Flexible Pathways for Modernisation of Undergraduate Engineering Programmes by Country-Adapted Implementation of the Practice-Integrated Dual Study Model in Bulgaria and Romania

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ABSTRACT
The paper addresses the need for more flexible routes for acquiring current industry-related skills necessary to boost and sustain innovation in the sectors identified by the national strategies of Smart Specialisation and regional innovation in Bulgaria and Romania. For this purpose, regular practical phases in enterprises were integrated in the ongoing engineering curricula to accelerate the update of knowledge traditionally provided by higher education institutions. The paper presents a summary of the feasibility study conducted to identify the transferability of a country-adapted model of dual higher education in Bulgaria and Romania. Consequently, the approaches of curriculum adaptation followed by the implementing universities in both countries are briefly described. Finally, the paper discusses the outcomes and provides an outlook for future development of the dual study model in Bulgaria and Romania.

Keywords: dual higher education, responsive engineering curricula, industry-related skills

INTRODUCTION
The need for flexible and responsive engineering curricula is a challenge in order to keep pace with the rapid technological advancement and increasing innovation pressure. In EU aspect, the need for modernising the ongoing engineering curricula is particularly acute in the new Member States Bulgaria, Romania and Croatia, which were ranked as the modest innovators in the EU scoring the last three places in the 2018 European Innovation Scoreboard. This leads to missed economic opportunities for both the states and EU investors since industrial sectors such as manufacturing represent one of the main sectors of opportunity in the region. However, the shortage of skills has been widely recognized as a key obstacle for innovation in the sectors.
Problem Definition

Advanced technologies are changing manufacturing industries transforming traditional business models and supply chains into dynamic and interconnected systems. Thus, there is an urgent need to create a flexible, adaptable and active learning workforce [Marr, B., 2019]. Education providers are challenged to regularly update engineering curricula in order to respond to the rapidly changing business and technological environment. However, the modernisation of the ongoing curriculum is often obstructed by long process of design, approval and accreditation phases within the laggard legal framework (university perspective). On the other hand, there is a lack of methodology how to involve industry stakeholders in the design and delivery of curriculum content and practical in-company training (business perspective). To tackle these problems, the project “DYNAMIC” established a knowledge alliance between academic organisations, industrial enterprises and chambers of industry and commerce to ensure better labour market intelligence and improve innovation capacities of the academic and industrial stakeholders. The alignment of objectives can be materialised through a practice-integrated dual study education programme, which strengthens the supply-demand feedback chain between business and academia.

METHODOLOGY

The implementation of the dual study model in Bulgaria and Romania was examined in the scope of a feasibility study under the name “EUDURE – European Dual Research and Education”. Objective of the feasibility study was to identify the potentials and experiences of the countries in order to find adaptive elements for transfer that can best be harmonized and adapted to the regional structures and conditions. The EUDURE project examined the framework conditions and transfer options of the German dual study principles in Bulgaria and Romania and formulated specific recommendations for implementation. Subject of the study were two of the main forms of dual study programmes in Germany – programmes with integrated vocational training and practice-integrated dual programmes as defined by the German Council of Science.

The study was conducted in cooperation with stakeholders from Bulgaria and Romania, represented by higher education institutions and social partners. The EUDURE feasibility study has adopted for the country-specific investigation the transfer factors formulated by the German Academic Exchange Services (DAAD) for measuring the adaptation potential in other countries. Based on the DAAD methodology, country-specific data was collected in order to answer the following questions:

- What type and quality of binational exchange already exists?
- Does the educational governance structure promote transfer initiatives?
- Is there already an understanding of dual education models in the target countries?
- Are the economic conditions in the target country conducive?
- Legal framework and country specifics related to university internal rules
- Are there German companies in the target country who are interested in cooperations?

A further important condition for the transfer of the dual study form is the fundamental interest of social, economic and political decision-makers in the target country, e.g. through reforms and initiatives to promote dual training models. Results of the feasibility study will be exposed in the following section.

SUMMARISED RESULTS OF THE FEASIBILITY STUDY

Both Bulgaria and Romania offer study programs at the level of the German Bachelor's degree programs as part of the Bologna Process. In both countries, especially at universities, the focus is on practical and job-oriented university degrees. Both countries have comparable quality standards in
teaching, a uniform higher education system with ECTS and a similar semester schedule, divided into winter and summer semesters. Furthermore, the framework conditions (both political and economic) are set up so that a fundamental transfer potential exists. In both countries, the efforts to upgrade vocational training are prominently located with the adaptation of the German dual vocational training system in the implementation stage. Extensive networks and cooperation between national and international economic and institutional partners already exist in both countries. Many companies with German participation are located in Bulgaria as well as in Romania. Based on the evaluation factors of the DAAD study on the transfer potential, both in Bulgaria and in Romania very good starting points for the initiation of pilot projects on dual study are a further step within the readiness to reform and the paradigm change in the education sector.

In Bulgaria and Romania, there is a significant shortage of skilled workers in the forecasted economic upswing. This increases the demand for more practical orientation in highly qualified occupations and higher education. Therefore, the dual degree program is an attractive model for both countries. In both countries, a strong initiative of the economy is currently restructuring and rebuilding the vocational training structures, based on the German vocational training system.

**APPROACHES FOR CURRICULUM ADAPTATION FOR DUAL IMPLEMENTATION IN COUNTRY-SPECIFIC CONTEXT**

This section focuses on the adaptation of curricula of two of the university-partners in project Dynamic to curricula with dual education elements.

**Context of curriculum adaptation**

Higher education across Europe is strongly characterised by the Bologna Process, which reforms aim at more coherence to higher education systems across Europe. The implementation of education reforms based of Bologna objectives in the countries Bulgaria and Romania, in particular the three-cycle system, as well as use of ECTS and Diploma Supplement tools, are fundamental for the introduction of dual studies at higher education level. The tools of EHEA establish comparability between programmes at the same graduation level throughout Europe. In this context, similarities in the operational environment of the partner higher education institutions could be drawn in order to justify the transferability of the dual education model across Europe. These were used to identify common parts in the degree structures between Germany and Austria, where dual studies at undergraduate level are well established, with those in the transfer target countries Bulgaria and Romania.

**Constrains and limitations of the curriculum adaptation process**

Despite the similarities in higher education structures across the partnering countries in project Dynamic, different approaches, explained by the country specifics of the single national higher education systems, were followed by the academic partner institutions during the curricula adaptation process. Beside the constrains in curriculum adaptation imposed by the national regulations in higher education, certain domains are subject to additional control and standard implications that must be taken into account. A practical example is provided by Technical University Varna, Bulgaria during the curriculum evaluation and realignment of undergraduate programmes, which underlay the regulation of the Executive Agency “Maritime Administration”.

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Practice-integrated dual higher education in Romanian context Practical example “Mechatronics” in Lucian Blaga University Sibiu

The selected approach to tailor the educational process in order to comply with the requirements of the industrial partners was to adapt/change the syllabuses of specialty subjects. The adaptation of the curriculum for the dual study specialization were made by adapting/ changing the syllabuses of specialty subjects. Certain specialty subjects were selected for this change (Computers programming, Digital Electronics, Power Electronics, Microcontrollers Hydraulic and pneumatic driving systems and Programmable Logic Controllers). For the dual-study Mechatronics study program, supplementary hours of practical activities were added. A supplementary amount of 810 hours of practical activities were added to the existing 240, which will lead to a total amount of 1050 hour for the dual study option. Nine weeks of supplementary hours were added at the end of the 2nd, 4th and 6th semesters (a period which now is allocated to the summer holidays). Another difference between the regular and dual study forms is that students from dual study program must attend the extracurricular courses organized by the companies (mandatory requirement), while for the students from the regular study program the attendance is optional. A new syllabus for practical activities was designed for the dual-study program. Also new rules for assessing the students for the practical activities were established by LBUS and agreed with the industrial partners. All diploma works/graduation papers for the graduates of dual study program must be unfolded in companies (mandatory requirement).

The implementation of the practical phases for dual study specialization were formalized by contractual agreements between the university and the industrial partner (contract on practical work) as well as between the industrial partner and the student (contract of internship). The differences between the regular and the dual study form were also formalized by designing a modified curriculum for the dual-study option of Mechatronics study program, which was approved by the Council of the Faculty of Engineering and by the University Senate of “Lucian Blaga” University of Sibiu.

Practice-integrated dual higher education in Bulgarian context Practical example from Technical University Varna

The Innovation Strategy for Smart Specialization of Bulgaria as one of the thematic area includes “Mechatronics and clean technology”. At the end of 2018 the strategy was updated including new priority directions “Blue economy – development technologies”. Currently, there is an urgent need for personnel in the shipbuilding and ship repair industry in Bulgaria. For this reasons, the Bulgarian academic partner Technical University of Varna has selected the programmes “Naval Architecture and Marine Technology”, “Marine Engineering” and "Design of Marine Power Plants and Systems" for update of ongoing curricula and alignment with industry needs. The specific of the selected engineering domains is characterized by the strong regulation of the ongoing curricula and syllabus by the Executive Agency “Maritime Administration” and the International Maritime Organization – for the specialty of “Marine Engineering” only. In addition all specialties follow the rules and legislations provided by the Law on Higher Education and the rules of activity of the Technical University Varna. For this reason, the curricula could be only partly adapted for dual implementation by integrating of practical components in the existing plans. The approach for curricula update and integration of practical phases can be described with the following principles:
- all practical trainings (practices) included in the students' curriculum should not be conducted in the laboratories of TU-Varna, but on the territory of an industrial and design enterprises;
- laboratory exercises in specialized subjects (if possible) - to be conducted in the territory of an industrial and design enterprises.
- in the specialty of “Naval Architecture and Marine Technology” and “Marine Engineering” there are planned hours (respectively credits) for independent work, which were also incorporated into the
industrial enterprise training.

**Integrating practical components in the programme “Marine engineering”**

Students from the specialty of "Marine machinery" (“Marine engineering”), in the fourth year of their study, from the Bachelor's Degree program, have subject "Repair of Ship Machinery" in the winter semester. The programme was rescheduled in order to free two weeks at the beginning of December in which students were accepted for training at the industrial partner MTG Dolphin. During this period of two weeks, the students could pass their practical training directly involved in the repairs of marine machines and mechanisms. Classes were full-time for two weeks. All students signed a contract with MTG Dolphin, as well as they were asked to fill-in every day their diary with explanation of provided and solved tasks. A contract between TU-Varna and MTG Dolphin was also signed in advance before the training. Students who have already completed their practical training in the subject of “Repair of marine machinery” and have passed successfully their state exams in “Marine engineering” and English language for mariners, at the end of June, are currently employed on board of marine ships, part of the World Maritime Merchant Fleet.

**Integrating practical components in the programme "Design of marine power plants and systems"**

According to the increasing demand for marine engineers and designers of marine power plants and systems, in 2018 the Department of “Naval Architecture and Marine Engineering” has accepted the four students to study at the Master's Degree Program of "Design of marine power plants and systems". These four students, enrolled to the Master's degree program are part-time students. They currently work at Industrial Holding Bulgaria - “Ship Design”. Due to the small number of students and higher degree of flexibility, the programme was selected for test in dual mode. During the first two semesters of their study, students passed practical training at the Industrial Holding Bulgaria - "Ship Design" in the following subjects:

- „Computer systems for design of ships and marine equipment“- 1 part - 15 hours of lectures / 45 hours of exercises
- „Design of systems and devices for ships and marine equipment“- 30 hours of lectures / 15 hours of exercises
- „Computer systems for design of ships and marine equipment“- 2 part - 60 hours of exercises

The specialty of "Design of marine power plants and systems" is not under the specific regulations of Maritime Administration Executive Agency. This means that changes in the curriculum content are allowable and changes can be acceptable in accordance with the Law on Higher Education, the regulations, the rules of activity of the Technical University - Varna and the requirements of the industry.

**Integrating practical components in the programme “Naval Architecture and Marine Technology”**

According to the actual curriculum three are two practical activities. After second semester there is so-called “Introduction Practice” (30 hours) and after 6-th semester “Specialized practice” (60 academic hours - 2 ECTS). There are other subjects like Marine Piping Systems, Electrical Equipment of Ships and Marine Structures, Technical Safety, Structural Mechanics of Ships and Marine Structures, Welding of Marine Structures, Strength and Structure of Ships that include more than 500 extracurricular activities. Based on this the structure of the dual –study is organized in two phases: During semesters in TUV and in partner company – in summer vacation after 6th semester. The practical training is held in the summer months after the 6th semester in BULNAS (Bulgarian National Association of Shipbuilding and Shiprepair) companies with which TU-Varna has concluded partnership agreements.

The practice starts with the student application followed by approval by the company. In summer vacation after 6-th semester there are total 640 academic hours (480 astronomical hours). This is
equal to 60 working days (eight hours working day). The practice will be paid according to the company conditions. This and all other conditions will be described in the corresponding agreement. Special training logbooks will be elaborated for the needs of pilot implementation. All the necessary documentation - contracts, logbooks, reports etc. will be developed taking into account local conditions, based on good practices in partner countries involved in the project. Pilot implementation of dual study will be based on a voluntary choice by the students of the 3-year course.

OUTLOOK

The described activities of curricula adaptation and implementation in form of dual practice-integrated programmes aim to demonstrate the need of closer cooperation between education providers and business actors in the countries Bulgaria and Romania. Although the dual model itself is known from the past in both countries, the connection between the stakeholders needs to be re-established and strengthened. The developed programmes described in this paper are understood as a pilot introduction of the dual study model at higher education level. At this stage, only flexibilisation of ongoing curricula within the frame of the existing legislation could be achieved by integrating practical phases in the pilot programmes. The additional efforts of the dual students in comparison with those enrolled in the regular form of study could be demonstrated by using EU recognised tools such as the Diploma Supplement. However, for the future development of the dual study model in Bulgaria and Romania, there is a need for political action and adjustment of the higher education legislation that officially recognises the dual form of study. Within the scope of the project Dynamic, examples of dual higher education solutions were created and shall be serve to facilitate the dialog with policy makers.

CONCLUSIONS

Skills shortage and rapid workplace change create the need for agile workforce. To achieve this goal, higher education curricula should be more flexible and adaptive to the current industrial needs. The close business-academia cooperation is expected to strengthen the employability of the graduates by providing them with improved knowledge, skills and motivation. The dual higher education model provides a solution for more responsive education and talent growing for the benefit of all stakeholders.

ACKNOWLEDGEMENT

This paper was created with the support of the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

We thank our colleagues from the projects DYNAMIC - Towards responsive engineering curricula through europeanisation of dual higher education (588378-EPP-1-2017-1-DE-EPPKA2-KA) and EUDURE – European Dual Research and Education (01DS15017) who provided insight and expertise that greatly assisted the research, as well as for their active contribution and documentation of project results.
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