certain sectors of the company, for empowering for independent work. Also, the company has shown the willingness to offer employment to students who successfully complete their practice, depending on the needs of the company and in accordance with the needs for the process of work.

Recognizing the benefits of MAS Industry 4.0., the company Star Import d.o.o. Belgrade is ready to provide business and technical cooperation for the realization of mutual business interests in

areas covering basic activities of the company. The company Star Import is ready to participate through the realization of the program of professional practice for students of dual studies, by realizing the research required for writing scientific papers and theses, as well as by realizing the scientific and research projects in which students of these studies participate.

Furthermore, another company taking part in the support of dual model studies is the company Inmold plast doo, that is actively participating in the realization of class activities and professional practice for students of MAS Industry 4.0, as well as the realization of various types of laboratory and industrial research and to design studies and project covering the business operations of this company.

The company Iva 28 d.o.o. Belgrade has shown the willingness to provide students of the master study program Industry 4.0 with the realization of professional practice in their company, providing them with the possibility to involve students in the development of products during that period, as well as monitoring technical parameters of work and realizing various types of laboratory and industrial research, all with the aim of obtaining practical knowledge for professional training of students.

In addition to the readiness to provide the realization of professional practice, having in mind the benefits of introducing dual studies, the company Key IT d.o.o. is ready to take part in scientific and professional conferences in the country and abroad, as well as to create more favorable conditions for improvement and application of scientific knowledge, improving mutual relationships, initiating, considering, solving matters of mutual interest and needs.

The following companies have recognized the importance of introducing dual model studies: Servoteh d.o.o. Dobanovci, Composite Technology Team doo, Festo Gesellschaft m.b.H. branch in Belgrade, and Stell Product and Project, Bratel - Kron doo. These companies are also ready to participate in the organization and realization of the teaching activities, professional practice, courses and other forms of education covering the business operations of these companies, as well as to lead and participate in the development of the product, monitoring and setting the technological parameters of the plant, realizing various types of laboratory and industrial research, preparation of various studies and projects, participation in the preparation of scientific, education and professional projects and organizing joint professional conferences, announcements, papers and other publications.

The cooperation of the faculty with all the listed companies is based on respecting the principle of mutual trust, solidarity and good business relationships and mutual provision of the most

favorable advantages with equal conditions and respecting mutual needs and desires, and keeping trade secrets.