

Organization of the digital learning environment: experience of the COUL project in Ukrainian higher education institutions

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Abstract

The article analyses the experience of organising and implementing the collaborative online Ukrainian learning (COUL) educational project dedicated to mathematical modelling and artificial intelligence. The project was successfully implemented in the context of the digital learning environment in 2025 with the participation of leading Ukrainian research and educational institutions: Borys Grinchenko Kyiv Metropolitan University, Taras Shevchenko National University of Kyiv, Institute of Mathematics of the National Academy of Sciences of Ukraine, and Institute of Digitalisation of Education of the National Academy of Pedagogical Sciences of Ukraine. The research is focused on adapting the COIL model to the digital Ukrainian educational environment, considering the national higher education system's digital learning technologies, language, and organisational and pedagogical features. The project's key objectives were to develop a digital learning environment based on inter-institutional cooperation, build teamwork skills of project participants, introduce project-based learning, and strengthen digital communication between students of different study programmes and regions. The article describes three main stages of the COUL project: preparatory (January–February 2025), which included agreeing on goals, choosing topics, and developing criteria for assessing the level of academic achievement; main (March–April 2025), during which participants carried out research activities using digital technologies in mixed interdisciplinary teams on projects to integrate artificial intelligence into education (artificial intelligence in mathematics teaching: from theory to practice, handwriting recognition: how mathematics and AI help in education, adaptive learning: creating a mockup of an intelligent maths tutor, optimising learning processes); and the final one (April 2025), which included final project presentations and an anonymous survey.

Keywords

digital learning environments, digital cooperation, digital collaboration, collaborative online Ukrainian learning

1. Introduction

In the context of transformations caused by the globalisation processes of our time, quality higher education requires not only professional knowledge, but also the development of intercultural communication skills, digital interaction and teamwork experience in the online environment. One of the effective ways of implementation that combines these components is the collaborative online learning (COL) model, which is actively developing in the context of the Internationalisation at Home (IaH) concept.

In response to these challenges and opportunities, we have initiated an educational experiment in the format of collaborative online Ukrainian learning (COUL) – online collaboration between students

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from different Ukrainian higher education institutions. The difference between our approach and the European COL model is that the project was implemented domestically and in Ukrainian, with the aim of preparing the academic community for further participation in full-fledged international COIL-projects. This phased approach is first testing the model in the national context, and then scaling it up to the international level allows us to take into account the specifics of Ukrainian higher education, the needs and readiness of students and teachers for inter-institutional cooperation.

Despite the active promotion of COIL in the world, in the Ukrainian context, such initiatives remain few and far between. There is currently a lack of systematic descriptions of local experience in implementing such forms of learning. Therefore, the publication of case studies, analysis of educational outcomes and identification of challenges is particularly relevant.

2. Problem statement

Given these needs, the task is to find effective mechanisms and means of forming digitalised educational trajectories for higher education students that can simultaneously ensure compliance with both the requirements of the higher education institution and the educational needs of the students themselves. In the process of implementing this task, a number of contradictions arise, the main ones of which are presented below:

Contradictions between the global nature of the COIL model and the specifics of national higher education:

On the one hand, COIL as an internationally recognised model promotes open inter-university interaction in a digital learning environment, provides multidisciplinary and intercultural learning. On the other hand, there is a need to take into account the specifics of national higher education: language, organisational, pedagogical features, as well as standards, traditions and requirements of a particular country (in this case, Ukraine).

Contradictions between the specialisation frameworks of disciplines and the need for interdisciplinary project interaction: On the one hand, higher education students acquire a deep specialisation within specific educational programmes (mathematics, pedagogy, computer science, etc.). On the other hand, modern challenges in education, especially in the context of the integration of artificial intelligence into the educational process, require the interaction of specialists from different disciplines, collective project thinking, and mutual learning.

The purpose of this article is to highlight the experience of organising and implementing a COIL project between Ukrainian universities, analyse the educational outcomes obtained by students in the process of online collaboration, describe the chosen project topic as unique in terms of interdisciplinarity, and formulate recommendations for the further use of COIL approaches in the curricula of Ukrainian universities.

3. Review of recent works

Zaitseva et al. [1] analyse the development of communication and collaboration skills in computer science students using ICT tools and reveal the experience of implementing pilot projects that simulate professional tasks for educational collaboration.

Semerikov et al. [2] outlines the key components and principles of implementing innovative ICT environments, including immersive ones, and considers the development of digital competencies of teachers necessary for effective work in an immersive digital environment.

The study by Oleksiuk et al. [3] presents a model of an integrated cloud-based learning environment, which includes communication tools, and reveals learning opportunities for deploying programmes through Google services, which is useful for our study in terms of collaboration in learning.

The modern tasks of digital transformation of education, which are outlined in the studies of Bykov et al. [4] and the analysis of digital transformation of open scientific and educational environments

[5], encourage the authors of the study to adapt and implement world educational practices in the educational process of Ukrainian higher education institutions.

Collaborative online international learning (COIL) is an innovative educational practice that allows students and teachers from different countries to work together on academic tasks through online communication. The model was initiated by Jon Rubin, who founded the COIL Centre at SUNY [6]. The main goal of COIL is to promote the internationalisation of curricula by creating a common virtual space for intercultural interaction, development of global competences and critical thinking.

Rubin and Guth [7] emphasise that COIL can be an effective tool not only for intercultural exchange, but also for updating the content of academic disciplines. They also point out that project-based learning in an online format requires careful coordination between teachers, which requires new support strategies from universities.

However, COIL is implemented in English, which creates barriers to the inclusion of students with uneven levels of English proficiency. In this context, the idea of localised models, such as Collaborative Online Ukrainian Learning (COUL), is relevant, as they allow the methodology to be developed on the basis of universities in one country and gradually integrated into the international space.

Mathematical modelling has traditionally been seen as a key component of training for students of science, mathematics and engineering. The study by Lytvynova [8] notes that the introduction of computer modelling systems contributes to the development of systemic thinking and the ability to formalise applied problems. The relevance of the topic is enhanced by the needs of digital transformation of the economy, which requires students not only knowledge of classical mathematics but also skills in applying data mining. In this context, the integration of artificial intelligence (AI) elements into the educational process is an important step towards updating STEM education. According to the analytical report AI House Ukraine [9], AI is becoming not only a subject of research but also a learning tool, especially in the areas of modelling, forecasting, and automated decision-making.

Thus, the project topic is the combination of mathematical modelling and artificial intelligence is extremely relevant, and its implementation within COUL allows for the integration of modern content, inter-university cooperation, development of future skills, and the digital educational environment.

The aim of the study is to analyse the experience of organising and implementing the Collaborative Online Ukrainian Learning (COUL) educational project on mathematical modelling and artificial intelligence (using a digital educational environment), which was implemented in 2025 with the participation of four leading Ukrainian research and educational institutions: Borys Grinchenko Kyiv Metropolitan University, Taras Shevchenko National University of Kyiv, Institute of Mathematics of the National Academy of Sciences of Ukraine, and the Institute of Digitalisation of Education of the National Academy of Pedagogical Sciences of Ukraine. The project was implemented in the format of a virtual educational exchange localised to the Ukrainian educational environment, which allowed us to test the COIL model taking into account the language, organisational and pedagogical features of the national higher education system. The working language was Ukrainian, and the main focus was on the development of inter-institutional cooperation, teamwork, project-based learning, and digital communication between students of different study programmes and regions. The study was conducted as part of the comprehensive scientific project of the Department of Computer Science titled “Mathematical methods and digital technologies in education, science, technology”, DR No. 0121U111924.

4. Results of the research

We understand the concept of “Digital learning environment” as a component of the educational process that includes a variety of digital platforms, tools and techniques that are due to the intensification of the use of information and communication technologies (ICT) and online resources, which leads to the transformation of learning tools, interaction and assessment in the educational process, as revealed in the studies [4, 10].

4.1. Stages of the COUL project implementation

1. Preparatory stage (January–February 2025).

The organising teachers held a series of online coordination meetings to agree on key aspects of the project. At this stage, it was important to establish effective communication between all teachers involved in the project. Teachers from the Ukrainian higher education institutions, Borys Grinchenko Kyiv Metropolitan University and Taras Shevchenko National University of Kyiv, met online to discuss the details of the project.

During the series of meetings, the general principles of cooperation and organisational issues were discussed. Particular attention was paid to issues related to the adaptation of national educational standards to the COUL format. Each teacher got acquainted with the programmes of other universities, which allowed them to better understand the requirements and specifics of the disciplines to avoid misunderstandings in the course of the project.

One of the key tasks of this stage was to choose a suitable topic that would not only interest students but also meet the current requirements of the educational process in Ukraine and abroad. As a result of the discussions, it was decided to focus on mathematical modelling and artificial intelligence, two relevant topics that have great potential for application in the educational process.

The learning objectives were to formulate tasks that would help students: develop critical thinking through the application of mathematical models to real-world problems; acquire basic skills in working with algorithms and artificial intelligence in the context of education; and improve their ability to project-based learning through collaboration in international teams.

Overall, the aim of the project was to provide students with the opportunity to study complex theoretical issues in practice through a digital learning environment, using modern AI tools to solve mathematical problems.

After identifying the learning topic, it was decided that the project would be implemented in a virtual teamwork format. Students from different universities will be grouped into mixed teams, which will allow them to work on common tasks and exchange ideas through online platforms. The following online platforms have been selected for the project: Zoom for regular online meetings on Thursdays; Google Docs for collaborative work on documents, reports, and presentations. In addition, clear evaluation criteria were developed, including: the quality of the task (scientific approach, accuracy of results, application of mathematical methods); innovation of the solution (creative approach to solving the problem, application of AI); teamwork (effectiveness of communication and cooperation between students from different universities); presentation of results (quality of presentation, clarity and comprehensibility of presentation). Each of the 5 criteria has a weight of 20%; each criterion is scored on a 5-point scale (1–5 points). After evaluation, each score is multiplied by the weighting factor (20%) to arrive at a final score. These evaluation criteria provided an objective approach to assessing student work. The project was implemented as part of independent work within the following academic disciplines: Probability Theory, Big Data Analysis, Mathematical Studies, and Systems Analysis.

Since the project was conducted with a limited time frame (4 weeks), an important step was to agree on a work schedule. The teachers agreed on a clear timetable for completing assignments and presentations: The first week getting to know students, forming teams, discussing the project topic; the second and third weeks researching the topic, developing mathematical models and algorithms; the fourth week demonstrating team presentations.

2. Main stage (March–April 2025).

The active phase of the project involved 31 students from four leading Ukrainian research and educational institutions. Students from different study programmes worked in mixed teams, which allowed them to share experiences and apply an interdisciplinary approach to solving problems. Here is a list of project participants: 2nd year students of the Mathematics (Secondary Education) study programme at the Faculty of Mechanics and Mathematics of Taras Shevchenko National University of Kyiv (13 students); 3rd year students of the Mathematics study programme (6 students) and 2nd year students of the Computer Science study programme (6 students) of the Faculty of Information Technologies and Mathematics of Borys Grinchenko Kyiv Metropolitan University; Postgraduate

students of the Institute of Mathematics of the National Academy of Sciences of Ukraine (2 students) and the Institute of Digitalisation of Education of the National Academy of Pedagogical Sciences of Ukraine (4 students).

After the teams were formed, the students actively discussed topics and approaches to solving the tasks. Each team chose a specific topic that reflected their interests and scientific orientations. Team “Secondary Education + Mykola” (students majoring in Mathematics (Secondary Education) of Taras Shevchenko National University of Kyiv and a PhD student of the Institute of Mathematics of the National Academy of Sciences of Ukraine) chose the topic “Artificial Intelligence in Mathematics Teaching: From Theory to Practice”. The team focused on the integration of artificial intelligence methods into the mathematics learning process, exploring the possibilities of creating automated learning platforms that could adapt the material to the individual needs of students.

The Genius People team (students of the Computer Science of the Borys Grinchenko Kyiv Metropolitan University) chose the topic Handwriting Recognition: How Mathematics and AI Help in Education. The topic involved the development of machine learning algorithms for automatic handwriting recognition. The team focused on developing tools to process students’ handwritten assignments, which would greatly simplify the process of checking and analysing them.

The team “In Love with Mathematics” (a team of students majoring in Mathematics at Borys Grinchenko Kyiv Metropolitan University and Mathematics (Secondary Education) Taras Shevchenko National University of Kyiv) chose the topic “Adaptive learning: creating a mock-up of an intelligent maths tutor”. The team worked on to create a prototype of an adaptive learning application in mathematics that uses artificial intelligence methods to personalise learning. This app was able to change the difficulty of tasks depending on the student’s level, providing individualised recommendations to improve results.

The Mathoptimum team (students majoring in Mathematics at Borys Grinchenko Kyiv Metropolitan University, students majoring in Mathematics (Secondary Education) of Taras Shevchenko National University of Kyiv and a PhD student of the Institute of Mathematics of the National Academy of Sciences of Ukraine) chose the topic “Optimisation of Educational Processes”. As part of this project, the team investigated the impact of using mathematical models on: optimising the educational process, improving classroom organisation; and effective time management.

During the main stage, students worked in teams, where each participant made an individual contribution to a common task. Interaction between representatives of different educational institutions and specialities facilitated the exchange of knowledge, approaches and styles of thinking. In the process of teamwork, students not only combined theoretical knowledge with practical skills, but also found themselves in conditions as close as possible to a real professional environment. They had the opportunity to prove themselves as specialists: to learn how to communicate effectively with representatives of other industries, coordinate teamwork, distribute roles according to competencies and take responsibility for the result. This experience shaped their understanding of interdisciplinary interaction and the importance of teamwork for the successful implementation of complex projects, both within the educational process and in their future professional activities.

3. The final stage (April 2025) The final event of the project was a face-to-face meeting of all participants at Borys Grinchenko Kyiv Metropolitan University. This event was not only a presentation of the developed solutions, but also an important stage of professional growth for students. Each team presented its project to a wide audience of teachers, experts in mathematical modelling, artificial intelligence, and invited representatives of the academic community.

During the final presentation, the students demonstrated not only the results of teamwork, but also public speaking, argumentation, data presentation and visualisation skills. The projects covered both theoretical aspects and practical solutions, which confirmed their applied value.

4.2. Team projects

Team “Secondary Education + Mykola”, topic: “Artificial intelligence in mathematics teaching: from theory to practice”.

The aim of the project was to empirically study the effectiveness of using artificial intelligence (AI) tools in teaching mathematics to secondary school students. The project involved students of pedagogy who conducted a series of experimental lessons in grades 7–11 on the following topics: “Graph of a linear equation”, “Area of a trapezoid”, “Classical definition of probability”, “Functions. Their graphs. Linear function”.

AI-based digital tools were involved in the project: ChatGPT, GeoGebra, Gradescope, Kahoot! AI, and Wolfram Alpha. In particular, ChatGPT was used to generate variable tasks (figure 1), create lesson plans and interactive didactic materials, which contributed to the individualisation of the learning process. A positive example in the project’s implementation practice was the identification of the ability of artificial intelligence to generate original mathematical problems on the topic of probability theory. The analysis showed that ChatGPT is able to create variable tasks with a changed context; however, achieving full originality requires additional editing and evaluation of the didactic effectiveness of tasks by a specialist.

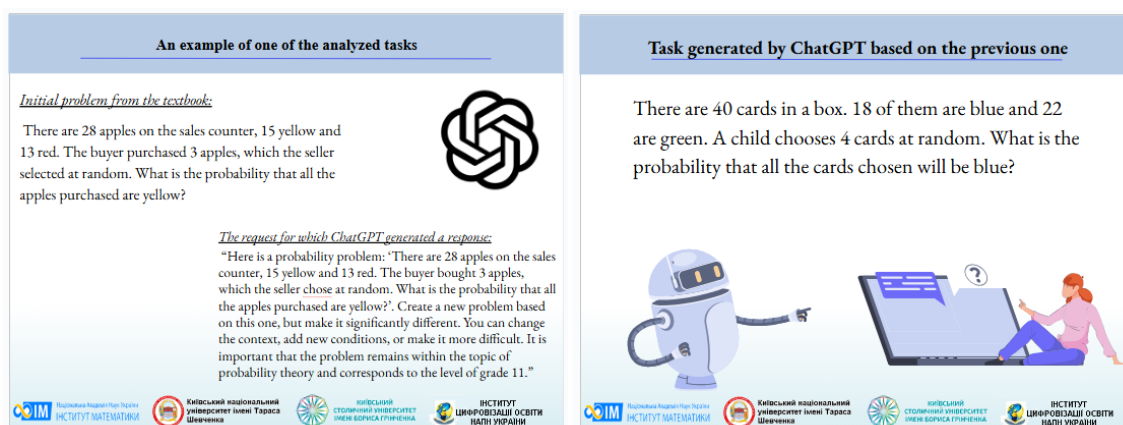


Figure 1: ChatGPT usage infographics: classic task, answer generation, new task generation.

The results of the experimental lessons showed a positive perception of the innovative approach by students and teachers. The main advantages were identified as: quick feedback, the ability to adapt the material to the student’s level, and stimulating students’ independence and critical thinking. Challenges include a low level of skills in interacting with AI, technical limitations (including parental control), and insufficient mathematical training of some students.

The project emphasises the importance of using AI as an auxiliary tool in the educational process, aimed at transforming pedagogical practice through the active use of digital tools rather than replacing the teacher. This approach reflects the current trend towards digital modernisation of the educational environment through the integration of technology into the learning process.

Team “Genius People”, topic: “Handwriting Recognition: How Mathematics and AI Help in Education”.

The team conducted interdisciplinary research and developed a digital tool for recognising handwritten mathematical text based on machine learning and computer vision algorithms. The project focused on the applied aspect of combining mathematical modelling and artificial intelligence in the educational environment. COUL competitors and teammates of the Genius People team were involved in testing this product.

The aim of the project was to create a web application capable of recognising mathematical handwriting, formulas, and symbols and converting them into a machine-readable printed format. The target audience of the project is schoolchildren, students, and teachers who need a convenient tool to quickly transfer information from paper or handwritten media to digital format. The proposed solution not only simplifies text entry, but also creates conditions for automating the checking of tests, analysing mathematical records, and providing feedback, which is important for building an effective educational process.

Product development involves several key stages: analytical research of current solutions in the

field of OCR (optical character recognition), mathematical modelling of convolutional neural networks, building an application architecture, creating a prototype interface, and implementing the functionality. At the initial stage of testing, the system worked using the Tesseract.js library, but the limited accuracy and slow speed of image processing, especially handwriting, necessitated the transition to the Google Cloud Vision API service. The latter provided a significant improvement in recognition due to the use of deep convolutional neural networks, LSTM modules for sequence processing, and the ability to determine the language of the text without manual intervention.

The front-end of the application was implemented using React.js, which allowed us to create a minimalistic but intuitive user interface. All calculations are performed in the cloud, which ensures fast image processing and high accuracy of the results. The user can upload an image, get the text recognised, copy it or save it, making the app suitable for everyday use in education.

The project is innovative due to the interdisciplinary combination of mathematical theory, IT solutions and practical educational value. The web application can be used on a variety of devices and supports multilingual text input, which expands the scope of its potential use. In addition, the project participants outlined prospects for further development of the system, including the introduction of image preprocessing algorithms (binarisation, noise filtering), improvement of UX design, interface adaptability, and increased accuracy of mathematical symbol recognition.

Thus, the case study demonstrates an example of deep integration of artificial intelligence into educational practice and a high level of analytical, technical, and team training of students. The successful implementation of such a project within the COUL approach confirms the success of student collaboration, the development of digital skills, and the ability of students to create relevant digital educational tools.

Team “In love with mathematics”, topic: “Adaptive learning: creating a mock-up of an intelligent mathematics tutor”.

The project was aimed at creating the concept of a digital platform for adaptive learning in mathematics based on artificial intelligence tools. The goal is to provide personalised support to students, taking into account their pace, style of perception and level of knowledge. The research base of the project involved applicants from higher education institutions, professional higher education institutions, and general secondary education institutions.

As part of the preparation of the project architecture, a sociological survey was conducted on the effectiveness of learning modes, motivational factors, and challenges of the distance learning process. Based on the results, a platform model was formed that includes the use of modern LLMs (GPT-4, Claude, Gemini AI), mathematical API services (Wolfram Alpha, Symbolab, Mathpix), as well as gamification and multimedia components (including D-ID Studio for creating a virtual teacher).

The technological basis of the project includes a stack of Python, FastAPI, React.js, PostgreSQL, as well as WebSocket protocols for implementing a system of instant communication between users (figure 2). The platform architecture provides scalability, flexibility, and integration with cloud services for its full deployment.

Thus, the case study of the student project “In Love with Mathematics” is an example of an interdisciplinary educational experience that combines modern technological approaches, analysis of pedagogical needs, and research on digital educational environments. The results obtained indicate a high potential for engaging future professionals in the development of innovative solutions at the intersection of education, artificial intelligence and UX design. The presented model has prospects for practical implementation in the context of the digital transformation of education and contributes to the formation of students’ digital competence, development of their creativity and ability to work in a team in a global intercultural educational environment.

Team “Mathoptimum”, topic: “Optimisation of educational processes”.

The project is dedicated to the development of a digital solution for the formation of individual educational trajectories of students in higher education institutions using artificial intelligence tools and mathematical optimisation models. At the initial stage, more than 100 students were surveyed to identify key difficulties in choosing a speciality, adapting to the educational environment, and building a professional strategy (figure 3).

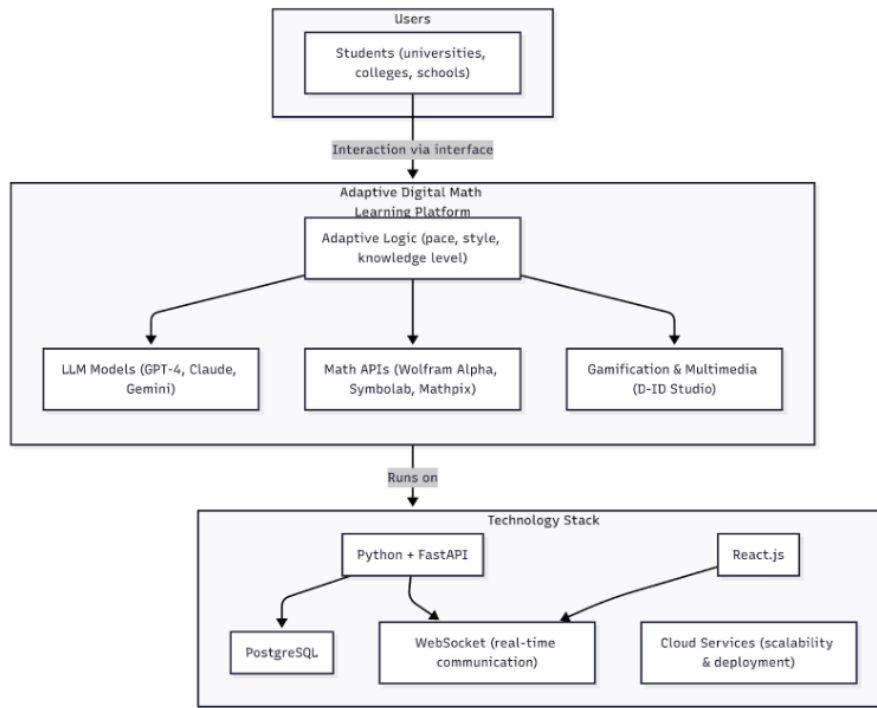


Figure 2: The schematic diagram of component interaction.

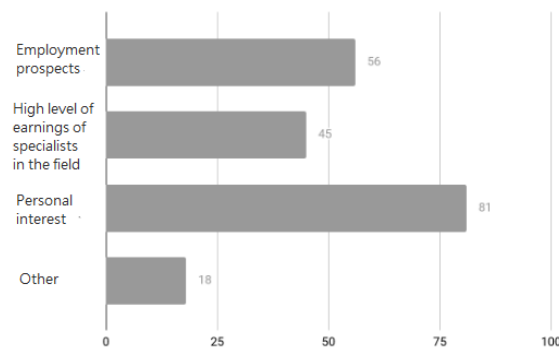


Figure 3: Demonstration of a fragment of the defence of the project “Optimisation of educational processes”. Infographics of answers to the question “The most influential component of choosing a speciality”.

Based on the data obtained, the concept of an intelligent assistant is proposed, which, using algorithms for analysing educational requests and mathematical models (for example, the “backpack problem”), offers individual curricula. It takes into account regulatory and legal restrictions, the logical sequence of disciplines and the possibility of independent choice of educational modules.

The next steps include building a prototype of the tool using LLMs, expanding the survey sample, and integrating it with the internal educational systems of universities. The project demonstrates a high level of analytical and methodological training of students and has the potential to be implemented at both the institutional and national levels.

4.3. Research tools

The jury, consisting of independent experts from relevant institutions, evaluated the submitted papers according to the following criteria: innovation, interdisciplinarity, practical relevance, quality of presentation and teamwork. Based on the results of the evaluation, the winning team was determined and received certificates and an award for the best project implementation.

Immediately after the final meeting, all participants completed an anonymous survey designed to collect feedback on their participation in COUL. The questionnaire contained both quantitative and open-ended qualitative questions to assess student satisfaction, engagement, self-assessment of skills acquired, and to identify the main challenges, such as difficulties in online communication, time coordination, and division of responsibilities. The results of the survey formed the basis for further analysis of the effectiveness of COUL as a tool for developing students' professional and interpersonal competences.

The analysis of the project's feasibility was based on: a questionnaire developed in Google Forms; detailed open responses from students; and reflective comments from participating teachers.

An analysis of the survey was conducted. The entrance questionnaire helped to determine the starting position of the participants, their goals and expectations, as well as the most comfortable forms of interaction (messengers, online platforms). It collected contact details (emails, phone numbers, etc.), information about the participants' knowledge of the latest technologies and digital competence, and identified their desired roles in the teams. The collected data was used to individualise the approach and align the project objectives with the wishes of the participants. The entrance survey helped to identify: the level of self-assessment of participants' digital competencies (figure 4) – most participants felt quite confident (61.5% answered "Good"); the level of proficiency in the proposed Google Workspace services and graphic editors, AI services – more than 84%, while 3D modelling applications (natural sciences, computer science, etc.) – only a few cases (about 4%) (figure 5); competencies desired to be mastered after the training (figure 6).

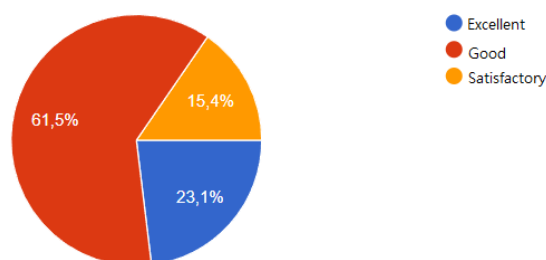


Figure 4: Infographics of answers to the question "Self-assessment of own digital competences: ability to use digital technologies".

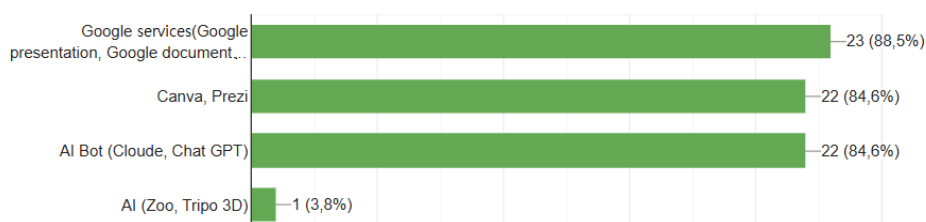


Figure 5: Infographics of answers to the question "Which of the following digital services do you use?".

In the survey, respondents were asked to assess whether, in their opinion, they had acquired or improved certain knowledge and skills in the course of project activities. The collected responses showed that the vast majority of participants (85%) positively assessed their experience of participating in the project, with only a small number (about 10%) indicating that they did not feel any significant changes. The respondents noted an increase in both theoretical knowledge and practical skills in the relevant field, which indicates the positive impact of the project form of work as a means of professional and personal development (figure 7a) and noted that the knowledge gained would be useful in your future studies or career (figure 7b).

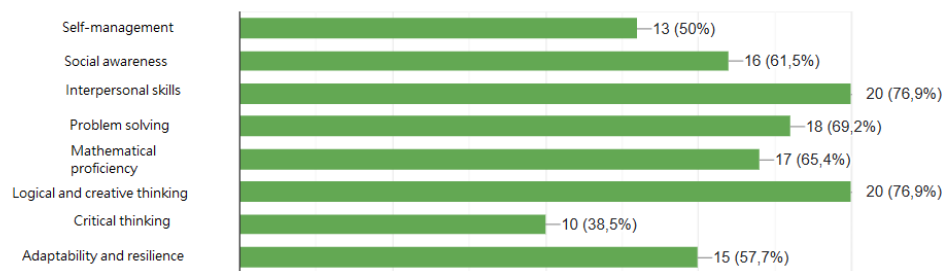


Figure 6: Infographics of answers to the question “What competences do you want to develop within the COUL project?”.

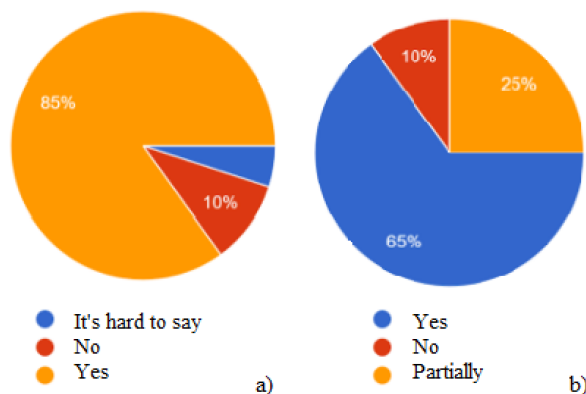


Figure 7: Infographics of answers to the questions: a) Do you think that you have gained or improved certain knowledge and skills while working on the project? b) Do you think that the knowledge gained will be useful in your future studies or career?

The survey assessed the level of development of key professional skills that respondents indicated as having been acquired or improved during the project. The results allow us to identify priority areas for personal and professional growth of the participants. The highest score was recorded in the category of teamwork – 17 respondents (85%) noted this competence, which indicates the significant role of joint activities in the project format. High scores were also recorded for communication and collaboration skills, with 11 respondents (55%) each indicating an improvement in these aspects. Time management and digital skills were noted by 8 participants (40%), which indicates a moderate level of development of these skills in the framework of project work. To a lesser extent, the development of leadership skills was recorded – 7 respondents (35%) reported their improvement (figure 8).

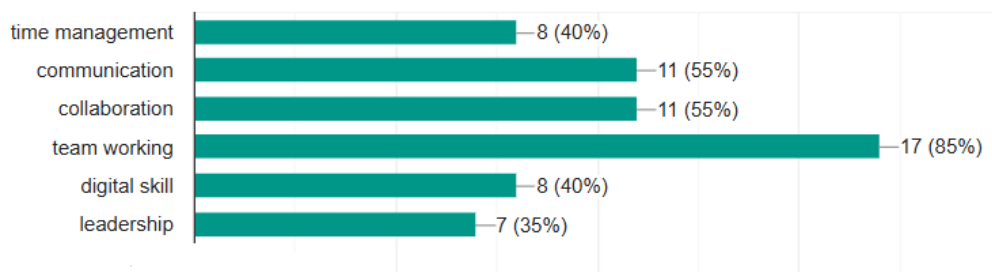


Figure 8: Infographic of answers to the question: “What knowledge and skills do you think you have developed during the COUL project?”.

In general, the results of the survey show that the experience of organising a COUL project learning environment can be an effective means of developing soft skills, in particular in the context of teamwork, communication and cooperation, which are of key importance for a modern specialist.

The qualitative questions also include the question “What national or international projects would you like to participate in in the future?”. The answers show that respondents are highly motivated to participate in project activities aimed at professional and personal growth. Participants show interest in a wide range of topics: from educational and scientific to business and practice-oriented initiatives, which indicates their readiness to actively participate in interdisciplinary and international cooperation formats. Such a request also emphasises the importance of such competencies as critical thinking, creativity, adaptability and the ability to work in a global environment.

Discuss

The Collaborative Online Ukrainian Learning (COUL) pilot project demonstrated the potential of digital inter-institutional learning in the field of mathematical modelling and artificial intelligence. The participation of students and postgraduates representing various Ukrainian educational and scientific institutions made it possible to create an integrated learning and research environment in which participants were able to immerse themselves in conditions that were as close as possible to real professional activity. In particular, they had the opportunity to work in multidisciplinary teams, collectively analyse and solve complex problems, present their results to a wide audience, and receive a reasoned professional assessment of their work. Our project is consistent with the findings of international studies [6, 7], which emphasise the importance of teamwork and soft skill development in the distance learning process. The introduction of the Ukrainian-language COIL format was an important step in the development of innovative approaches to the organisation of the educational process, which, in turn, opens up prospects for the further integration of this practice into a broader international context. In particular, this refers to the need for more active involvement of foreign partners, expansion of inter-university cooperation, and participation in joint global projects aimed at strengthening intercultural communication and academic mobility.

The analysis of the survey results shows high motivation, engagement and satisfaction of the training participants, which confirms its significance in both didactic and social aspects. At the same time, the findings allow us to outline a number of areas for further improvement of the project, taking into account the identified organisational difficulties caused by the heterogeneity of the participants.

1. Optimising online communication in teams. Given the difficulties associated with establishing effective interaction between participants from different institutions, it is advisable to introduce tools for structured online communication. In particular, it is recommended to provide participants with a single digital platform for team interaction, introduce preliminary instructions on digital etiquette, and provide moderator support at the initial stages of team work.

2. Regulate the distribution of tasks in teams. To avoid imbalances in the workload between team members, clear algorithms for the distribution of responsibilities should be proposed, with the possibility of recording the contribution of each member. The introduction of self-assessment and mutual assessment tools within teams will help to distribute the workload more fairly and increase the responsibility of each member.

3. Improve time management and time coordination. Given the difficulties in coordinating the time for completing tasks, it is advisable to introduce calendar planning with intermediate deadlines, as well as provide participants with instructions and recommendations on effective time management. It is also possible to engage facilitators or mentors to support teams in planning their work and ensuring that they stay on track.

The implementation of the proposed measures has the potential to become an important factor in stimulating students' research activity, forming effective models of team interaction, and achieving a higher level of performance in the process of completing project tasks. COUL projects should be viewed not only as an innovative educational practice, but also as a modern pedagogical technology aimed at the comprehensive development of professional, communicative, digital and social competencies of higher education seekers. An important aspect is that the implementation of such projects creates conditions for deepening the processes of internationalisation of higher education, which is evident even within a single national education system thanks to the formation of a multicultural environment for cooperation.

Further development of the initiative is envisaged in two key dimensions. Firstly, in quantitative

terms, by involving more students and teachers in project activities. Secondly, in qualitative terms – by establishing partnerships with representatives of foreign universities, expanding the range of teaching and research tasks and increasing their complexity, which will contribute to raising academic standards and integrating students into the international scientific and educational space.

5. Conclusions

The implementation of the COUL pilot project has demonstrated the effectiveness of digital inter-institutional learning in the field of mathematical modelling and artificial intelligence. The involvement of undergraduate and postgraduate students from various Ukrainian educational and research institutions allowed us to create an environment in which participants could feel themselves in conditions close to professional activities: work in multidisciplinary teams, solve complex problems together, present results, and receive professional evaluation.

The project proved that even within the national educational space, it is possible to implement a high-quality COIL experience that meets international standards. Successful implementation of the Ukrainian-language COUL involves further expansion of the practice in the international context, with the involvement of foreign partners (and participation in COIL projects).

Analysis of the survey results shows a high level of academic motivation, cognitive and emotional engagement, and satisfaction among participants in the educational project, confirming its significance in terms of both didactic and social parameters. At the same time, the organisational difficulties identified outlined areas for improvement, in particular: optimisation of online communication, introduction of clear algorithms for task distribution, and improvement of time management and coordination.

The implementation of these measures will help to increase research activity, strengthen teamwork, and achieve better results in project work. COUL projects are a pedagogical technology that promotes the development of students' professional, communicative, digital and social skills, as well as the internationalisation of higher education even within one country. In the future, it is planned to scale up the initiative – both in quantitative (involving more participants) and qualitative (involving foreign partners, complicating tasks) dimensions.

Prospects for further research

The pilot implementation of the COUL project provides the potential for further research in the field of innovative pedagogy, digital collaboration and professional training of students. In particular, promising areas for further study include:

- Analysing the educational outcomes of students who participated in COUL compared to traditional forms of education, with a focus on the development of soft skills, critical thinking, and the ability to interact interdisciplinarily.
- Improving the project interaction model: developing standard COUL course formats for STEM disciplines that take into account different levels of student training, as well as the use of digital tools for project management.
- Internationalisation of COUL: development of a strategy for implementing Ukrainian experience in an international context, including language adaptation, cultural sensitivity, and organisational features of cooperation with foreign universities.

Thus, COUL projects require not only further scaling but also systematic study by educators, methodologists, psychologists, digital specialists and educational data analysts. This will help to form a scientifically sound basis for their widespread implementation in higher education in Ukraine and abroad.

Author contributions

Conceptualization, Dmytro Bodnenko and Oksana Hlushak; methodology, Maryna Hrysenko and Oleksandra Lokaziuk; writing – original draft preparation, Dmytro Bodnenko and Oksana Hlushak and Oleksandra Lokaziuk; writing – review and editing, Dmytro Bodnenko and Oksana Hlushak and

Maryna Hrysenko and Oleksandra Lokaziuk. All authors have read and agreed to the published version of the manuscript.

Declaration on Generative AI

The authors have not employed any Generative AI tools.

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