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FINANCIAL SUPPORT FOR THE DEVELOPMENT OF DIGITAL COMPETENCES IN EDUCATION IN EUROPEAN UNION COUNTRIES

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ABSTRACT

The article examines financial support for the development of digital competences in education in European Union countries. The relevance of the study is determined by the growing need to distinguish financial resources directly related to the development of digital competences from broader expenditure on education and digital transformation. The aim of the article is to assess the scale, structure and differences in financial support for the development of digital competences in selected European Union countries within their national recovery and resilience plans. The study is based on official European Commission data for Belgium, the Netherlands, Slovakia, Ireland, Poland, Lithuania and Cyprus. Financial analysis combines the amount of resources allocated to educational measures related to digital competences with the overall digital financing of the corresponding national plans and a qualitative assessment of the content of funded activities. The results demonstrate substantial cross-country differences in both the absolute amount and the structure of financing. Poland has the largest identified financial resource in absolute terms, whereas Belgium and the Netherlands demonstrate a stronger concentration of digital financing on educational and competence-related activities. The analysis identified three principal financing models: infrastructure-competence, inclusion-competence and pedagogical-innovation. The findings show that financial support for digital competences cannot be reduced exclusively to expenditure on equipment or training, as effective measures combine infrastructure, digital content, access, teacher development and learner support in different proportions. The scientific novelty lies in the financial differentiation of digital competence development within the broader resource of digital transition and in the systematisation of financing models according to the dominant objects of expenditure. The practical significance lies in the possibility of using the results to improve programme budgeting, separate capital and current expenditure, and strengthen the financial monitoring of digital competence development initiatives.

Keywords: digital competences, education financing, Recovery and Resilience Facility, digital transition, budget expenditure, human capital, European Union

JEL Classification: H52, I22, I25, O33

INTRODUCTION

The development of digital competencies is emerging as a separate area of investment in human capital, as the use of modern digital technologies in education, professional activities, and everyday interaction is no longer limited to the availability of technical equipment.

The education system must simultaneously provide access to appropriate infrastructure, updating the content of education, training of teaching staff, creation of digital content and support for applicants who have different starting opportunities. Each of the above components requires funding, and therefore the problem of developing digital competencies has a direct financial and economic meaning. For state authorities, the fundamental importance is not the total amount of education spending, but what financial resources are actually allocated to certain measures that ensure the formation of digital competencies.

In the countries of the European Union, the Recovery and Resilience Mechanism, which combined the financing of reforms and investments with certain benchmarks of the green and digital transition, has given additional importance to this problem. According to the rules of the Mechanism, each national plan must allocate at least 20% of the estimated resources to digital goals. At the same time, the digital component covers very different areas, including high-speed communication, digitalization of public administration, support for enterprises, cybersecurity, digital infrastructure of education, and the formation of basic and advanced digital skills. Therefore, even a high total share of digital funding does not show how much money is actually directed to the development of competencies in the education system.

Financial analysis of the digital transformation of education requires a clear distinction between indicators. Total state expenditures per applicant characterize the resource intensity of education as a whole, but they include wages, building maintenance, energy resources, social support, nutrition, administration, logistics, and other costs. Without separate budgetary or program detailing, it is impossible to correctly state what part of such funding was used specifically for the development of digital competencies. Further correlation of total expenditures with the share of individuals with digital skills or with the employment of graduates creates another methodological problem, as it combines financial and non-financial indicators that describe different aggregates and depend on a significant number of external factors.

The relevance of the study is determined by the need to move from a broad interpretation of "financing the digitalization of education" to the identification of a specific financial resource assigned to targeted measures. In our opinion, it is this sequence that forms the basis for further assessment of effectiveness, since it is first necessary to establish the subject of expenditure, its place in general financing, and the boundaries of responsibility of the relevant program. Only after this is it appropriate to proceed to the analysis of physical results, economic effect, or budgetary return. In the absence of a separate financial indicator, any assessment of the effectiveness of digital competencies risks actually characterizing the effectiveness of the entire education system or the general state of the country's digital development. Thus, the subject of this article is the financial provision of targeted educational activities directly related to the development of digital competencies, within the framework of national recovery and resilience plans of the European Union countries.

The issue of financial identification of such expenditures acquires particular importance due to the programmatic nature of modern education financing. One and the same measure may include the purchase of equipment, the development of digital content, the improvement of the qualifications of teaching staff, the creation of platforms, the support of network access and the direct training of applicants. If all of the above-mentioned expenses are automatically considered expenses for the formation of digital competencies, the object of financial analysis becomes excessively broad. If, on the contrary, only the payment of training courses is taken into account, the resources fall outside the field of study, without which the corresponding competence cannot be formed and applied. Therefore, the program approach is economically justified, in which the cost of an officially defined target measure is taken into account, and its composition and boundaries are directly established by the source of funding. It is this approach that is used in the article, which allows maintaining the connection between the purpose of funds and the subject of research. At the same time, financing the development of digital competencies is not the same as assessing its effectiveness.

For a full assessment of budgetary effectiveness, it is necessary to have data on the actual implementation of expenditures, a quantified result of a specific program, the time horizon for obtaining this result and, if possible, financial or socio-economic benefits that can be reasonably associated with the financed measure. In open cross-country data, such indicators have not yet been standardized at a level sufficient for correct comparison. Therefore, this article deliberately focuses on the preliminary financial stage of analysis – determining the scale and structural weight of the target resource. Such consistency makes it impossible to make premature statements about budget returns and, at the same time, forms the basis for its further evaluation after the completion of the programs and the accumulation of comparable factual data.

LITERATURE REVIEW

The theoretical basis for financing competence development is related to the concept of human capital. Becker (1993) considered education as an investment process that requires current costs and generates future economic benefits. Hanushek et al. (2015) expanded this vision, showing that it is not the formal duration of training that is of economic importance, but the skills actually formed.

Psacharopoulos and Patrinos (2018), based on a large international set of assessments, confirmed the sustainability of economic returns from investments in education. At the same time, these approaches relate to investments in human capital in general and do not address the question of how to allocate a resource aimed at the formation of a specific group of competences in the structure of budget financing.

Research on digital competences is mostly focused on their content, levels of formation, and development factors. Vuorikari et al. (2022) systematized the structure of citizens' digital competence in DigComp 2.2, which provides a substantive basis for the formation of educational program goals. Falck et al. (2021) have proven the economic value of information and communication skills, and Wild and Schulze Heuling (2020) have shown differences in the digital competences of vocational and cooperative higher education students. Cattaneo et al. (2022) have established that the digital competence of vocational education teachers depends on a set of individual and institutional factors. Barboutidis and Stiakakis (2023) and Zubizarreta Pagaldai et al. (2025) have detailed the factors in the development of digital competence of vocational education students. These works confirm the multi-component nature of the process, but financing in them mainly acts as an external prerequisite, and not an independent subject of analysis.

A separate direction of scientific discussion concerns the financing of education and the connection of resources with results. De Witte and López-Torres (2017) emphasize the complexity of assessing educational effectiveness due to the dependence of results on the context and the choice of input indicators. Machin and Vignoles (2018) examine funding alongside the broader economic implications of education. OECD (2023) systematizes the sources and directions of funding for education systems, while emphasizing the need for comparability of indicators.

Londar et al. (2025) examined the relationship between accumulated spending on secondary education and PISA results, while Prykhodko et al. (2025) analyzed the digital transformation of higher education and the economic processes that accompany it. Such works are important for understanding the general role of finance in education, but their subject matter is different from the financing of a specific competency component.

The development of digital education requires a combination of capital and current spending. UNESCO (2023) shows that technology in education creates additional financial needs related to equipment, connectivity, learning content, teacher training and user support. The updated UNESCO toolkit on financing the digital transformation of education considers public, private, international and mixed funding as interrelated sources, emphasizing the high cost of systemic digital transformation. Therefore, spending on digital competences cannot be reduced to the purchase of equipment or a one-off training course. Their economic content is formed through the financing of a set of complementary actions. European policy forms a separate level of research. The Recovery and Resilience Mechanism provides for a normatively defined digital labeling of expenditures, and the Recovery and Resilience Scoreboard provides information on the share of digital goals in national plans.

Michels et al. (2026) examined the macroeconomic, sectoral and cross-country effects of the Mechanism’s digital measures, showing the significant scale of such funding at the European Union level. At the same time, the macroeconomic assessment of the digital package does not answer the question of what part of a particular country’s resources is directed specifically to educational activities related to digital competences. The European Commission's official materials for 2026 confirm that funding for education and training under NextGenerationEU covers infrastructure modernisation, digital transformation, skills development and inclusion, and therefore requires internal financial detailing.

The review allows us to identify the unresolved part of the problem. Scientific works sufficiently explain the economic value of human capital and digital skills, and official statistics provide a significant amount of information on the overall financing of education and digital transition. At the same time, to assess the financial support of digital competencies, it is necessary to first isolate a documented resource directly assigned to the relevant educational activities. Then, it is advisable to correlate this resource with higher-level financial indicators, namely, the total cost of the plan and its digital component. This approach does not pretend to assess the final efficiency, but forms a correct financial basis for it (Table 1).

The scientific literature reveals another position that is important for this study. Investment in digital competences has a mixed nature because part of the expenditure creates tangible assets, while another part is directed directly towards human capital. Becker (1993) and Psacharopoulos and Patrinos (2018) provide the basis for interpreting training expenditure as investment in future productivity, while studies of digital education show that such outcomes depend on technological access and pedagogical capacity. It follows that financing competences should be viewed as a set of interrelated expenditures with different useful lives. Equipment and networks may be used for several years, teacher training requires periodic updating, while digital content and software have their own support cycles. For financial management, such heterogeneity means a need for separate accounting of capital and current components, and for cross-country analysis it means rejecting mechanical comparison of total amounts without considering the content of the financed measure.

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Table 1. Systematisation of scientific approaches to the problem under study.

Area	Key sources	Main finding of previous studies	Unresolved issue
Human capital	Becker (1993); Hanushek et al. (2015); Psacharopoulos & Patrinos (2018)	Education and acquired skills generate long-term economic returns	Financing of a specific group of competences is not separated
Digital competences	Vuorikari et al. (2022); Cattaneo et al. (2022); Barboutidis & Stiakakis (2023); Zubizarreta Pagaldai et al. (2025)	The structure of digital competences and the factors of their development have been identified	Existing studies identify the determinants of digital competence development but do not determine the amount and structure of financial resources allocated directly to its development
Education financing	Machin & Vignoles (2018); OECD (2023); Londar et al. (2025)	Financial resources are related to education quality, accessibility, and outcomes	Total expenditure does not show spending on digital competences
Digital transformation of education	UNESCO (2023); Prykhodko et al. (2025)	Digital transformation requires infrastructure, content, staff training, and management changes	Expenditure on infrastructure, digital content, teacher training, and learner support is usually aggregated, which prevents identification of the financial structure of competence-development measures
Financing the EU digital transition	European Commission (2026); Michels et al. (2026)	The Recovery and Resilience Facility forms a substantial targeted digital resource	Educational measures directly related to digital competences need to be separated

The European Union's position also indicates a gradual shift from funding the technological infrastructure itself to funding people's ability to fully use it. The European Union Council Recommendations on Vocational Education and Training link sustainability and competitiveness to skills acquisition, adaptation of programmes and interaction with the labour market. DigComp 2.2 details the content of digital competence through information literacy, communication and collaboration, digital content creation, security and problem solving (Vuorikari et al., 2022). For financial analysis, it is important that each of these groups may require different resources. Therefore, the mere fact of including an educational project in the digital part of the plan does not yet allow us to establish what amount is allocated to the formation of a specific competence. In our opinion, this circumstance explains why it is advisable to conduct research at the level of officially identified measures and not to detail them below the level confirmed by financial documents.

AIMS AND OBJECTIVES

The aim of the article is to assess the scale, structure and cross-country differences in financial support for the development of digital competences in education in selected European Union countries within their national recovery and resilience plans. To achieve this aim, the following objectives were set:

1. To clarify the economic content of financial support for the development of digital competences and distinguish it from general financing of education and broader financing of the digital transition.
2. To identify and compare the financial resources allocated to educational activities directly related to digital competence development in the selected European Union countries.
3. To determine differences in the scale and structure of such financing and identify the principal models according to the dominant objects of expenditure.
4. To substantiate practical directions for improving financial planning, expenditure structuring and monitoring of programmes aimed at developing digital competences in education.

METHODS

The study was conducted in four consecutive stages. At the first stage, scientific literature, European Union regulatory documents, and official European Commission materials were analysed. The purpose of this stage was to distinguish general education financing from the financing of specific measures directly related to the development of digital competences. In this article, financial support for the development of digital competences means a documented amount of funds

assigned in a national or supranational programme to a measure whose aim or component explicitly includes the development of digital skills, digital competences, digital literacy, or the corresponding training of teaching staff and learners. This indicator is not equated with total expenditure on education, purchases of equipment that do not have a stated competence-development objective, or general expenditure on the digitalisation of the state.

At the second stage, a targeted comparative sample was formed. The information base was fixed as of August 11, 2026. The sample included Belgium, the Netherlands, Slovakia, Ireland, Poland, Lithuania, and Cyprus. The inclusion criteria were the simultaneous availability on official European Commission pages of three financial parameters, namely the total value of the national plan, the official share of the plan directed towards the digital transition, and the value of a separate educational measure who's wording explicitly refers to the development of digital skills or competences. The sample is purposive, and therefore its mean values are not interpreted as average indicators for all European Union countries. This selection was used to ensure the economic homogeneity of the indicators and the verifiability of each initial value.

An important methodological condition is that the study does not combine expenditure from one year with results from another year. National recovery and resilience plans are considered as programme financial documents for the 2021–2026 cycle, and all values are recorded in the form in which they were published by the European Commission on the observation date. Thus, the analysis characterises the structure of the planned financial resources rather than the cash execution of a particular budget year. The difference between planned commitments, actual payments, and completed investments is not combined within a single indicator.

At the third stage, structural financial analysis was used. For each country, the total value of the plan F_i, the official share of financing for the digital transition d_i, and the value of the identified educational measure C_i were determined. First, the approximate amount of financial resources corresponding to the digital share of the plan is calculated. This calculation reproduces the official principle of digital tagging but does not replace detailed estimates for individual measures (1):

$$Di = Fi \cdot di / 100, \quad (1)$$

where Di is the estimated amount of financing for the digital transition in country i, EUR million; Fi is the total value of the national recovery and resilience plan, EUR million; di is the official share of the plan directed towards the digital transition, %.

The financial weight of the identified educational measure in the total value of the plan is determined using Formula 2.

$$Si = Ci / Fi \cdot 100\%, \quad (2)$$

where Si is the share of the identified digital competence development measure in the total value of the plan, %; Ci is the documented amount of financing for this measure, EUR million; Fi is the total value of the plan, EUR million.

To assess the place of the same measure within the digital component of the plan, the concentration coefficient of targeted educational financing was used (2):

$$Ki = Ci / Di \cdot 100\%, \quad (3)$$

where Ki is the share of the identified educational measure in the estimated amount of financing for the digital transition, %; Ci is the financing of the targeted measure, EUR million; Di is the estimated digital financial resource of the plan, EUR million.

To summarise the results of the purposive sample, the mean value of the concentration indicator was determined. It is used exclusively to describe the cases under study and is not generalised to the entire population of European Union countries (4):

$$K = (1 / n) \cdot \Sigma Ki, \quad (4)$$

where $\bar{K}$ is the mean value of the concentration coefficient in the formed sample, %; n is the number of countries in the sample; Ki is the indicator value for country i.

The degree of heterogeneity in financial concentration was assessed using the coefficient of variation (5):

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$$CVK = \sigma K / K \cdot 100\%, \quad (5)$$

where CVK is the coefficient of variation of the concentration indicator, %; σK is the standard deviation of Ki values in the purposive sample; $\bar{K}$ is their mean value.

At the fourth stage, comparative and content analysis was applied. Educational measures were grouped according to the dominant direction of the use of funds. The first group includes a combination of infrastructure and competence development, the second includes competence development with a pronounced inclusion orientation, and the third includes targeted development of teaching staff competences and renewal of digital educational content. This grouping is not used to assign scores or construct an artificial integrated index. Its purpose is to explain why financial areas with the same name may have different internal structures. Calculations were performed in Python 3.13.5 using pandas 2.2.3 and NumPy 2.3.5. The source data and all calculated indicators are presented directly in the tables, which makes it possible to verify the arithmetic (Table 2).

Table 2. System of research indicators.

Notation	Indicator	Unit	Economic meaning	Source
Fi	Total value of the national plan	EUR million	Total financial resource of the plan in the current official presentation	European Commission
di	Share of the plan for the digital transition	%	Official digital tagging of the plan's total resource	European Commission
Di	Estimated digital financial resource	EUR million	Financial value obtained from F and d using (1)	Calculated by the authors
Ci	Financing of the identified educational measure	EUR million	Funds for a measure directly related to digital skills or competences	European Commission
Si	Share of the targeted measure in the total plan	%	Structural weight of C relative to F	Calculated by the authors
Ki	Share of the targeted measure in the digital resource	%	Structural weight of C relative to D	Calculated by the authors

To ensure comparability, a single rule for fixing the data was applied. All financial values were taken from European Commission pages current on the observation date, while C was included in the dataset only when the official description simultaneously contained a monetary amount and an explicit substantive reference to digital skills, digital competences, teacher training, digital education, or the digitalisation of the learning process. Measures that referred only to the purchase of general information and communication infrastructure without an educational competence component were not used as C. This rule reduces the risk of arbitrary attribution of expenditure to the subject of the study. The calculations were checked twice, first using the initial values and then after rounding the results for the tables. The calculated indicators in the text were determined using unrounded values, and therefore minimal discrepancies may arise when manually reproducing the calculations from the tabular data presented to two decimal places.

RESULTS

The initial data reveals significant differences in the scale of national plans. This difference makes a direct comparison of the absolute funding amounts for targeted measures inappropriate. Poland has the largest identified educational resource in absolute terms in the sample, but the total cost of its plan is several times higher than that of other countries. Ireland and Cyprus, by contrast, have much smaller overall plans, so even relatively small amounts can form a significant share of the financial structure. Therefore, the further analysis combines absolute and structural financial indicators.

For each country, the Ci indicator was determined based on the official description of the specific measure. In Belgium, this indicator includes funding for education related to digital and STEM competencies and access to digital tools. In the Netherlands, separate funding was used for digital skills development at different levels of education and digital inclusion. In Slovakia, funding for school digitalization was included, combining equipment with digital skills development and the creation of a new educational environment. In Ireland, a resource for providing connectivity and ICT equipment for vulnerable job seekers was identified, officially linked to the development of digital skills in education. In Poland, investments in digital infrastructure and school equipment were included, along with teachers' digital skills. For Lithuania, a separate EdTech project was used, aimed at digital innovation and strengthening teachers' digital competencies. For Cyprus, a

targeted measure for the digital transformation of school units was used, along with the development of digital and STEM competencies and professional training for teachers.

This detail is crucial for interpreting the results. The Ci indicator does not represent the country's total expenditure on digital competencies in education. It reflects the cost of a targeted activity or a set of explicitly identified educational activities, the financial value of which is clearly stated in an official source. Consequently, the calculated shares characterize the financial weight of a documented activity, rather than the full national digital education budget. This cautious approach precludes attributing expenditures officially attributed to the educational competencies component to expenditures officially attributed to broader digital transformation (Table 3).

Table 3. Source financial data for the purposive sample. *(Source: compiled by the authors based on official European Commission pages on national plans and Recovery and Resilience Facility projects)*

Country	F_i, EUR million	d_i, %	C_i, EUR million	Content of the identified measure
Belgium	5 299	27	395	Education, digital and STEM competences, access to digital tools
Netherlands	5 400	26	329	Development of digital skills at different levels of education and digital inclusion
Slovakia	6 408	22	187	Digitalisation of schools, equipment, digital skills, new educational environment
Ireland	1 163	34.20	64	Connectivity and ICT equipment for vulnerable learners, support for digital skills
Poland	59 800	21.30	1 200	Digital infrastructure and equipment for schools, teachers' digital skills
Lithuania	3 850	23.3	29.8	Digital Education Transformation EdTech, teachers' digital competences
Cyprus	1 020	30.03	13.8	Digital transformation of schools, digital and STEM competences, teacher training

The official digital transition share in all analysed plans exceeds the regulatory minimum of 20%. Ireland has the largest excess in the formed sample, followed by Cyprus and Belgium. At the same time, the value of d_i itself does not determine the priority of the educational component. A high digital share may be formed by public electronic services, connectivity, support for enterprises, cybersecurity, or other areas. Therefore, financial analysis of digital competences requires a second level of detail through Ci.

The calculated values are presented in Table 4. To ensure verifiability, D_i was obtained directly from the two published financial parameters, while Si and Ki were determined using (2) and (3). Rounding was performed after the calculations were completed, which prevents the accumulation of error in intermediate operations.

Table 4. Calculated indicators of the financial structure. *(Source: calculated by the authors using (1), (2), and (3) based on the data in Table 3)*

Country	D_i, EUR million	S_i, %	K_i, %	Excess of d_i over 20%, p.p.
Belgium	1 430.73	7.45	27.61	7
Netherlands	1 404.00	6.09	23.43	6
Slovakia	1 409.76	2.92	13.27	2
Ireland	397.75	5.50	16.09	14.2
Poland	12 737.40	2.01	9.42	1.3
Lithuania	897.05	0.77	3.32	3.3
Cyprus	306.31	1.35	4.51	10.03

Within the target sample, the average share of the identified activity in the total plan cost is 3.73%, while the median is 2.92%. For the share in the estimated digital resource, the corresponding values are 13.95% and 13.27%. The coefficient of variation for S_i is 64.60%, while for K_i it is 60.84%, confirming the significant heterogeneity of the funding structure even among countries for which the European Commission directly allocates digital educational activities. These averages are characteristic only of the current target sample. Belgium has the largest share of identified educational activities, both overall and in the estimated digital resource, among the cases studied. A similar profile is observed in the Netherlands. Both countries allocate significant financial resources to human capital in the digital transition, although the internal structure of their measures differs. In Belgium, the emphasis is on combining digital and STEM competencies with access to technology, while in the Netherlands, the development of digital skills is emphasized with digital inclusion at different levels

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of education. Ireland exhibits a different financial configuration. The absolute volume of the identified measure is significantly smaller than in Belgium, the Netherlands, Slovakia, or Poland, but its structural weight remains significant due to the smaller overall size of the national plan. At the same time, Ireland has the highest overall digital share in the sample. This combination demonstrates why absolute amounts cannot be used as a stand-alone indicator of financial priority. Poland, by contrast, has the highest absolute C_i amount, but its share in the large-scale plan is moderate. A similar conclusion applies to K_i. Thus, €1,200 million is a large target resource, but it does not dominate overall digital funding. In our opinion, this example particularly clearly demonstrates the need to simultaneously use absolute and structural indicators. Lithuania and Cyprus have the lowest C_i values in the sample. However, the nature of the measures is more specific. The Lithuanian project focuses on digital educational innovations, content, equipment for distance and hybrid learning, and the development of digital competencies for teachers. The Cyprus initiative combines the transformation of teaching materials, e-classrooms, digital equipment, and teacher professional development. The low structural share does not imply a low importance of these measures, as they represent specific projects rather than a comprehensive list of national expenditures on digital education.

The results allow us to systematize the monetary models. The first model combines capital expenditures on digital infrastructure with expenditures on skill development. This is typical for Belgium, Slovakia, Poland, and Cyprus. The second model has a pronounced inclusive focus and links digital skills with access to equipment or training for specific groups of job seekers, as observed in the Netherlands and Ireland. The third model focuses on teachers and digital educational innovations, most prominently represented in Lithuania. In the practice of a single country, these models can be combined (Table 5).

Table 5. Generalisation of financing models for the development of digital competences. *(Source: systematised by the authors based on the analysis of the official content of the measures)*

Model	Example countries	Dominant objects of financing	Financial and management feature
Infrastructure-competence	Belgium, Slovakia, Poland, Cyprus	Equipment, networks, digital content, competences of learners and teaching staff	Capital and current expenditure form a single measure
Inclusion-competence	Netherlands, Ireland	Digital skills, access to devices, support for vulnerable groups	Financing combines competence development with reducing the digital divide
Pedagogical-innovation	Lithuania	Teacher competences, digital content, EdTech, hybrid learning	Resources are concentrated on teaching quality and the system's capacity to create digital content

Financial planning for each model should take into account the different nature of costs. In the first model, it is inappropriate to evaluate the result by a single indicator, since some of the funds create long-term assets, and some finance training and content updates. In the second model, it is important to separate general accessibility from targeted support for target groups. In the third model, the key object is the professional capacity of teaching staff, so budget planning should provide for the recurrence of costs for advanced training, updating materials, and maintaining digital tools. Therefore, the same name "financing digital competencies" can cover fundamentally different economic elements, which should be taken into account when forming budget programs (Table 6).

Table 6. Directions for using the results in the financial management of educational programmes.

Problem	Required action	Financial indicator for control
Total education expenditure does not show the digital component	Separately identify the programme, measure, or budget item for digital competence development	C_i and its share in the relevant budget
Digital financing covers many incompatible areas	Separate education from e-government, connectivity, support for enterprises, and cybersecurity	K_i
Absolute amounts distort cross-country comparison	Analyse both the absolute value and the structural weight of the measure	C_i, S_i, K_i
Infrastructure and training have different economic natures	Maintain separate accounting of capital and current expenditure within the measure	Shares of capital and current expenditure
Planned amounts are not equal to actual execution	Form the next level of analysis based on cash expenditure and completed results	Plan, actual expenditure, deviation, achieved results

The results presented in Table 6 provide grounds for formulating practical proposals for improving the financial management of programmes aimed at developing digital competences in education.

First, the financing of digital competence development should be identified as a separate expenditure component within broader educational and digital transformation programmes, since the use of total education expenditure does not allow the actual financial resource directed towards competence development to be determined.

Second, programme documentation should clearly distinguish expenditure on digital infrastructure, equipment, educational content, software, teacher training, learner support, and other competence-related activities, with a further separation of capital and current expenditure.

Third, financial reporting should consistently distinguish planned allocations from actual cash expenditure and link the latter to the specific activities completed within the programme. Such an approach would make it possible to move from an assessment of the structure of financing to an assessment of the actual use of financial resources without changing the economic object of analysis.

Fourth, cross-country comparison should combine absolute expenditure with its structural weight within both the total financing plan and the financing allocated to the digital transition, since an identical absolute amount may have a fundamentally different financial significance depending on the scale and structure of the national programme.

Finally, further development of the financial management system requires the introduction of standardised programme-level reporting that would combine the amount and structure of expenditure with clearly defined target groups, completed activities, and results of competence development.

In our view, the implementation of these proposals would create a substantially stronger information basis for subsequent assessment of the effectiveness of expenditure on digital competences, where the financial resources used and the achieved results belong to the same programme, the same target group, and the same reporting period. Such an approach would also prevent the methodological substitution of financing for digital competence development with general expenditure on education or with the broader financing of digital transformation.

DISCUSSION

The study's results confirm the need to separate the content of digital competencies from the process of digital transformation in education. Cattaneo et al. (2022), Barboutidis and Stiakakis (2023), and Zubizarreta Pagaldai et al. (2025) demonstrate that the development of digital competencies depends on teacher training, instructional design, access to technology, practical use, and institutional support. The financial models identified in this article effectively reflect the financial support for these interrelated factors. Consequently, equipment costs should not be automatically interpreted as competency-related expenses, but they can be included in the target measure when formally linked to updating curriculum content, teacher training, and developing digital skills.

A comparison with Londar et al. (2025) clearly demonstrates the distinction between the two types of financial research. The aforementioned authors analyze overall funding for secondary education and PISA results, which corresponds to the scope of the education system as a whole. In our study, the scope is much narrower: the financial support for digital competencies. Therefore, transferring the total expenditure per applicant to the denominator of the "digital competencies return" indicator would be economically incorrect. It is first necessary to allocate funds directly related to the relevant competency component. It is this change in the subject of analysis that is the fundamental difference of the proposed approach. Prykhodko et al. (2025) demonstrate growing scientific attention to the digital transformation of higher education and its economic consequences. However, the bibliometric approach does not reveal the structure of financial resources. Our results complement this approach by identifying specific financial measures. They are also consistent with the position of UNESCO (2023), according to which the digital transformation of education requires the simultaneous funding of infrastructure, access, content, and competencies. The identified infrastructure-competency, inclusive-competency, and pedagogical-innovation models are practical manifestations of such integrated funding. Michels et al. (2026) assess the economic impact of digital measures of the Recovery and Resilience Mechanism at the macroeconomic and sectoral levels. Their study demonstrates that the Mechanism's digital package is significant in scale and heterogeneous in its focus. Our results support this position at the level of the educational component of human capital. A high official share of digital transition (d_i) does not imply a high share of funding for digital competencies, as infrastructural, managerial, entrepreneurial, security, and educational areas compete within the digital resource. This circumstance explains the need for the K_i indicator.

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The scientific novelty of the study lies in the development of a two-stage approach to analyzing the financial provision of digital competencies. At the first level, the total funding for the digital transition is determined using the official share of the national plan. At the second level, documented educational activities directly related to digital competencies are separated from this financial array. Their weight is then assessed using two financial bases – the full plan and the digital resource. In our opinion, this approach eliminates the methodological error of correlating total education expenditures with non-financial results that cannot be directly attributed to a specific budget resource.

However, the study does have a limitation. The first is the targeted nature of the sample. The analysis includes only countries for which all necessary financial parameters can be clearly identified on the official websites of the European Commission. The second limitation is related to the varying levels of detail in the official descriptions. In some countries, the C_i amount covers a broad package of school digitalization and skills development, while in others it covers a specific project. The third limitation is determined by the programmatic nature of the data. The values characterize the planned or officially reported financial resources, not the full cash execution. The fourth limitation is the lack of a standardized, separate accounting of costs solely for digital skills training, without infrastructure, content, and support. Therefore, the results are not considered an assessment of budgetary effectiveness.

The above limitations do not reduce the practical value of financial detailing. On the contrary, they show what information public authorities should generate for further full-fledged performance assessment. The budget program for the development of digital competencies should separately show planned allocations, actual expenditures, capital and current components, the number of completed training activities, standardized results of competency assessment, and the period of use of the created infrastructure. Only after the formation of such an array does the basis for cost-effectiveness analysis or cost-benefit analysis appear, where costs and results have a clear causal-program relationship. The fundamental advantage of the proposed approach is its suitability for the subsequent transition from the analysis of the financial structure to the assessment of performance without changing the subject of expenditure. After the appearance of data on the actual implementation of a specific measure, C_i can be replaced by actual cash expenditures, and separate indicators of capital and current expenditures can be added to the financial part of the model. The performance component should correspond specifically to the target group and the content of the program. For example, for a measure to improve the digital competences of teaching staff, a valid outcome would be a standardized change in the level of their competences, and for a digital inclusion programme, the achievement of a specified level of access and skills among the target group. Graduate employment or general digital literacy of the population can only be used as long-term outcomes if there is a separate, substantiated causal link. Thus, the financial detail proposed in the article does not replace future performance assessment, but rather defines a valid baseline for it.

CONCLUSIONS

The first objective of the study clarified the economic content of financial support for digital competence development. The findings made it possible to clarify the scope of financial support for digital competence development and establish the boundaries of its measurement. It encompasses documented funding allocated through national or supranational programmes to measures explicitly aimed at developing digital skills, digital competences, or digital literacy, including the relevant training of teaching staff and learners. At the same time, the indicator excludes total education expenditure, equipment purchases without a defined competence-development objective, and general public expenditure on state digitalisation.

The second objective was to identify and compare the relevant financial resources in the seven countries of the European Union. The results demonstrate substantial differences in their scale. Poland has the largest identified amount of financing in absolute terms, whereas Belgium and the Netherlands demonstrate a substantially stronger relative orientation of the analysed digital resources towards educational and competence-related activities. The findings confirm that absolute amounts should not be interpreted independently of the scale and structure of national recovery and resilience plans.

The solution of the third task made it possible to identify three models of financial support for the development of digital competencies. The infrastructure-competence model combines investment in equipment and digital infrastructure with the development of skills. The inclusion-competence model links competence development with access to devices and support for vulnerable groups. The pedagogical-innovation model concentrates financial resources on teacher competences, digital educational content and EdTech solutions. This differentiation demonstrates that similar policy objectives can be financed through substantially different combinations of capital and current expenditure.

The fourth objective was to substantiate directions for improving financial management. We believe that such areas of improvement that should be implemented at the state level are the following: program documentation should separately

identify financial resources for the development of digital competence, distinguish capital from current expenditures, separate planned funding from actual expenditures, and link the latter to specific completed tasks and results; Interstate financial analysis should combine absolute financial values with relative indicators only when these indicators improve comparability between programs of different scales.

Further research should focus on actual rather than planned expenditure, separate accounting for infrastructure, content and training costs, and the formation of comparable indicators of achieved digital competence outcomes.

ADDITIONAL INFORMATION

AUTHOR CONTRIBUTIONS

All authors have contributed equally.

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CONFLICT OF INTEREST

The Authors declare that there is no conflict of interest.

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ФІНАНСОВЕ ЗАБЕЗПЕЧЕННЯ РОЗВИТКУ ЦИФРОВИХ КОМПЕТЕНТНОСТЕЙ В ОСВІТІ КРАЇН ЄВРОПЕЙСЬКОГО СОЮЗУ

Статтю присвячено дослідженню фінансового забезпечення розвитку цифрових компетентностей в освіті країн Європейського Союзу. Актуальність дослідження зумовлена необхідністю виокремлення фінансових ресурсів, безпосередньо пов'язаних із розвитком цифрових компетентностей, із ширшої сукупності видатків на освіту й цифрову трансформацію. Метою роботи є оцінювання масштабів, структури та міжкраїнних відмінностей фінансового забезпечення розвитку цифрових компетентностей в освіті окремих країн Європейського Союзу в межах національних планів відновлення та стійкості. Інформаційну основу сформовано за офіційними даними Європейської Комісії щодо Бельгії, Нідерландів, Словаччини, Ірландії, Польщі, Литви та Кіпру. Фінансовий аналіз поєднує визначення обсягу ресурсів, спрямованих на освітні заходи, пов'язані з розвитком цифрових компетентностей, із загальним фінансуванням цифрового переходу у відповідних національних планах і змістовним оцінюванням напрямів використання таких коштів. Отримані результати засвідчили істотні міжкраїнні відмінності й в абсолютних обсягах, і в структурі фінансування. Найбільший абсолютний обсяг ідентифікованого фінансового ресурсу встановлено для Польщі, водночас у Бельгії та Нідерландах виявлено вищу концентрацію цифрового фінансування на освітніх і компетентнісних заходах. За результатами дослідження виокремлено три основні моделі фінансового забезпечення розвитку циф-

ровних компетентностей — інфраструктурно-компетентнісну, інклюзивно-компетентнісну та педагогічно-інноваційну. УВстановлено, що фінансування розвитку цифрових компетентностей не повинно зводитися виключно до витрат на обладнання чи навчання, оскільки відповідні заходи в різних пропорціях поєднують інфраструктуру, цифровий контент, доступ до технологій, розвиток компетентностей педагогічних працівників і підтримку здобувачів освіти. Наукова новизна полягає у виокремленні фінансового забезпечення розвитку цифрових компетентностей як самостійного об'єкта фінансового аналізу в межах ширшого ресурсу цифрового переходу та систематизації моделей фінансування за домінуючими об'єктами спрямування коштів. Практичне значення результатів полягає в можливості їх використання для вдосконалення програмного бюджетування, розмежування капітальних і поточних видатків і посилення фінансового моніторингу заходів, спрямованих на розвиток цифрових компетентностей.

Ключові слова: цифрові компетентності, фінансування освіти, механізм відновлення та стійкості, цифровий перехід, бюджетні видатки, людський капітал, Європейський Союз

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