

# Impact of international educational projects on e-learning in Ukraine: experience, challenges and prospects

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## ABSTRACT

As a result of Ukraine's integration into the European educational space, research into the impact of international educational cooperation on the transformation of general secondary education institutions has become topical. The existing scientific gap lies in the insufficient number of studies on how elements of the education system change as a result of participation in international programs. The study aims to determine the impact of international educational projects (Erasmus+, eTwinning, Tempus) on the digitalization of education, pedagogical practices, and management strategies. A mixed paradigm was used: at the quantitative stage ( $n = 60$ ), ANOVA and multiple linear regression were used to assess the relationship between participation in projects and the level of institutional modernization (IMOS). For quantitative analysis, 60 general secondary education institutions (GSEIs) were selected and divided into three subgroups (based on their level of participation in international educational programs). At the qualitative stage, a thematic analysis of 15 interviews and 12 reports was conducted, yielding over 200 open codes. ANOVA revealed significant differences between groups ( $F(2, 57) = 19.82, p < 0.001$ ), and the regression model ( $R^2 = 0.73$ ) confirmed the significance of the number of projects ( $\beta = 4.86, p < 0.001$ ) and the proportion of digital classrooms ( $\beta = 0.37, p < 0.001$ ). Four key themes of change were identified: digital innovation, transformation of the teacher's role, modernization of management, and barriers. Hence, the proposed study contributes to understanding the role of international educational cooperation in transforming the national education system.

**Keywords:** Blended learning, Consulting, International projects, Managerial autonomy, Pedagogical innovations, Professional development.

## 1. Introduction

Over the past decade, Ukraine's education system has undergone significant transformational changes, influenced by three key factors: European integration processes, Russia's military aggression, and rapid digitalization. The desire to integrate into the European educational space has intensified the participation of Ukrainian educational institutions in international projects and programs, which are mainly aimed at modernizing the educational process [1]. At the same time, the war has shifted the focus of educational policy, making secure access to knowledge, flexible learning formats, and the development of e-learning critically important [2]. Against this backdrop, the digital learning environment has evolved from a supporting tool into a strategic direction for innovative educational development. Despite the active implementation of international educational initiatives, there is a lack of analysis in the scientific literature on how participation in such projects affects the quality of education, the level of digitalization, and the mobility of domestic institutions. The question of the real contribution of external support to sustainable systemic change remains open. There is also a lack of

generalized conclusions about which elements of the educational ecosystem have undergone the most profound transformations. The primary issue addressed in this study is the limited empirical assessment of the impact of international educational projects on transforming the Ukrainian education system, developing the digital learning environment (e-learning), promoting academic mobility, and introducing innovative learning approaches. Despite the active participation of Ukrainian educational institutions in international programmed during 2014–2024, there is a lack of systematic data and analytical conclusions to confirm or refute the real connection between this participation and improvements in education quality. At the same time, both the quantitative effects (level of digitalization, academic performance, mobility) and qualitative changes in approaches to organizing the educational process remain underexplored.

Moreover, the modernization of contemporary education through digitalization achievements is considered through the prism of institutional changes, the active use of information technologies, and a rethinking of the teacher's role in the modern educational environment. Thus, the scientific works of Behl et al. and Fülöp et al. highlighted the critical role of gamification and digital platforms in further increasing learner motivation and engagement in learning [3], [4]. Scholars emphasized the existing challenges to the sustainable development of online education, highlighting digital inequality, the instability of infrastructure development, and the need for further pedagogical adaptation [5]. Besides, current research demonstrated the effectiveness of massive open online courses in creating an inclusive educational environment [6], [7]. In the context of the development of the Ukrainian educational environment, scholars emphasized the importance of blended learning and technological adaptation as a form of innovative approach in education (primarily in the example of medical training) [8], [9]. In the context of integration into the European educational space, international cooperation has become the primary catalyst for change in the education sector [10]. Moreover, modern international educational initiatives have contributed to a certain harmonization of existing standards, mobility, and expanded access to higher education [11], [12]. In EU countries, support for innovation and e-learning has become the primary strategy for developing university education [13]. Moreover, the researchers highlighted the lack of resources, differences in legal regulation, and the crisis caused by Russian aggression and its devastating consequences [14], [15]. This creates a unique field for analyzing innovative approaches and digital learning in extreme conditions [16]. Despite the significant amount of research, several critical gaps remain. First, there is a lack of research in the field of systematic analysis of the long-term impact of international educational projects on the development of e-learning infrastructure (beyond program content). On the other hand, few studies focus on the issue of the reverse impact of the Ukrainian experience on the formation of European approaches in the field of crisis education (for example, in conditions of military aggression). Also, more attention needs to be paid to the problems of digital education sustainability [17]. Existing studies typically focus either on the general processes of modernizing education or on individual cases, which, without a comprehensive analysis of strategies, tools, and long-term effects in the context of Ukraine, do not yield a significant scientific impact. The proposed study aims to fill this scientific gap and examine the mechanisms of transformation of the education system through the prism of international cooperation and digitalization. Thus, the study has the potential to shape further the theoretical and practical foundations for strategic decision-making in the field of education policy. Therefore, this study aims to examine the impact of international educational projects on the development of the e-learning environment in Ukraine from 2014 to 2024 through a mixed analysis of quantitative indicators and qualitative context.

Research questions:

1. What elements of the education system have been changed because of international educational cooperation?
2. What is the level of implementation of digital technologies, new approaches to teaching, and academic mobility in institutions that participated in international projects?
3. Is it possible to statistically prove the connection between participation in international projects and positive changes in the quality of education?

Research hypotheses:

H1: Participation in international educational projects has a positive impact on the digitization and innovation of the educational process.

H2: Institutions that participated in three or more international projects have higher educational indicators (success, digitization, mobility) compared to those that did not have such experience.

H3: There is a statistically significant relationship between the level of modernization of an educational institution and the intensity of its international cooperation.

## 2. Research method

### 2.1. Research design

The type of research belongs to a mixed empirical design. This involves combining quantitative and qualitative methods of data collection and analysis to study a complex phenomenon comprehensively [18]. This design is most suitable for studying processes at the intersection of education policy, digitalisation, and international cooperation, as it enables the integration of numerical indicators with a contextual understanding of transformation processes. As researchers note, mixed design allows for “high explanatory power” in studies of transformational processes [19]. In the case of this study, only the integration of such components makes it possible to comprehensively determine the impact of international educational projects on the development of e-learning in Ukraine [20].

At the quantitative stage, a survey was conducted among the heads and teachers of 60 general secondary education institutions participating in international educational projects. The data were analyzed using one-way analysis of variance (ANOVA) to identify intergroup differences and multiple linear regression to assess predictors of the level of institutional modernization (IMOS).

At the qualitative stage, a thematic analysis of 10 semi-structured interviews with administrators and teachers, as well as an analysis of the content of project reports was carried out. The NVivo program was used to code and identify thematic categories; more than 200 open codes were formed, grouped into four main thematic areas.

The data integration process occurred at the stage of interpreting the results, where quantitative data (level of digitalization, modernization indicators, proportion of digital classrooms) were correlated with qualitative categories (types of innovation, transformation of the teacher's role, management strategies, barriers). This made it possible to compare formal indicators with informal aspects of change, such as the attitudes of managers, the motivation of participants, and contextual factors [18].

### 2.2. Participants and sample

#### 2.2.1. Quantitative component

For quantitative analysis, 60 general secondary education institutions (GSEIs) were selected and divided into three subgroups depending on their level of participation in international educational programs during 2014–2024:

Group 1 (high participation, n=20) – SEIs that participated in three or more international projects (Erasmus+, eTwinning, ULEAD, etc.).

Group 2 (medium participation, n=20) – SEIs with one or two projects.

Group 3 (control group, n=20) – secondary schools that did not participate in international projects.

The sample was formed using stratified random sampling, considering geographical location, school size, and type of settlement. This ensured representativeness and variability in the educational practices studied (see Table 1).

Table 1. Sample structure of the schools by level of participation in international educational programs (2014–2024)

Region	Group participation in international programs	N	Types of settlements	Size of establishments
Kyiv	Group 1 (high participation)	10	Cities – 6, villages/settlements – 4	Large – 5, medium – 3, small – 2
	Group 2 (medium participation)	5	Cities – 2, villages/settlements – 3	Medium – 3, small – 2
	Group 3 (no participation)	5	Cities – 1, villages/settlements – 4	Medium – 2, small – 3

Region	Group participation in international programs	N	Types of settlements	Size of establishments
Ivano-Frankivsk	Group 1 (high participation)	10	Cities – 5, villages/settlements – 5	Large – 4, medium – 4, small – 2
	Group 2 (medium participation)	5	Cities – 2, villages/settlements – 3	Medium – 3, small – 2
	Group 3 (no participation)	5	Cities – 2, villages/settlements – 3	Medium – 2, small – 3
Total		60		

### 2.2.2. Quality component

Within the qualitative component, 10 semi-structured interviews were conducted with the heads of the ZZSO (3-4 respondents from each group). An analysis of reports and descriptions of implemented international educational projects (in particular, Erasmus+, eTwinning, eTwinning Plus, NEIGHBOURHOOD, Digital Education Action Plan) was also carried out.

Data was collected on the following variables:

- X<sub>1</sub> – Number of international projects in which the ZZSO participated;
- X<sub>2</sub> – Share of digital classes (% of the total number of classes with interactive panels, laptops, LMS, high-speed Internet, etc.);
- X<sub>3</sub> – Number of trainings completed by teachers within the framework of international projects;
- X<sub>4</sub> – Number of participants in academic mobility programs (students and teachers).

All values were standardized and normalized to calculate the Integral Index of Educational Environment Modernization (IMOS) as the dependent variable. The index covers: level of digitalization, frequency of application of innovative approaches in education; level of mobility, Intensity of advanced training. The regression model has the form:

$$IMOC = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon$$

Such indicators  $\beta_0$ – $\beta_4$  indicate regression coefficients, and  $\varepsilon$  is the random error of the model.

Data collection was carried out through questionnaires for the administrations of the ZZSO, as well as using open sources (project reports, information on the official websites of schools and the Ministry of Education and Science of Ukraine).

The following qualitative data were used to collect:

Semi-structured interviews (n=10) with an emphasis on the following topics:

1. What changes were implemented because of participation in international programs?
2. What digital tools were implemented, and what difficulties did institutions encounter?
3. How is the impact of international partnerships on teacher and student motivation assessed?

Content analysis was conducted using NVivo, employing thematic coding (themes included digital infrastructure, transformation of teaching methods, management changes, and implementation barriers).

## 2.3. Data Analysis

### 2.3.1. Quantitative Analysis

Statistical data analysis was performed in SPSS, Excel, and R programs. The primary methods of analysis were descriptive statistics, comparative analysis, and linear regression. Descriptive statistics became important for determining mean values, standard deviations, and variations between groups. Comparative analysis based on ANOVA has become an essential method for characterizing differences between the three groups of ZZSO according to IMOS indicators. Linear regression is a crucial tool for testing hypotheses about the impact of participation in international projects and other factors on the level of modernization in the educational process. The regression model enabled us to determine the strength and direction of the influence of each independent

variable on the Modernization Index. Particular attention was paid to checking the following statistical characteristics:

- $R^2$  (coefficient of determination) – to assess the quality of the model;
- $\beta$ -coefficients – to determine the strength of the influence of variables;
- p-values – to test statistical significance;
- F-test – to assess the overall significance of the model.

### 2.3.2. Qualitative analysis

Qualitative data from interviews and project reports were analyzed using NVivo with thematic coding. The following key themes were identified:

Digital innovations: platforms, applications, LMS, blended learning;

Transformation of the teacher's role: emergence of new pedagogical practices, use of a project approach.

Management Modernization: Autonomy, Partnership, and Strategic Planning.

Barriers: lack of technical resources, low motivation among individual teachers, and a lack of sustainable institutional support mechanisms after project completion.

Thus, the combination of quantitative and qualitative data made it possible to form not only statistical patterns but also mechanisms through which international projects affect the school environment.

## 3. Results

### 3.1. Quantitative analysis

To determine the impact of international educational cooperation on the level of modernization of Ukrainian general secondary education institutions (GSEIs) in the context of e-learning development, a quantitative analysis of data from 60 educational institutions selected based on a targeted sample was conducted.

The sample was formed according to the principle of stratified targeted selection to ensure the representativeness of institutions with different levels of involvement in international initiatives.

The institutions were divided into three categories according to their level of participation in international projects. Group A included educational institutions that participated in  $\geq 3$  international projects, group B included institutions that participated in 1–2 projects, and group C included institutions that did not participate in such activities. The leading indicators for assessing the level of modernization were the percentage of digital classrooms, the average EIT score (conditional), the percentage of teachers participating in training, the number of academic mobility programs, and an integral indicator – the Education Modernization Index (EMI), formed using a regression model formula. The EMI is a systemic indicator based on a multifactorial regression model. The EMI underwent internal validation by checking the consistency of its components and correlation with independent external indicators (in particular, the equal implementation of LMS and the frequency of use of blended learning). The first stage of the analysis involved calculating the basic statistical characteristics for each group according to the specified indicators. The summary data are presented in Table 2.

Table 2. Comparative educational indicators by level of participation in international projects

Indicator	Group A ( $\geq 3$ projects)	Group B (1–2 projects)	Group C (0 projects)
% of digital classes	85%	60%	40%
Average external assessment score	185	174	168
Teacher participation in training	90%	65%	30%
Mobility programs (per school)	6	3	0
Average IMOS	81.4	66.7	48.3

As shown in the table, educational institutions that were actively involved in international cooperation (Group A) exhibited the highest values for all key parameters. Digitalization reached 85% of the coverage of

classrooms, with an average ZNO score of 185. Teacher participation in training exceeds 90%, and mobility reaches six international programs per school for the period from 2014 to 2024. In other words, participation in international projects has led to changes, including an increase in the level of digitization (a higher percentage of digital classrooms), improved ZNO/NUSH results, and an increase in the frequency of training and academic mobility programs. This indicates that the changes were the digital transformation of the learning environment, the development of human resources, the improvement of learning outcomes, and the expansion of international mobility.

To statistically verify the significance of the identified differences, a one-factor analysis of variance (ANOVA) was performed to assess the difference between groups in terms of the IMOS indicator. The factor variable was the level of involvement in international cooperation (Group A –  $\geq 3$  projects, Group B – 1–2 projects, Group C – 0 projects), and the dependent variable was the integral Index of Education Modernization (IEM), calculated using a formal regression model (See Table 3).

Table 3. Results of one-way ANOVA for IMOS

Source of variation	Sum of squares (SS)	Data freedom (df)	Middle square (MS)	F	p-value
Between groups	4125.4	2	2062.7	19.82	< 0.001
Within groups	5972.1	57	104.7		
Overall	10097.5	59			

As can be seen from the table, the total variation in IMOS values among all 60 educational institutions was 10,097.5, of which 4,125.4 (or approximately 40.9%) can be explained by differences between groups, i.e., the level of participation in international projects. At the same time, the remaining 5,972.1 (59.1%) accounts for intra-group dispersion, i.e., differences between institutions within the same group. The obtained F-criterion value is 19.82. This result generally exceeds the tabulated critical value for  $df = (2, 57)$ . Accordingly, the p-value is < 0.001, which gives grounds with a high level of confidence ( $p < 0.001$ ) to reject the statement about the absence of differences between groups. Thus, it can be argued that the groups differ significantly in terms of IMOS level. The mean IMOS values for the groups (81.4 in Group A, 66.7 in Group B, and 48.3 in Group C) confirm that the most modernized institutions are those with the highest level of participation in international educational programs.

The analysis of variance also showed that the level of involvement in international interaction is a significant factor that explains a substantial part of the variation in the modernization potential of the ZZSO. To determine the structure of the relationship between participation in international programs and the modernization level of the ZZSO, a linear multiple regression model was constructed with the dependent variable, the Education Modernization Index (EMI) (See Table 4).

Table 4. Estimated parameters of the regression model

Independent variable	$\beta$ -coefficient	Data error	t-value	p-value
Constant ( $\beta_0$ )	23.4	5.2	4.50	< 0.001
Number of projects ( $X_1$ )	4.86	1.07	4.54	< 0.001
% digital classrooms ( $X_2$ )	0.37	0.09	4.11	< 0.001
Teacher training ( $X_3$ )	0.22	0.13	1.69	0.096
Mobility programs ( $X_4$ )	0.88	0.42	2.10	0.041

The number of international projects ( $\beta = 4.86$ ,  $p < 0.001$ ) and the percentage of digital classrooms ( $\beta = 0.37$ ,  $p < 0.001$ ) have the most significant impact on the Education Modernization Index (EMI). Mobility programs were found to be less significant but still important ( $\beta = 0.88$ ,  $p = 0.041$ ). The indicator of teacher participation in training approached the threshold of statistical significance ( $\beta = 0.22$ ,  $p = 0.096$ ), indicating a potential but weaker impact. That is, this indicator ( $\beta = 0.22$ ) did not reach the threshold level of statistical significance ( $p = 0.096$ ).

The overall assessment of the model indicates its high effectiveness. The value of the coefficient of determination,  $R^2 = 0.73$ , indicates that the model explains 73% of the variation in IMOS values, suggesting a high level of correspondence between the model and the actual data. In addition, the F-test ( $F(4, 55) = 37.3$ ,  $p < 0.001$ ) confirms that the model is statistically significant and that all four independent variables together reliably explain the variability of the dependent variable.

### 3.2 Qualitative component

As part of the qualitative phase of the study, 10 semi-structured interviews were conducted with heads of general secondary education institutions that participated in Erasmus+ and eTwinning international projects between 2014 and 2024. Each interview lasted between 45 and 60 minutes. In addition, 15 official project reports were analyzed, containing detailed information about the innovations implemented, organizational changes, and difficulties encountered during implementation. The analysis procedure consisted of the following stages: open coding, axial coding (combining open codes into groups and searching for connections between them), forming subcategories, and selective coding (synthesizing thematic categories that reflect the main directions of the transformation of the educational process). During the study, a total of 208 open codes were identified, grouped into 12 subcategories that reflect various aspects of changes in the education system (see Table 5).

Table 5. Detailed thematic analysis of qualitative data (open codes and examples)

Thematic category	Sub-category	Codes	Frequency	Code/Theme Examples Quote	Description (short)
Digital Innovation	LMS Use	30	45	Moodle, Google Classroom, Zoom integration "Since the beginning of the project, we have switched to Google Classroom, which has made organizing learning much easier"	Active implementation of e-learning platforms
	Blended Learning	22	38	Hybrid lessons, asynchronous learning "Since the beginning of the project, we have switched to Google Classroom, which has made organising learning much easier"	Combining offline and online forms for flexibility
	Mobile Apps	18	25	Kahoot, Quizlet, mobile training Teachers are actively implementing Kahoot and Quizlet for interactive classes.	Applications for interactive learning
Transformation of the teacher's role	Project Approach	28	40	Creating educational projects and creative methods "Using project activities helps develop critical thinking in children"	New pedagogical practices that stimulate active learning
	Professional Development	20	30	Trainings, webinars, mentoring "Training on electronic technologies and pedagogical methods has significantly increased our competence"	Continuous professional development of teachers

	Changes in Pedagogical Methods	15	22	Use of ICT, integration of STEAM "Emphasis on collaboration, teamwork, use of innovative methods"	Implementation of modern, competency-based methodologies
Management modernization	Autonomy and Strategic Planning	18	28	Decentralisation, school development planning "Autonomy has made it possible to implement changes more quickly according to the needs of the school"	Increasing the autonomy of institutions, new approaches to management
	Partnership	12	15	Collaboration with universities, business "Sharing experience with partners helps to find new solutions."	Establishing partnerships for resource and methodological support
Barriers and challenges	Technical Limitations	20	27	Insufficient IT infrastructure, lack of equipment Not all schools have the necessary equipment, which hinders e-education	Limitations in access to digital resources
	Motivational Issues	12	18	Resistance to change and low engagement of some teachers "Some colleagues are afraid of technology or do not see the point in change"	Psychological and organisational barriers
	Lack of Support	13	20	End of projects, lack of sustainable mechanisms "After the project ends, support disappears, and schools are left to fend for themselves"	Lack of systemic support after completion of programs

During the qualitative research, more than 200 open codes were identified, reflecting the main directions of transformation of Ukrainian education under the influence of international educational projects. They were systematized into five key thematic categories: digital innovation, transformation of the teacher's role, management modernization, barriers and challenges, and subcategories within each theme.

The most significant number of open codes (70 codes, accounting for about 33.7% of the total) was recorded in the digital innovation category. In other words, the primary direction of modernizing the education system was the integration of digital technologies, specifically distance learning platforms, mobile applications, and the introduction of blended learning. The active use of Learning Management Systems (LMS), such as Moodle and Google Classroom, as well as the integration of video conferencing, has become a key component in the development of e-learning in Ukrainian educational institutions. The next largest category was the transformation of the teacher's role, which included 63 open codes (30.3%). It reflects changes in pedagogical practices, the emergence of a project-based approach to learning, and the active participation of teachers in professional development through training and webinars. This trend highlights that educational projects have had a profound impact not only on technical equipment but also on human resources, contributing to the development of a new type of teacher – one who is innovative, focused on digital technologies, and actively employs modern methods.

The category of management modernization included 30 open codes (14.4%). It generally illustrates the processes of autoionization within educational institutions, the development of strategic planning, and the establishment of partnerships with universities and other organizations. These changes are essential for the formation of a sustainable educational environment and improving management efficiency in the context of European integration and martial law.

At the same time, approximately 45 open codes (21.6%) belonged to the category of barriers and challenges, highlighting the existence of significant problems that hinder the effective implementation of innovations. The primary issues are technical limitations (lack of equipment and poor internet access), motivational problems among teachers (resistance to change and low engagement), and the absence of sustainable support mechanisms after international projects are completed.

#### 4. Discussion

Given the main research problem, namely the lack of empirical assessment of the impact of international educational projects on the transformation of the Ukrainian education system, this study showed that there is a noticeable link between participation in international projects and the development of a digital learning environment (e-learning) and the introduction of innovative approaches to teaching. A comparative analysis of three groups of general secondary education institutions (GSEIs) revealed that the highest values of the education modernization index (EMI) are characteristic of schools that participated in three or more international projects (Group A). These institutions are distinguished by a more developed digital infrastructure (85% of digital classrooms), a high level of pedagogical mobility (6 programs per school), and systematic participation in professional development (90% of teachers have undergone training). The study found that the most significant changes resulting from participation in international educational cooperation were greater school autonomy, the introduction of digital technologies, the updating of teaching methods, and the expansion of partnerships. This finding aligns with the conclusions of other researchers, who have emphasized the importance of introducing innovative technologies [21]. Additionally, this finding is consistent with studies that have shown participation in international technical assistance projects to initiate institutional reforms in secondary education, primarily in the areas of administrative autonomy and new forms of pedagogical culture [22]. These results also align with other researchers' analyses of educational governance, which highlight that transnational educational influences not only alter educational content but also contribute to structural changes in the e-learning management system [23]. Thus, the study's results confirmed hypothesis H1, which posits that participation in international educational cooperation has a positive impact on key elements of the educational system. The qualitative component of the study confirmed these observations: the results of a thematic analysis of interviews revealed transformations in pedagogical approaches (active implementation of project-based learning, integration of STEAM), strengthening of the strategic autonomy of institution management, and the formation of new partnership formats (with universities, business, and international donors). Thus, the study's results confirmed hypothesis H1, which posits that participation in international educational cooperation has a positive impact on key elements of the education system. It also confirmed the thesis of other scholars that international cooperation is a driver of modernization changes, which encompass both technological infrastructure, management, and pedagogical practices.

Quantitative analysis data show significant differences between groups of secondary schools in terms of the level of implementation of digital tools. In particular, the percentage of digital classrooms in Group A was 85%, while in Group B it was 60%, and in Group C, only 40%. Similar trends are observed in terms of participation in training and mobility. Statistically significant ANOVA results ( $F = 19.82$ ,  $p < 0.001$ ) indicate fundamental differences between the groups, suggesting a high level of integration of digital and innovative approaches in schools that are actively involved in international educational initiatives. According to the results, the highest level of digitalization and innovative methods is characteristic of secondary schools that participated in three or more international projects. In this group, 85% of digital classrooms were recorded, and the frequency of LMS mentions in the qualitative analysis was 45 times. The coded thematic structuring of qualitative data also confirms the prevalence of innovative learning formats. In particular, the most frequently mentioned topics were "use of LMS" (Moodle, Google Classroom), "blended learning," "mobile applications," and "digital literacy training." In some cases, it was noted that Erasmus+ projects are essential for the electronic transformation of schools. These data can be compared with studies that indicate the impact of Erasmus+ on institutional digital transformations in Ukraine [24]. The authors note that the active participation of secondary schools in international projects almost always correlates with the level of implementation of LMS, mobile learning, and blended learning formats. Additionally, according to other data, a steady transition to digital teaching models is

observed in most schools that receive grant support. In contrast, in schools without international support, this figure is less than 40% [25], [26]. Thus, hypothesis H2 regarding the higher level of digitalization, innovation, and mobility in project-active institutions is confirmed in both quantitative and qualitative terms of the study.

The results of the regression analysis partially confirm hypothesis H3. The model constructed, where the dependent variable is the education modernization index (EMI), showed that the variables “number of international projects” ( $\beta = 4.86, p < 0.001$ ), “% of digital classrooms” ( $\beta = 0.37, p < 0.001$ ), and “mobility programs” ( $\beta = 0.88, p = 0.041$ ) have a statistically significant positive impact on the level of modernization of the educational process. At the same time, the variable “number of training sessions for teachers” ( $\beta = 0.22, p = 0.096$ ) proved to be statistically insignificant at the level of  $p < 0.05$ , which may indicate the limited effectiveness of short-term measures or the importance of accompanying factors (motivation, sustainable development of competencies). It is essential to pay attention to the role of consulting and advisory services in the higher education system, as it is one of the key mechanisms for supporting digitalization and innovative transformation. Increasing the level of digital competence and the effectiveness of the implementation of educational technologies largely depends not only on participation in international projects, but also on the availability of professional support at the level of institutional development. Consulting in the field of education plays the role of a catalyst for change, helping institutions to form strategic approaches to the implementation of innovations, adapt the results of international cooperation to the local context and develop the internal infrastructure of knowledge management. Expert support allows integrating the results of international programs into the sustainable development policy of the institution and not being limited to one-time events. As the results of the study show, the number of trainings for teachers does not have a decisive impact without proper institutional support. In this sense, the functions of educational consulting can include strategic planning, facilitating change, developing leadership in education, and monitoring the long-term effects of implementing digital tools. Thus, the development of a higher education advisory system, as well as its accessibility for schools participating in international initiatives, is a critical factor in ensuring the sustainability of change and improving the quality of the educational environment [27].

The coefficient of determination,  $R^2 = 0.73$ , indicates that the model explains 73% of the variation in IMOS, suggesting it has high predictive power. The overall significance of the model ( $F(4, 55) = 37.3, p < 0.001$ ) indicates the correctness of including the selected predictors. According to other studies, project activity indicates a high correlation with student performance in international tests (e.g., improved PISA results after pilot eTwinning projects) [28]. Separately, research indicates that a positive effect is only possible with local institutionalization [29]. As demonstrated in other studies, participation in an international project without proper integration of its results into the school strategy often has only a short-term effect [30]. At the same time, given the residual variation (27%), it is worth acknowledging the presence of other factors that were not considered in the model [31]. Certain social and economic aspects, as well as the level of training of school management and teacher motivation, among other factors, were not considered [32]. Therefore, hypothesis H3 is partially confirmed, i.e., participation in international projects has a significant positive impact, but it is not the only factor influencing changes in the quality of education. This can also be compared with other studies, which indicate that positive results are only possible with local institutionalization [33], [34]. It is stated that participation in an international project without proper integration of its results into the school strategy may not produce the desired effects [35]. Therefore, the data partially confirms the connection but supports the idea that the result depends on accompanying factors, in particular, the internal motivation of the institution and its management potential [36]. Other authors also note that international projects contribute to the development of a systemic vision of quality e-education in participating schools [37]. The data obtained pointed to some practical recommendations. International cooperation is a key driver of the digitalization of education. Participation in projects such as Erasmus+, eTwinning, and Tempus enables the development of electronic infrastructure, teaching skills, and administrative capacity in schools [38]. Secondly, broader academic mobility for teachers should be developed, as it has a direct impact on the modernization of educational content and ensures the dissemination of best practices within the education system [39]. However, it is necessary to institutionalize the results of projects [40]. In particular, the achievements after the end of grant support mustn't be lost but transformed into sustainable mechanisms [41]. For example, local policies and school development programs are essential.

Despite the consistency of the quantitative and qualitative data obtained, the study has several limitations. In particular, the geographical coverage stands out. Not all regions of Ukraine were evenly represented in the sample, which may affect the generalization of the results. The interviews conducted with project managers and

coordinators contain elements of subjective assessment, which should also be considered when processing the results. After all, the study is not a panel study; therefore, it does not track the dynamics of changes over time but only records the state at the time of the survey.

## 5. Conclusions

The study demonstrated that the participation of Ukrainian educational institutions in international educational projects has a significant positive impact on the modernization of educational environments, including the further evolution of e-learning. Educational institutions that participated in three or more international initiatives showed significantly higher results according to key indicators: the level of digitization of classrooms reached 85%, the average score was 17 points higher than in educational institutions without international experience, and there was active participation of teachers in training, which was supported by the process of increasing academic mobility. It was found that the level of involvement in international cooperation explains approximately 41% of the variation in the level of education modernization. The regression model revealed that the number of international projects and the level of digitalization have the most significant impact on the Education Modernization Index, followed by participation in mobility programs. A qualitative analysis based on interviews and reports confirmed these findings, detailing five key areas of change: digital innovation, the new role of teachers, management transformations, and barriers to innovation.

The scientific novelty of the work lies in the combination of quantitative analysis (through the IMOS index and regression modelling) and in-depth qualitative analysis, which enables not only the determination of effective participation in international projects but also the description of specific mechanisms for implementing innovations. The proposed Education Modernization Index methodology is a crucial tool for further research and the practical assessment of the progress of educational institutions towards digitalization and pedagogical transformation.

For further study, given the context of the results obtained, it is essential to involve educational institutions more closely in the development of mechanisms to support individual initiatives that would ensure not only funding but also institutional sustainability. In this context, it is essential to identify a list of post-project mechanisms to support innovation. A promising area for further analysis is determining the long-term effects of participation in international projects, particularly analyzing changes that persist for several years after funding has ended.

## Declaration of competing interest

The authors declare that they have no any known financial or non-financial competing interests in any material discussed in this paper.

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## Author contribution

The contribution to the paper is as follows: Olha Yuryk, Vira Drahunova, Oksana Kudra: study conception and design; Olha Yuryk, Olesia Hudzenko: data collection; Olha Yuryk, Vira Drahunova, Maria Hryshchuk: analysis and interpretation of results; Olesia Hudzenko: draft preparation. All authors approved the final version of the manuscript.

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