Integration of Emerging Technologies in Dual Education in the European Union and Romania: Trends and Challenges

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Abstract

The development of new emerging technologies, together with the continuous transformation of labour market requirements, has increased the importance of dual education. Dual education represents an educational and training system concerned with incorporating theoretical knowledge acquired after studying in educational units with practical training in the corporate field. This concept aims to develop young people's professional competencies in order to promote their integration in the labour market. The main players within dual education are economic operators who are responsible with the practical training and employment integration of the participants. The purpose of this paper is to analyse dual education and the role of emerging technologies within this framework. The research is based on an exploratory analysis involving the examination of a series of statistical data. The results indicate that dual education in Romania has developed progressively in recent years and shows further growth potential in the period ahead. Nevertheless, regarding individuals' digital competencies, Romania remains below the European average across several indicators. Consequently, there is a clear need to further develop digital competencies at the national level in order to facilitate young people's labour market integration and to support the educational process innovation.
Keywords: Dual Education, Emerging Technologies, Digital Transformation in Education, Digital Skills Development, Educational Innovation

Introduction

Novel digital technologies' rapid development has led to considerable changes in the labour market, notably in the requirements of skills necessary for professional integration. This transformation has resulted in an increased demand for professionals with multiple

specialisations applicable to different sectors. Professional experience has become an essential criterion for economic operators, making relevant practical experience a major advantage for those seeking employment. At the same time, the evolution of digital technologies has led to the automation of a considerable number of jobs, thereby making professional integration more challenging for young people. In this context, dual education has gained increasing importance in developing the competencies required by the labour market. Consequently, young people have become more open to change and to the integration of new technologies into professional activities (Koudahl, 2010). In recent years, the implementation of this type of education has gained greater relevance, as it relies on partnerships between economic operators, educational institutions, and local administrative authorities (Ciobănică, 2023).

In this context, the dual education system (Cherkashyn, 2021) has been analysed and applied across several European countries. Nevertheless, there are still countries where the regulatory frameworks required for its effective implementation are lacking. According to Castro et al. (2022), dual training is primarily used in supplementary professional education and vocational training, combining practical activities carried out within companies with theoretical preparation provided by educational institutions (Kondratska et al., 2023). At present, dual education is widely implemented in countries such as Germany (Kravchenko et al., 2023), Austria, France, and Switzerland. To facilitate the learning process, this model employs simulations and case studies aimed at supporting the practical application of theoretical knowledge (Abdeen et al., 2025).

A defining feature of dual education is the direct involvement of participants in both theoretical learning and practical workplace activities. For this model to function effectively, it is necessary to create optimal conditions for the assimilation of both theoretical and practical knowledge (Nagy and Hokstok, 2026). Furthermore, recent digital transformations have highlighted the need for continuous adaptation among young people in order to meet evolving labour market requirements. In addition, research indicates that people registered in dual education systems gain increased resilience, which leads to enhanced performance, as well as lower school dropout rates compared with other forms of education (Masten and Ann, 2021).

From a conceptual perspective, dual education is defined as an educational model that combines learning within educational institutions with practical training conducted in the workplace (Kutumova and Yarkova, 2016). The two components hold comparable importance; however, the practical component generally accounts for at least 50% of the training process (UNESCO, 2011). The concept of duality refers both to the existence of two learning environments, the educational institution and the company, and to the collaboration between public and private actors involved in the training process (European Parliament, 2014). Through this collaboration, theoretical knowledge can be integrated with practical experience, increasing graduates' ability to apply what they have learned effectively.

According to the 3P model proposed by Tynjala (2013), learning outcomes within the dual system result from the interaction between personal, contextual, and organisational factors, including those specific to the companies where practical training takes place. In this regard, dual education has been implemented over time in both Europe and the United States

(Fernandez-Salinero et al., 2024). The first modern forms of dual education emerged in Germany around the 1970s and later expanded to countries such as Switzerland, France, and Austria (Rustico et al., 2020). Dual training emerged as a response to the need to combine theoretical learning with practical workplace experience. In this context, companies frequently requested educational institutions to train specialists who could later be integrated into organisations, allowing students to apply theoretical knowledge without interrupting their studies (Muratbayeva et al., 2020).

The dual education system therefore presents both advantages and disadvantages for students, companies, and educational institutions (Pogatsnik, 2018). Among the main advantages are reduced training costs and time, the development of independence and responsibility, and increased perseverance and efficiency in work activities (Organisation for Economic Co-operation and Development, 2018). Moreover, dual education contributes to improving the quality of professional training (Martseniuk and Hruzdiev, 2021), facilitating faster labour market integration (Hu et al., 2022), and generating better academic outcomes compared with traditional educational systems (Kocsis and Pusztai, 2021). Previous research indicates that this type of training enhances students' practical preparation and increases employability due to the experience gained (Mora et al., 2022; Pozo-Llorente et al., 2020). Furthermore, dual education strengthens the relationship between educational institutions and the economic environment (Koudahl, 2010). Nevertheless, among the identified disadvantages of dual education are potential discrepancies between company requirements and educational curricula. Additionally, some organisations may show reluctance to integrate trainees, while differences between theoretical and practical components may affect the overall effectiveness of the educational process (Bogush et al., 2024).

In addition to these aspects, previous research has highlighted the importance of integrating emerging technologies (Criollo-C et al., 2023) into the educational process within dual education systems. These tools offer benefits for teachers, companies, and learners alike by facilitating information delivery, enabling the simulation of real-life situations, and supporting the development of virtual laboratories for knowledge consolidation (Seitaliyeva et al., 2025). Digital technologies also contribute to improved communication among participants and to the creation of a more interactive educational environment (Timotheou et al., 2023).

Moreover, digitalisation allows the personalisation of educational content according to learners' individual needs, supporting self-paced learning and reducing pressure associated with the training process (Contrino et al., 2024; Martin et al., 2020). Digital tools are increasingly used for practical training through virtual simulations that enable the analysis of risks and the consequences of decisions (Valverde-Berrocoso et al., 2021). At the same time, the rapid development of artificial intelligence has generated further changes in the educational process, prompting educators and practitioners to adapt teaching methods to new market demands (Peterson and Miller, 2022). The integration of artificial intelligence into education has also contributed to the development of innovative platforms that support knowledge acquisition and interactive simulations (Alieksieieva, 2024; Leong, 2025). However, the implementation of digital technologies may face barriers such as limited resources, insufficient teacher training, or difficulties in adapting technologies to diverse learner needs (Howorth et al., 2024)

Another aspect worth highlighting is that dual education currently has a significant contribution to young people's preparedness to work in innovation-driven domains, such as Information Technology (IT). Disruptive technologies have had a significant impact on the labour market, as young individuals increasingly specialise in new domains such as artificial intelligence, blockchain, augmented reality (Lee, 2012), virtual reality (Chen et al., 2025), and IoT. By alternating theoretical instruction with practical training, dual education facilitates the development of competencies required for professional integration into the IT sector (Cristian, 2025).

In conclusion, the integration of emerging technologies into the dual education system represents an essential direction for the modernisation of education. It plays a key role in the professional training of young people by preparing them for current labour market demands. Emerging technologies, together with intelligent learning platforms developed on their basis, have contributed in recent years to improving the teaching–learning–assessment process and to strengthening the competencies acquired by students throughout their training. Therefore, the digitalisation of dual education should not be viewed merely as the implementation of new technologies, but rather as a structural transformation of the educational process aimed at facilitating collaboration and communication among all actors involved in training.

Building on the above considerations, the present study addresses the role of dual education in the context of ongoing digital transformation. In analysing the novelty of the present study, it should be emphasized that its main objective is to highlight the importance of dual education within the context of the current transformations of the labour market, as well as the relevance of implementing emerging digital technologies within this form of education. The study illustrates that the integration of such technologies into dual education contributes significantly to the development of young people's competencies and facilitates their integration into the labour market. From the perspective of its contribution to the field of social sciences, the research provides relevant insights into the evolution of the dual education system in recent years and examines the role played by digitalisation and emerging technologies in improving the professional training process. Through the analysis carried out, the study highlights the way in which the adoption of innovative technological solutions within dual education can support the development of skills required by contemporary labour markets. The results obtained contribute both at a theoretical and practical level, offering valuable information for economic operators, educational institutions, and policymakers by illustrating the ways in which these actors can become more actively involved in the development and implementation of dual education programmes in the future.

Research Methodology

This study was based on an exploratory analytical approach. In particular, a comparative examination was performed using statistical information obtained from several international databases. The analysis focused on two aspects, the first being the adoption and utilization of novel technologies within the education sector at the European level and particularly in the case of Romania. The second aspect is focused on the advancement of Romania's dual education. The central purpose of the present research was assessing the incorporation level of novel technologies within Romania's educational system, respectively analyzing the evolution of dual education and identifying areas that require further improvement in order to facilitate its effective implementation at the national level and

increase its overall performance. To accomplish the objectives of the study, various statistical datasets were analyzed. The research activities were conducted between January and February 2026.

Results

Analysis of European LevelDigital Skills

According to the data regarding Europe for the year 2025, 60% of the European Union (EU) citizens aged 16–74 presented at least minimal level of digital skills. Exception to this were four countries which overtook the share: the Netherlands with a percentage of 84%, Ireland with 83%, Denmark, followed by Finland (81%). The available data also show that, at EU level, young women demonstrate higher levels of digital skills than men. However, an imbalance between genders can be observed within the 35–44 age group. As illustrated in the figure below, most European Union member states fall within the 50%–70% range, reflecting a moderate level of digital competency development. From Romania's perspective, the analysis shows that the country ranks among the lowest positions, with approximately 30–35% of individuals aged 16–74 possessing digital skills. Consequently, Romania remains below the EU average, highlighting the need to accelerate investments in digital education and in the development of labour market–relevant competencies. Without consistent measures aimed at increasing digital skills among the population in the coming years, challenges may emerge that could negatively affect competitiveness and the effective integration of young people into the labour market over time (Eurostat, 2026).
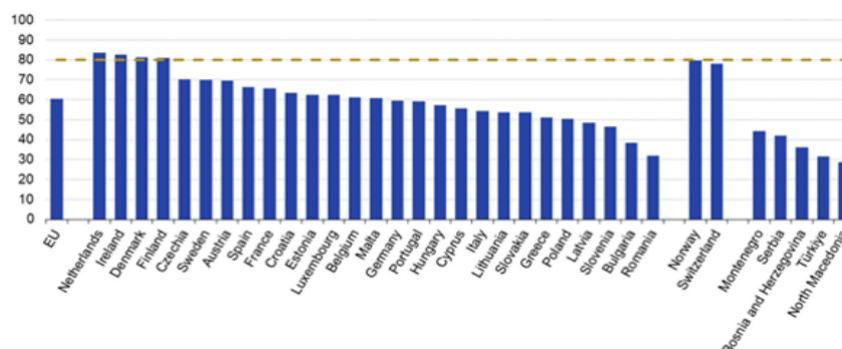

Figure 1. Peoplepresenting at least minimal level of digital skills, 2025 (% of individuals aged 16–74)
Source: Eurostat, 2026

From the perspective of internet users who have taken an online course or used online educational materials in the past three months, a 30% increase was observed compared with the values recorded in 2023. This trend illustrates people's growing inclination toward online learning resources and their willingness to study in digital environments. The highest shares of individuals involved in online learning were recorded in Ireland (61%), followed by the Netherlands (59%) and Finland (53%). Figure 2 below shows that, in Romania, certain challenges persist, as only 10% of internet users participated in an online learning process. Other countries with lower shares included Cyprus (11%) and Bulgaria (17%) (Eurostat (a), 2025).
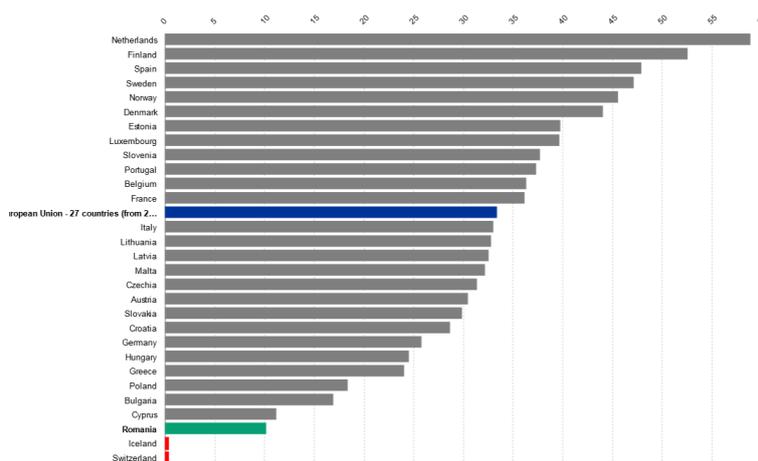
Figure 2. Internet users who have taken an online course or used online educational materials in the last three months
Source: Eurostat (a), 2025

Another important aspect analysed, aimed at illustrating the use of new digital technologies in the learning process, was the percentage of individuals who rely on artificial intelligence for acquiring new information. In 2025, it was observed that 32.7% of people aged 16–74 across the European Union used artificial intelligence tools. Among them, 25.1% used these tools for personal purposes, 15.1% for work-related activities, and 9.4% for formal education. Artificial intelligence is used most extensively in Denmark (48.4%), Estonia (46.6%), and Malta (46.5%). The countries with the lowest shares of AI tool usage are Romania (17.8%), Italy (19.9%), and Bulgaria (22.5%). The low proportion recorded in Romania suggests the existence of limitations in the integration of new technologies into educational processes. This situation may be caused both by the relatively low level of digital competencies and by unequal access to technological resources. Consequently, the reduced use of artificial intelligence may affect the pace of educational modernisation and the adoption of new skills required by the labour market (Eurostat (b), 2025).

Comparative Analysis from the Perspective of the ESI Indicator

Within the scope of this analysis, it was considered necessary to examine the ESI (European Skills Index) indicator. This is a composite indicator designed to illustrate the performance of national skills systems. Its role is to measure how well skills are developed within a country, how effectively they are activated in the labour market, and how well they align with labour market demands. The indicator is based on three key pillars: skills development, skills activation, and skills matching.

The analysis included model countries recognised for dual education systems (Germany, Austria, and Denmark), comparable countries from Central and Eastern Europe (Poland, the Czech Republic, and Slovakia), as well as two countries facing similar challenges, namely Bulgaria and Greece. The results reveal significant differences in the performance of national skills systems. The Czech Republic ranks first according to the ESI indicator, suggesting an efficient system for skills development and utilisation. Its strong performance is particularly supported by the *Skills Matching*component, where the country holds the top position. Denmark and Poland also rank highly. In Denmark's case, a balanced performance across all three dimensions can be observed, indicating a stable system. Poland also records positive results, with high values in *Skills Activation* contributing substantially to its overall score.

Austria, Germany, and Slovakia occupy middle positions in the ranking. This indicates that, although Austria and Germany are widely recognised for their dual education systems, they did not occupy the top positions in the 2024 ranking. At the bottom of the ranking are Bulgaria and Greece, both recording low values across all analysed dimensions. Romania ranks 28th in the overall ESI ranking, reflecting a relatively low performance of its skills system compared with other European countries. This suggests the existence of difficulties related to the implementation and activation of skills within the labour market (CEDEFOP, 2024).

Table 1

Evolution of the ESI indicator in 2024 in Germany, Austria, Denmark, Poland, the Czech Republic, Slovakia, Bulgaria, and Greece

	European Skills Index	**Skills Development**	**Skills Activation**	**Skills Matching**
Czech Republic	1	11	23	1
Denmark	3	5	8	8
Poland	9	17	20	3
Austria	15	7	5	20
Germany	16	15	11	16
Slovakia	19	14	26	12
Bulgaria	26	29	29	15
Greece	29	28	27	30
Romania	28	30	31	5

Source: CEDEFOP, 2024

Dual Education in Romania

Currently, in Romania, 56% of all upper secondary students (enrolled in grades 9–12) are part of the vocational and technical education sector. This percentage is higher than the EU average, which stands at 48%. In Romania, dual vocational education represents an alternative pathway for education and professional training. It was first implemented in the 2017–2018 academic year. During the 2018–2019 period, the number of students enrolled in dual education in Romania reached 5,594, increasing to a total of 15,805 students by the 2023–2024 academic year (National Recovery and Resilience Plan, 2026). Existing statistical data show that dual education programmes offering some of the most in-demand qualifications have recorded a steadily growing number of participants in recent years. One example is the programme dedicated to auto mechanics, where enrolment increased from 127 participants in 2017–2018 to 662 participants in 2019–2020 (CEDEFOP, 2020).

In what regards the implementation of dual education within the 9th-grade, it has to be mentioned that from the introduction of dual education (2017–2018) until the start of the school year 2023–2024, a substantial increase of economic operators involved in vocational training through the dual education system has occured. Their number grew gradually from 227 in the 2017–2018 academic year to 855 in 2023–2024 (representing a 3.8-fold increase compared to the initial stage of implementation). Analysing the evolution of student enrolment in dual education between 2017 and 2024, it can be observed that while the first year of implementation registered 2,568 students, the number increased substantially to 6,938 students in 2023–2024. As shown in Table 2 below, the share of students enrolled in dual education as a proportion of total technological high school enrolment increased

progressively, from 7.77% in 2017–2018 to 18.83% in 2023–2024 (Ministry of Education, 2024).

Table 2
Evolution of the main indicators of dual education in Romania (2017–2024)

Academic year	Number of economic operators involved in dual education	Number of students registered in technological high school dual education at the start of the school year (9th grade)	Percentage of students registered in dual education out of total technological high school enrolment
2017-2018	227	2568	7.77%
2018-2019	527	4244	12.62%
2019-2020	769	6970	15.96%
2020-2021	886	6916	16.91%
2021-2022	498	4649	15.27%
2022-2023	740	5958	17.15%
2023-2024	855	6938	18.83%

Source: Ministry of Education, 2024

Another aspect analysed refers to the evolution of the number of pre-university educational institutions which registered students in dual education in Romania during the 2017–2020 period. An important point to note is that, prior to the official approval of dual education at national level in the 2017–2018 period, there were already some vocational education institutions incorporating dual-type elements. Thus, between 2012 and 2014, there were four vocational institutions with dual components, and between 2014 and 2016 their number increased to six, reaching 22 institutions in the period preceding the formal introduction of dual education (2016–2017).

At the time of the official approval and launch of dual education at national level, there were a total of 73 pre-university educational institutions providing training within this system. During the 2018–2019 period, their number increased by 44%, reaching a total of 105 institutions. In 2019–2020, an increase of 67% of the institutions that implement dual education has occured, reaching a total number of 175 educational facilities (Ministry of Education, 2024).

Table 3
Evolution of pre-university educational institutions enrolling students in dual education at national level, during the period 2017–2020

Educational facilities	Period of time
73	2017-2018
105	2018-2019
175	2019-2020

Source: Ministry of Education (2024)

At the level of Romania's dual education, another important aspect that has been analyzed regards the raise in the number of localities with pre-university educational institutions enrolling students in the dual system at national level. Until the 2017–2018 academic year (before the official implementation of dual education in Romania), the number

of localities hosting such institutions was relatively low. Thus, during the 2012–2013 period, their number stood at two, increasing to three localities in 2013–2014. In 2014–2015, the number of localities open to implementing this form of education began to rise, reaching five, and subsequently increasing to 13 localities in 2015–2016. At the time of the establishment of dual education in Romania, 42 localities had institutions where this form of education could be implemented. Their number increased by approximately 43% in the following year (2018–2019), reaching 60 localities. In 2019–2020, the increase was approximately 63%, with the number of localities implementing dual education reaching 98.

From the perspective of the evolution in the number of vocational training fields for which dual education classes were offered, a slight increase can be observed, from 13 to 15 fields during the 2019–2020 period. Furthermore, analysing the number of professional qualifications for which dual education classes were available shows an increase of approximately 66%, from 44 qualifications in 2017–2018 to 73 qualifications in 2019–2020. In what concerns the dual education classes that were included within national schooling plans, there has been a major increase from 120.5 classes in the period of time 2017–2018 to 313.7 classes in the period 2019–2020 (Ministry of Education, 2024).

Table 4
Evolution of dual education within vocational training fields, professional qualifications and classes included in national schooling plans during the period 2017–2020

Period	Number of vocational training fields for which dual education classes are offered at national level	Number of professional qualifications for which dual education classes are offered at national level	Number of dual education classes included in national schooling plans
2017-2018	13	44	120,5
2018-2019	14	58	188,75
2019-2020	15	73	313,7

Source: Ministry of Education, 2024

Conclusions

The emergence of new technologies and the continuous changes occurring within the labour market have led to increased attention being given to dual education in recent years. This model is regarded as one of the most effective educational solutions due to its ability to respond to labour market transformations. Its main role is to combine theoretical training with practical experience, thereby facilitating young people's integration into the labour market. By linking learning carried out within educational institutions with practical activities undertaken in companies, dual education contributes to the development of relevant professional competencies and supports the acquisition of new skills across various fields of activity.

The study conducted within this paper highlights the importance of integrating emerging technologies into dual education. The analysed statistical data revealed significant differences among EU member states with regard to digital skills, the use of digital tools, and the overall performance of skills systems. From the perspective of digital skills in Romania, the analysis shows that the country remains below the European average. This indicator is also correlated

with the low proportion of individuals participating in online learning and with the limited use of artificial intelligence tools. At the same time, the analysis of dual education in Romania indicates a positive evolution and a progressive expansion of this model following its official implementation beginning with the 2017–2018 academic year. Significant increases have been recorded in recent years in what regards the number of registered students in dual education programmes, of participating economic operators, respectivelyof localities implementing this form of education.

In conclusion, the results of this research emphasise the need to further develop dual education in Romania in the coming years, alongside improving digital competencies and integrating emerging technologies into the educational process. These aspects should be considered priority directions at national level in order to enhance the competitiveness of Romania's educational system and to facilitate young people's successful integration into the labour market.

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