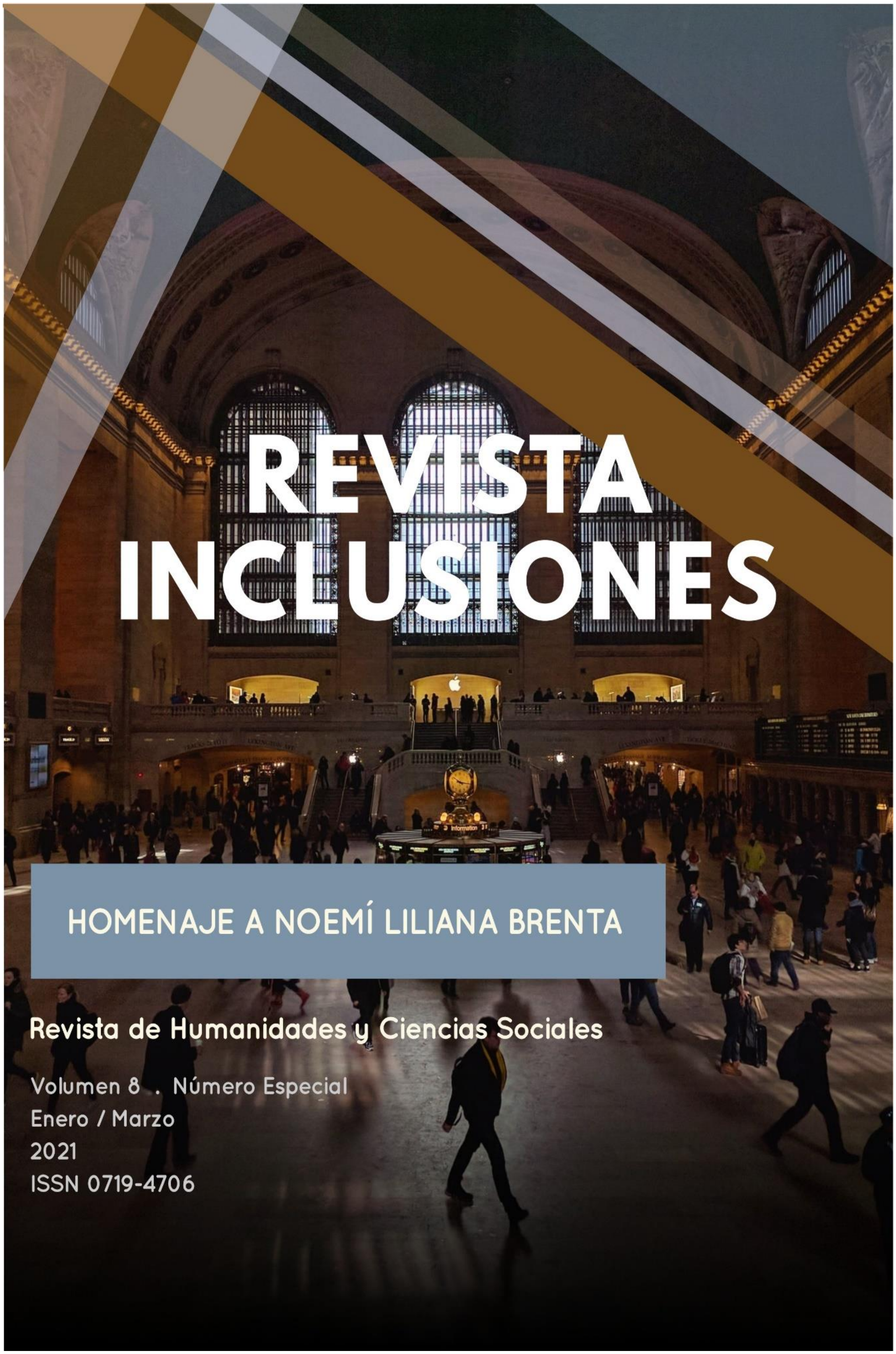
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CURRENT CHALLENGES IN THE CONDITIONS OF DISTANCE EDUCATION: INQUIRY BASED LEARNING

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Abstract

The article highlights the relevance of using innovative teaching methods by means of modern digital tools and resources. The authors present the pedagogical capabilities of Go-Lab ecosystem (https://www.golabz.eu) for the implementation of Inquiry Based Learning (IBL), digital competence development and critical thinking of students. It is noted that this educational platform today has the largest collection of remote / virtual laboratories, educational applications, more than a thousand research learning environments (Inquiry Learning Space – ILS) for distance learning. This is especially relevant in the modern era of the spread of the coronavirus pandemic, because the platform provides interesting resources to motivate students to learn, stimulate their cognitive interests and develop social skills. The advantages of virtual / remote laboratories in working with students, as opposed to traditional learning, including in inclusive education, are described. The stages of a holistic research cycle on the Go-Lab portal are described: orientation, conceptualization, research, conclusions and discussion. Examples of some ILSs for active online experimentation, self-study, development of research skills, group work, etc. are given. Emphasis is placed on the need for teachers to create their own virtual lesson using laboratories and Go-Lab educational applications. The criteria for evaluating the quality of ILS on the Go-Lab portal are presented.

Keywords

Inquiry Based Learning – Go-Lab ecosystem – Inquiry Learning Spaces – E-Learning

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Introduction

In the context of globalization and the digitization of all spheres of life, an expansion of communication skills, development of critical thinking and promotion of the literate usage of information technology is key. In this context, the European Commission introduced the Digital Competence Framework for Citizens[1], which has since become a core document for the creation of new educational standards in modern Europe.

Today, when educational establishments around the world remaining closed due to the pandemic (COVID-19), e-research training, which involves the remote acquisition and management of new skills using appropriate learning platforms and digital tools, is extremely valuable. Digital competence students is also a prerequisite for the awareness of legal and ethical principles regarding the use of information technology and digital resources, a critical attitude in respect to the reliability of received information and the overall adequate employment of modern media for personal, professional and social purposes.

In many countries of Europe and America are actively implementing innovative teaching methods based on independent acquisition of knowledge, search for scientific information, "National Science Education Standards that inquiry strategies should be the focus of the teaching of science within school classrooms"[2]. Researchers analyze progressive practices in this area to improve the quality of student learning, using of ICTs and educational innovations (Inquiry Based Learning, Project Based Learning, Blended Learning, Problem Based Learning, etc.) and there performs an interactive interaction between the teacher and students[3].

The issue of improving the quality of education with the help of free software is typical of many countries where active digitalization has begun. For example, Latin American scientists today are working to make free digital tools more widely used in student education. After all, there are all the benefits for distance education, reproduction of the laboratory practice environment or the usual work on digitized files. This expands the pedagogical opportunities for teachers and students[4]. An effective tool for using ICT is the Go-Lab[5] ecosystem, a free international educational platform that includes virtual labs, educational games, simulations, applications, and other query-based learning tools. Inquiry Based Learning (IBL) involves students gaining new knowledge by creating hypotheses, finding answers to problematic questions, formulating their own original questions to solve educational problems, conducting experiments, online collaboration and more.

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[1] R. Vuorikari; Y. Punie; S. Carretero Gomez & G. Van Den Brande, "DigComp 2.0: The Digital Competence Framework for Citizens", Publications Office of the European Union. 2016. DOI: 10.2760/38842. https://ec.europa.eu/jrc/en/digcomp/digital-competence-framework (04-01-2019).
[2] R. Akkus, M.; Gunel & B. Hand, "Comparing an Inquiry-Based Approach Known as the Science Writing Heuristic to Traditional Science Teaching Practices: Are There Differences?", International Journal of Science Education, Vol: 29 num 14 (2007): 1745-1765. https://doi.org/10.1080/09500690601075629
[3] O. Budnyk, "Innovative Competence of a Teacher: best European Practices", Journal of Vasyl Stefanyk Precarpathian National University, Vol: 6 num 1 (2019): 76–89. doi: 10.15330/jpnu.6.1.76-89.
[4] F. A. Cordovilla; L. C. Salvatierra & A. C. Lara, "Free Software as a Tool for a Quality Education in Latin America", Revista Inclusiones, Vol: 7 num Especial – Abril/Junio (2020): 316.
[5] Go-Lab ecosystem, https://www.golabz.eu/ (12-05-2020).

This method is based on the independent search for scientific information, focusing on research strategies in teaching[6]. IBL aims to develop students' ability to analyze, synthesize and evaluate information[7], create a holistic concept or model, think critically, creatively [8].

"Inquiry-based science adopts an investigative approach to teaching and learning where students are provided with opportunities to investigate a problem, search for possible solutions, make observations, ask questions, test out ideas, and think creatively and use their intuition," says Dr. Robyn M. Gillies, a Professor in the School of Education at The University of Queensland, Brisbane, Australia. Students have opportunities to "develop explanations for the phenomena under investigation, elaborate on concepts and processes, and evaluate or assess their understandings in light of available evidence. This approach to teaching relies on teachers recognizing the importance of presenting problems to students that will challenge their current conceptual understandings so they are forced to reconcile anomalous thinking and construct new understandings"[9].

The purpose of this article is to substantiate the pedagogical capabilities Go-Lab ecosystem for the implementation of tasks Inquiry Based Learning, the development of digital competence and critical thinking of students in distance learning.

Results of Research

The transition to distance and blended learning in educational establishments raises the issue of quality educational services, improving the efficiency of pedagogical communication with digital tools and resources, the introduction of innovative technologies and more. In pedagogical practice, it is important to stimulate students to independently construct the process of cognition, the acquisition of new knowledge through research. At the same time, teachers face difficulties in conducting experiments, educational experiments with students online. To implement Inquiry Based Learning tasks, we offer the Go-Lab platform, which presents a large collection of online labs, interactive inquiry, combine labs and apps into Inquiry Learning Spaces (ILS), etc.[10]. ILS are personalized learning resources for students, where they can conduct scientific experiments, get new knowledge by themselves, develop research skills. On this platform, most ILSs are English (336), Portuguese (149), Greek (147), Spanish (88), German (53) and others. This platform is constantly expanding its capabilities in the study of STEAM subjects, and has received positive feedback from theorists and teachers-practitioners on the use of distance (inclusive) education. Consider in more detail the features of its construction in terms of pedagogical design.

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[6] R. Akkus; M. Gunel & B. Hand, "Comparing an Inquiry-Based Approach Known as the Science Writing Heuristic to Traditional Science Teaching Practices: Are There Differences?", International Journal of Science Education, Vol: 29 num 14 (2007): 1745-1765. https://doi.org/10.1080/09500690601075629

[7] M. Guido, "All About Inquiry-Based Learning: Definition, Benefits and Strategies", 2017, https://www.prodigygame.com/blog/inquiry-based-learning-definition-benefits-strategies/ (10-03-2020).

[8] T. de Jager, "Can First Year Student's Critical Thinking Skills Develop in a Space of Three Months?", Procedia – Social and Behavioral Sciences, Vol: 47 (2012): 1374-1381. https://doi.org/10.1016/j.sbspro.2012.06.829.

[9] J. Gunn, "The Art of Inquiry in STEAM Education", 2018, https://education.cu-portland.edu/blog/classroom-resources/steam-inquiry-based-learning/ (15-03-2020).

[10] Go-Lab ecosystem, https://www.golabz.eu/ (12-05-2020)

The Go-Lab ecosystem offers Inquiry Learning Cycle[11] incorporated in the lesson structure – specifies the steps of an inquiry learning process. This cycle contains five main inquiry sequences: Orientation, Conceptualization, Investigation, Conclusion and Discussion (Figure 1).

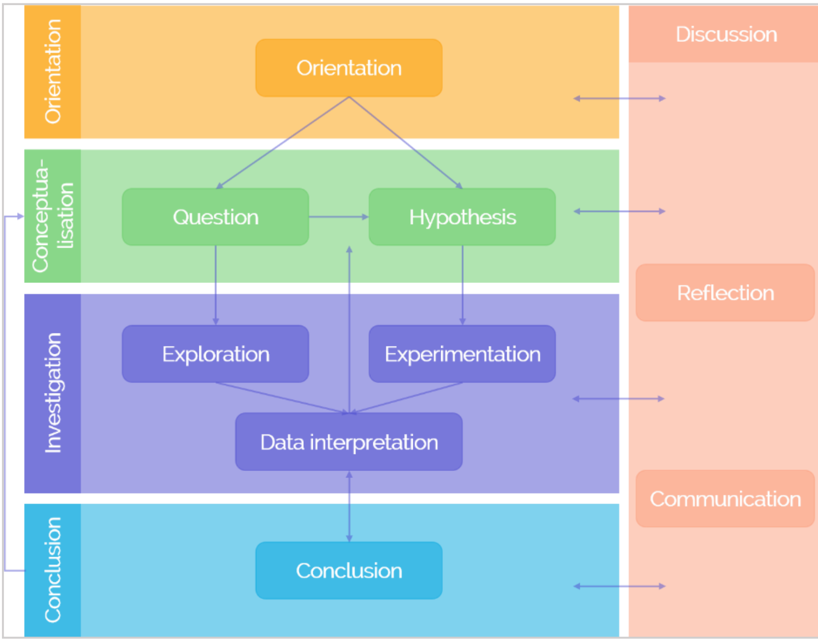

Figure 1
Go-Lab Inquiry Learning Cycle

Briefly, Orientation phase intends to stimulate interest and curiosity about a lesson topic and to address a learning challenge through a problem statement. At Conceptualization phase students start to build research task generating hypotheses and research questions based on the stated in Orientation phase problem. The Investigation is devoted to activities such as exploration, experimentation, and data collection and interpretation. In the next phase, Conclusion, students design the conclusions based on the data obtained, compare the experimental findings and their stated previously hypothesis as well as write a scientific report. The Discussion sequence encourages students to present outcomes of an inquiry phase or of the entire inquiry cycle and discuss them with classmates. The Discussion is also the phase where students can either connect the performed science experiment with real-life situations, e.g. local community challenges, or plan and dig up further additional research with a set of questions[12]. As we can see, ILS is a special scenario of online research learning, where the student independently or with the help of a teacher goes through the relevant stages of learning as research. For example, ILS "*Importance of Light in Photosynthesis*"[13] (Figure 2).

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[11] M. Pedaste; M. Mäeots; L. A. Siiman; T, de Jong; S. A. N. van Riesen; E. T. Kamp; C. C. Manoli; Z. C. Zacharia & E. Tsourlidaki, "Phases of Inquiry-based Learning: Definitions and the Inquiry Cycle", Educational Research Review, Vol: 14 (2015): 47-61.

[12] O. Dziabenko & O. Budnyk, "Go-Lab Ecosystem: using Online Laboratories in a Primary School", 11th annual International Conference on Education and New Learning Technologies, Palma de Mallorca, Spain. 1st - 3rd of July, 2019. EDULEARN19 Proceedings, ISBN: 978-84-09-12031-4. https://iated.org/edulearn/publications

[13] "Importance of Light in Photosynthesis", https://www.golabz.eu/ils/importance-of-light-in-photosynthesis (16-05-2019).

All users can view this educational content, including the steps of the proposed ILS for use or further modification using the "Preview" option. Depending on the age of students or educational goals of the teacher, the number of stages of the research cycle, their names, background image for each stage can be changed.

As a result of research training in "*Importance of Light in Photosynthesis*" students receive the following learning outcomes:

– Students understand the concept that light is necessary for photosynthesis.
– Students understand the principle of photosynthesis and the factors affecting photosynthesis.
– Students will be able to do the experiment more accurately in the real lab once they understand the steps through the animation and simulation.

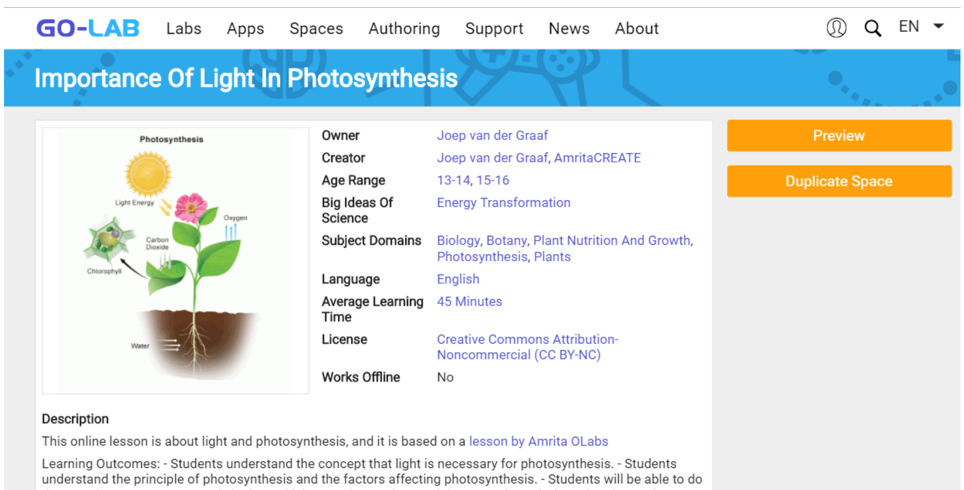

Figure 2
ILS "Importance Of Light In Photosynthesis" (screenshot)

It is important that the ILS contains an extremely varied training material: online labs, problem questions, video clips, games, illustrations, rules, etc. Students work on their own according to the relevant instruction. At the same time, the teacher has the opportunity to see the results of each student (the time and quality of continuing their respective phases of training) with the help of platform-specific tools for evaluation[14]. Note that such tasks are quite accessible to students with special educational needs. Working remotely, such studies can be recommended to the teacher to work in an environment[15]. The next ILS "*Windmill With Science Journal*"[16] (Science Journal from Google has a windmill project where the technology and engineering of an Anduino One and a lightsensor are helping to understand how the windmill works) for students aged 13 and older (Figure 3a, 3b).

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[14] O. Budnyk, "Innovative Competence of a Teacher: best European Practices", Journal of Vasyl Stefanyk Precarpathian National University, Vol: 6 num 1 (2019): 76-89. DOI: 10.15330/jpnu.6.1.76-89.

[15] H. Vasianovych, O. Budnyk, M. Klepar, T. Beshok, T. Blyznyuk & K. Latyshevska, "Pragmatism in Philosophy of Inclusive Education Studies and Problems of Teacher Training", Revista Inclusiones, Vol: 7 núm 4 Octubre/Diciembre (2020): 59-73.

[16] "Windmill With Science Journal", https://www.golabz.eu/ils/windmill-with-science-journal-google (12-12-2019).

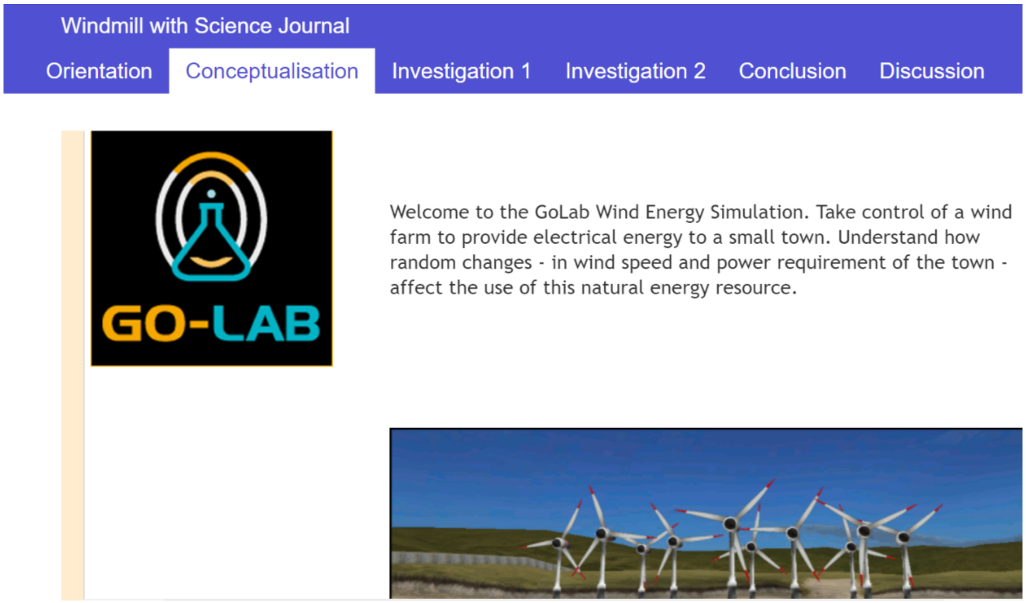

Figure 3a
ILS "Windmill With Science Journal" (Phase: Conceptualisation) (screenshot)

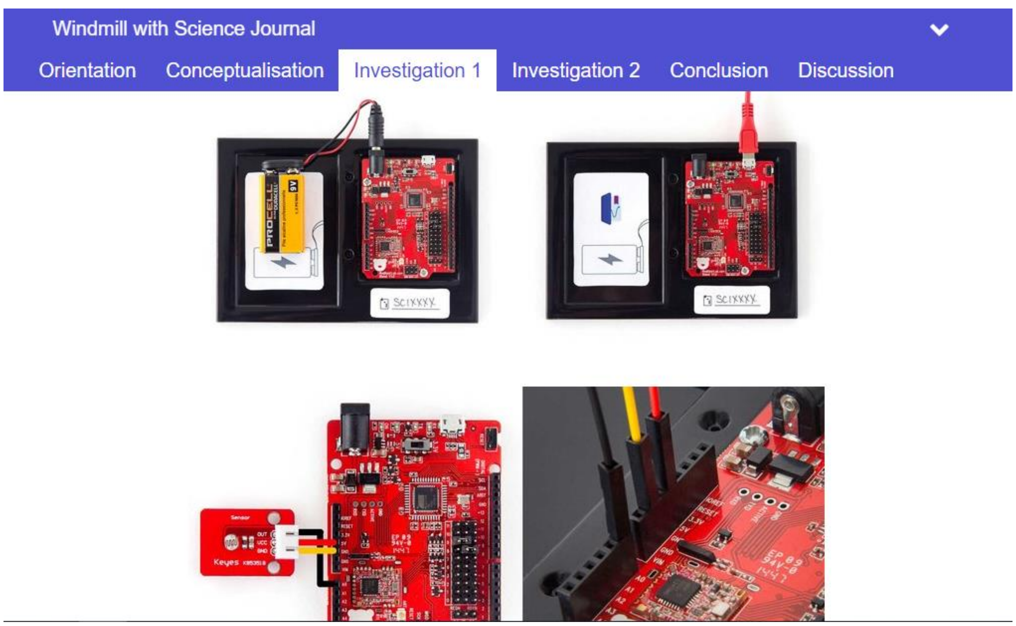

Figure 3b
ILS "Windmill With Science Journal" (Phase: Investigation 1) (screenshot)

Students have the opportunity to learn, that "windmills usually were used to mill grain, pump water or both… Modern windmills take the form of wind turbines used to generate electricity, or windpumps used to pump water, either for land drainage or to extract groundwater" (http://graasp.eu/ils/5afd469402e852fe99b39676/?lang=en). In the "Conceptualization" section, they get the task of making a Concept Map about the windmill, and also create their hypotheses. For this useful questions are: How can you determine the number of blades that your windmill will need to spin at top speed? How efficient is a wind mill?

The pedagogical value of this type of learning is that students receive practical knowledge that is related to life. Example, in GoLab Wind Energy Simulation they will be able to solve "problems" that will require a critical comprehension of the material, the integration of knowledge on various subjects: Engineering, Mathematics, Physics, Technology, Computer Science, Architecture, Design, etc. To do this, they get the following tasks:

"Take control of a wind farm to provide electrical energy to a small town. Understand how random changes – in wind speed and power requirement of the town – affect the use of this natural energy resource";

"Learn about the concept of efficiency as it relates to power generation at a wind turbine using our interactive simulation", etc.

At the same time the students can experiment and among them are the following: to create a windmill, to test it, to analyze the principle of its action and applied application, etc.

This is a feature of IBL, because students have the opportunity to learn to experiment in virtual and remote labs. Virtual and remote labs offer many advantages for school teachers over hands-on laboratories. We would like to mention some of them[17]:

- an introduction of the top-notch ICT developments and apps in the educational process and, therefore, increasing students interest in the scientific world;
- saving resources – no need in purchasing expensive equipment and materials;
- a design and visualization of scientific processes that is basically impossible in laboratory settings;
- an observation of experiment processes in great detail and at different timescales;
- a safety during the work with dangerous materials and/or devices;
- a rapid implementation of series of experiments with different input parameters;
- real-time feedback;
- rapid control of student learning progress;
- offering scientific experiments in an inclusive class with children with different learning styles;
- simultaneous application of a large number of students to the same experiment or laboratory;
- conducting an experiment many times (at the student's request) 24 hours a day, 7 days a week, and so forth.

To solve research tasks, the student needs certain skills of logical and creative thinking. In the process of research teaching the teacher aims to form students the skills that are the basis of their research behavior. It is the ability to determine the problem, ask questions and answer them, put forward and review the hypotheses, explain the nature of scientific concepts and give them the definition, classify the material, observe, conduct experiments, draw conclusions, discuss educational problems, convincingly defend their opinions, etc.

[17] O. Dziabenko & O. Budnyk, "Go-Lab Ecosystem: using Online Laboratories in a Primary School", 11th annual International Conference on Education and New Learning Technologies, Palma de Mallorca, Spain. 1st-3rd of July, 2019. EDULEARN19 Proceedings, https://iated.org/edulearn/publications

So, "inquiry requires students to engage in active learning by generating their own driving questions, seeking out answers, and exploring complex problems. Research, though often a component of inquiry, addresses the process of finding answers"[18].

Another, no less interesting ILS – "Collaborative Rabbit Genetics Lab"[19]. This laboratory is aimed at developing skills of joint solution of educational problems in genetics. Students simultaneously study remotely in two different ILSs share a simulation of rabbit genetics. Students study remotely at the same time Each student works in his room and at the same time observes what the other participant is doing. As you can see in Fig. 4, in one version, there are black rabbits and in the other version white rabbits. In both versions, there are rabbits with straight and floppy ears. The students can discover which traits are dominant and which ones are recessive. In addition, they can determine the probabilities of dihybrid crossing.

Cooperation between two students can also be organized using the SpeakUp application, where it is possible to solve problems and exchange text messages at the same time.

It is important that students receive clear instructions for working in this laboratory. They can look for answers, for example, to the following problematic questions:

1) Can two black rabbits give birth to white offspring?

2) Can two black rabbits give birth to white offspring?

3) Can two white rabbits give birth to different offspring at the same time (white and black)?

4) Is it possible in this simulation for two rabbits with straight ears to produce a rabbit with floppy ears?

5) Is it possible in this simulation for two rabbits with straight ears to produce a rabbit with floppy ears?

At the same time, the teacher can also create his own room to work in and immediately see the experiments that his students are doing. Based on the results of work in the laboratory, students must analyze and synthesize the information obtained, draw conclusions about the laws of genetics. In this laboratory, they can conduct experiments for as long as they need to answer the teacher's questions. They can also solve these problems at home with their parents.

[18] B. Holland, "Inquiry and the Research Process: Tips for ensuring that your students' research fosters genuine inquiry", 2017, https://www.edutopia.org/article/inquiry-and-research-process (12-03-2020).

[19] "Collaborative Rabbit Genetics Lab", https://www.golabz.eu/lab/collaborative-rabbit-genetics-lab (22-03-2020).

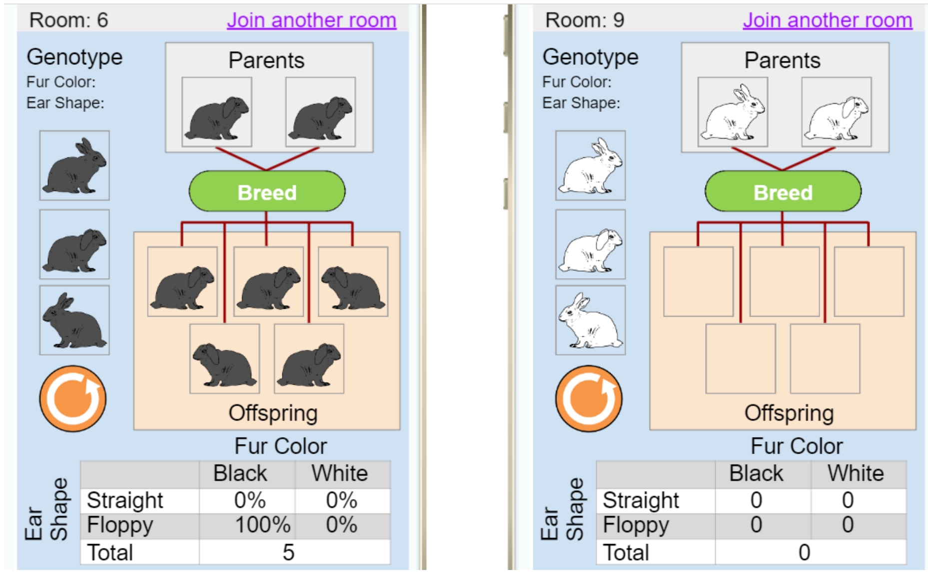

Figure 4
ILS "Collaborative Rabbit Genetics Lab" (screenshot)

At the same time, these educational researches are based on the corresponding theoretical knowledge which students substantiate after carrying out empirical research in laboratory.

Virtual experiments involving selection, mutation, migration, non-random mating, small population, reproduction, etc., are also conducted in the laboratory "Fishbowl Population Genetics New"[20] (Figure 5 Students have the opportunity to solve various problems related to the regulation of fish populations, adjusting the initial parameters. As a result of any experiment, clear conclusions on the research topic must be substantiated. At the same time, students can engage in discussion in the chat, as well as evaluate the results of their work with the help of educational analytics tools.

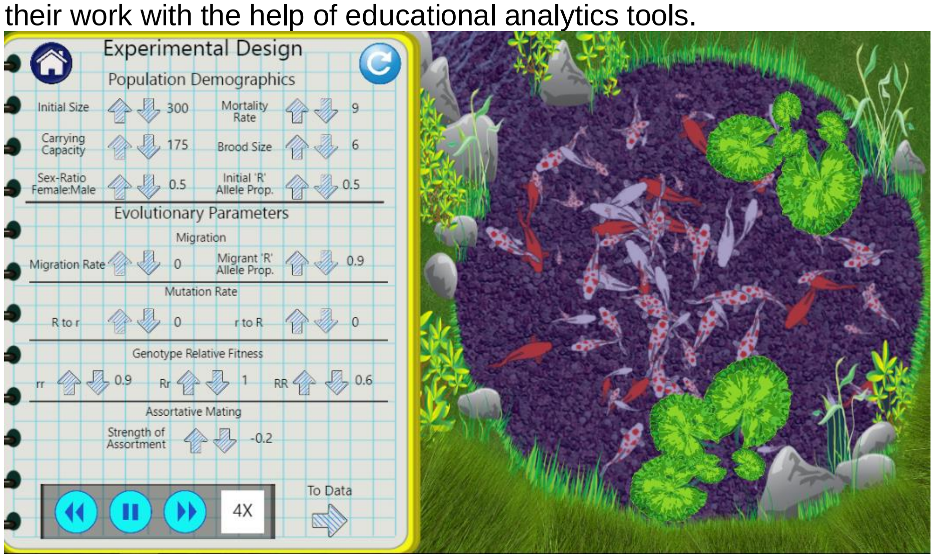

Figure 5
ILS "Fishbowl Population Genetics New" (screenshot)

[20] "Fishbowl Population Genetics New", https://www.golabz.eu/lab/fishbowl-population-genetics-new (22-03-2020).

Each teacher has the opportunity to create their own virtual script for their lesson on the Go-Lab platform. To do this, you need to choose a virtual laboratory or simulation for experiments, didactic material (videos, games, drawings, creative tasks, etc.), as well as create your own ILS design. In the process, the teacher takes into account the age characteristics of students, the specifics of the curriculum of their country or region, the ability of students in the class to think critically, mental characteristics, etc.

We offer the following criteria for evaluating a qualitatively created ILS:

- availability of all phases / stages of the research cycle;
- the feasibility of choosing applications of the Go-Lab platform at certain stages of the ILS research cycle;
- use of virtual laboratories / simulations / games and description of stages of experiment;
- directing educational material to create problematic issues; availability for students of available templates for hypotheses;
- compliance with the content of school education;
- compliance of the material with the age characteristics of students;
- attractive artistic and computer design;
- availability of clear additional instructions for students;
- opportunities to work in pairs, groups.

According to our observations, online laboratory experiments enable much higher learning achievements of students, in contrast to traditional teaching methods. Above all, they are effective in distance and blended learning, as there are experiments that are sometimes not possible in real time.

Thus, learning based on research, active experimentation online allows students to independently acquire new knowledge, think critically, test hypotheses and problematic questions, to show creativity and more. Therefore, it is extremely important for teachers to create their own educational content, adapted to the individual needs and age characteristics of students, the level of development of their independence and creativity, the specifics of the curriculum, the specifics of a particular country (region) and more. ILS is an innovative tool to meet the educational needs of students in response to the new societal challenges of globalization, as the learning resources of the Go-Lab ecosystem are used in many countries around the world.

Conclusions

In the conditions of rapid development of technologies, information society, digitalization of all spheres of life, the need for development of research culture and critical thinking of students is growing. At the same time, the pedagogical community is facing new societal challenges in organizing distance and blended learning for students due to the spread of the coronavirus pandemic. Therefore, there is a growing need to master new educational platforms for productive work online. An effective tool in solving Inquiry Based Learning tasks in general secondary and higher education institutions is the use of the Go-Lab ecosystem, which is now in demand in Ukraine and other Eastern European countries for formal and non-formal education. With the help of this platform conditions are created for interactive interaction of teacher and students, expansion of educational and cognitive and research opportunities of students, development of critical thinking when working with

Go-Lab tools. The use of remote / virtual laboratories helps to carry out experiments, build hypotheses and problem questions, analyze, synthesize, evaluate and discuss the information obtained during the experiment, etc. Therefore, we consider it appropriate to recommend teachers to use the described platform as a personalized research environment for active self-study of STEAM subjects, including in inclusive education. After all, such distance learning has its advantages: it can be carried out in comfortable conditions for the student and at any time convenient for him; students have the opportunity to work at their usual pace, if they wish to repeat the experiments, work in a team in real time, etc.

Unfortunately, the limited volume of the article does not allow to describe in more detail the methodological aspects and recommendations for the use of Go-Lab ecosystem in the educational process, in particular in distance learning. However, this platform provides detailed instructions for using individual applications, training programs, laboratories, and more. We hope that in future publications we will continue to explore these and other issues to present effective digital resources in distance education.

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