

Analysis of existing accredited study programs with a dual model in relation to labor market requirements in Serbia

Analiza postojećih akreditovanih studijskih programa sa dualnim modelom u odnosu na zahteve tržišta rada u Srbiji

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Abstract

The paper presents the results of a study conducted by the Academy of Applied Studies Politehnika within the project "Support to the Reform of the Dual System of Secondary Vocational Education and the National Qualifications Framework in the Context of Lifelong Learning in Serbia." The subject of the research is the analysis of the alignment between accredited dual study programs in higher education and the requirements of the labor market in the Republic of Serbia. The research is based on a qualitative-quantitative approach and includes an analysis of curricula, defined learning outcomes, and the results of a survey conducted among employers. The findings indicate a partial alignment between the competencies acquired by students and the needs of the economy, along with insufficiently developed mechanisms for the systematic involvement of employers in the evaluation and development of study programs. Based on the findings, guidelines are proposed for improving the dual higher education system and increasing the employability of graduates.

Keywords: dual education, learning outcomes, competencies, labor market, employability

Sažetak

Rad prezentuje rezultate istraživanja sprovedenog od strane Akademije strukovnih studija Politehnika u okviru projekta „Podrška reformi dualnog sistema srednjeg stručnog obrazovanja i Nacionalnom okviru kvalifikacija u svetlu celoživotnog učenja u Srbiji“. Predmet istraživanja je analiza usklađenosti akreditovanih studijskih programa sa dualnim modelom studija u visokom obrazovanju sa zahtevima tržišta rada u Republici Srbiji. Istraživanje je zasnovano na kvalitativno-kvantitativnom pristupu i obuhvata analizu kurikuluma, definisanih ishoda učenja i rezultate ankete sprovedene među poslodavcima. Rezultati ukazuju na delimičnu usklađenost između kompetencija koje studenti stiču i potreba privrede, uz nedovoljno razvijene mehanizme za sistemsko uključivanje poslodavaca u procese evaluacije i razvoja studijskih programa. Na osnovu dobijenih podataka predlažu se smernice za unapređenje sistema dualnog visokog obrazovanja i povećanje zapošljivosti diplomiranih studenata.

Glavne reči: dualno obrazovanje, ishodi učenja, kompetencije, tržište rada, zapošljivost

1. Introduction

Dual education represents one of the key directions in the development of contemporary educational systems, aimed at strengthening the link between education and the labor market. The introduction of a dual study model in higher education in the Republic of Serbia is expected to enhance the employability of graduates through the integration of

theoretical knowledge and practical experience acquired in real working environments. This model implies the active involvement of employers in the educational process, thereby enabling students to develop competencies that are directly applicable in practice. Within the framework of the project "Support to the Reform of the Dual System of Secondary Vocational Education and the National Qualifications Framework in

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the Context of Lifelong Learning in Serbia,” four studies have been envisaged, focusing on the development of the dual study model in higher education. The primary objective of these studies is to formulate conclusions and recommendations that contribute to the improvement of the dual education system and facilitate a smoother transition from education to employment. The Academy of Applied Studies Polytechnic implemented these studies during the period from 2024 to 2026, in accordance with the project assignment and action plan. This paper presents the results of one of the conducted studies—“Analysis of Existing Accredited Study Programs with a Dual Model in Relation to Labor Market Requirements in Serbia”—which focused on reviewing and evaluating currently accredited study programs with a dual model in higher education in the Republic of Serbia and their alignment with labor market demands. In recent years, a significant number of dual study programs have been developed, particularly within technical and technological fields; however, the question remains as to what extent the defined learning outcomes are aligned with the actual needs of the labor market. Existing practice indicates that the accreditation process does not sufficiently encompass the systematic verification of this alignment, nor does it clearly define mechanisms for evaluating the quality of the dual study model.

The objective of the conducted research was to examine the level of alignment between the learning outcomes defined within accredited study programs implementing the dual model and the requirements of the labor market, with the aim of enabling a more efficient transition of students from the education system into the world of work. In addition, the research sought to contribute to the development of a model for monitoring and evaluating dual education in higher education, as well as to enhancing the existing quality assurance framework. Particular emphasis was placed on identifying opportunities for the systematic involvement of industry in the development and evaluation of study programs, as well as on formulating recommendations for improving accreditation procedures and advancing qualification standards. The results of the research are intended to contribute to increasing the relevance of study programs, improving their alignment with the needs of the contemporary economy, and strengthening the overall system of dual higher education in the Republic of Serbia.

2. Theoretical framework

Dual education in higher education represents a model that integrates academic learning with practical experience in real work environments, with the aim of developing competencies relevant to the labor market. In the international literature, this approach is frequently associated with the concept of work-integrated learning (WIL), which implies the systematic linkage between educational institutions and industry in the process of knowledge and skills development (Cooper, Orrell, & Bowden, 2010). Within such models, students acquire not only theoretical knowledge but also practical skills and professional competencies through direct participation in

work processes. Contemporary research on dual higher education further emphasizes the importance of structured integration between academic and vocational components, highlighting the need for clearly defined models of curricular alignment and stakeholder involvement. Studies on dual study programmes in developed systems, such as Germany, demonstrate that the effectiveness of these models largely depends on the degree of integration between theoretical instruction and workplace learning, as well as on the governance mechanisms that connect higher education institutions and industry partners (Mordhorst & Jenert, 2023; Graf & Lohse, 2021). In this context, dual education can be understood as a specific form of work-integrated learning that requires a carefully designed curriculum and continuous coordination among stakeholders. Furthermore, the quality and outcomes of dual higher education are closely linked to the development of measurable indicators and quality assurance mechanisms, particularly in emerging systems such as Serbia (Marinkovic et al., 2022). The importance of university–business cooperation is additionally emphasized through comprehensive frameworks that define different levels and forms of collaboration, ranging from curriculum co-design to joint innovation activities (Galan-Muros & Davey, 2019). Finally, in the context of rapid technological change and Industry 4.0 transformation, dual education systems are increasingly expected to support the development of advanced technical, digital, and entrepreneurial competencies, which are essential for employability in modern industrial environments (Zheng et al., 2021).

Contemporary education systems increasingly emphasize employability as a key outcome of education. Reports by international organizations indicate that the development of competencies aligned with labor market needs represents one of the major challenges of educational policy (International Labour Organization et al, 2016). Dual education models are recognized as an effective response to this challenge, as they enable a smoother transition from education to employment and reduce the gap between theoretical knowledge and the practical requirements of the work environment. Within the framework of dual education, particular importance is attributed to learning outcomes, which serve as the foundation for defining the competencies that students acquire upon completion of their studies, i.e., upon graduation. Learning outcomes encompass knowledge, skills, and attitudes, and their clearly defined structure enables the assessment of the level of competence development and its alignment with labor market demands (Savić et al., 2021). The concept of constructive alignment emphasizes the need for coherence among learning outcomes, teaching activities, and assessment methods in order to ensure the quality of the educational process (Biggs & Tang, 2011).

In the context of the dual study model, learning outcomes acquire an additional dimension, as they include experiential learning in real work environments, which is often less formalized and encompasses a combination of

formal and non-formal learning. Research indicates that this approach contributes to the development of practical skills, professional socialization, and a deeper understanding of the work environment (Lock et al., 2009). However, it also highlights challenges related to the implementation of such models, particularly with regard to the standardization and evaluation of acquired competencies. A specific aspect of dual education concerns the development of generic (soft) competencies, including communication, teamwork, problem-solving, and adaptability. These competencies are widely recognized as essential for employability in contemporary society; however, their integration into curricula and assessment remains a significant challenge for higher education institutions (Chan et al., 2017). Dual study models provide an appropriate framework for their development, as they facilitate learning through real-life situations and interdisciplinary collaboration.

In addition, research points to the importance of integrating generic and academic competencies through teaching activities that transcend traditional educational frameworks. Lievens (2012) emphasizes that students in technical disciplines, through appropriate pedagogical approaches, can develop communication and reflective skills that are often neglected in conventional engineering curricula. Similarly, Treleaven and Voala (2008) highlight the significance of constructive alignment in the development of so-called “graduate attributes,” i.e., key competencies that include critical thinking, teamwork, and problem-solving abilities. These approaches confirm that competence development in dual education requires a carefully designed integration of theoretical and practical components, as well as clearly defined learning outcomes that reflect the real demands of the professional environment.

On the other hand, empirical studies focusing on students' experiences in industrial practice indicate a significant contribution of dual and related educational models to the development of professional competencies. Luk and Chan (2021) identify key dimensions of learning outcomes during engineering placements, including technical skills, professional behavior, and the ability to adapt to the work environment. Furthermore, Najid et al. (2012) point to the positive impact of industrial training on students' perceptions of their own competencies and their readiness for the labor market. However, Hussey and Smith (2002) draw attention to the limitations of the concept of learning outcomes, particularly in terms of their operationalization and evaluation, which further underscores the need for more flexible and context-sensitive assessment models in dual education.

This paper presents an analysis of existing accredited study programs in the fields of mechanical engineering and electrical and computer engineering that implement the dual study model in higher education, based on an assessment of program quality and their alignment with labor market requirements. This alignment is achieved through a systematic analysis of learning outcomes, continuous cooperation with industry, and the regular adaptation of curricula to changes in the economy. The

collection of feedback from students and employers, as well as the monitoring of employment trends, represents key mechanisms for improving the quality and relevance of study programs. In this regard, learning outcomes in dual studies can be observed through three main categories: academic knowledge, professional skills, and generic competencies. Academic knowledge encompasses theoretical foundations and disciplinary understanding; professional skills refer to the application of knowledge in practical contexts; while generic competencies enable effective functioning within professional environments. Their mutual alignment and connection with labor market requirements represent a key indicator of the quality of dual education.

Despite the potential of the dual study model, findings derived from the literature review indicate the need to enhance mechanisms of cooperation between educational institutions and industry, as well as to develop clear criteria for evaluating the quality and relevance of study programs. In this context, the analysis of the alignment between learning outcomes and labor market requirements serves as a foundation for identifying challenges and formulating recommendations for the improvement of dual higher education.

3. Research methodology

The research was designed as an empirical analysis of the alignment between study programs implementing the dual model in higher education and the requirements of the labor market in the Republic of Serbia. The methodological approach is based on a combination of qualitative and quantitative methods, enabling a comprehensive examination of the observed phenomenon from multiple perspectives. The qualitative component of the research includes a content analysis of accredited study programs, their objectives, structure, and defined learning outcomes, while the quantitative component involves the collection and analysis of data obtained through surveys of industry representatives. This approach enables the linking of formally defined educational outcomes with the actual needs of the labor market and facilitates the identification of key areas for improving the dual study model.

The research sample consisted of accredited study programs implementing the dual model in higher education within the fields of mechanical engineering, as well as electrical and computer engineering. These fields were selected due to their dominant representation within the dual higher education system in the Republic of Serbia, as well as their strong connection to economic sectors characterized by a continuous demand for highly educated professionals. According to data from the National Accreditation Body for Higher Education Quality Assurance, as of July 25, 2024, a total of 55 study programs implementing the dual model were accredited in the Republic of Serbia. Taking into account the duration of the accreditation cycle, programs accredited in 2017 were excluded from the analysis, while the focus of the research was on active programs accredited from 2021

onward, thereby ensuring greater timeliness and relevance of the data obtained.

The research encompassed three study programs: the professional bachelor's program in Mechanical Engineering, the professional bachelor's program in Mechatronics, and the professional master's program in Industry 4.0. The selected programs represent illustrative examples of dual study models within the technical and technological field and encompass different levels and profiles of education. The Mechanical Engineering program is oriented toward the development of knowledge and skills in the areas of design, manufacturing technologies, thermal engineering, and CNC systems, with a strong connection to production processes and industrial practice. The Mechatronics program is based on the integration of mechanical engineering, electrical engineering, electronics, automation, and information technologies, thereby educating professionals for work in modern automated and interdisciplinary systems. The master's program in Industry 4.0 is focused on advanced competencies in the fields of industrial digitalization, the Industrial Internet of Things, automation, data processing, smart systems, and contemporary production management models. A common characteristic of all three programs is their strong orientation toward work-based learning and the development of competencies directly applicable in industrial environments.

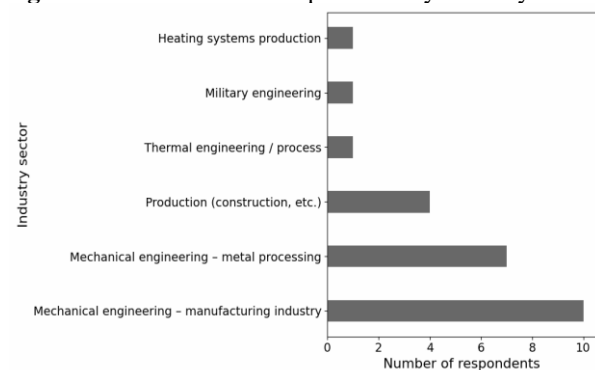
From a methodological perspective, as previously noted, a combined qualitative–quantitative approach was applied. The qualitative component of the research included a content analysis of the study programs, focusing on their key structural and substantive elements: the objectives and purpose of the program, the structure of the curriculum, and the defined learning outcomes. Particular attention was given to professional and practice-oriented courses, as they represent a crucial component in the development of competencies relevant to the labor market. In addition to the analysis of the study programs themselves, the research also incorporated available job descriptions and competency standards from real work environments in order to examine more precisely the relationship between educational outcomes and specific job tasks.

The quantitative component of the research was based on data obtained through a survey of employers, specifically through responses to a questionnaire designed to assess the alignment of the learning outcomes of dual study programs in higher education with the expected and required skills, knowledge, and competencies. The survey included 29 employer representatives, of whom 24 were selected for detailed analysis, as they are directly involved in the implementation of work-based learning within dual study programs. The questionnaire collected data related to the industrial sector in which respondents are employed, their position within the company, their length of professional experience, the study programs in whose implementation they participate, as well as the level of involvement of their organizations in the delivery of the dual study model and professional practice.

The structure of the respondent sample indicates a high level of relevance of the data collected. The majority of respondents come from the mechanical manufacturing and metal processing sectors, while sectors such as thermal engineering, military engineering, and the production of heating systems are represented to a lesser extent. In terms of professional roles, engineers and maintenance engineers predominate, alongside managers, directors, technical staff, and mentors.

The respondents are professionals with substantial experience, with an average of 17.29 years of professional experience and a median of 20 years. Such a sample structure adds further credibility to the findings, as the responses were provided by individuals directly engaged in technical, operational, and developmental processes within industry.

Figure 1. Distribution of respondents by industry sectors



Source: Authors' research

Survey data also indicate a high level of industry involvement in the implementation of dual education. All analyzed companies participate in the delivery of study programs based on the dual model, while a significant number are also engaged in the implementation of professional practice. With regard to the representation of study programs within companies, the Mechatronics and Mechanical Engineering programs are the most prevalent, whereas the Industry 4.0 program is somewhat less represented, although still significantly present. These findings confirm that the selected study programs are relevant to the needs of industry and constitute an appropriate framework for assessing the alignment of educational outcomes with labor market requirements.

Based on the comparison of the learning outcomes of the analyzed study programs with employer expectations, an assessment was conducted of the degree of their alignment with labor market needs. In addition, a comparative analysis of the curricula of these programs was carried out in relation to similar programs abroad and at other domestic higher education institutions in order to evaluate their alignment with contemporary trends in education and industry. By combining these approaches, a comprehensive framework was established for analyzing the relevance of dual study programs and formulating recommendations aimed at improving their quality and the employability of graduates.

4. Results and analysis

The results of the survey conducted among employers indicate a high level of alignment between the analyzed study programs implementing the dual model and the requirements of the labor market in the Republic of Serbia. Employers rated very highly the statement that learning outcomes are aligned with labor market needs within the relevant sector, with an average score of 4.72. No respondent provided a negative or neutral evaluation, indicating a clear consensus that the defined learning outcomes largely correspond to the needs of industry. Similarly, the curricula of the study programs were highly evaluated in terms of enabling the acquisition of professional and specialized knowledge required for work in the respondents' companies, with an average score of 4.71. These results confirm that the analyzed programs substantially meet the contemporary demands of the working environment and support the development of a professional workforce relevant to industry.

A particularly significant finding relates to the assessment of technical and professional skills acquired by students during their studies. Employers rated the curricula as highly effective in developing the professional skills required for work in their companies, with an average score of 4.63. Although this rating is also very high, it is slightly lower than those related to the overall alignment of learning outcomes and professional knowledge, which may indicate that there is room for further improvement in the practical application of knowledge. In other words, employers recognize that the study programs are well structured in terms of objectives, content, and defined competencies, while also pointing to the need for further development of specific professional skills through more intensive practical instruction and greater integration of real work tasks into the learning process.

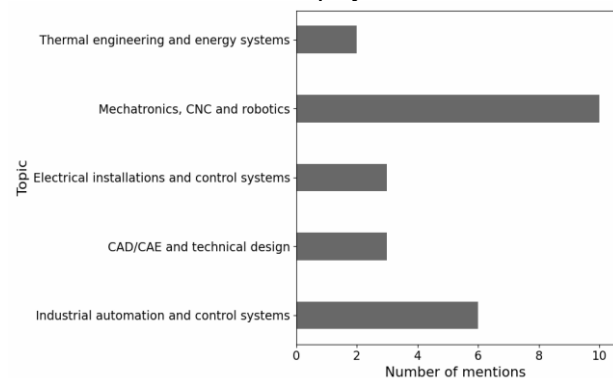
Similarly, the soft skills developed through the analyzed study programs were evaluated very positively. An average score of 4.71 indicates that employers believe the programs successfully foster the development of communication, teamwork, and organizational competencies, which are essential for effective functioning in contemporary industrial environments. Particular emphasis was placed on teamwork, creativity and problem-solving, flexibility and adaptability, as well as communication skills. These findings are of considerable importance, as they confirm that the dual study model contributes not only to the development of technical knowledge but also to shaping a broader competency profile of graduates, including interpersonal and organizational abilities.

The highest average score in the survey was assigned to the statement that learning outcomes enable the monitoring of technological changes and emerging industrial standards, with an average score of 4.83. This result is particularly significant in the context of technical and technological disciplines and processes of industrial transformation, as it indicates that employers perceive the analyzed study programs as sufficiently flexible and modern to respond to dynamic changes in production and

technological systems. This finding also underscores the importance of programs such as Industry 4.0, which focus on digitalization, automation, data processing, and the integration of new industrial technologies.

However, despite the overall results indicating a high level of alignment, a more detailed analysis of employers' open-ended responses reveals the existence of a certain gap between educational outcomes and the specific needs of industry. This gap is not reflected in a lack of fundamental knowledge, but rather in the need for a stronger practical application of existing content and a deeper development of certain competencies directly related to the work environment. Employers particularly highlighted production technologies and CNC machining, CAD/CAM and technical documentation, industrial automation and control systems, software and digital skills, maintenance and diagnostics, robotics and programming, as well as knowledge in the field of energy and thermal systems as key professional competencies expected of new employees. These findings confirm that the labor market places the highest value on applicable, operational, and technologically up-to-date knowledge.

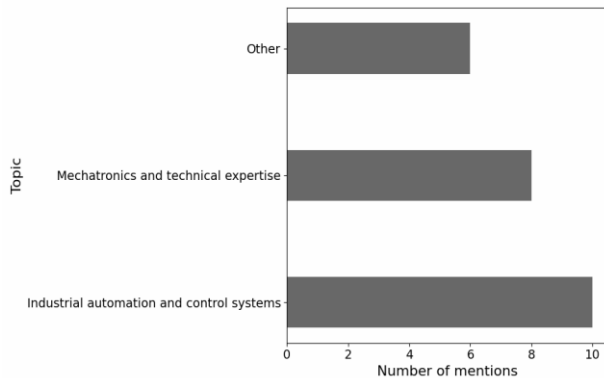
Figure 2. Results of respondents' answers to the question regarding the key technical skills they seek in new employees



Source: Authors' research

With regard to missing professional knowledge, the majority of respondents indicated that they do not perceive significant deficiencies in the learning outcomes of the study programs. However, a portion of employers pointed to the need for a stronger emphasis on content related to the Internet of Things (IoT) and industrial digitalization, maintenance and diagnostics, as well as energy and thermal systems. Similar patterns were observed with respect to technical skills. Although the study programs were assessed as being well aligned with labor market requirements, employers emphasized that students often lack sufficient practical experience in areas such as predictive maintenance, fault diagnostics, working with energy and process systems, as well as familiarity with quality standards and standardization. This suggests that the gap between education and the labor market is not primarily content-related, but rather functional and implementation-oriented, as employers recognize the relevance of these subject areas while highlighting the need to further strengthen practical training and its connection to real industrial tasks.

Figure 3. Respondents' answers to the question of which learning outcomes (knowledge, skills, attitudes) will be important for the future implementation of their company's development plans



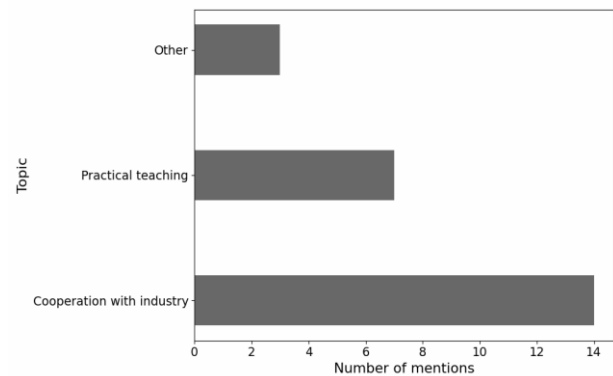
Source: Authors' research

The analysis of responses regarding knowledge and skills that employers consider less necessary or outdated further illuminates this issue. The majority of respondents indicated that there is no redundant knowledge within the analyzed study programs, confirming that the programs are designed on a sufficiently broad and relevant foundation. However, some employers noted that certain highly specialized and theoretically oriented content is less directly applicable in their work context. This primarily refers to advanced robotics and autonomous systems, highly specialized research-oriented knowledge, content related to technological entrepreneurship and innovation management, additive manufacturing, and certain advanced topics in artificial intelligence. The data obtained do not suggest that these areas are unimportant; rather, they indicate that industry does not perceive them as a priority for initial professional engagement in most of the analyzed sectors. Therefore, it can be concluded that it is desirable to retain contemporary and development-oriented content, while positioning it more carefully in relation to the core, directly applicable competencies expected of graduates by the labor market.

The role of employers represents one of the most significant findings of the research. On the one hand, the results indicate a very high level of industry involvement in the implementation of the dual study model, as all analyzed companies participate in the delivery of dual study programs, while a significant number are also involved in the organization of professional practice. Such findings confirm the existence of a solid foundation for cooperation between educational institutions and industry. Furthermore, the respondent profile reinforces the credibility of the data collected, as engineers, maintenance engineers, and managers with substantial professional experience constitute the majority of participants. On the other hand, employers' responses also indicate that their role is not yet sufficiently systematized when it comes to shaping and periodically improving learning outcomes and curricula. Most recommendations provided by respondents relate specifically to the need to strengthen cooperation with industry, increase the involvement of companies in the design of study program content, and

expand the scope of practical teaching through case studies, simulations, project-based tasks, and engagement with real production-related problems.

Figure 4. Results of respondents' answers to the question requesting recommendations for aligning the learning outcomes of dual study programs with current and future labor market needs



Source: Authors' research

In this regard, the research indicates that the key weakness of the dual study model does not lie in its fundamental concept, but rather in the degree of institutionalization of cooperation with employers. Employers have clearly articulated the need for deeper partnerships with higher education institutions, not only in the implementation of work-based learning, but also in the planning, evaluation, and revision of study programs. This entails the regular collection of feedback from industry, the involvement of practitioners in redefining learning outcomes, and the strengthening of mechanisms to ensure that curricula reflect both current and future labor market needs.

In addition to the identified challenges, the research also highlights several positive findings, including examples of good practice. First and foremost, the results confirm that the analyzed study programs are well oriented toward the development of competencies relevant to contemporary industry. Key strengths of the programs include strong coverage of technical areas such as manufacturing technologies, automation, mechatronics, CNC systems, digital technologies, and industrial standards, as well as the inclusion of generic competencies recognized as important for employability. It is particularly significant that employers recognize the ability of these study programs to keep pace with technological changes, which confirms their relevance and potential for further development.

A positive finding is also reflected in the fact that Mechatronics and Mechanical Engineering are among the most represented study programs within companies participating in dual education, while the Industry 4.0 program, although somewhat less represented, demonstrates clear developmental potential in the context of the growing demand for professionals focused on automation, digitalization, and contemporary industrial systems. Furthermore, employers' recommendations are not directed toward radical changes in existing study programs, but rather toward their further enhancement

through increased practical instruction, stronger links with industry, the development of digital and analytical competencies, and a more systematic approach to the development of communication, organizational, and professional skills.

Based on all the findings, it can be concluded that the analyzed study programs implementing the dual model possess a high level of relevance to the labor market. However, their further development should be directed toward strengthening the practical dimension of learning, more closely linking learning outcomes with real work tasks, and enhancing the institutional involvement of employers in quality improvement processes. It is precisely within this balance—between a well-established educational framework and the need for its continuous adaptation to the contemporary industrial environment—that the key to the future development of dual higher education lies.

The competency framework of the study programs included in the comparison is based on three analyzed programs: Mechanical Engineering, Mechatronics, and Industry 4.0. The Mechanical Engineering program has the broadest engineering foundation and encompasses knowledge in mechanics, thermodynamics, manufacturing technologies, CAD/CAE/CAM tools, metrology, quality standards, and CNC technologies, along with skills in design, technical calculations, production process management, and fault diagnostics. The Mechatronics program is multidisciplinary in orientation and integrates mechanics, electronics, automation, sensors, actuators, PLC systems, robotics, and industrial communication, enabling students to develop competencies for the design and management of automated and robotic systems. The Industry 4.0 program focuses on the digitalization of production, IoT/IIoT, industrial networks, data processing, cyber-physical systems, digital twins, and process optimization, with a particular emphasis on managing smart factories and data-driven decision-making.

The results of the comparison indicate that the study programs differ in the depth and breadth of coverage of specific occupations and competency domains. Mechanical Engineering demonstrates the highest level of alignment with most of the analyzed occupations, particularly in the areas of traditional mechanical design, manufacturing, thermal engineering, maintenance, and CNC technologies. Mechatronics shows the highest degree of alignment with occupations involving automation, servo and CNC systems, sensors, diagnostics, and the integration of electromechanical components, particularly for the profiles of mechatronics engineers and production and maintenance engineers for machine tools. Industry 4.0 demonstrates the greatest relevance in the domains of digitalization, industrial communication, IoT/IIoT systems, smart maintenance, and industrial data management.

A comparison across knowledge, skills, and competency domains indicates that Mechanical Engineering provides a broad foundation for the majority of traditional

engineering positions, while Mechatronics and Industry 4.0 exhibit more specialized profiles. Mechatronics is particularly strong in the fields of automation, robotics, and integrated systems management, but provides more limited coverage in areas such as thermal engineering, process plants, and energy calculations. Industry 4.0 offers significant advantages in digital and analytical competencies but shows limitations in areas such as classical mechanical calculations, design, and traditional manufacturing technologies. The weakest alignment of this program is observed in occupations related to process engineering and thermal energy systems.

The quantitative summary confirms these findings, as the average alignment of the Mechanical Engineering program with the analyzed occupations is 4.125, compared with 3.0 for Mechatronics and 2.125 for Industry 4.0 on a scale from 0 to 5. These results indicate that the analyzed study programs are not competitive but complementary: Mechanical Engineering provides a broad foundation for traditional technical profiles, Mechatronics covers integration and automation, while Industry 4.0 strengthens the digital, communication, and data-driven dimensions of contemporary industry. Based on these findings, it can be concluded that the further development of dual study programs should be directed toward strengthening elective options, specialized modules, and micro-credentials in order to better address underrepresented areas and further improve alignment with the specific needs of the labor market.

5. Discussion

The obtained results indicate that the analyzed study programs implementing the dual model in higher education achieve a high level of alignment with labor market requirements, particularly in terms of professional knowledge, technical skills, and general competencies considered important by employers for work in a contemporary industrial environment. The high average ratings assigned by employers regarding the alignment of learning outcomes with labor market needs, as well as the ability of the programs to keep pace with technological changes and emerging industrial standards, suggest that the dual study model largely fulfills its primary function of linking education and employment. It is particularly important to emphasize that employers do not perceive a significant discrepancy between what study programs formally prescribe and what industry requires; rather, they point to the need for a stronger practical application of this content. In a broader context, these findings confirm that the dual study model in higher education within technical and technological fields in the Republic of Serbia has reached a certain level of functional relevance, although its full potential has yet to be realized. The dual education model is expected to entail not only the formal inclusion of work-based learning but also a continuous, structured, and mutually beneficial partnership between higher education institutions and industry. In this regard, the research results indicate that the foundational architecture of this model is well established, yet there remains a need for stronger alignment between learning outcomes and specific work tasks, technological developments, and

sector-specific industry requirements. A particularly important finding is that the identified gap does not relate to the absence of relevant topics in the curriculum, but rather to the need to further strengthen certain areas, such as maintenance and diagnostics, IoT integration, standardization, communication skills, and work organization, through practical forms of teaching and real industrial projects.

The obtained results are largely consistent with previous international and national studies on dual higher education. Similar to the findings of Mordhorst and Jenert (2023) and Graf and Lohse (2021), this research confirms the importance of strong integration between academic learning and practical work environments, as well as the need for continuous cooperation between higher education institutions and industry. The results also correspond with those of Marinkovic et al. (2022), particularly regarding the importance of quality assurance mechanisms and employer involvement in the development of dual study programmes. Furthermore, the identified need for stronger digital and Industry 4.0 competencies is aligned with the trends discussed by Zheng et al. (2021). Unlike some international studies that identify larger structural gaps between education and labor market needs, the results of this research indicate a relatively high level of alignment between learning outcomes and industry expectations, especially in technical and technological fields.

The results of the comparative analysis of competency frameworks further deepen the understanding of this issue. They demonstrate that the study programs Mechanical Engineering, Mechatronics, and Industry 4.0 are complementary and correspond to different segments of contemporary industry. Mechanical Engineering shows the broadest alignment with the analyzed occupations and represents a stable foundation for traditional engineering profiles, while Mechatronics and Industry 4.0 strengthen the automation, digital, and integration dimensions of competencies. This indicates that the dual education model should not be viewed solely through the lens of individual study programs, but rather as a broader system in which different educational profiles collectively respond to the complex needs of the labor market. At the same time, this analysis highlights those certain specific areas, such as process industries, thermal energy systems, and precision engineering, require additional specialized content, elective modules, or micro-credentials in order for the education system to respond more flexibly to industry demands. The implications of these findings for higher education institutions primarily concern the need for continuous curriculum revision, greater reliance on feedback from industry, and stronger integration of theoretical instruction with the work environment. For policymakers in education, the results point to the importance of developing clearer criteria for evaluating the quality of dual study programs, particularly with regard to the relevance of learning outcomes, employer involvement, and graduate employability. For industry, the findings confirm that its contribution is important not only in the implementation of professional practice and

work-based learning but also in the planning, evaluation, and improvement of study programs. In this sense, the further strengthening of dual higher education requires an institutionalized partnership between education and industry, based on the regular exchange of knowledge and experience, the joint definition of priorities, and the flexible adaptation of educational content to the dynamic changes of the contemporary labor market.

6. Conclusion and recommendations

The conducted research confirmed a high level of alignment between accredited dual study programs and labor market requirements in the Republic of Serbia. Through the analysis of curricula, learning outcomes, and employer perspectives, the study showed that the analyzed programs—Mechanical Engineering, Mechatronics, and Industry 4.0—provide relevant professional knowledge and practical skills, with high employer evaluations confirming the contribution of the dual model to graduate employability. The results particularly emphasize the importance of work-based learning and the strong alignment of competencies with the needs of modern industry, especially in the areas of production, automation, maintenance, and digitalization. At the same time, the research identified several challenges, primarily the need for stronger employer involvement in the development and evaluation of study programs, as well as the further improvement of practical instruction through real industrial projects. Additional attention should also be given to the clearer integration of generic competencies, particularly communication, teamwork, organization, and adaptability, into defined learning outcomes.

Based on the findings obtained, the following recommendations can be identified:

In the area of accreditation:

- to enhance accreditation standards for dual study programs through a clearer definition of learning outcomes in relation to specific competencies required by the labor market;
- to introduce more flexible curriculum models that enable the development of specialized modules and micro-credentials (e.g., IoT, maintenance, standardization, process engineering);
- to further develop criteria that assess the applicability of knowledge and graduate employability.

In the area of industry involvement:

- to institutionalize the role of employers in all phases of study program development (planning, evaluation, and revision), rather than limiting their involvement solely to the implementation of work-based learning;
- to develop models of long-term partnerships between higher education institutions and companies through joint projects, mentorship, and the co-development of teaching content;
- to encourage more active participation of industry in defining qualification standards and professional competencies.

In the area of quality assurance:

- to improve mechanisms for the continuous monitoring of the alignment between study programs and labor market requirements;
- to systematically incorporate feedback from employers, graduates, and students into quality improvement processes;
- to develop models for evaluating work-based learning as an integral component of the quality assurance system.

Future research should focus on expanding the analysis to a larger number of study programs and scientific fields in order to provide a broader perspective on the dual higher education system. In addition, future studies could examine the long-term effects of dual education on graduate employability and career development, as well as develop models for the quantitative monitoring of competencies and their development throughout the educational process and within the workplace. Particular attention should also be devoted to analyzing the effects of emerging technologies, such as artificial intelligence, digital twins, and Industry 4.0, on the structure of learning outcomes and curricula.

The conducted analysis leads to the conclusion that dual study programs in higher education in the Republic of Serbia represent a stable and promising model that contributes to strengthening the link between education and industry, improving the quality of study programs, and increasing the competitiveness of the workforce. The results of the research provide a solid foundation for the further development of the regulatory, institutional, and methodological framework of dual higher education, in accordance with the needs of contemporary society and the principles of lifelong learning.

Despite the valuable findings obtained through the research, certain limitations should be acknowledged. The research was conducted on a relatively limited sample of employers and focused exclusively on selected dual study programmes within technical and technological fields, which may limit the generalizability of the findings to other scientific and professional areas. The selected study programmes were chosen because the majority of accredited dual study programmes in the Republic of Serbia are currently developed within technical and technological fields, where the dual model is most strongly represented. In addition, the analysis included only selected accredited study programmes in the Republic of Serbia; therefore, the results should be interpreted within the specific institutional and sectoral context of the analyzed programmes. Nevertheless, the research provides a relevant basis for further analysis and the development of dual higher education models in Serbia.

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