

# Implementation of the New Curricula in Smart Products and Services Engineering

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**Abstract**— Education system proved to have a challenge to cope with today's world of accelerated development of new technologies and ever changing industry. New paradigm dictates not only new teaching contents, but whole new holistic approach to the education of engineers, especially in the field of development of smart products and services. A group of professors from the University of Niš (Faculties of Electronic and Mechanical Engineering) developed a new teaching module named "Smart Products and Services Engineering" and successfully applied for funding from European Education and Culture Executive Agency in the scope of Jean Monnet Erasmus+ project call. Raising the level of knowledge and skills of students in the field of smart products and services should further encourage the development of a modern educational system in one of the most important areas of technology.

**Index Terms**—Smart products, smart services, engineering education.

## I. INTRODUCTION

The advancement of information and communication technologies is emerging at such a pace that they are increasingly penetrating traditional industries, changing products, processes, organizations, business models and entire value chains. Existing products are transformed into smart products [1], [2] which can intelligently communicate with other smart products and react autonomously to changes in their environment. Smart products are expanding into smart services or smart service systems. Designers today must quickly and flexibly integrate new trends and standards into their solutions. Therefore, the application of modern efficient engineering of the new generation of smart products and services, characterized by high interdisciplinarity, networking, complexity and heterogeneity, is more than necessary. Today, it is convenient to consider a holistic approach to engineering, where, in addition to the development of products and services, their complete life cycle is also taken into account. The components of holistic engineering are the models and methods used in the development process, IT tools, information models and organizational structures, united by human resources with appropriate competencies. The key competence of development engineers is creativity, because it enables successful innovations, i.e. the development of creative and market-competitive products. All these modern

tendencies dictate a new approach to education of engineers in the field of smart products and services [3], [4], [5].

With the goal to enable master students of technical faculties to acquire adequate competencies in the application of methods, models and IT tools in the efficient engineering of smart products and services, group of professors from the University of Niš successfully applied for funding from EACEA (European Education and Culture Executive Agency). Concrete project application was for Erasmus+ programme call Jean Monnet Actions in the field of Higher Education: Modules, with the project named "Smart Products and Services Engineering" (acronym SPaSE) 101047566-JMO-2021-HEI-TCH-RSCH. Project team consists of ten professors from two faculties: six from the Faculty of Electronic Engineering and four from the Faculty of Mechanical Engineering. Project duration is December 2021 - November 2023 (36 months), and during that time, project team is obligated to hold teaching module dedicated to Smart Products and Services Engineering for three generations of students. Students applicable for the module will be the students from technical faculties who already finished basic level of studies (either master students or working persons).

## II. PROJECT OBJECTIVES

Main objectives of the project "Smart Products and Services Engineering" (SPaSE) are:

- Acquiring the necessary knowledge and skills by the master students of technical faculties in the field of innovation and creative techniques for the development of smart market-competitive products and services.
- Mastering the methods, models and IT tools applicable in efficient engineering of the new generation of smart products and services.
- Transfer of acquired engineering competencies in the field of smart products and services to the business entities in the region.
- More efficient use of available human resources and faster integration of the region in the application of European achievements in this area.

Project aims to contribute to the acquisition of professional competencies and innovative readiness in the field of smart product development both in educational institutions and in economic entities in the region. New student teaching module will be the focal point, where the students will learn the basics of Industry 4.0 (I4.0), application of creativity and innovation in product development, basics of digital product development, application of artificial intelligence, sensor

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technologies and business models I4.0. Special attention will be paid to the development of relevant competencies [6]: professional, methodological, and social. Students will work in teams on practical projects where they will be able to strengthen creativity and teamwork.

Besides teaching part, project team will have numerous related activities oriented toward teaching and scientific community as well as toward local business entities in the field of smart products and services. A lot of events are planned like: round tables with business, workshops, study visits, writing research papers as well as a handbook on smart products and services. All these activities will help reaching the project specific objectives:

O1: Raising the level of knowledge and skills in the field of smart products and services

O2: Efficient application of methods and IT tools for engineering a new generation of smart products and services

O3: Application of creative and innovative techniques, which provides an opportunity for multidisciplinary application of advanced technologies

O4: Strengthening human and institutional resources in the field of research and development

O5: Encouragement to development of a modern educational system in one of the most important areas of technology

O6: Encouragement to strengthen the competitiveness of the national economy

O7: Increasing the technological readiness of educational institutions and economic entities for Serbia's integration into the EU.

### III. MODULE COMPOSITION

Jean Monnet Module "Smart Products and Services Engineering" is composed of 11 courses with 118 school hours of teaching in total. Module is organized in 15 weeks (3 months), two teaching days in a week, with 4 hours teaching blocks.

C1. Introduction to European integration and legislation in the field of smart engineering (6 teaching hours). The main goal is to enhance the existing theoretical understanding of legal, economic, political, and social aspects of European integration. The lectures are based on the interdisciplinary approach regarding the European integration process and its benefits, law, and future aspects with emphasize on the field of smart engineering.

C2. I 4.0: Smart products and services engineering (12 teaching hours). The main goal of the course is to master the knowledge and skills for the efficient application of engineering of the new generation of smart products and services. As part of the course, students will study basic approach in product design and development, modular principle in product development, Industry 4.0 and Reference Architecture Model for Industry 4.0 - RAMI 4.0, holistic approach in product development, smart product and service development models [7], [8].

C3. Creativity and innovation in product development (12

teaching hours). The main aim of this course is for students to master creative skills and competencies and also to present them innovative techniques which will be helpful in developing of future smart products and services [9].

C4. Digital product development (12 teaching hours). The course program will train students to independently use state of the art technologies and methods in the process of development of digital products. The acquired knowledge will enable students to create and holistically administer information, documents and resources in the digital product development process, thus fostering innovation [10].

C5. 3D CAD construction (10 teaching hours). Getting the knowledge about the basic geometrical objects and their relative positions and sections, developing surfaces, as well as the vector analysis and computing graphics. The focus of the course is on parametric design and the proper use of CAD software to produce 3D models, engineering parts, and documentation [11].

C6. Information technology (12 teaching hours). Introduction to the basic IT principles, methods, and techniques. The ultimate goal is the IT education of IT experts, capable of application of information technologies in the industry at all stages during the development of software solutions [12], [13].

C7. Artificial intelligence (12 teaching hours). The aim of course is to introduce the concepts and algorithms at the foundation of modern artificial intelligence, and explore the ideas that give rise to smart products and services. Through real world examples, students will gain knowledge to recognize and apply main tools and algorithms of AI and machine learning with the special emphasize on multilayer artificial neural networks (deep learning) [14], [15].

C8. Big data and data analytics (12 teaching hours). Upon completion of this course the students should become familiar with the principles of Big data and data analytics, gain understanding of the basic tools and techniques for data collection, processing and analysis. The desired outcome is to stimulate the students to adapt EU legislative in this area and apply main tools and algorithms of these concepts in design of simple smart products and services [16], [17].

C9. Internet and sensing technology (12 teaching hours). This course aims to provide an overview of technologies focusing on the Internet of Things and Industrial Internet of Things. Besides fundamentals and operational principles, the emphasize will be on introducing legal EU requirements and frameworks for building secure and reliable systems, opportunities and challenges, successful real-world practices, and efficient internet and sensing applications [18].

C10. Digital twins (10 teaching hours). Digital twin fundamentals, which integrate the internet of things, artificial intelligence, and software programming, will be introduced as a virtual representation of an object or system during its lifecycle, which is updated from real-time data and uses simulation, machine learning, and reasoning to help decision-making [19].

C11. Business models I4.0 (8 teaching hours). This course will be focused on analysing business model characteristics

for Industry 4.0, providing an in-depth perspective of companies' processes, structures, and tools for business model innovation. The course will also provide insight in EU good practices and competencies for business model innovation in the course of Industry 4.0 [20].

#### IV. CONCLUSION

This paper presented main aspects of newly designed student module at the University of Niš, named "Smart Products and Services Engineering". Module implementation is financially supported by European Education and Culture Executive Agency (EACEA) under the umbrella of Jean Monnet Erasmus+ project call. Module is jointly designed by professors from two faculties – Faculty of Mechanical Engineering and Faculty of Electrical Engineering. Module "Smart Products and Services Engineering" is composed of 11 courses with 118 school hours of teaching in total, organized during 15 weeks (3 months), two teaching days in a week, with 4 hours teaching blocks. Topics to be mastered are: Introduction to European integration and legislation in the field of smart engineering, I4.0: Smart products and services engineering, Creativity and innovation in product development, Digital product development, 3D CAD construction, Information technology, Artificial intelligence, Big data and data analytics, Internet and sensing technology, Digital twins, Business models I4.0.

Besides the main goal of the project which is acquiring the necessary knowledge and skills by the master students of technical faculties in the field of innovation and creative techniques for the development of smart market-competitive products and services and mastering the methods, models and IT tools applicable in efficient engineering of the new generation of smart products and services, project has several additional goals. Most important ones are the transfer of acquired engineering competencies in the field of smart products and services to the business entities in the region as well as more efficient use of available human resources and faster integration of the region in the application of European achievements in this area. In order to achieve all these goals, project anticipates besides teaching part, numerous related activities oriented toward teaching and scientific community as well as toward local business entities in the field of smart products and services. A lot of events are planned like: round tables with business, workshops, study visits, writing research papers as well as a handbook on smart products and services.

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