

The use of information and communication technologies in training ecology students

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Abstract. Increasing demand for experts capable of high-quality assessment of the impact of a particular planned activity on the environment involves a more effective use of information and communication technologies (ICT) in the educational process of training ecology students. The authors present a methodology for students to study the educational material of the “Environmental Impact Assessment” course by using ICT. The methodology and algorithm for using the Padlet interactive whiteboard, Mindomo mind maps, Easel infographics, Google Drive and Google Docs in lectures and practical lessons are described. Particular attention is paid to the preparation of a group project using ICT. Tested in the Ternopil Volodymyr Hnatiuk National Pedagogical University, the methodology allows to implement a number of tasks such as: promotion of intensification and effectiveness of teaching; acquisition of practical skills to quickly find the necessary information on various online resources for ecology students; simulation of the real procedure of environmental impact assessment in the classroom; development of the ability to professionally communicate with experts in other fields of knowledge or activity, etc. Examination of the results of using ICT to study the “Environmental Impact Assessment” course has shown a significant increase in informational literacy among ecology students and their individual professional growth.

1 Problem statement

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 the environmental impact assessment, it is possible to identify environmentally damaging economic projects in advance. Alongside with 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 No 1076 of 04.10.2018), apart from the cumulative knowledge, skills and proficiencies, students must also acquire the following general competencies:

- ✓ 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 (with experts in other fields of knowledge/types of economic activity);
- ✓ ability to work in a team;
- ✓ 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, namely:

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1. The knowledge of current national and international ecological legislation achievements;
2. The ability to evaluate the impact of technogenesis on the state of the environment and identify ecological risks associated with production activities;
3. The ability to use modern information resources for ecological research;
4. The ability to inform the public about the state of ecological security and the 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 in 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.

A. J. Macrinnon et al. 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 [1].

In Ukraine, since the advent of environmental impact assessment scientists in the field of ecology I. Barna and O. Naumenko have conducted an analysis of environmental impact assessment in comparison with ecological examination [2, 3].

The issues of using ICT to achieve sustainable development goals have been raised in the works of E. Williams [4]. J. Houghton explores how the Internet and ICT can help solve environmental problems in developing countries [5].

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 domestic and foreign scholars [6-10]. V. V. Fedoniuk, V. V. Ivantsiv, M. A. Fedoniuk, S. G. Pankevych provide examples of use of internet resources in the practical course of the “Natural Reserves Education” subject [11]. The results show that ICT qualitatively influence the improvement of teaching and evaluation methods and contribute to the development of students’ information culture [12, 13].

However, researchers have not outlined ways to use ICT in the process of studying the “Environmental Impact Assessment” course so that ecology students could acquire practical skills. 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, which makes the above issues insufficiently explored.

The article is aimed at explaining the features of utilization of information and communication technologies in the process of studying an academic discipline by future ecology experts.

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.

3 Results and discussion

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, to 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. In December 2019,

two years passed since EIA was first used, however, the applied aspects of its implementation require methodological development and improvement. There is also 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 comparative method with the aid of ICT is the most optimal in this situation. The latter 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 (Fig. 1).

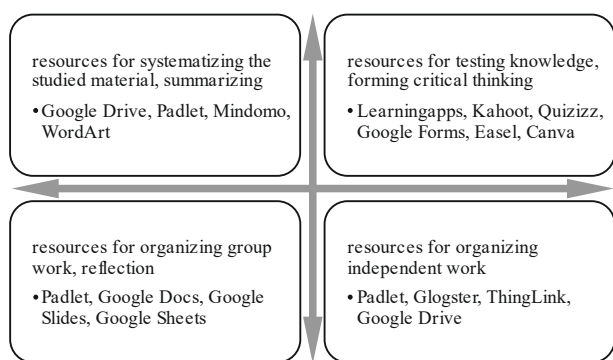


Fig. 1. ICT in the academic setting.

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.

Lectures. The use of ICT for this 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

the Padlet interactive whiteboard, 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, namely:

- ✓ Padlet;
- ✓ Whiteboard;
- ✓ Realtime Board;
- ✓ WikiWall;
- ✓ Dabbleboard;
- ✓ Popplet.

The use of these boards not only allows professors to communicate in real-time online but also to record the lesson [14]. 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, 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;
- ✓ 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) (Fig. 2). The search result leads to an image with a link to the law on environmental impact assessment, as the main document for studying (Fig. 3).

The law of Ukraine on environmental impact assessment (lecture), **topic:** “EIA as a mechanism of ensuring environmental security”, **task:** learn about the

article 1 of the law of Ukraine on environmental impact assessment. 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.

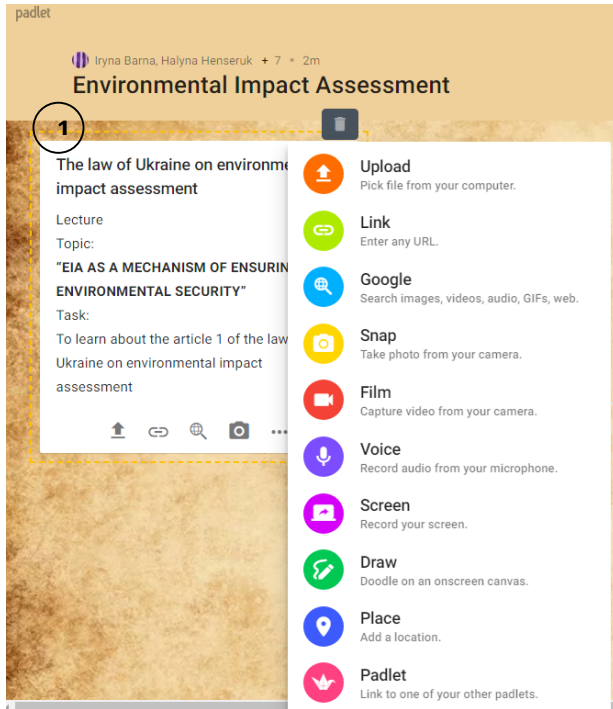


Fig. 2. Padlet board content 1 (information search).

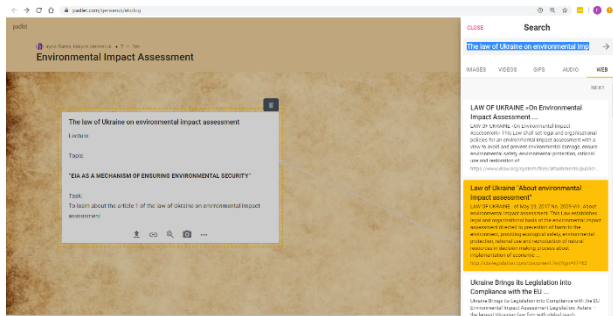


Fig. 3. Padlet board content 2 (information search).

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 (Fig. 4).

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.

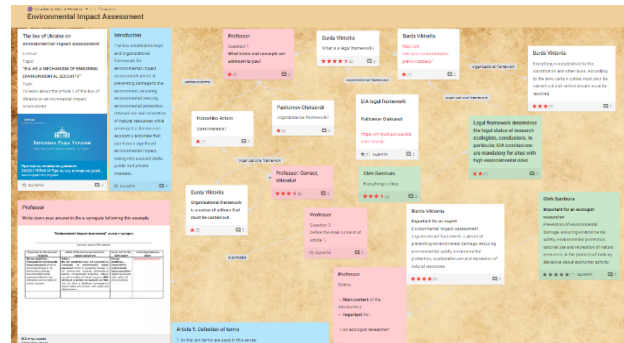


Fig. 4. Padlet board content (information discussion).

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) (Fig. 5).

E-synopsis «Environmental Impact Assessment» course

<i>surname, name of the student</i>			
Important for the ecologist-researcher	Article of the law on environmental impact assessment	Important for the state expert	Confusing/unknown terms
<p>The law establishes ... environmental impact assessment aimed at preventing damage to the environment, ensuring environmental security, environmental protection, rational use and recreation of natural resources</p>	<p>The law establishes legal and institutional framework for environmental impact assessment aimed at preventing damage to the environment, ensuring environmental protection, rational use and recreation of natural resources while arriving at a decision on economic activities that can have a significant environmental impact, taking into account state, public and private interests.</p>	<p>The law establishes ... framework for environmental impact assessment taking into account state, public and private interests.</p>	<p>Institutional framework...</p>

Fig. 5. Content of the e-synopsis.

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. 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 (Fig. 6, Fig. 7).

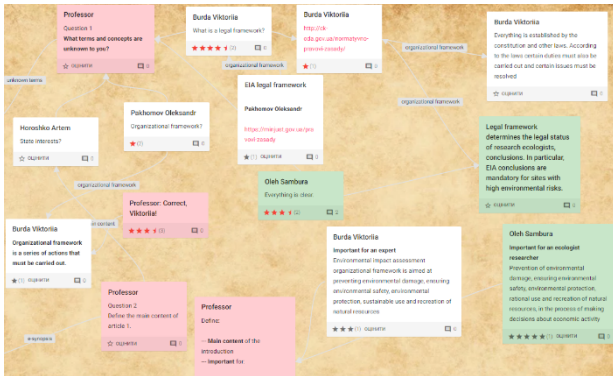


Fig. 6. Professor's comments on the students' posts.

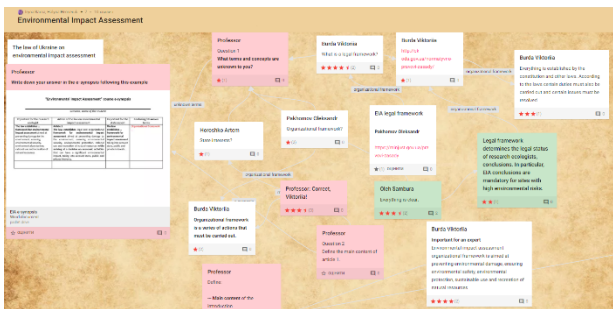


Fig. 7. Students' posts assessment.

The students analyzed the connections between the articles of the law in an electronic document for a fully understand them and to apply them properly.

Group project. The educational process of the "Environmental Impact Assessment" course included preparation of an e-project with mind maps by two groups of students. 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 [15]. The most popular ones are Mindomo, MAPMYself, Mind42, MindMap, Glinkr. 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 (Fig. 8).

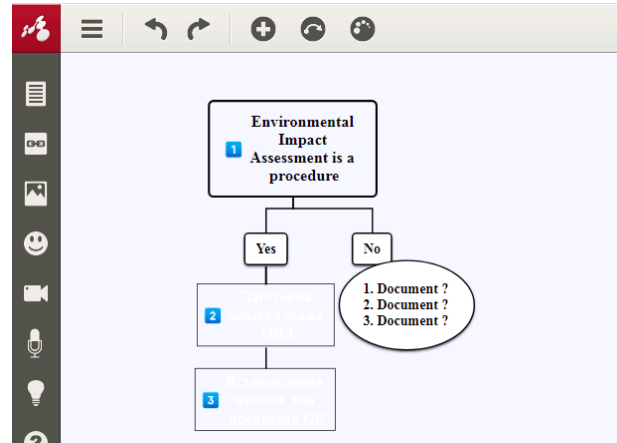


Fig. 8. A model of algorithm construction on the example of the EIA procedure.

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 (Fig. 9).

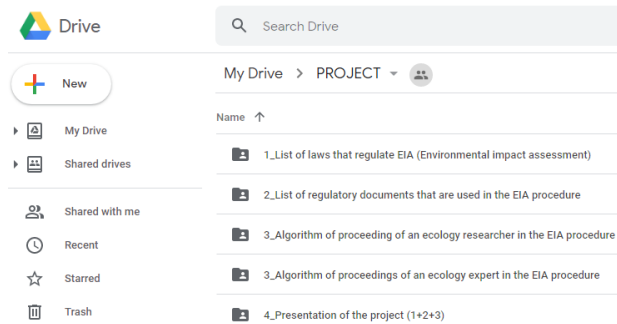


Fig. 9. Tasks for the group project.

The students saved the project on their personal Google Drive and gave access to another group of students who were to evaluate the project using SWOT analysis technology. We find that this method of saving the results has the following advantages:

- auto-saving of the latest version of the document;
- variability when checking the work by the professor (the student could choose how to communicate with the professor: through Google Drive or email);
- the tools to check the notes of several students on the example of a single work by the professor online in Google Drive;
- 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 use of ICT in the study of the "Environmental Impact Assessment" course allowed us to achieve didactic tasks and to form professional competencies for students. It is possible to establish the qualitative performance indicators of the effectiveness of ICT use while studying

the “EIA” course based on the results of the students’ performance or the results of the students’ survey by questionnaire on the quality of teaching. In TNPU, surveys are conducted anonymously by way of answering the questionnaire.

However, it is difficult to quantify the effectiveness of using ICT in the study of the “EIA” course for several reasons. First, in our view, objective evaluation involves the comparison of students of the control group, the test group, and their performance indicators. Only one group is enrolled in this year of study and it is not advisable to divide it into subgroups for the sake of the experiment (and this is not provided for in the regulatory documents of the Ministry of Education and Science of Ukraine) because of the small number of students (10-20 persons). Taking this into account, a sample of 5-10 respondents will not produce a statistically reliable result and will not be representative. Secondly, it is only the second academic year that this course is being studied (since the EIA procedure has been used since December 2017) and currently the methodology suggested by the authors is tested only by one academic group during the study of the course.

The “before” and “after” test can be used as one of the methods to assess the effectiveness of ICT use and to evaluate the students’ performance. The results of such a test will make it possible to assess students’ basic skills in using ICT.

We consider the study of the effectiveness of ICT use, as well as the determination of the criteria to assess students’ success and the formation of professional competencies as further research.

4 Conclusions and prospects for further research

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.

The methodology of conducting lessons and preparing a project in the “Environmental Impact Assessment” course, suggested and tested by us, allowed the students to optimize the time spent searching for educational materials, preparing them and making them applicable as much as possible. Each student was given the opportunity to organize their e-synopsis and project simultaneously via using ICT during at lectures and while preparing for practical lessons. In the e-synopsis they constructed an algorithm of actions of an ecologist as a potential researcher or expert in the field of environmental impact assessment, through the use of distinct guidance from the professor, group work during lessons, and independent study.

While studying the “Environmental Impact Assessment” course, students developed skills of using information and communication technologies in lectures and while preparing a group project.

Through the use of the Padlet interactive whiteboard, students gained the ability to adapt and act in new situations when studying the law of Ukraine on environmental impact assessment or discussing its articles.

With the use of ICT during brainstorming at lectures, practical lessons, group assignments, group projects, students were able to practice communicating with experts in other fields of knowledge or activities. By simulating the real-world environmental impact assessment procedure, students developed interpersonal skills that were reinforced by the use of online resources.

Learning the material of all modules of the course, the students acquired the skills to evaluate the impact of technogenesis on the environment through the use of ICT at the stage of studying the EIA procedure.

Examining the learning outcomes showed us that the use of ICT provided students with the ability to use information resources in ecological research for sustainable development goals and individual professional growth.

Positive feedback from students proves the efficiency of using ICT while training future ecologists.

References

1. A.J. Macrinnon, P. Duinker, T.R. Walker, *The Application of Science in Environmental Impact Assessment* (Routledge, London, 2018)
2. I.M. Barna, EIA (Environmental Impact Assessment) as a mechanism for ensuring environmental safety. Scientific Notes Ternopil National Volodymyr Hnatiuk Pedagogical University. Series: Geography. **1**, 217–225 (2019). doi:10.25128/2519-4577.19.2.27
3. O. Naumenko, Environmental Impact Assessment vs Environmental Assessment: What changed? (Yurydychna Gazeta, 2018), <https://yur-gazeta.com/publications/practice/inshe/ocinka-vplivu-na-dovkillya-vs-ekologichna-ekspertiza-shcho-zminilosya.html>. Accessed 04 Jan 2020
4. E. Williams, Environmental effects of information and communications technologies. *Nature* **479**, 354–358 (2011). doi:10.1038/nature10682
5. J. Houghton, ICT and the Environment in Developing Countries: A Review of Opportunities and Developments. *IFIP AICT* **328**, 236–247 (2010). doi:10.1007/978-3-642-15479-9_23
6. N.V. Morze, I.P. Vorotnikova, The model of ICT-competencies of the teachers. *ScienceRise: Pedagogical Education*. **10**, 4–9 (2016). doi.org/10.15587/2519-4984.2016.80644
7. V. Bykov, O. Ovcharuk, *Assessment of students and educators information and communication competence in the context of European integration processes in education* (Pedahohichna Dumka, Kyiv, 2017)
8. S. Semerikov, I. Teplytskyi, Yu. Yechkalo, O. Markova, V. Soloviev, A. Kiv, Using spreadsheets as learning tools for computer simulation of neural

- networks. SHS Web of Conferences **75**, 04018 (2020)
9. V.S. Kruglyk, V.V. Osadchy, Developing Competency in Programming among Future Software Engineers. *Integration of Education* **23**(4), 587–606 (2019)
 10. V. Osadchy, N. Valko, L. Kuzmich, N. Abdullaeva, Studies of impact of specialized STEM training on choice further education. SHS Web of Conferences **75**, 04014 (2020)
 11. V.V. Fedoniuk, V.V. Ivantsiv, M.A. Fedoniuk, S. H. Pankevych, Case studies of web-resources application in the practical course of Natural reserves Education. *Information Technologies and Learning Tools* **2**, 109–123 (2015). doi:10.33407/itlt.v46i2.1192
 12. A. Lantz-Andersson, G. Fauvilleldine, ICT tools in environmental education: Reviewing two newcomers to schools. *Environmental Education Research* **20**, 248–283 (2014). doi:10.1080/13504622.2013.775220
 13. E.O. Adu, M.A. Akosu, The Influence of Information and Communication Technology (ICT) in Improving Teaching of Environmental Education? *Journal of Human Ecology* **55**, 1–8 (2016). doi:10.1080/09709274.2016.11907003
 14. N. Khmil, Padlet social service as an element of pedagogical activity. *Informatics and information technologies in educational establishments* **2** (2014)
 15. O.G. Romanovskyi, V.M. Grineva, O.O. Rezvan, Mental maps as an innovative way of the information organization within the higher education process. *Information Technologies and Learning Tools* **2**, 185–196 (2018). doi:10.33407/itlt.v64i2.2187