

# Enhanced utilization of information and communication technology in teaching environmental impact assessment

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**Abstract.** The increasing demand for experts capable of high-quality environmental impact assessment necessitates effective integration of information and communication technologies (ICT) in training ecology students. This paper presents a comprehensive methodology for utilizing ICT in the “Environmental Impact Assessment” course, detailing the implementation of various digital tools including the Padlet interactive whiteboard, Mindomo mind maps, Easel infographics, Google Drive, and Google Docs. The methodology encompasses both traditional in-person and remote learning environments, addressing the evolving educational landscape. Additionally, we analyze the alignment between academic ICT implementation and current professional EIA practice, highlighting how digital competencies developed through our approach prepare students for industry requirements. Building upon our previously established pedagogical framework, we introduce enhanced approaches incorporating emerging technologies and remote learning adaptations. Our tested methodology demonstrates significant improvements in students’ informational literacy, practical skill acquisition, and professional competence development. This paper further explores future directions in ICT integration for environmental education, addressing evolving technological landscapes and changing industry needs.

**Keywords:** ecology, environmental impact assessment, information and communication technology, digital competence, online resources, interactive boards, mind maps, remote learning, professional alignment, higher education

## 1. Introduction

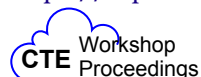
Long-term use of biosphere resources by humans has led to a significant transformation of the natural environment. The analysis of degradation processes indicates a violation of regulatory mechanisms that support the stability and durability of ecosystems. Awareness of the problem of natural ecosystems losing their ability of self-recovery has prompted the search for ways to stabilize their state. However, in modern environmental strategies and approaches considerable attention is paid not only to technologies to overcome the already existing effects of anthropogenic impact but also to the development of preventive measures that should avert the negative impact of economic activity on the environment.

Such measures include environmental impact assessment, the purpose of which is to carry out a predictive environmental impact assessment of a particular industrial object or activity at its development stage. According to the expert findings provided in

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the environmental impact assessment, it is possible to identify environmentally damaging economic projects in advance. Alongside environmental protection technologies that can reduce anthropogenic pressure, preventive measures ensure the implementation of a sustainable development strategy in the field of ecology. Environmental impact assessment is one of such preventative measures.

Therefore, the compulsory “Environmental Impact Assessment” (EIA) course is included in the curriculum for bachelors of the 101 “Ecology” speciality of Ternopil Volodymyr Hnatiuk National Pedagogical University (TNPU). Studying this subject provides students with the necessary professional skills to qualify as an ecology expert. It should be noted that the learning outcomes provided by the Higher Education Standard of the 101 “Ecology” speciality for the first (bachelor) degree of higher education (according to the decree of the Ministry of Education and Science of Ukraine No. 1076 of 04.10.2018), apart from the cumulative knowledge, skills and proficiencies, students must also acquire several general competencies. These include proficiency in using information and communication technologies; ability to adapt and act in new situations; ability to communicate with professionals of different spheres and of various levels; ability to work in a team; and proficiency in interpersonal interaction.

An ecology student can become a competitive expert in ecology and be able to respond to the needs of society only when they master professional competencies, which are also specified in the standard. These encompass knowledge of current national and international ecological legislation; ability to evaluate the impact of technogenesis on the environment and identify ecological risks; ability to use modern information resources for ecological research; and ability to inform the public about ecological security and sustainable management of nature.

In general, such a range of competencies as a learning outcome reflects not only the extraordinary dynamism of modern ecology development and its research methods but also the approaches to obtain reliable up-to-date information for a prompt and substantiated response to environmental changes. On the other hand, the content component of the standard for training ecologists stipulates that within the legally set periods of training they must not only accurately master the knowledge base of the profession, but also new methods and technologies of obtaining relevant information to identify trends in the state of ecological objects under the influence of anthropogenic activity.

Environmental impact assessment in Ukraine began to be carried out since December 2017, which is why the “Environmental Impact Assessment” course appeared in the bachelor’s degree program in the 101 “Ecology” speciality of TNPU only in 2018. This fact determines the relevance of the development of its educational and methodological base.

Our distinct understanding of these tasks within this course of study has led to the search for methods and learning tools through which the educational process would ensure a great didactic effect. Being concerned about the professional image of our students we perceived this problem as a task that needed an immediate and high-quality solution. In our opinion, one of the ways to solve this problem is to use information and communication technologies while studying the “Environmental Impact Assessment” course.

## 2. Literature review

The strategy for sustainable development in the field of ecology involves scientific studies concerning the reduction of anthropogenic impact on the environment. Recently (since 2018), the topic of ecological studies in Ukraine has included the issue of environmental impact assessment. The analysis of the degree of scientific knowledge

reveals a lack of study of this issue in contemporary scientific literature.

MacKinnon, Duinker and Walker [14] study the history of use of science in environmental impact assessment, as well as provide a conceptual and technical overview of scientific developments related to environmental impact assessment since its inception in the early 1970s.

In Ukraine, since the advent of environmental impact assessment Barna [3] and Naumenko [17] have conducted an analysis of environmental impact assessment in comparison with ecological examination.

The issues of using ICT to achieve sustainable development goals have been raised by Williams [25]. Houghton [9] explores how the Internet and ICT can help solve environmental problems in developing countries.

ICT has a major impact on education as it opens up opportunities to introduce completely new teaching methods. The introduction of ICT in the educational process is substantiated in the works of many scholars. Fedoniuk et al. [8] provide examples of use of Internet resources in the practical course of the “Natural Reserves Education” subject. The results show that ICT qualitatively influence the improvement of teaching and evaluation methods and contribute to the development of students’ information culture [1, 7].

Recent research by Zhong, Zhou and Wang [27] examines software for environmental impact assessment of air pollution dispersion based on GIS technologies, providing valuable insights into specialized digital tools that can be incorporated into EIA education. Additionally, Northmore and Hudson [18] explores emerging digital approaches for non-technical reports in EIA, including interactive digital reports using interfaces like ESRI StoryMaps and purpose-built web solutions, which have significant pedagogical potential.

In the context of remote education, Contreras-Mendieta et al. [5] describe the implementation of a remote laboratory as a support resource in distance education, which has particular relevance for adapting EIA teaching to remote learning environments. Similarly, Kist et al. [13] investigate supporting remote laboratory activities at an institutional level, discussing how remote access laboratory technology can be extended to various disciplines including environmental studies.

Another important dimension is explored by Segoni [22], who demonstrates the effectiveness of role-playing games to complement teaching activities in an environmental impact assessment course. This innovative approach enables students to experience the complexity of decision-making processes involving multiple stakeholders, thereby enhancing their understanding of real-world EIA applications.

However, researchers have not outlined comprehensive ways to use ICT in the process of studying the “Environmental Impact Assessment” course so that ecology students could acquire practical skills aligned with current industry standards. Without this approach it is difficult to provide quality professional training of future experts.

Thus, the research analysis allows us to infer that there is a lack of scientific papers that would depict the features of the use of ICT in the study of the “Environmental Impact Assessment” course, particularly in relation to emerging technologies, remote learning adaptations, and industry alignment, which makes the above issues insufficiently explored.

This article aims at explaining the features of utilization of information and communication technologies in the process of studying the EIA discipline by future ecology experts, with particular attention to how these approaches align with industry practices and accommodate remote learning environments. The object of study involves an analysis of application of information and communication technologies in different types of lessons in higher education institutions when studying the “Environmental

Impact Assessment” course.

The article that we have presented is based on the analysis of our own experience of teaching the “Environmental Impact Assessment” course for several years, enhanced with contemporary insights on emerging ICT tools and methodologies.

Monitoring of the students’ knowledge quality indicators and the level of professional competencies they formed based on the results of testing our previously developed methods of teaching EIA using ICT tools shows a positive didactic effect. This indicates the expediency of continuing to work on improving the methodology of teaching the course. In our opinion, the expansion of the range of ICT tools will likewise allow to implement the concept of assessment, which will contribute to more effective individual student progress, increase their motivation and redirect their priorities from external assessment to self-assessment. As a result, it will positively affect the level of formation of professional competencies of future ecology experts, which meets the needs of the modern vision of education.

### **3. ICT-enhanced methodology for EIA education**

At present sustainable development of Ukraine is impossible without EIA. Environmental impact assessment is a procedure in which potential investors, who plan a specific type of activity, interact with state inspectors, who are required to provide an environmental impact assessment report. The participants also include experts who at the request of potential investors must evaluate the impact of the planned activity on the environment and, if necessary, propose measures to bring the environmental impact of such an activity to the current regulations of the environmental legislation. The EIA procedure calls forth the involvement of the public, which is empowered to approve or reject the planned activity projects based on the consequences for the environment. Thus, EIA involves the work of investors, ecologists, state experts and the public with basic environmental impact assessment documents, the features of preparation of which future ecologists need to know.

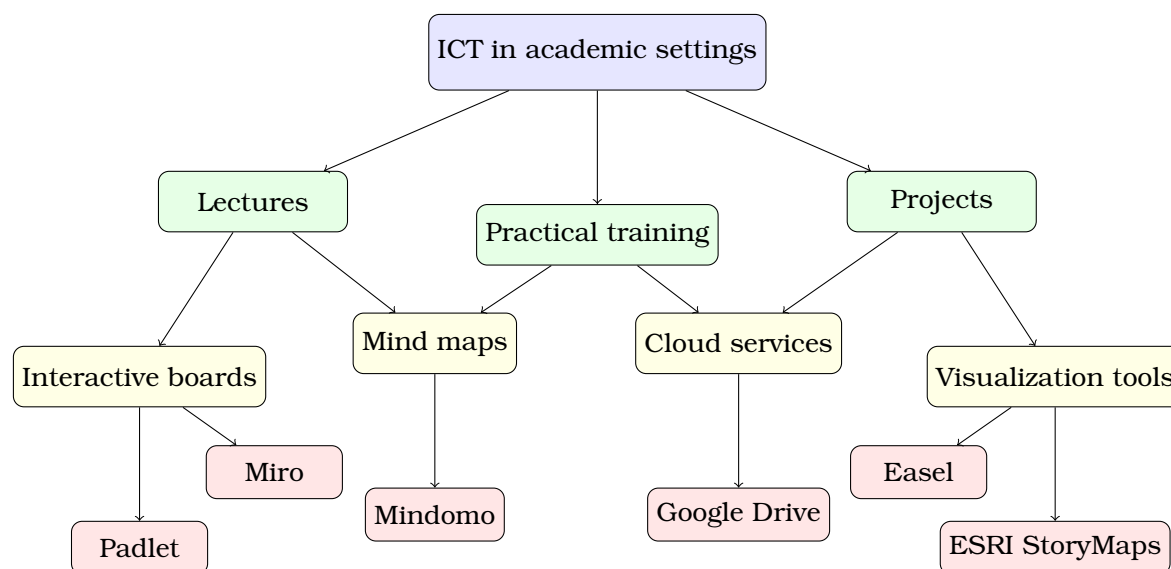
EIA in Ukraine has been carried out since December 18, 2017, according to the law of Ukraine on environmental impact assessment. While the initial implementation phase has passed, the applied aspects of EIA require continuous methodological development and improvement. There remains a lack of textbooks for professional training of EIA experts. This significantly complicates the teaching process of this course. For these reasons, the search for effective teaching methods of this subject is relevant and substantiated. It should be taken into consideration that while teaching the “Environmental Impact Assessment” course it is necessary to develop the students’ ability to work both as ecology experts and as state experts. Ecology experts need to be able to prepare EIA reports. State experts need to be able to analyze the EIA reports to issue the appropriate conclusion. These two roles are different, but studying the “Environmental Impact Assessment” course stipulates that the educational competencies of both components of the future profession are developed.

We believe that a comparative method enhanced with ICT is the most optimal in this situation.

The use of ICT is a necessary component of the EIA educational process for several reasons: changes to laws and subordinate legislations are most promptly reflected on official websites of the relevant ministry, institutions and organizations; the EIA procedure involves the registration of a potential investor in an e-cabinet, online filing of documents in the EIA register, online communication with the public and state institutions. This involves the formation of future ecology experts’ information competence. All of this has been taken into account by us when developing a methodology for using

ICT in the process of teaching the “Environmental Impact Assessment” course.

At the initial stage, we examined information and communication technologies, and as a result, found online resources that allow professors to create conditions in the academic setting for the students’ active educational trajectory (figure 1). At the second stage, the most effective online resources for different forms of the educational process (lectures, practical training, group projects) were selected. At the third stage, the developed methodology was tested during the “Environmental Impact Assessment” course.



**Figure 1:** ICT tools and resources in the academic setting for EIA education.

Generalization, synthesis and integration of the obtained data concerning the effectiveness of the initially tested method showed the expediency to improve it, which we carried out in the fourth stage of our study.

### 3.1. Lectures and interactive tools

The use of ICT for lecture form of educational process compensates for the lack of textbooks and manuals for this course. The use of ICT allows students to create an electronic synopsis using Internet resources and interactive whiteboards, which provides the opportunity to discuss a higher number of questions than that of a traditional lecture.

The lessons were held in computer classrooms where each student was able to use ICT. Issues like course objectives and methods of conducting the lessons, ways of evaluating the level of professional and informational competence, and determined methods of preparing projects using ICT were discussed in the first lecture.

Among the wide variety of online services for conducting lectures, interactive whiteboards have been selected to create teaching materials that contain certain information in the form of text, pictures, graphs, photos, videos, infographics. These include Padlet, Whiteboard, Realtime Board, WikiWall, Dabbleboard, and Popplet. More recently, Miro has emerged as a powerful collaborative whiteboarding tool that offers enhanced functionality for remote collaboration processes, allowing shared real-time interaction in a web browser without plugins [19].

The use of these boards not only allows professors to communicate in real-time online but also to record the lesson [11]. Recording the lesson can be done both by the professor and the students. In addition, professors and students can leave text notes and comments on certain elements, upload and edit files, attach text and PDF files,



and integrate graphic images using special services on the virtual board. Using simple and straightforward tools, professors can clearly visualize information as a diagram. It is important that group work is integrated on a single site.

In the educational process, virtual boards can be created to post information on the studied topic; post information or questions to find information; brainstorm to gather ideas; organize group work to find a collective opinion concerning the problem; and do projects together.

Such virtual board learning opportunities have allowed them to be used in the “Environmental Impact Assessment” course lectures. The use of the Padlet interactive whiteboard turned out to be the most optimal use of a virtual board. One of the advantages of this service is that Padlet is convenient to use as a document storage system. Materials uploaded to the board will be available at any time, which is especially relevant for students who were absent from the lesson and those in distance learning.

As an example, we demonstrate the methodology of conducting a lecture on the topic: “EIA as a mechanism to ensure ecological safety”. The first post on the board contained information about the subject of the lesson and the task. It was convenient to search for the EIA law from a dropdown menu of the post directly on the board, which allows you to optimize time spent (without opening new browser tabs). The search result leads to an image with a link to the law on environmental impact assessment, as the main document for studying.

In the lecture, after reading another article of the law the students were asked questions in the following sequence:

Question 1. What terms and concepts are confusing or unknown?

Question 2. Define the main content of the article of law, for instance, article 1.

Typically, in response to the first question, students could have written: “What is an institutional framework”. The most confusing terms were determined by allowing students to mutually evaluate their posts. Using Padlet’s search engine, students found definitions of these terms, offered links, established connections to posts with the corresponding caption on the connection line. In this way, the process of learning new material in the short term “materialized” on the Padlet board during group work.

It should be noted that at the initial stages of studying the course the students were not active. This is partly due to the inability to use such information and communication technologies. However, within 10–15 minutes students quickly gained proficiency in the means of ICT, became active and showed considerable interest. At this stage, the lesson was conducted in the form of a brainstorming session. This teaching format contributed to the formation of a positive emotional dimension to the lessons, which increased didactic results.

Being able to access a significant portion of articles of the EIA law in Padlet’s search engine via hyperlinks was a great advantage. For instance, article 1: “Planned activity is planned economic activity that includes construction, reconstruction, ... according to the criteria (originally a hyperlink), approved by the Cabinet of Ministers of Ukraine”.

While working with the Padlet board students created a document as a part of an e-synopsis and saved it on a virtual drive. Students took notes (as a separate document) in the form of a table which had 4 columns. While filling in each of the columns the students:

1. Studied an article of the law.
2. Established the main content of the article of the law.
3. Established the significance of the article for an ecology expert.
4. Established the significance of the article for a state expert.

To answer the second question students analyzed the content highlighting the main content (in bold or with a colour). The format of the table in the text document of the e-synopsis made it easy to organize and summarize the learning material and promoted the qualitative acquisition of knowledge and formation of professional skills. The e-synopsis thus fulfilled the function of a textbook to study the course, prepare for practical lessons and the basis for proper and timely completion of a group project as well as an individual project, which the students were expected to execute in accordance with the organization of the educational process according to our improved teaching methods.

To involve all students in active participation the professor provided them with the chance to analyze all the terms using ICT and to take notes for themselves. The professor's comments on the students' posts on the Padlet board made it possible for the students to focus on the key information and transfer it to their e-synopsis. In the case of repeated references to the article in the law, the students did not have to reopen the document since the information had already been saved in their e-synopsis.

### **3.2. Group and individual projects**

According to the organization of the educational process of the "Environmental impact assessment" course two student groups were expected to prepare an e-project which also used mind maps, in accordance with the initially developed teaching method.

Today the mind map technology is a new tool for structuring and storing information in human memory. One effective way of structuring memorization stages is to provide educational material with a tree structure. Such structures are widely used everywhere where it is necessary to picture a large amount of information in a short and compact way. Mind maps are a convenient and effective technique for visualizing thought and graphic displays of associative connections. They can be used to create and capture new ideas, analyze and systematize information, and make decisions.

There are many online services to create connection diagrams in mind maps [21]. The most popular ones are Mindomo, MAPMYself, Mind42, MindMap, Glinkr [10]. To create an EIA project, we suggest using Mindomo. Designing a mind map allowed the students to create a system of related data and identify the stages of activity the sequence of which is consistent with the logic of the EIA process, which in our case will allow us to construct an algorithm of actions of an ecology researcher or an ecology expert.

Our study also used the didactic resources of Google Drive, which include tools for creating text documents, spreadsheets, presentations, data visualizations. Saving the results of the group project in Google Drive in the suggested by the professor structure was a mandatory and practical work condition, in our opinion. The students saved the project on their personal Google Drive and gave access to another group of students.

We find that this method of saving the results has several advantages: auto-saving of the latest version of the document; variability when checking the work by the professor; the means to check the notes of several students on the example of a single work by the professor online in Google Drive; and the ability to mutually analyze the obtained data by multiple users.

One way to present the first folder of the group project was to create an infographic in Easel. It could include a set of pictures of official pages of different state institutions and text blocks from the point of view of their importance for the EIA procedure.

The student groups were tasked to evaluate the project using SWOT analysis technology. The SWOT analysis method involved mutual evaluation of a group project by students according to four criteria. The students evaluated the "strengths" of the project according to the following criteria: the completeness of the answer; the

correctness of the answer; adherence to the sequence of stages of the EIA procedure; the manner of representation of items 1-3 in the structure of the presentation.

If the above criteria were partly or fully not met, the students listed them as “weaknesses” of the project. Comparative analysis of the “strengths” and the “weaknesses” of the project at the level of pluses “+” and minuses “-” performed a motivational function, because it identified opportunities or threats.

“Opportunities” during the SWOT analysis of the project were viewed as a sign of full (provided the prevalence of strengths) or partial (provided there were weaknesses) readiness to work as an ecology expert or a state expert. In the evaluation 1 met criterion stood for 1 point or in the case of partial execution – 0.5 points. For example, if a group project fully met the criteria, students rated it at 4 points.

“Threats” as one of the categories of the group project SWOT analysis ascertained the fact of the existence of gaps in knowledge, which could potentially lead to the inability to work as an expert in the field of EIA.

The utilization of the group project SWOT analysis allowed students with a low level of acquired knowledge of the course to fill in the gaps during interpersonal interaction with those with a good understanding of the course.

The method of teaching the “Environmental Impact Assessment” course tested by us proved to be effective, as didactic goals were achieved and professional competencies of students were formed. This ensured a high level of knowledge among the majority of students. Students noted that the lessons possessed a positive emotional nature, which promoted their cognitive functions.

However, this approach to the content and implementation of teaching the “Environmental Impact Assessment” course on the example of the proposed methodology, in our opinion, can be improved, which was achieved as follows.

Lectures and practical classes were carried out according to the previously described method using the resources of the interactive whiteboard Padlet, creating an e-synopsis and saving it on a virtual drive, systematically consulting the professor. However, at the stage of the creating of the project we proposed the following tasks, which were evaluated according to the new approach and with the use of additional ICT resources.

First of all, the nature of the project was changed from a group assignment to an individual one, and its content involved the creation of presentations and infographics.

During the study of the “Environmental Impact Assessment” course presentation as a method of work and a means of assessment of students’ academic achievement should include all the documents required in accordance with the EIA procedure, prepared according to the examples, and the chronological order of presentation of documents according to the EIA procedure.

To determine the quality of the students’ knowledge and the formation of their professional competencies and skills, the following evaluation criteria were selected: the semantic component, i.e. the correctness of the filled out documents in accordance with the requirements of the Law of Ukraine on EIA; adherence to the procedure during the preparation of the documents, which is reflected in the order of the documents in the presentation; and the list of used sources, in particular, online pages of relevant organizations.

By their own choice, students formed pairs in which they mutually evaluated their presentations. Students evaluated the presentation of their partner on the basis of “correct-incorrect”, which denoted +1 or -1 point.

In order to eliminate any displays of biased evaluation, which would be evident through abnormally high or low marks, the students’ evaluation was overseen by the professor acting as a facilitator, who simultaneously evaluated presentations according to the same criteria.



The discussion of the mistakes in the presentation took place with the assistance of excellent students. After giving their fellow student a chance to correct their mistake they proposed the correct solution. Moreover, the discussion took place from the standpoint of assessment, which allows you to assess and adjust the educational process.

Assessment of tasks executed by students should be diagnostic in nature, as it allows to identify inconsistencies between the program requirements for the students' education level and to establish gaps in the acquisition of the educational material. Assessment has particular goals, methods and means of implementation.

Earl [6] substantiates assessment as “assessment for learning”, which occurs when professors use observations about students' progress, and “assessment as learning”, which occurs when students reflect and monitor their progress to form their learning goals.

Assessment for learning is the process of searching for and interpreting data used by students and professors to address issues concerning their level of learning, in which direction they need to move in and how best to do so [2].

Thus, assessment enables students to be aware of and track their own progress and to create their own learning trajectory with the help of a professor or a consultant.

Assessment develops the students' skill of “studying by learning” and provides an opportunity to involve students as consultants and experts in the educational process. It helps them develop effective strategies of learning. Students who take an active part in the discussion during the learning process; assess the quality of their assignments and their peers' assignments according to clearly defined criteria; develop their own digital competence, in particular, one of its components problem solving.

The introduction of assessment in the educational process is becoming more relevant and effective with the use of ICT tools. Assessment technology provides feedback aimed at improving the educational process.

ICT tools for assessment can be used at different stages of the lesson depending on its goals. Based on the results of the discussion of the presentations from the standpoint of assessment, the students determined which tasks they performed successfully, and which ones need to be analyzed, adjusted and re-done.

The process of evaluating the presentations was carried out using the Mentimeter resource, which students utilized to cooperate in the presence of a professor acting as a facilitator.

Our choice of Mentimeter as a feedback tool is due to three main criteria: an intuitive interface; no need for students to register; multifunctionality, i.e. it is possible to use the resource during any stage of the lesson for various tasks.

Mentimeter is a simple and easy-to-learn voting tool that provides instant feedback from your classroom. It is convenient to use to interview students in real time, as it is available on both mobile devices and on the web.

It is an excellent tool for assessment: students can record their points and assign marks for completed tasks based on certain criteria (correctness, completeness, chronological order). The professor can demonstrate such assignments on lectures when checking homework to brush up on the material, during initial monitoring of understanding of the new material, in the middle of the lesson as a means to identify problem areas, at the end of the lesson during introspection.

The next step of the project involved working on creating infographics.

The utilization of illustrative materials in the educational process is an integral part of a modern professor's activity, and the use of infographics, as one of the new means of visualization, improves the learning quality of the studied material.

Smiciklas [23] defines infographics as a type of illustration that combines design and various data, which allows you to concisely and quickly convey information to the

target audience.

The purpose of infographics is to improve the process of information perception; explanation of complex material in simple terms using images; transfer data in a creative, compact and interesting way, which has special advantages over the usual textual presentation of information [12].

During the research, we have identified two approaches to the use of infographics in the educational process: “professor-student” and “student-professor”. In the first approach, infographics are created by the professor to solve certain educational aims (attracting students’ attention, structuring data, etc.). In the second approach, infographics are created by the students during the learning process.

The creation of infographics was individual in nature. When creating the infographic the students took into account the mistakes that were made during the creation of the presentation, and therefore it helped them to increase their level of knowledge acquisition. Students independently analyzed the information, structured it and presented it graphically. This type of work allowed students to study the material better, analyze its important aspects and contributed to the development of their critical thinking. Thus, infographics became a tool for systematization of knowledge based on the discussion of mistakes made during the presentation. If necessary, the professor provided assistance as a facilitator.

#### 4. Adapting ICT methodology for remote learning

The global shift toward remote and hybrid learning models has necessitated adaptations in educational methodologies across disciplines. For the Environmental Impact Assessment course, we have explored several approaches to ensure effective knowledge transfer and skill development in remote learning environments, building upon our established ICT-based methodology.

##### 4.1. Remote learning technologies in EIA education

Remote learning presents both challenges and opportunities for teaching EIA, a subject that traditionally benefits from hands-on experiences and collaborative problem-solving. Our adaptation strategy incorporates several key technologies and approaches (table 1).

**Table 1**

Remote learning adaptations for ICT-enhanced EIA education.

Technology	Implementation in EIA course	Benefits for learning outcomes
Remote access laboratories (RAL)	Virtual simulation of environmental sampling and testing procedures	Practical experience in data collection and analysis without physical presence
Collaborative learning platforms	Structured online spaces for group projects and peer review of EIA reports	Enhanced communication and teamwork skills despite physical separation
Mobile learning technologies	Offline access to course materials and EIA case studies	Improved accessibility and continuity of learning regardless of internet connectivity
Interactive simulation tools	Virtual role-playing of EIA stakeholder consultations	Understanding of complex social and political dimensions of impact assessment
Comprehensive online platforms	Integrated systems for lectures, assessment, and feedback	Seamless learning experience that mimics classroom dynamics

Remote access laboratories (RAL) have emerged as particularly valuable tools for environmental education in remote settings. As Contreras-Mendieta et al. [5] demonstrate, these technologies allow students to perform experimental practices remotely, providing alternatives to traditional laboratory experiences. For EIA education, this means students can engage with environmental data collection and analysis tools without physical presence, developing critical technical competencies for professional practice.

The implementation of collaborative learning systems leveraging electronic communication technologies has proven effective in creating interactive and engaging remote learning environments [26]. These systems facilitate group activities and collaborative projects, which are essential for courses like EIA that require teamwork and discussion of complex environmental issues.

Mobile-based learning content delivery addresses challenges related to bandwidth and internet accessibility, particularly in resource-constrained environments [15]. By enabling offline access to learning materials, this approach ensures that students can continue their studies regardless of connectivity issues, improving participation and engagement.

Interactive tools such as virtual labs, simulations, and role-playing games significantly enhance remote learning effectiveness. As demonstrated by Segoni [22], role-playing games in EIA education help students understand the real-world complexity of decision-making processes involving multiple stakeholders. When adapted for online environments, these approaches maintain their pedagogical value while accommodating remote participation.

Our comprehensive online learning platform integrates video conferencing, course management, remote desktops, and various online tools to support real-time interaction and content delivery [16]. Continuous feedback from students has been essential in refining this platform to meet their needs and preferences.

#### 4.2. Case study: remote implementation of collaborative EIA project

To illustrate our approach to remote EIA education, we implemented a collaborative project that required students to develop a complete environmental impact assessment for a hypothetical development. The project was structured to mirror professional practice while leveraging remote collaboration tools.

The project involved the following phases, each supported by specific ICT tools:

1. **Scoping phase:** using Miro collaborative whiteboard, student teams mapped potential environmental impacts of the development, identifying key areas for assessment.
2. **Baseline data collection:** through simulated remote access to environmental monitoring stations (using pre-prepared datasets), students gathered and analyzed baseline environmental conditions.
3. **Impact assessment:** using cloud-based spreadsheets and statistical tools, teams quantified potential impacts and assessed their significance.
4. **Mitigation planning:** through structured online brainstorming sessions, teams developed mitigation strategies for identified impacts.
5. **Reporting:** using ESRI StoryMaps, teams created interactive digital reports that presented their findings in an accessible format for technical and non-technical audiences.
6. **Public consultation:** through role-playing in video conferencing sessions, teams presented their findings to other students acting as stakeholders, responding to questions and concerns.

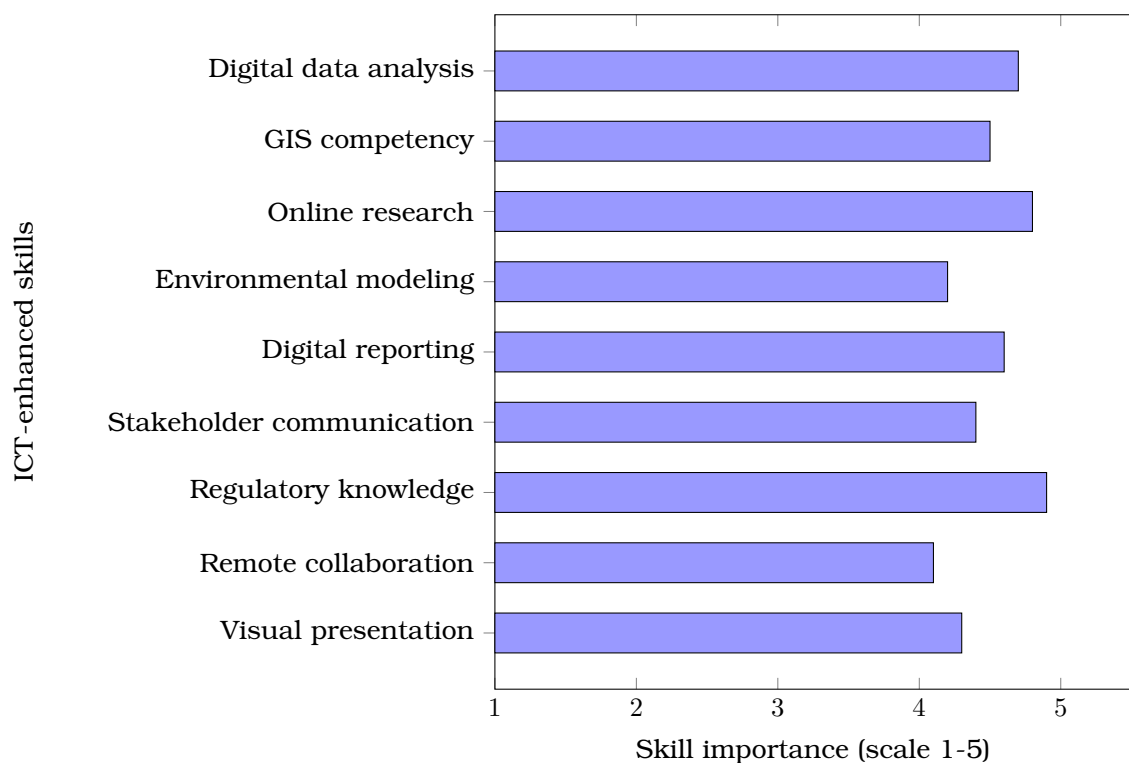
This approach successfully translated the collaborative and practical aspects of EIA education to a remote learning environment. Student feedback indicated high levels of engagement and effective skill development, particularly in the areas of data analysis, report preparation, and stakeholder communication – all essential competencies for professional EIA practice.

## 5. Alignment with industry practice and professional requirements

A critical aspect of effective EIA education is ensuring that the skills developed through academic training align with current industry practices and professional requirements. Our ICT-enhanced methodology has been designed with this alignment in mind, drawing on insights from industry partners and analysis of professional EIA procedures.

### 5.1. Industry-relevant skills in ict-enhanced eia education

Based on our analysis of industry needs and feedback from environmental professionals, we have identified several key skills that are particularly valued in professional EIA practice (figure 2).



**Figure 2:** Industry-relevant ICT skills prioritized in our EIA educational methodology, based on professional feedback (scale 1-5, where 5 represents highest importance).

Our ICT-enhanced methodology specifically targets these industry-relevant skills through several approaches:

#### 1. Simulation of real procedures

The use of ICT tools such as Padlet, Mindomo, Easel, Google Drive, and ESRI StoryMaps helps simulate real-world EIA procedures [4]. This approach enhances students' ability to quickly find necessary information and professionally communicate with experts from various fields, which are essential skills in professional EIA practice.

## 2. Practical skill development

Our methodology has shown to significantly increase informational literacy and professional growth among students [4]. This mirrors the practical skills required in the industry, such as data analysis, project management, and effective communication.

## 3. Professional communication

The ability to professionally communicate with experts in other fields, developed through ICT-based group projects, is highly valued in the industry. This skill is essential for interdisciplinary collaboration, which is a common requirement in professional EIA practice.

## 4. Technical software competency

As noted by Zhong, Zhou and Wang [27], professional EIA practice increasingly incorporates specialized software such as GIS-based tools for environmental modeling and analysis. Our curriculum integrates training in these technologies, preparing students for their use in professional settings.

## 5. Digital report preparation

The emergence of digital reporting formats in professional practice, as identified by Northmore and Hudson [18], is reflected in our emphasis on developing interactive digital reports using tools like ESRI StoryMaps. This prepares students for evolving industry expectations regarding report presentation and accessibility.

## 5.2. Challenges and recommendations for enhancing industry alignment

Despite the strong alignment between our ICT-enhanced methodology and industry requirements, we have identified several challenges and opportunities for further improvement:

### 1. Teaching-practice gap

As noted by Weiland [24], there remain discrepancies between teaching and actual industry demands in some areas. Continuous dialogue with industry partners is essential to address these gaps and ensure curriculum relevance.

### 2. Rapid technological evolution

Environmental assessment tools and technologies evolve rapidly, requiring regular curriculum updates to remain current. A flexible curriculum structure that can accommodate new tools and approaches is essential.

### 3. Regulatory context

EIA practice is highly influenced by evolving regulatory frameworks. Our methodology emphasizes cultivating skills in regulatory research and interpretation that allow students to adapt to changing legal requirements throughout their careers.

### 4. Balance of technical and social skills

While technical ICT skills are important, industry feedback consistently emphasizes the equal importance of “soft skills” such as stakeholder communication and conflict resolution. Our methodology balances technical training with opportunities to develop these interpersonal competencies.

Based on these challenges, we recommend a continuous improvement approach to EIA education that includes: regular industry consultation to validate curriculum relevance; flexible incorporation of emerging technologies; emphasis on adaptable research and analytical skills; and integration of professional ethics and social responsibility throughout the curriculum.

## 6. Results and discussion

The use of these ICT resources allows you to significantly optimize the process of teaching the EIA course. However, it is only possible to evaluate the effectiveness



of our developed and tested methodology by determining the level of formation of professional competencies in ecology students.

The analysis of scientific and pedagogical literature showed that among scientists there is no singular approach to determine qualitative and quantitative criteria for evaluation of the level of formation of professional competencies. For example, Pavlyutenkov [20] distinguishes five levels of professional competence: very low, low, medium, high and very high. We proposed four levels (L) of professional competence of a future ecologist: high (LA), medium (LB) and low (LC) and very low (LD). We determined them by the quality of the knowledge acquired by students in the process of studying the “Environmental Impact Assessment” course.

As mentioned above, the methodologies we developed differed in their approaches to the use of ICT resources. The initial (I-M) methodology involved the use of ICT for lectures and group projects [4]. In the improved (II-M) methodology, ICT resources were also used for individual assignments. We hypothesize that this will affect the levels of formed competencies in students.

To support or refute this working hypothesis we analyzed the level of formed competencies in two groups of students, which differed in the methodology of using ICT in the process of studying EIA. The two groups were: the I-M group and the II-M group. In each of the groups, we determined the share of students with a certain level of formed competence. To achieve this, they were ranked according to the number of points gained: LD – from 0–60 points; LC – from 60–74 points; LB – 75–89 points; LA – from 90–100 points. In each group, the share of students with a certain level of competence can range from 0% to 100%.

The analysis of the obtained research results showed that by using ICT resources only during lectures and group projects of the I-M group there was a share of students with a very low level of formed competencies.

**Table 2**

Comparison of competence levels across different methodologies.

<b>Methodology</b>	<b>High level (LA)</b>	<b>Medium level (LB)</b>	<b>Low level (LC)</b>	<b>Very low level (LD)</b>
Initial (I-M)	25%	40%	25%	10%
Improved (II-M)	35%	50%	15%	0%
Remote-adapted	30%	55%	15%	0%

The share of students with a different level of competencies in the I-M group is lower by 10 percent compared to the II-M group. The obtained results are presumably caused by the fact that the execution of the group project allowed some students to take a smaller part in its realization. The identification of “weaknesses” and strong “threats” in the process of project evaluation based on the method of SWOT analysis was not individual in nature. Therefore, a low mark for the group project was not perceived by the students as a personal failure. The II-M group students were personally responsible for the execution of their individual project. The use of the Mentimeter resource in the process of discussion of the presentations and infographics incentivized each student to fill in their gaps in knowledge and motivated a more creative and effective presentation of their work.

When implementing our remote learning adaptations, we observed that despite the physical separation, student competency levels remained comparable to the improved in-person methodology (II-M). This suggests that well-designed remote learning approaches can effectively maintain educational quality even without physical presence. The slight differences observed (notably a small shift from high to medium

competency levels) may be attributed to the adjustment period required for students to acclimate to remote learning environments.

Notably, our analysis of industry alignment revealed that students who experienced the improved methodology (II-M) and remote adaptations demonstrated stronger capabilities in areas highly valued by employers, particularly in digital data analysis, online research, and regulatory knowledge. This suggests that our ICT-enhanced approaches are effectively preparing students for professional practice regardless of the delivery modality.

## 7. Conclusions and future directions

The training of future ecologists in the context of the transformation of higher education involves the acquisition of knowledge and the formation of skills. One of the ways to achieve this goal is to use information and communication technologies in the process of studying the course by future ecology experts.

Our ICT-enhanced methodology for teaching the “Environmental Impact Assessment” course has demonstrated significant benefits for student learning and professional development. The integration of interactive whiteboards, mind mapping tools, collaborative platforms, and assessment technologies has created a rich learning environment that effectively prepares students for professional practice in environmental assessment.

Key findings from our implementation include:

1. The use of ICT tools significantly optimizes the educational process, allowing students to efficiently access, analyze, and apply complex regulatory information.
2. Individual accountability in ICT-enhanced projects leads to higher levels of competency development compared to purely group-based approaches.
3. Well-designed remote learning adaptations can maintain educational quality comparable to in-person instruction, provided they incorporate appropriate collaborative and interactive elements.
4. Alignment with industry practices through ICT integration enhances student readiness for professional roles in environmental impact assessment.

Looking toward the future of ICT integration in EIA education, several promising directions emerge:

1. The rapid evolution of technologies such as augmented reality, virtual reality, and artificial intelligence presents opportunities for further enhancement of EIA education. These technologies could enable more immersive simulations of environmental impacts and assessment procedures.
2. As remote and hybrid work becomes increasingly common in professional practice, developing advanced remote collaboration skills will be essential for future EIA practitioners. Further refinement of our remote learning methodologies will prepare students for this evolving professional landscape.
3. Professional EIA increasingly involves complex data management across multiple environmental parameters. Expanding our curriculum to include more advanced data science techniques and tools would enhance student preparedness for contemporary practice.
4. Environmental impact assessment inherently spans multiple disciplines. Future development of our methodology could include more structured collaboration with other academic departments to provide students with authentic interdisciplinary experiences.

In conclusion, our experience with ICT-enhanced teaching in the “Environmental Impact Assessment” course demonstrates the potential for technology to transform environmental education, particularly in preparing students for professional practice. By continuing to refine our approaches in response to technological evolution, remote learning needs, and industry requirements, we can ensure that future ecology experts develop the comprehensive competencies needed to address complex environmental challenges.

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