

# Features of Utilization Information and Communication Technology in the Process of Teaching the “Environmental Impact Assessment” Course

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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 and individual projects 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 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 as-

essment, 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

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(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 the following general competencies:

1. Proficiency in using information and communication technologies.
2. Ability to adapt and act in new situations.
3. Ability to communicate with professionals of different spheres and of various levels (with experts in other fields of knowledge/types of economic activity).
4. Ability to work in a team.
5. 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:

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.

MacKinnon et al. (MacKinnon et al., 2018) 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 (Barna, 2019) and Naumenko (Naumenko, 2018) 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 in (Lobanova et al., 2020; Morkun et al., 2017; Williams, 2011). Houghton (Houghton, 2010) 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 investigation of ICT role in the educational process and its impact on improving the educational environment is substantiated in (Bykov and Ovcharuk, 2017; Gurzhiy and Lapinsky, 2013; Morze and Vorotnikova, 2016; Osadchy, 2014; Semerikov et al., 2020; Spirin, 2011). Fedoniuk et al. (Fedoniuk et al., 2015) 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 (Fauville et al., 2014; Adu and Mireku, 2016).

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.

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.

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 RESULTS

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 legisla-

tion. 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 (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 “Envi-

ronmental Impact Assessment" course.

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.

**Lectures.** 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 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 (Khmil, 2014). 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) (figure 2). The search result leads to an image with a link to the law on environmental impact assessment, as the main document for studying (figure 3).

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 (figure 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.

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

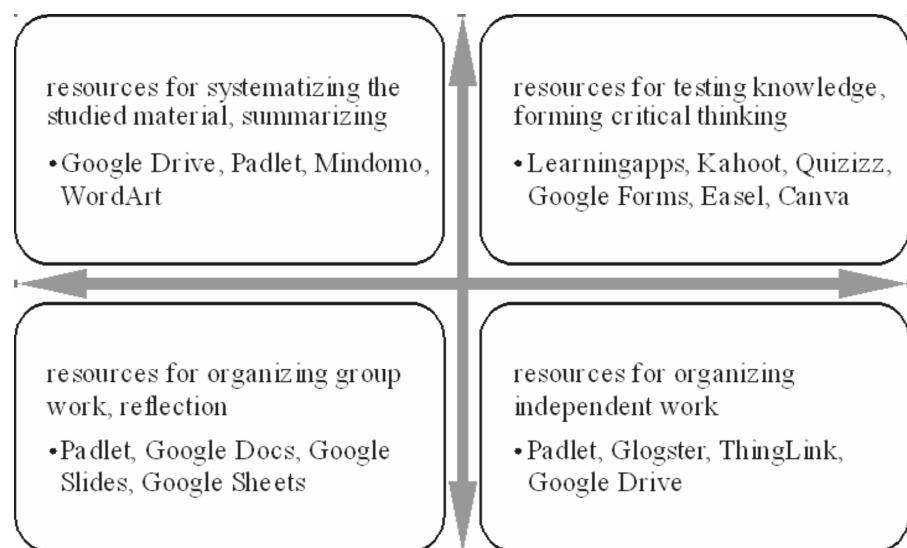


Figure 1: ICT in the academic setting.

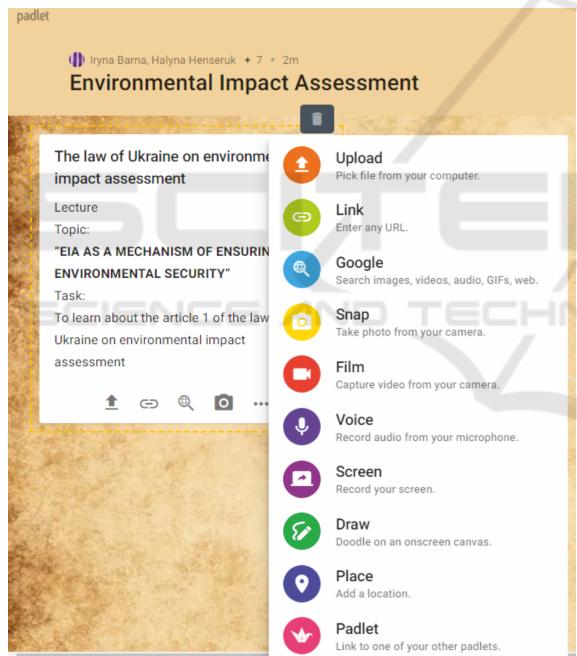


Figure 2: Padlet board content 1 (information search).

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) (figure 5).

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 (figures 6, 7).

The students analyzed the connections between

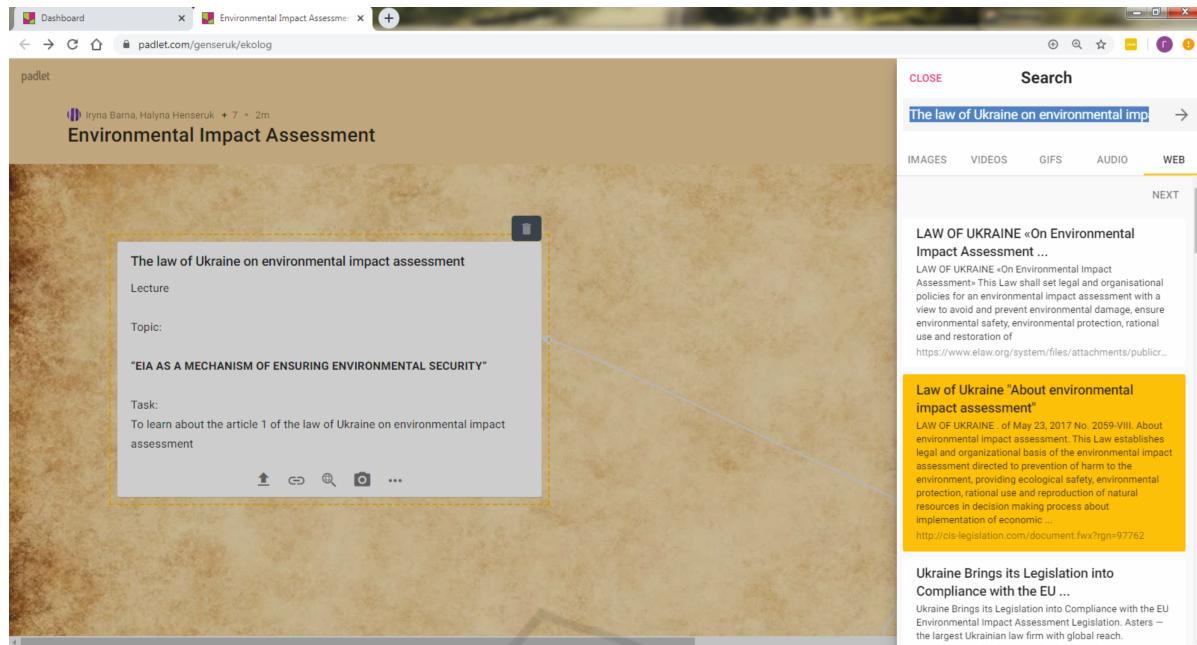


Figure 3: Padlet board content 2 (information search).

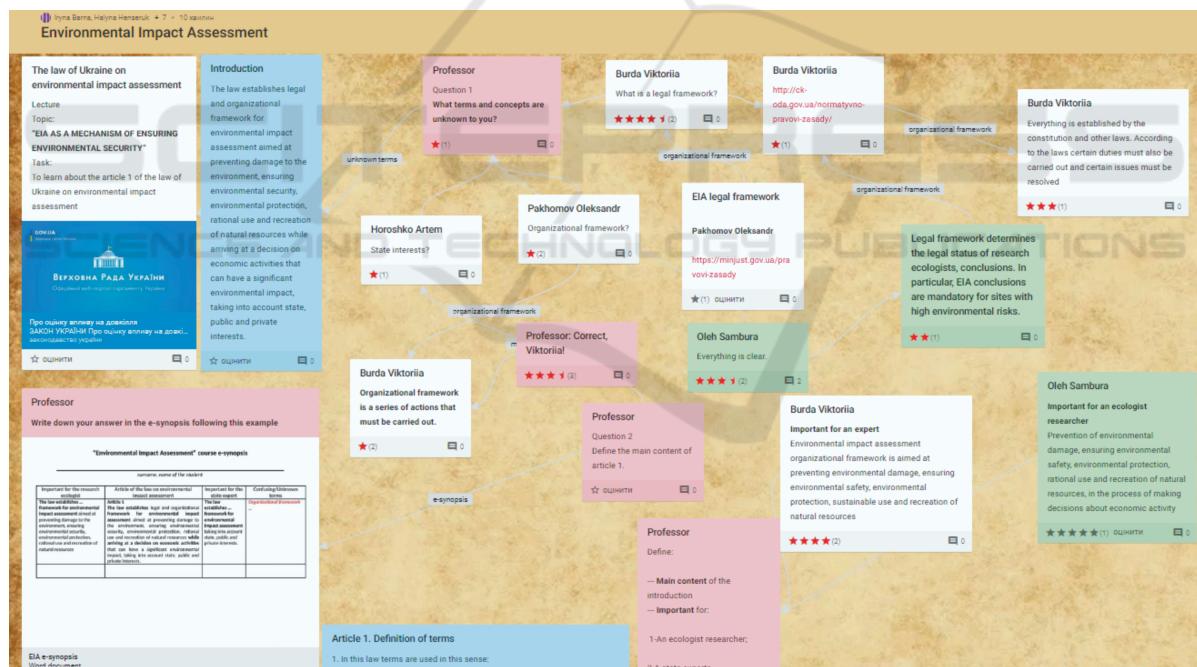


Figure 4: Padlet board content (information discussion).

the articles of the law in an electronic document for a fully understand them and to apply them properly.

**Group project.** 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 visualiz-

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

Figure 5: Content of the e-synopsis.

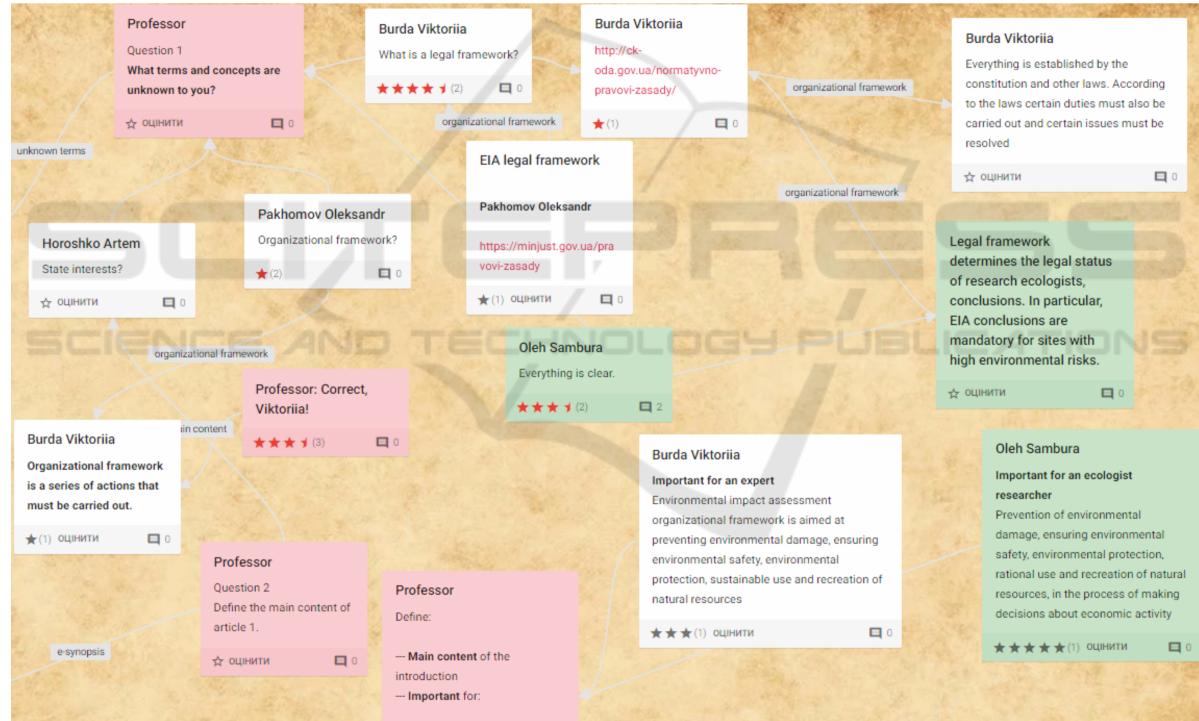


Figure 6: Professor's comments on the students' posts.

ing 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 (Romanovskyi et al., 2018). The most popular ones are Mindomo, MAP-MYself, Mind42, MindMap, Glinkr (Ivanova et al., 2020). 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 (figure 8).

Our study also used the didactic resources of Google Drive, which include tools for creating text

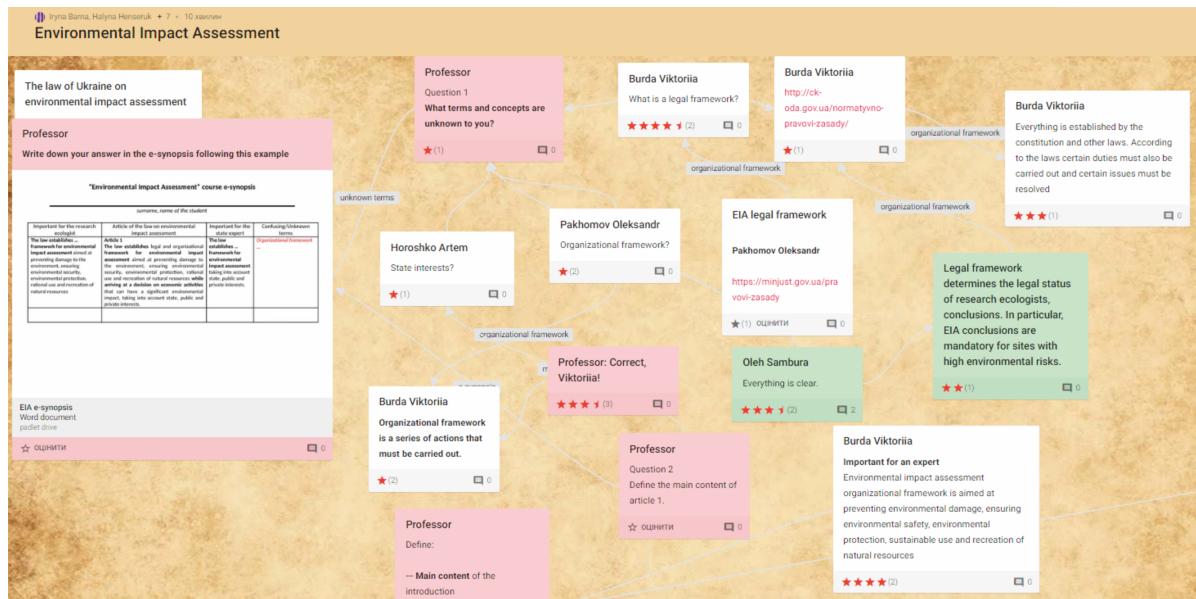


Figure 7: Students' posts assessment.

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 (figure 9). 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 the following advantages:

- 1) auto-saving of the latest version of the document;
- 2) variability when checking the work by the professor (the student could choose how to communicate with the professor: through Google Drive or email);
- 3) the means to check the notes of several students on the example of a single work by the professor online in Google Drive;
- 4) 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:

- 1) the completeness of the answer;
- 2) the correctness of the answer;
- 3) adherence to the sequence of stages of the EIA procedure;
- 4) 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 (figure 10).

“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.



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

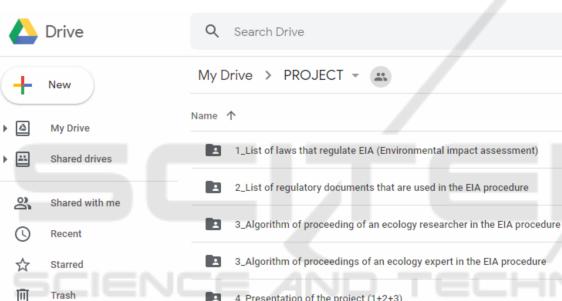


Figure 9: Tasks for the group project.

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;
- 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;
- 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:

1. The semantic component, i.e. the correctness of the filled out documents in accordance with the requirements of the Law of Ukraine on EIA.
2. Adherence to the procedure during the preparation of the documents, which is reflected in the order of the documents in the presentation.
3. 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

Strengths		Weaknesses	
1. Complete answer	+	-	1. Incomplete answer
2. Correct answer	+	-	2. Incorrect answer
3. Adherence to the sequence of stages of the EIA procedure	+	-/+	3. Full/partial nonadherence to the sequence of stages of the EIA procedure
4. Well-reasoned/well-founded representation of items 1-3 in the presentation	+	-/+	4. Unreasoned/unfounded Representation of items 1-3 in the presentation
Opportunities		Threats	
<b>Strong</b> – if the strengths exceed the weaknesses by 4 points		<b>Strong</b> – if the weaknesses exceed the strengths by 4 points	
<b>Weak</b> – if the strengths are rated at 1-2 points		<b>Weak</b> – if the weaknesses are rated at 1-2 points	

Figure 10: The SWOT analysis matrix.

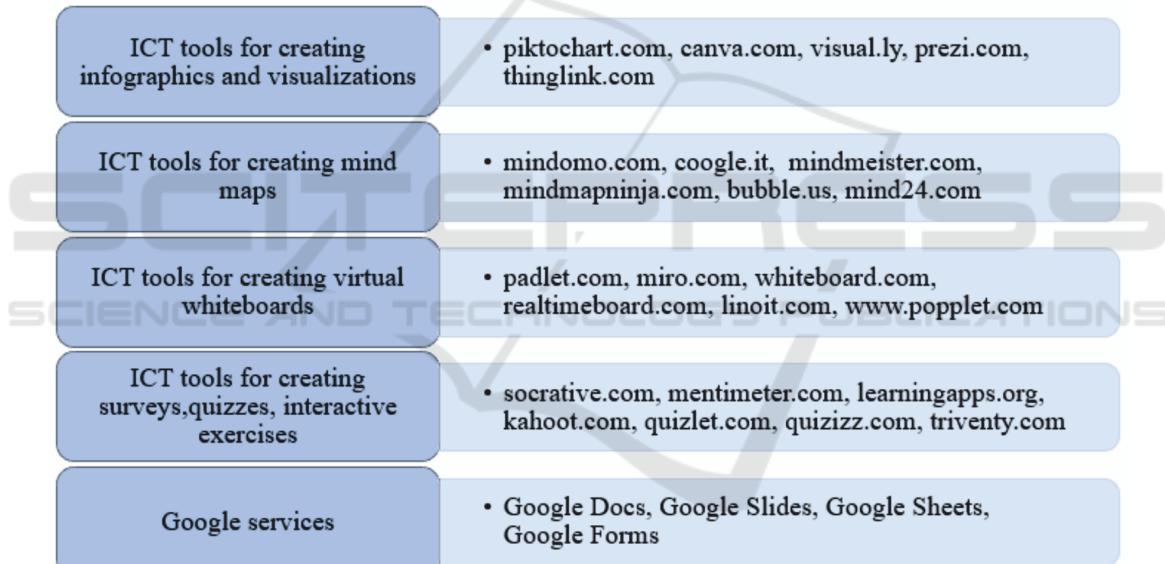


Figure 11: ICT tools for assessment.

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 (Earl, 2012) 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 (Assessment Reform Group, 2002).

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 (figure 11).

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) (figure 12). 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 iden-

tify 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 (Smiciklas, 2012) 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.

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 (figure 13). 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.

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 (Pavlyutenkov, 2008) distinguishes five levels of professional competence: very low, low, medium, high

Go to [www.menti.com](http://www.menti.com) and use the code 17 49 29 4

## Is the sequence of stages of the EIA procedure correct?

Mentimeter



0  
No

0

Figure 12: Assessment of completed tasks by students.

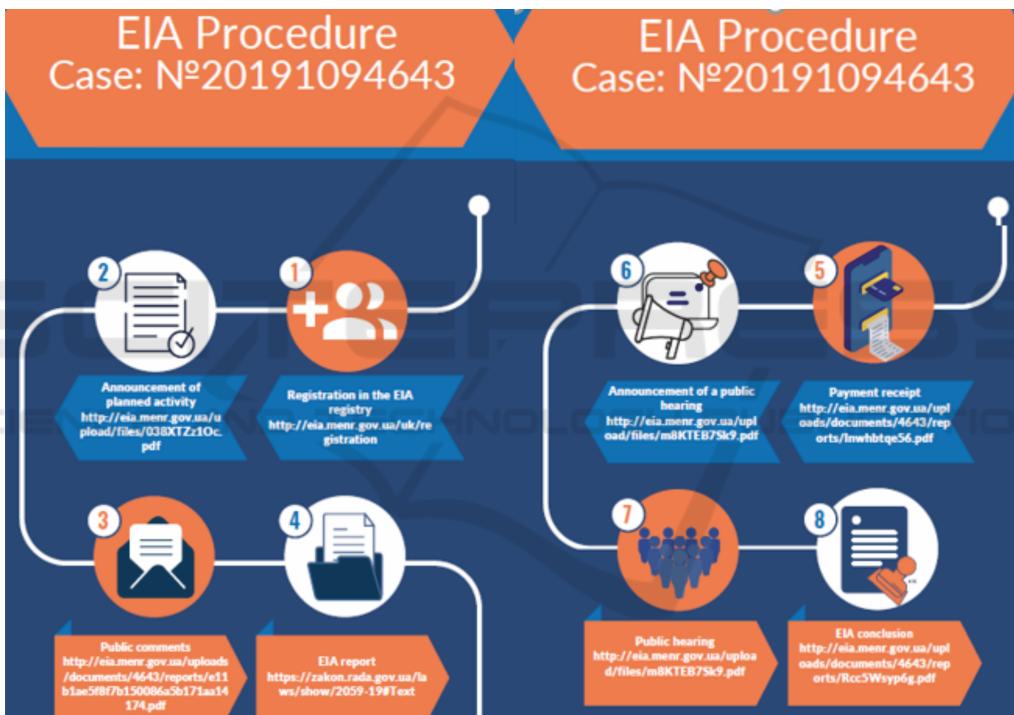


Figure 13: Example of an infographics.

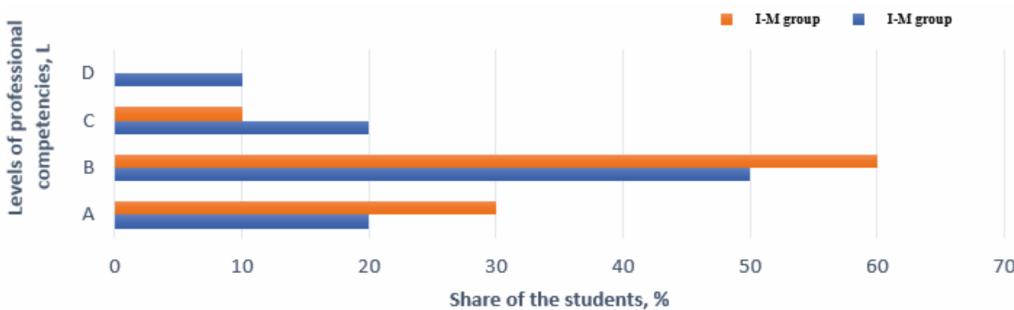


Figure 14: Formation of professional competencies in students based on the methodology of I-M and II-M.

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 (Barna et al., 2020). 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 (figure 14) 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.

The share of students with a different level of competencies in the I-M group is lower by 10 per cent 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.

## 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 initial 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.

The improvement of the initial methodology based on the use of assessment and additional ICT resources during the discussion of an individual project has provided an increase in the share of students with medium and high level of professional competencies.

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

- Adu, E. O. and Mireku, A. A. (2016). The Influence of Information and Communication Technology (ICT) in Improving Teaching of Environmental Education. *Journal of Human Ecology*, 55(1-2):1-8.
- Assessment Reform Group (2002). Assessment for learning: 10 principles: Research-based principles to guide classroom practice. [https://www.researchgate.net/publication/271849158\\_Assessment\\_for\\_Learning\\_10\\_Principles\\_Research-based\\_principles\\_to\\_guide\\_classroom\\_practice\\_Assessment\\_for\\_Learning](https://www.researchgate.net/publication/271849158_Assessment_for_Learning_10_Principles_Research-based_principles_to_guide_classroom_practice_Assessment_for_Learning).
- Barna, I. (2019). EIA (Environmental Impact Assessment) as a mechanism for ensuring environmental safety. *Scientific Notes Ternopil National Volodymyr Hnatiuk Pedagogical University. Series: Geography*, 46(1):217–225.
- Barna, I., Hrytsak, L., and Henseruk, H. (2020). The use of information and communication technologies in training ecology students. *E3S Web of Conferences*, 166(1):499–515.
- Bykov, V. and Ovcharuk, O. (2017). *Assessment of students and educators information and communication competence in the context of European integration processes in education*. Pedahohichna Dumka, Kyiv.
- Earl, L. M. (2012). *Assessment as learning: Using classroom assessment to maximize student learning*. Corwin Press.
- Fauville, G., Lantz-Andersson, A., and Säljö, R. (2014). ICT tools in environmental education: reviewing two newcomers to schools. *Environmental Education Research*, 20(2):248–283.
- Fedoniuk, V. V., Ivantsiv, V. V., Fedoniuk, M. A., and Pankevych, S. H. (2015). Case studies of web-resources application in the practical course of natural reserves education. *Information Technologies and Learning Tools*, 46(2):109–123.
- Gurzhiy, A. M. and Lapinsky, V. V. (2013). Electronic educational resources as a basis for the modern learning environment secondary schools. *Journal of Information Technologies in Education (ITE)*, (15):030–037.
- Houghton, J. W. (2010). ICT and the Environment in Developing Countries: A Review of Opportunities and Developments. In Berleur, J., Hercheui, M. D., and Hilty, L. M., editors, *What Kind of Information Society? Governance, Virtuality, Surveillance, Sustainability, Resilience*, pages 236–247, Berlin, Heidelberg. Springer Berlin Heidelberg.
- Ivanova, H. I., Lavrentieva, O. O., Eivas, L. F., Zenkovych, I. O., and Uchitel, A. D. (2020). The students' brain-work intensification via the computer visualization of study materials. *CEUR Workshop Proceedings*, 2643:185–209.
- Khmil, N. (2014). Padlet social service as an element of pedagogical activity. *Informatics and information technologies in educational establishments*, pages 24–30.
- Lobanova, A., Bayura, V., Viznytsia, Y., Bratchenko, L., and Karitka, V. (2020). Intelligent specialization as a promising strategy for the sustainable development of industrial regions of ukraine (the case of kryvyi rih industrial region). *E3S Web of Conferences*, 166:10020.
- MacKinnon, A. J., Duinker, P. N., and Walker, T. R. (2018). *The application of science in environmental impact assessment*. Routledge, London.
- Morkun, V., Semerikov, S., Hryshchenko, S., and Slovak, K. (2017). Environmental geo-information technologies as a tool of pre-service mining engineer's training for sustainable development of mining industry. *CEUR Workshop Proceedings*, 1844:303–310.
- Morze, N. and Vorotnikova, I. (2016). The model of ICT-competencies of the teachers. *ScienceRise: Pedagogical Education*, 6(10):36–44.
- Naumenko, O. (2018). Environmental impact assessment vs environmental assessment: What changed? <https://yur-gazeta.com/publications/practice/inshe/ocinka-vplivu-na-dovkillya-vs-ekologichna-ekspertizha-shcho-zminilosya.html>.
- Osadchy, V. (2014). *Distance learning technologies. Working with Moodle 2.4*. Bogdan Hmelnytsky Melitopol State Pedagogical University, Melitopol.
- Pavlyutenkov, Y. (2008). *Modelyuvannya v systemi osvity u skhemakh i tablytsyah*. Osnova, Kharkiv.
- Romanovskyi, O. G., Grineva, V. M., and Rezvan, O. O. (2018). Mental maps as an innovative way of the information organization within the higher education process. *Information Technologies and Learning Tools*, 64(2):185–196.
- Semerikov, S., Striuk, A., Striuk, L., Striuk, M., and Shalatska, H. (2020). Sustainability in Software Engineering Education: A case of general professional competencies. *E3S Web of Conferences*, 166.
- Smiciklas, M. (2012). *The power of infographics: Using pictures to communicate and connect with your audiences*. Que Publishing, Indianapolis.
- Spirin, O. M. (2011). Information and communication technologies training: Criteria for internal quality assessment. *Information Technologies and Learning Tools*, 19(5).
- Williams, E. (2011). Environmental effects of information and communications technologies. *Nature*, 479(1):354–358.