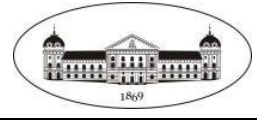**BULGARIAN ACADEMY OF SCIENCES**
INSTITUTE OF INFORMATION AND
COMMUNICATION TECHNOLOGIES

AVA AHMED CHIKURTEVA

INFORMATION AND COMMUNICATION TECHNOLOGIES IN EDUCATION

ABSTRACT OF PhD THESIS

Supervisor:

Prof. Dr. Dimitar Karastoyanov

Sofia, 2023

The dissertation was discussed and admitted to defense at an extended meeting of the Department of Distributed Information and Management Systems of IICT-BAS, held on 15.12.2022.

The dissertation contains 134 pages comprising 50 figures, 9 tables, 2 appendices and literature containing 129 titles.

The defense of the dissertation will take place on .... 2023 from .... hours in the hall .... of Unit 2 of IICT-BAS at an open meeting of a scientific jury consisting of:

1.   …………………………………………….

2.   …………………………………………….

3.   …………………………………………….

4.   …………………………………………….

5.   …………………………………………….

Reserve members:

6.   …………………………………………….

7.   …………………………………………….

The materials for the protection are available to those interested in room …… of IICT-BAS, ul. "Acad. G. Bonchev", bl. 2.

Author: *Ava Ahmed Chikurteva*

Title: *INFORMATION AND COMMUNICATION TECHNOLOGIES IN EDUCATION.*

Purpose and objectives

The aim of the dissertation is to research and develop information technologies, resources, methods and tools for expanding and improving e-education. The development of technologies such as web systems and servers, multimedia resources, simulation resources, digitalization and others will support the creation of improved training platforms and applications.

Tasks:
1. Overview, analysis and systematization of technologies and platforms for electronic / distance learning;
2. Research on existing ICT for the application of e-education and project-based learning (PBL) in an e-environment;
3. Development of an Interactive Platform for PBL application;
4. Development of (specialized, specific, basic) resources for work in an electronic environment;
5. Conducting Experiments and presenting the results obtained.

Publications of the doctoral student on the topic of the dissertation

Scientific publications in publications indexed in WoS, Scopus:

1. Chikurteva A., Chikurtev D., Model of Project-Based Learning Platform. 55th International Scientific Conference on Information, Communication and Energy Systems and Technologies, IEEE, 2020, ISBN:978-1-7281-7144-9, DOI:10.1109/ICEST49890.2020.9232753.
2. Chikurteva, A., Spasova, N., Chikurtev, D., E-learning: technologies, application and challenges. 29-th International Scientific Conference "Electronics" - ET2020, IEEE, 2020, ISBN:978-1-7281-7427-3, DOI:10.1109/ET50336.2020.9238176.

Scientific publications in peer-reviewed thematic journals and collections issued by national academic publishers:

3. Chikurteva, A. Multimedia in education. Problems of Engineering Cybernetics and Robotics, 71, Prof. Marin Drinov Publishing House of Bulgarian Academy of Sciences, 2020, ISSN:0204-9848, 27-34.
4. Chikurtev, D., Karastoyanov, D., Chikurteva, A. Иновативни технологии за дигитализация на обекти от културно-историческото наследство с приложение в образованието в помощ на хора с увредено зрение. „Автоматизация на дискретното производство", 3, Техническия университет-София, 2021, ISSN:2682-9584, 149-154.

Scientific publications at international conferences in Bulgaria, issued by national academic publishers:

5. Chikurteva, A. Роля на ПБО в електронното обучение. 'Robotics, Automation and Mechatronics' 20 RAM 2020, Prof. Marin Drinov Publishing House of Bulgarian Academy of Sciences, 2020, ISSN:1314-4634, 39-44.
6. Chikurteva, A. Използване на симулационни модели на роботи в образованието. 'Robotics, Automation and Mechatronics' 21 RAM 2021, Prof. Marin Drinov Publishing House of Bulgarian Academy of Sciences, 2021, ISSN:1314-4634, 55-61.

INTRODUCTION

The development of ICT over the past two decades has fundamentally transformed education. Building future-proof education systems requires the integration of innovative learning methods and technologies, combined with accessible digital educational resources that enable the facilitation of teaching and learning and the improvement of educational outcomes.

This paper addresses major issues of 21st century education related to the role and place of ICT in education, the advantages and disadvantages of e-learning, the need for continuous improvement of teachers' knowledge and skills, the need to integrate innovative training methods, a clear methodology in their implementation and the role of education management systems, specialized educational platforms and applications.

The present dissertation work is structured as follows:

Chapter 1 provides an overview, analysis and systematization of ICT in education. The process of integration of information and communication technologies in education over the past twenty years is analyzed. The development and role of ICT in education, the advantages and disadvantages of the use of innovative technologies in learning are analyzed. An overview of innovative methods and technologies implemented in education is made.

Chapter 2 presents research on learning methods and technologies in an electronic environment. Multimedia technologies and platforms used for e-learning in Bulgaria are studied. Innovative methods and approaches of training based on technologies or implying the use of technologies in their application are studied. A wider study has been made of the project-based method of training, which makes it possible to combine several different innovative methods and approaches and the use of information technologies.

Chapter 3 presents the development of information technologies for the application of project-based learning in an electronic environment. A PBL platform model has been developed and the ICT application in the developed model is presented. The interactive features of the proposed platform are developed and detailed in detail. A content management system and software architecture have been developed. An assistant for automating the process of creating a project-based lesson in a web-based educational platform is presented.

Chapter 4 presents the development and application of specialized educational resources for work in an electronic environment. The role of e-educational resources in the digital transformation of education is great. This determines the wide variety of software tools and applications for creating digital resources. In the current chapter, software for resource creation in the field of robotics and simulation applications in electronics is presented. An example lesson on the method of project-based learning has been developed in combination with an innovative method Flipped classroom and the use of virtual reality. An experiment was made: Application of project-based learning in school education.

Chapter 1 Overview, analysis and systematization of ICT in education.

1.1. Introduction.

Over the past thirty years, the education system in Bulgaria has been renewed and modernized, trying to achieve the level of Western countries, part of the European Union. Even before becoming a member of the EU (2007), Bulgaria made efforts to build a new, competitive and modern educational environment. The Lisbon European Council in March 2000 outlined to the European Union the strategic goal of becoming the most competitive and dynamic knowledge-based society in the world. The Barcelona meeting of the European Council in March 2002 reaffirmed this important role and mandated the transformation of European education by 2010 into a global standard.

In 2014. a new document has been adopted - Strategy for effective application of information and communication technologies in education and science of the Republic of Bulgaria (2014-2020). The main objective of the Strategy is to provide equal and flexible access to education and scientific information at any time and from anywhere - from a stationary computer, laptop, tablet, mobile phone. For the first time, a unified information environment is created, serving school education, higher education and science. New technologies in teaching will make lessons more interesting and attractive, will motivate students and teachers.

Along with the Pre-school and School Education Act (PSEA) - 2016. State educational standards (DOS), curricula and programs are approved, other important programs and strategies are adopted, which aim to develop and improve the educational system, to support the introduction, use of information and communication technologies in education, bringing the country closer to the world level of development in the field of education and digitalization. These documents are prepared in line with the perspectives set out in current strategic documents at global and European level, correspond to the implementation of Bulgaria's commitments under international treaties in accordance with the UN Sustainable Development Goals, the six priorities of the European Commission for 2019-2024 – the European Green Deal, Europe prepared for the digital age, Economy in the interest of people, A stronger Europe on the world stage, Affirming our European way of life and A new impetus for European democracy.

From this brief historical review of national programs, documents and laws, we can conclude that Bulgaria's education policies increase the value of education and help to establish it as a major path to achieving economic prosperity, social and personal satisfaction of the learner.

The digitization measures provided an opportunity not to interrupt the educational process after the start of the COVID-19 pandemic and the declared state of emergency, which allowed the education system to successfully pass into remote operation. The changes in the PSEA from 2020 regulate distance learning in an electronic environment and ensure the continuous education of children and students in various extraordinary circumstances – flu vacations, climatic or other factors.

Information is an essential part of knowledge, and through information technology we systematize, store, process and use this information. The modern digitalization of education automates these processes and thus improves the educational environment, supports teachers, prepares and facilitates access to digital educational resources, supports the implementation of innovative learning methods and approaches. The main goal of the use of ICT in education is

to achieve higher results of learners to become a driving force of society and the economy of the country.

    1.2. Stages of development of information technology in education.

Tracking the development of ICT and the relevant training methods can be schematically separated into five stages. The decoupling of the stages was made on the basis of the development of innovations which also influenced the development of education, which is presented in Figure 1.1.

Figure 1.1. Development of educational technologies (Kozhuharova, 2015).

Based on the notions of modern researchers of education, its development is presented as a "spillover" of patterns into each other in a common continuum - from Education 1.0., through Education 2.0. to Education 3.0, 4.0, etc. This 'pass' from species to species is reflected in Figure 1.2. and assumes that the new types of educational models will correspond to the next stages of the development of technology and the World Wide Web, with its specifics and projections in practice.

When we talk about ICT in education, we need to specify what exactly we include in this concept. The modern understanding of ICT used in education refers to technological tools and resources that are used to communicate, create, distribute, store and manage information. Also ICTs that add value to learning processes and the organisation and administration of educational institutions.
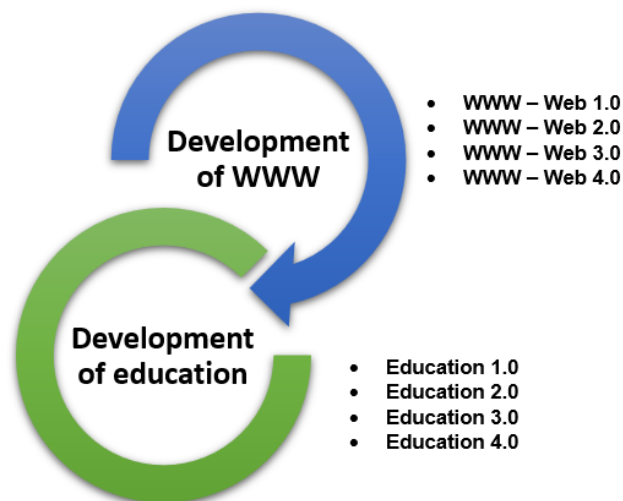
Figure 1. 2. The relationship between the development of WEB and education.

The introduction of ICT in education running in parallel with the processes in the development of technology is a subject of research interest, and after 2020 this interest has increased enormously due to the transition to distance learning worldwide. During this period, the use of ICT is the only option to continue the educational process. The epidemic situation turns the whole world into an "experimental field" for the possibilities of technology in education and other aspects of life. Depending on the problems being studied, we can distinguish the research as follows:

- Research defining the role and place of ICT in education;
- The advantages and disadvantages of using ICT in education;
- Research that examines innovative ICT embedded in education;
- An overview of innovative technology-based teaching methods.

I analyze and systematize studies from the last 20 years by authors from Bulgaria and the world. The purpose of this analysis is to get a comprehensive picture of the process of introduction, use, development of technology in education.

1.3. Analysis and conclusions.

At the moment, practical experience shows that information and communication technologies have a number of important didactic capabilities, which include:

- the possibility of rapid transmission at any distance of information of any volume, any form of presentation;
- storing information in the memory of a computer or laptop for the required period of time, the ability to edit, process, print, etc.;
- the possibility of accessing various sources of information through the Internet, working with this information;
- the possibility of organising electronic conferences, including real-time, computer audio conferencing and video conferencing;
- the ability to transfer the extracted materials to your media, print and work with them when and when necessary for the user.

The most important tasks of the informatisation of education at the present stage:

- development and improvement of educational software packages for teaching different school subjects;
- adapting ICT to the individual characteristics of the student;
- use of computer-based interactive learning methods;
- integration of different types of educational activities (educational, technical, research, etc.);
- development of distance learning technologies;
- creation on the basis of network technologies of a single information educational space of an educational institution, region, country, group of countries;
- the use of ICT in psychological and pedagogical research.

Chapter 2   Research on existing methods and technologies for learning in an electronic environment.

2.1. Methods and technologies for e-learning.

E-learning is a preferred option for users who prefer to explore a topic independently or have more daily commitments. During this period, the advantages and disadvantages of e-learning compared to the previous traditional training presented in Table 2.1 were clearly highlighted.

Table 2. 1. Advantages and disadvantages of e-learning and traditional learning.

	E-learning	Traditionally trained
Advantages	✓ learner-oriented; ✓ flexibility in choosing a time and place; ✓ price-oriented (cheaper); ✓ potentially accessible to a global audience; ✓ unrestricted access to knowledge; ✓ the ability to reuse and share knowledge;	✓ instantaneous feedback; ✓ acquaintance with everyone; teachers and students; ✓ motivating students; ✓ building a social community;
Disadvantages	✓ feedback delay in asynchronous e-learning; ✓ increased preparation time for the teacher; ✓ uncomfortable for some people; ✓ potentially more frustration, anxiety and confusion;	✓ Focus on the teacher; ✓ time and place dependence; ✓ more expensive;

Regardless of the chosen form of electronic communication, effective online learning should include both synchronous and asynchronous methods. In this way, learners and teachers will be able to benefit from the two different forms, regardless of their schedules or preferred training methods. On Table 2.2. technologies for the implementation of synchronous and asynchronous communication are presented.

Table 2.2. Technologies for the implementation of synchronous and asynchronous communication.

E-learning technologies	
Synchronous communication	Asynchronous communication
✓ Chat ✓ VoIP ✓ Web conference ✓ Audio podcasts ✓ Virtual Worlds	✓ Virtual libraries ✓ E-mail ✓ Forum ✓ Social networks ✓ E-portfolio ✓ Multimedia

2.2. Platforms used for e-learning in Bulgaria.

We can characterize two types of platforms that are used for e-learning.

Communication platforms – they are used in synchronous learning and include technologies such as web conferencing, chat, VoIP, audio podcasts, virtual worlds.

Learning Management Platforms (LMS) – are a set of interactive online services for creating, presenting, managing and using training content, as well as features for tracking, analyzing and reporting the results achieved. They automate the process of conducting distance learning and are a preferred means of achieving the educational goals of various types of institutions and organizations.

E-learning uses both types of platforms, complements them and provides a better connection between teacher and students. Most of the platforms allow integration with other platforms and educational tools available on the Internet.

2.3. Advantages and disadvantages of different technologies.

A major advantage of all platforms and applications is that they provide compatibility with each other. In addition, most have mobile versions created, allowing flexibility in the location of users. During the pandemic, it turned out that e-learning platforms are overloaded with a large number of registered and active users because they were not prepared to maintain and manage the large number of newly registered user accounts and the new additional data with learning content.

The different platforms used and their integration with additional tools allow great flexibility to present the material for study, both through files and presentations, visual clips. Which can be somewhat difficult for teachers, but also positive for students who can review and study the material at any time, as well as use it for self-study. The difficulty for teachers is actually expressed in the initial creation of an electronic material or checking for authenticity, because it takes time and good computer skills to work with tools and platforms.

In general, most platforms provide similar modules, services and tools. To a large extent, a key role in the choice of platform is played by well-made design and ease of use of all functions. The main problem facing the use of e-learning platforms is the need to train more teachers, then create the necessary e-learning materials. The last step is to activate the role of parents in school educated and to motivate the education of students and pupils.

2.4. Challenges to e-learning.

The development of technology and the digitalization of education is a challenge for educators who need to constantly update and improve their knowledge and competences. A possible solution here is offered by virtual classrooms with simulations included.

Exercising control over attendance is also part of the challenge of distance learning because of the necessary equipment on both sides as well as internet connection. For a large part of the population in underdeveloped countries there is a lack of computers, tablets and other devices for conducting electronic lessons and home training.

Another challenge is testing and evaluation. Time limit – meeting deadlines. While for students this should happen at the end of the school year, students have the opportunity to transfer their exams to the next year. The possibility of developing and disseminating virtual laboratories is still a challenge and difficult to achieve for all disciplines, but the possibility of realization in the future is of a person who would allow distance learning to cover an even larger field of technical and natural sciences.

2.5. Multimedia technologies.

Multimedia Systems and Technologies (MTFs) are designed to provide tools for merging the information arrays of the classical database with that of sound and graphic information into a single whole. The addition of sound or interactivity to the information product is necessary for it to be classified as multimedia. Multimedia is a kind of information product that combines two or more of the following main elements: text information, graphics (still illustrations), interactivity (ability to determine the course of action by the user), sound (speech, music), animation, digital video (moving pictures).

2.5.1. Multimedia in education and training.

Scientific studies have shown that when training with sounds alone, the trainer absorbs 20% of the information presented. When using sound and images in the so-called audiovisual approach, the percentage of knowledge acquired increases to 40%. And if the trainee is motivated to perform certain actions, the absorption reaches 80-90%. A multimedia personal computer offering the ability to work with the listed media is an ideal tool for creating a dialogue learning system that motivates the learner to perform various actions.

In general, the term: e-learning means education using a computer via the Internet and/or a local network. More clearly the application of ICT and multimedia in education is presented with a description of the types and technologies for the realisation of e-learning.

2.6. Project-based learning method.

As one of the methods of active learning (learning by action) in recent years, project-based learning (PBL) has expanded the boundaries of its applicability and has become a fundamental element of the education systems of many countries. PBL is a kind of reorientation of the education system, the demand for new or not so new teaching methods and technologies to meet the modern needs of the labor market and society. It is a guarantee of the practical applicability of the educational product.

In the project method, the learning process provides conditions for students to create products themselves and master experience in creative research activities. It is defined as a belief system in which learners gain knowledge in the process of planning and executing successively complicating practical tasks called "projects". Unlike ordinary projects, PBL requires critical thinking, solving a real problem and communication between participants. Students must organize their own work themselves and manage their own path in working on the project. Withthe reconciliation between traditional learning and project-based learning is reflected in Figure 2.1.
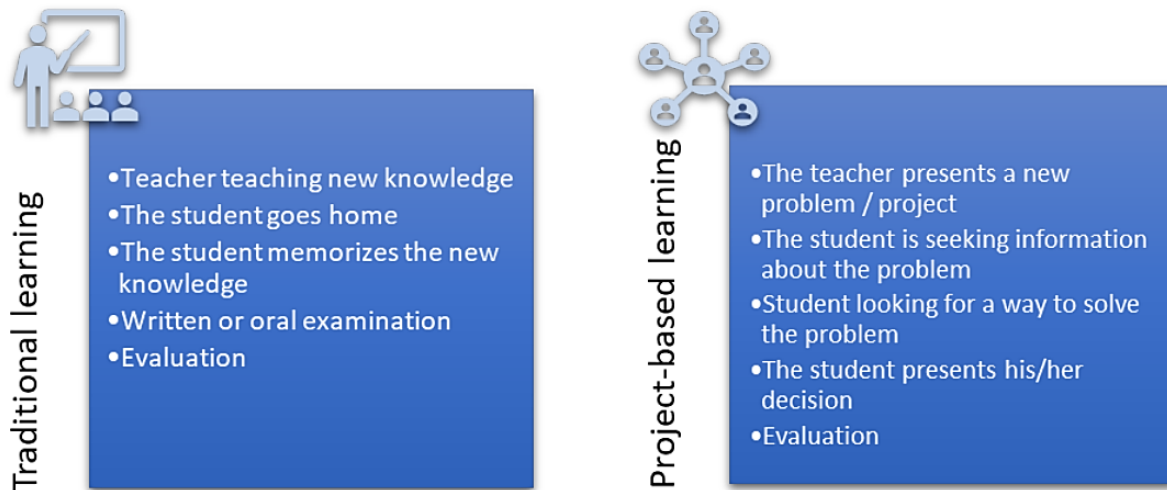
Figure 2.1. The process of training in the traditional method and PBL.

A comparison of PBL and the traditional shows differences in the learning process, the role of the participants in training (teachers and students), the representation of what has been learnt and assessment. The main advantages that PBL offers over the traditional method of training are:

- Students associate the learning material with real life.
- The learning material is better absorbed.
- Students' attitudes towards learning are improved.
- Cooperation between students is developing.
- Increases computer literacy of teachers and students

An important advantage of the PB method is that its verbal activity is not so dominant, but focuses on "learning by action". These advantages, together with the easy application of the method in an electronic environment, make it one of the most preferred training methods during the COVID-19 crisis and the subsequent distance learning (Saad, 2022).

2.6.1. Opportunities to combine innovative trainingmethods with modern training technologies.

The project-based method is one of the methods of active learning or learning through activity (Yusmaniar, 2022). As such, it can be successfully combined with other methods of active learning, in face-to-face or distance learning. In practice, during the learning process, methods and approaches of learning are mixed, combined.

In project-based training, the emphasis is on the learner, and the goal is the acquisition of certain knowledge and skills (competencies) by exploring a real problem (problem-based learning) using interdisciplinary knowledge and skills (STEM), information and communication technologies (Model 1:1). The project activities are usually carried out outside the classroom – observation, research, preparation of the final product, and in the classroom the teacher supports the activity by giving guidance to the students (Flipped Classroom). Thus, within one project, it is possible to use several educational methods and approaches (Fig. 2.2.), depending on the theme of the project, the age of the trainees and the final product of the project activity.
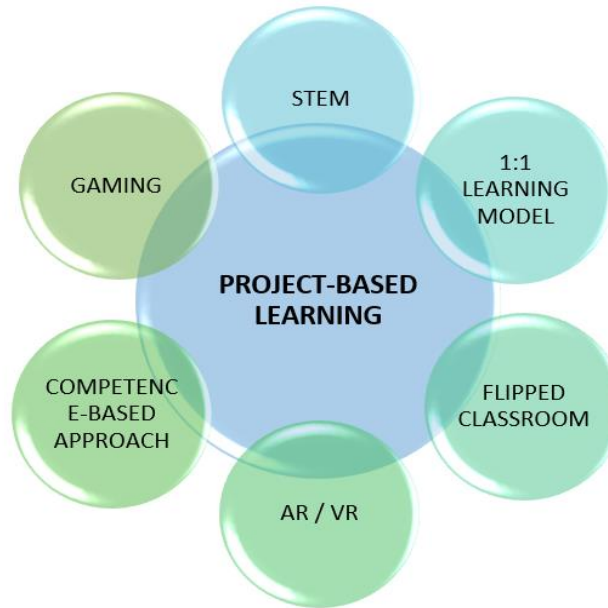
Figure 2.2. Combination of PBL with other training methods.

2.6.2. Project-based learning as a teaching method in an electronic environment.

Work on the project begins with the formulation of open questions to students. A situation is created that requires solving a real problem (Shin, 2021). Students are expected to do research, find a solution to the problem, and finally present to the public the result of their work (presentation, report, exhibition, site or other specific product).

To achieve PBL results, it must be well planned and with clearly defined goals and objectives. In this regard, I propose following a technological modular model (Fig. 2.3.), which will guarantee organised work and high project-based learning results.
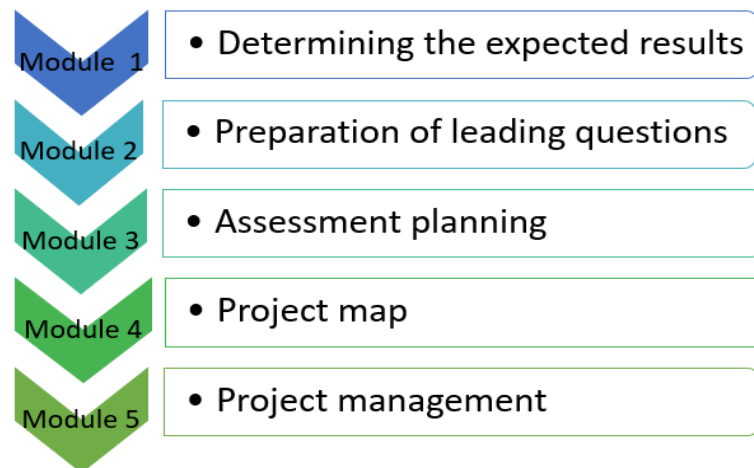

Module 1	• Determining the expected results
Module 2	• Preparation of leading questions
Module 3	• Assessment planning
Module 4	• Project map
Module 5	• Project management

Figure 2.3. Technological modular model of PBL.

2.6.3. PBL problems

At PBL, the teacher becomes an intermediary and the students work under his guidance. This research explores problems related to the creation and management of PB lessons by the teacher.

The problems that teachers encounter when creating a PB lesson are as follows:

- to identify significant issues;
- to structure meaningful tasks;
- to achieve the development of knowledge;
- to form social skills;
- to appreciate what students have learned from experience.

The specific challenges facing teachers in PBL are related to:

- the choice or construction of situations that presuppose the possibility of good projects;
- the structuring of problems as learning opportunities;
- cooperation to develop interdisciplinary projects;
- the dynamic management of the learning process and independent learning;
- the integration of technologies;
- assisting students in giving authentic grades.

For PBL, there are many studies proving the advantages and effectiveness of the method, ways to apply it, various developments of DB lessons and the results of its implementation, but there is no comprehensive platform to merge this data and provide it to the user in a convenient and selected form. In order to disseminate and validate the use of PBL as an integral part of the curriculum, support materials, guidelines, and appropriate conditions for working with PBL must be established.

2.7. Conclusions

From the conducted research, we can draw the following conclusions:

- The development of education is at a stage where ICT is not just part of the learning process, but plays the role of a transformer of education.
- The innovative methods and approaches that are implemented in the education system are based on information technologies. This provides new opportunities for inclusive education. These didactic and technological innovations allow the educational process to continue in times of crisis, without the constraints of space and time.
- The vision of future education is described as interdisciplinary, competent-oriented, practical and technological. The project-based method is the point of intersection of all these elements of future education.

Chapter 3 Development of technologies for application of Project-based learning in an electronic environment.

3.1. PBL platform model.

The research model provides an opportunity for the teacher to prepare and implement a project-based lesson by following a sequence of steps to create a new project (Chikurteva,

2020). To create a PB tutorial it is necessary to follow a technological modular model presented in Figure 3.1.

The management of the project modules organizes the participating modules in the lesson, making the interconnections between them and providing tools and services for working with the individual modules. Modules 1 to 5 are the main modules that make up a project-based tutorial. Each of these modules can be removed or edited according to the teacher's wishes.

The PBL platform must contain a large volume of materials and data on different directions, subjects and topics. These materials must be checked for reliability. Teachers will be able to add new materials and edit current ones. The material to the database of the platform will be: lessons, articles, lectures, electronic textbooks, presentations and videos.

Tools for module creation and editing have been developed. These tools are part of the module manager. Thanks to these tools, texts, assignments, learning materials and multimedia content can be easily edited. Evaluation criteria and automated performance checks can be created and edited.
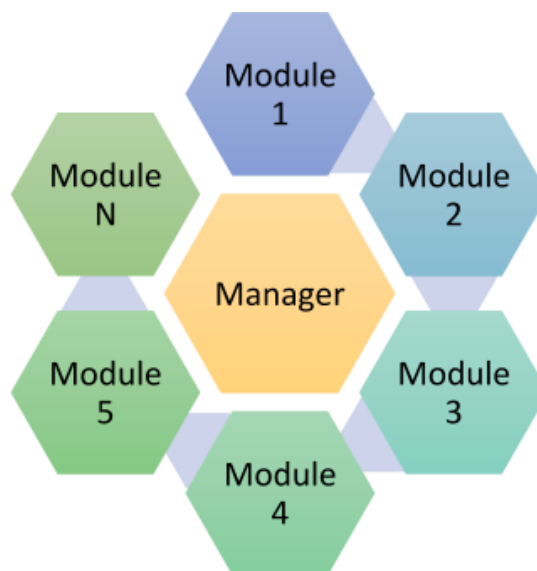

Figure 3.1. Modular PBL system.

Features and services have been developed to gradually check task performance by setting tags and a template to perform the stages of a project. Also, functions have been developed to connect between different components from one module to another. In this way, evaluation criteria or guidelines for the implementation of a project can be set.

Successful implementation of PBL requires a good knowledge of the nature and capabilities of this method of training. In order to support the activities of the lecturers, specialized information concerning project-based training is arranged. In Figure 3.2. the structure whose purpose is to answer the main question "What is PBL" is presented.
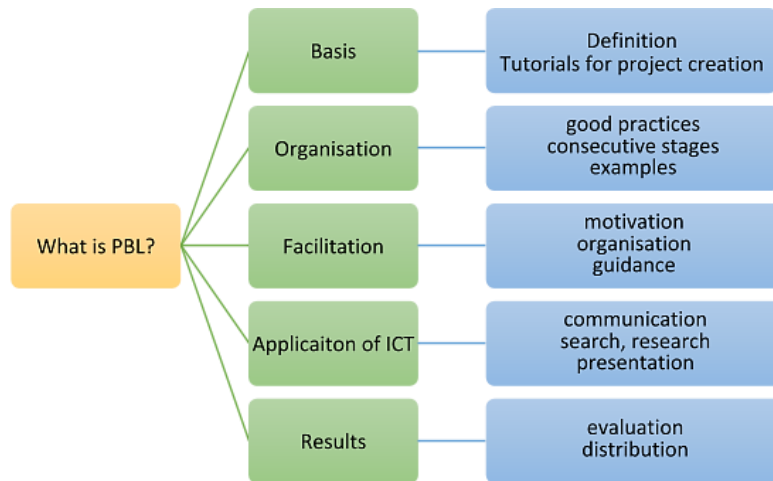
Figure 3.2. Structure of PBL handling information.

One of the important services of the developed platform is the Data Selection Service, which is presented in Figure 3.3. When creating a new lesson according to set criteria: subject, class and / or keyword, automatically output information about already completed projects and learning materials according to the teacher's assignment.
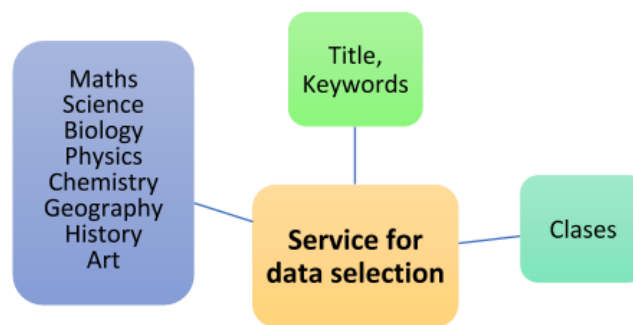

Figure 3.3. Organizing information by subjects, classes and keywords.

By default, the information offered is sorted according to the class and subject where the keywords occur. In addition, the user can change the ranking criteria according to popularity, rating, class, subject, date and more. The information in the database is organized by subject and by class. This makes it possible to differentiate the specifics of the subject, taking into account the age of the students (by class).

3.2. Application of ICT in the developed model.

The implementation of an PBL portal can be implemented in the form of a website or web application. For this purpose, the latest ICT in the field of mobile and web technologies, as well as technologies for working with databases, are used. The model is composed of three main blocks: databases, a management system and a user interface (Figure 3.4.). Each of these components plays a key role in implementing the PBL model functionalities described above.
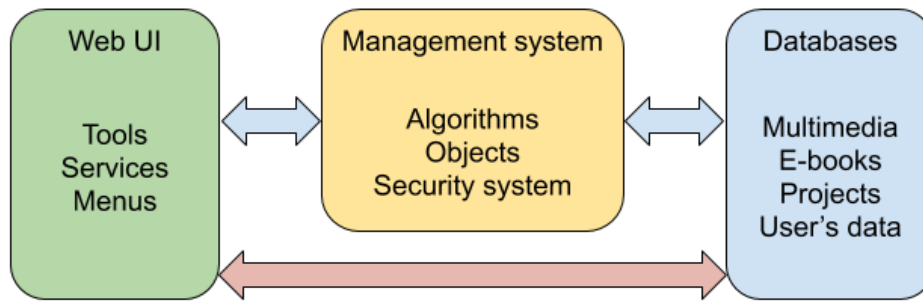
Figure 3.4. PBL platform architecture.

The database management unit stores all the information that is needed to create a project-based tutorial and its implementation. The already entered training materials and lesson templates are stored, the new lessons are recorded, as well as data on the profiles of each registered user. Data ordering and searching is done by standard database sorting algorithms.

3.3. Interactive features of the developed platform.

3.3.1. Assistant for interactive creation of project-based tutorial (PBT).

An important part of the platform for creating a PBT is an assistant for the creation of a PBU - a tool that will assist teachers in every stage of the creation of lessons. By asking questions (concerning subject and cross-curricular links, class, topic, etc.), the assistant will offer possible answers, provide related information from the database. The main goal of the "assistant" is to provide a structured project-based lesson through these questions. The assistant will have three sections of issues - organizational, operational and evaluation (Figure 3.5.).
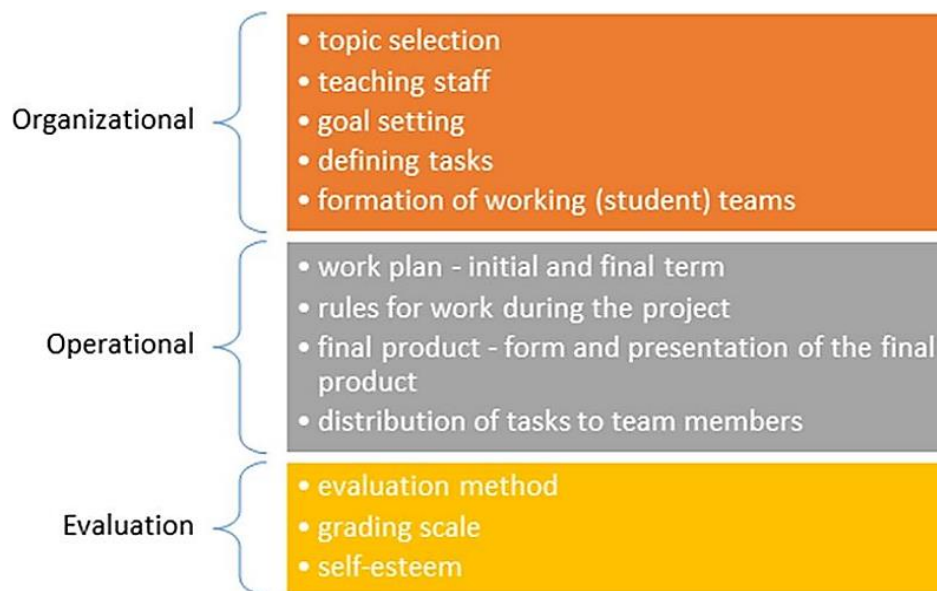

Figure 3.5. Main components of the teacher support assistant.

3.3.2. General interactive features for working with the platform.

The functionality of the developed platform includes the following capabilities:

- Create accounts - user and administrator. The idea is for users like students to have accounts with a username - first name and password faculty number, and for students - their first name, password and class. The administrator account will be for use only

17

by teachers, the goal is to track user activity, to have paths to show which user has logged in where, what they were interested in and with the help of this tracking administrators to be able to direct users to the next category that meets their demand and learning;
- ability to upload files, documents, clips, tests in all common formats to have access to them;
- possibility of real-time correspondence between users and administrators;
- automatically target users under each topic what else would be useful to them;
- automatic generation of scoring tables so that users can make an up-to-date self-assessment;
- creating a set of questions or tasks to support and guide students' work;
- A section with the most frequently asked questions by the students and the corresponding answers from the teachers. Ask a new question;
- the ability to download the materials in order to be useful to users at any time, even if they are not connected to the Internet or the platform;
- a field with the available logged in accounts (active users of the platform) for the purpose of informing both parties;

3.4. Content management system and software architecture.

The software architecture is based on the client-server principle (Figure 3.6.). In this architecture, the main part of the system is the Backend server which provides everyone with access to the content through a Web interface.
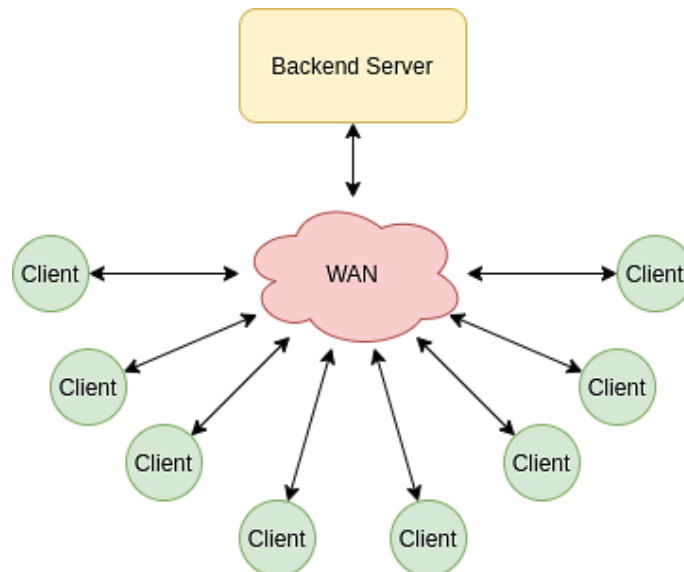

Figure 3.6. General software architecture.

Figure 3.7 presents the overall architecture of the Webbased Education Platform. In the proposed architecture, all important parts are divided into independent services that will be able to communicate with each other through **an internal interprocess communication interface.** The architecture has two types of databases: for storing information about customers and for storing information about courses. The client database will store information such as - username, passwords, university, courses, etc., all related information about the client, including their role in the system - student, teacher, administrator.

In addition to this, there will be a Database Manager (DB Manager) that will send all queries to both database blocks, similar to a router. This approach eliminates the possibility of getting a race when simultaneously sending requests and attempting unauthorized access to both databases.
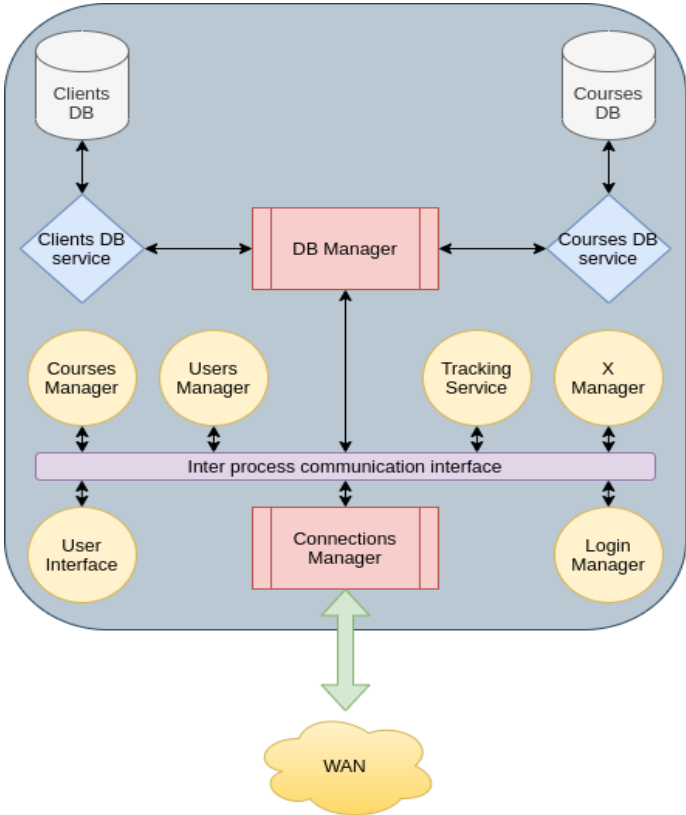

Figure 3.7. High-level software architecture.

3.5. Automate the process of creating a project-based tutorial in a web-based educational platform.

The main idea is to create a web-based educational platform specifically for project-based learning to help teachers. The platform offers specialized literature, sample projects, the opportunity for correspondence between teachers and students, teamwork and support for the creation of project-based lessons and the application of the method in different subjects. The main advantage of the platform is the automated creation of a project-based tutorial through a sequence of steps. Figure 3.8 presents the process of creating and running a project-based lesson in a web-based educational platform. The individual stages are developed and detailed below.
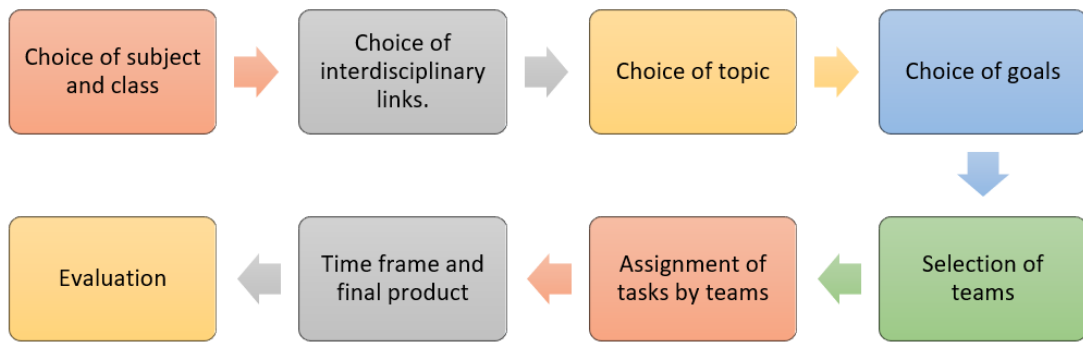
Figure 3.8. Stages of a project-based tutorial.

3.6. Development and presentation of an interactive PBL platform.

3.6.1. Results

An initial test version of the user interface has been developed. The homepage is shown in Figure 3.9. For easier operation at this stage, two buttons are available Log In and Registration. When selecting the registration button, the window presented in Figure 3.10 opens. Here each user enters the following data, such as: account type, email, password. After sending a registration request, it is confirmed by an administrator. When the registration is confirmed, an email is automatically sent to the user for activation.

Figure 3.9. Home page of the web platform.

Figure 3.10. Registration form in the platform.

Once the user "logins" into the system, according to the type of profile (teacher or student) there are different options. Here we have presented the profile of the teacher and more specifically part of the interactive assistant. Figure 3.10 shows a first step of establishing a new PBT, where the project theme is introduced (Fig. 3.11).

Once the project is created, the assistant generates two files. One is the one with the information about the project - title, participants, goal and others. The other is a table with data on project participants by teams and evaluation of the project implementation according to the following criteria: cooperation, distribution of tasks, content mastery, creativity, deadline, presentation. At the end, a final score is formed, obtained from the summation of points according to all criteria. Each student in their profile can check the points and marks given by the teacher and the team, as well as self-assessment. The presentation of the files is displayed in the interface in the form, using features in HTML, CSS and JavaScript.
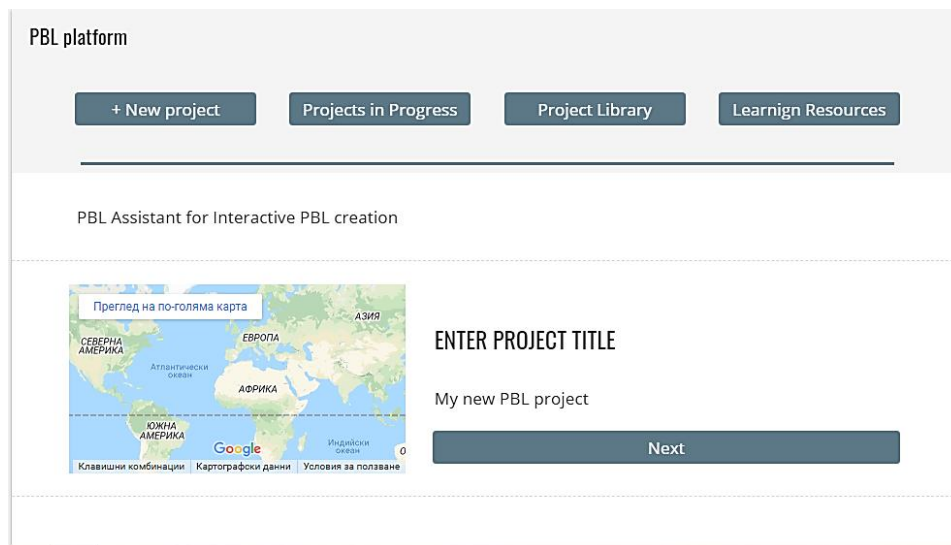

Figure 3.11. Creation of the PBL project in WebUI.

3.7. Conclusions

A web-based platform model for the application of PBL in electronic environment has been developed. An architecture of the platform has been developed to provide security and all functionalities for optimal performance. An interactive assistant for automatic creation of a project-based tutorial in the platform has been developed and presented. Results from the web-graphical interface and the stages of creating lessons are presented. The results achieved are due to the application of web technologies.

Chapter 4 Development and application of specialized educational resources for work in an electronic environment.

4.1. Software tools and applications for creating digital resources in robotics.

In the process of creating educational resources for robot simulation and control, we identified three types of applications: modeling, programming and simulation. Based on the types of applications, we can define three steps to create and operate simulation models: robot and simulation environment modelling, program (software) development for control, and tests in a simulation environment.

4.1.1. Development of a robot model.

To create a model of a robot, we need to make a full description of its components and the relationships between them. In order for ROS to understand this model description, the information is described in a file with the extension "xacro". Typically, three files of this type are needed - one to describe a robot, one to describe the materials and one to describe the specific characteristics of the units. An additional file is added." gazebo" to represent the simulation model. This file describes some simulation parameters, adds controllers, sensors and all robot characteristics. The programming language for the robot description in all files is XML. All these four files are placed in one folder as the main file with the robot description starts the others and is used to run the robot in the simulation and in the ROS.

The main and important files are that for the robot description and that for the simulation. In the first file, we need to describe the parameters and location of the robotized platform, wheels, camera and laser scanner. It should be noted that only the physical parameters of the robot are described here. Initially, each part of the robot is described, and in the code below is the description of its basis.

```
<link name='chassis'>
  <pose>0 0 0.1 0 0 0</pose>
  <visual name='chassis_visual'>
    <origin xyz="0 0 0" rpy=" 0 0 0"/>
    <geometry>
      <cylinder radius="0.2" length="0.05"/>
    </geometry>
    <material name="orange" />
  </visual>
  <inertial>
    <mass value="15.0"/>
    <origin xyz="0.0 0 0.08" rpy=" 0 0 0"/>
    <inertia
        ixx="0.5" ixy="0" ixz="0"
        iyy="1.0" iyz="0"
        izz="0.1"
    />
  </inertial>
  <collision name='collision'>
    <geometry>
      <cylinder radius="0.2" length="0.05"/>
    </geometry>
  </collision>
</link>
```

After a description of the physical parameters of the robot, the parameters for the simulation model such as the device and the platform control, the characteristics of the camera and the laser scanner should also be described. Different control and drive plugins can be used in Gazebo. We'll use the differential drive plugin. To add the plugin, we use the following code.

```
<plugin name="differential_drive_controller" filename="libgazebo_ros_diff_drive
.so">
    <updateRate>$30</updateRate>
    <leftJoint>left_wheel_hinge</leftJoint>
    <rightJoint>right_wheel_hinge</rightJoint>
    <wheelSeparation>0.40</wheelSeparation>
    <wheelDiameter>0.16</wheelDiameter>
    <wheelAcceleration>0.0</wheelAcceleration>
    <wheelTorque>5</wheelTorque>
    <commandTopic>cmd_vel</commandTopic>
    <odometryTopic>odom</odometryTopic>
    <odometryFrame>odom</odometryFrame>
    <robotBaseFrame>chassis</robotBaseFrame>
```

```
    <odometrySource>1</odometrySource>
    <publishWheelTF>true</publishWheelTF>
    <publishOdom>true</publishOdom>
    <publishWheelJointState>true</publishWheelJointState>
    <legacyMode>false</legacyMode>
    </plugin>
</gazebo>
```

Once the descriptive files for the robot and sensors are created, a new file must be created in which to run the simulation model as well as the environment. If the robot model is run on its own, it will be in an empty environment. For this purpose, a file with the extension "world" must be created. This file stores the information about the created simulation environment. We can save such a file directly from the Gazebo menu at any time when the simulation environment is ready to be used. Figure 4.1 shows the robot model in a simulation environment. When the necessary simulation files are already available, a file must be created which first starts the simulation environment and then the robot model itself.
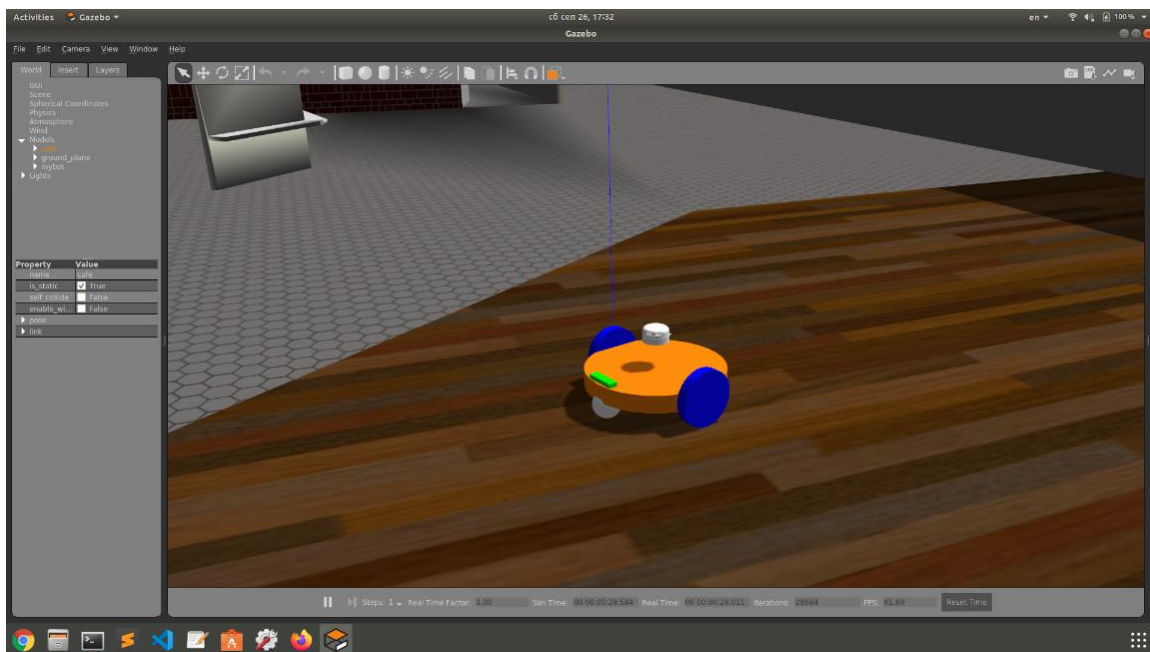

Figure 4. 1. Developed model of a robot in a simulation environment.

4.1.2. Experiments and results.

As we describe and investigate the development of educational materials and resources for robotics training, we conducted basic experiments. The aim is to confirm that the developed model and environment for the simulation of mobile robots, works properly and can be used for training students.

The first experiment was to control the robot via a control node via the keyboard. This will confirm that the robot is moving and that any node that publishes the topic of movement will be able to control the robot.

The second experiment is to visualize a video stream from the robot camera. This will show if we have a functioning simulation camera. Camera data can be used to recognize objects.

The third experiment involves tests with a laser scanner. The sensor data should delineate the environmental contour and can be used to apply localization and navigation.

Figure 4.2 shows a list of published commands from the topique to the robot. You can see the format of the messages, as well as the published data. Figure 4.3 shows the robot in the simulation environment and in an additional window to the right is the video from the camera.
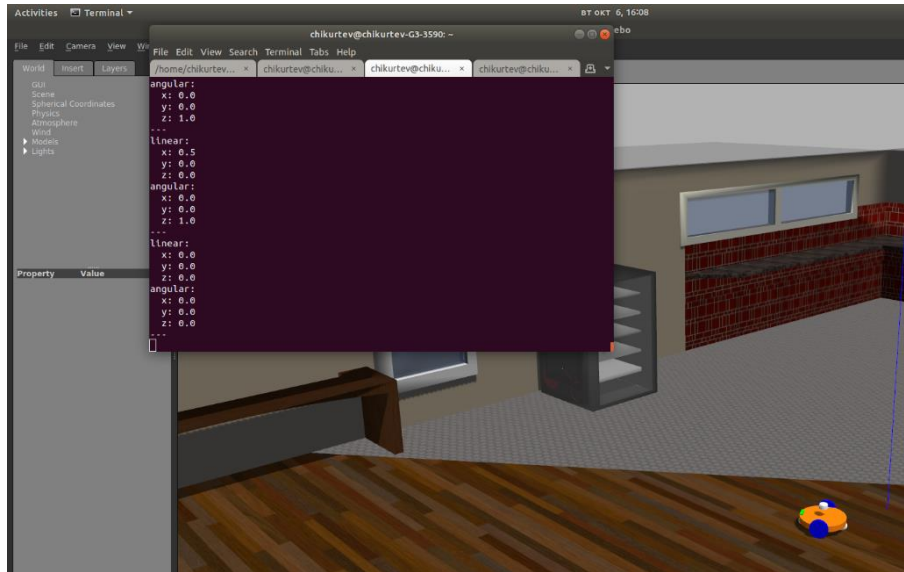

Figure 4.2. First experiment: controlling the robot by sending commands through the cmd_vel topic.
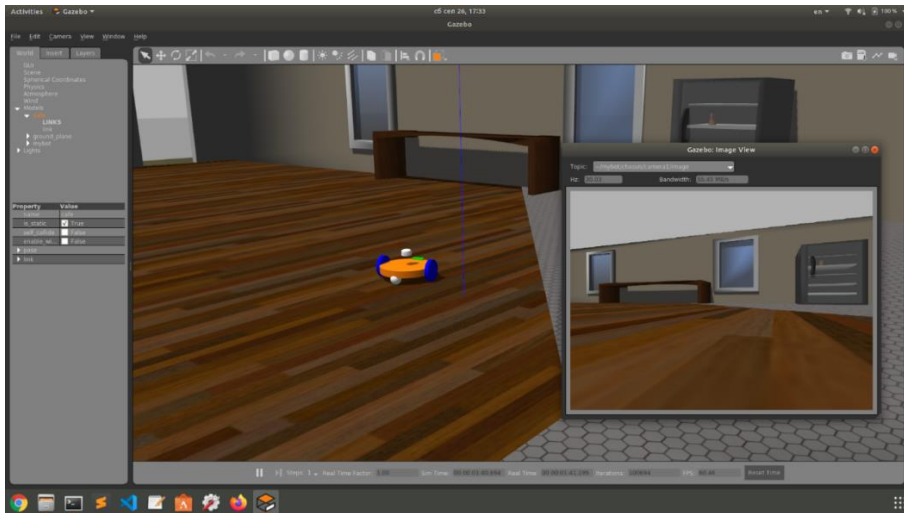

Figure 4.3. Second experiment: visualization of the video stream from the robot camera.

The obtained results show that the described methods and programs for creating and working with simulation models in a simulation environment are applicable and working. These methods can be used to create a different model of robots - mobile platforms or robotic manipulators. Using the methods described, various sensors can be simulated so that the real robot can be fully recreated and simulated.

4.1.3. Conclusion.

The created model of a simulation environment and a mobile robot is formed in a single package, which can be executed on any of the current ROS distributions installed on each computer. The development of ready-to-use simulations of fully equipped robots allows the widespread use of robotics in educational environments. The ease of use and modification of

simulation models allows teachers to lead highly effective and useful courses. As ICT advances, these teaching methods will develop significantly and become standard practices.

4.2. Simulation Applications in Electronics.

4.2.1. Experiments

The scheme that will be covered by the experiment is a symmetrical multi-vibrator, also known as Cat eyes. The vibrator is shown in Figure 4.4, referred to as Sch1. The behavior of this circuit is simple – it charges and discharges the capacitor (C1, C2) and the LEDs (LED1, LED2) are illuminated according to the charge in the capacitors. For drawing and simulating Sch1 we use an online tool which is available and free of charge: https://easyeda.com. Figure 4.5 shows the diagram in Figure 4.4, but on a prototyping board. The two implementations of the scheme are identical and tests for their operation can be performed.
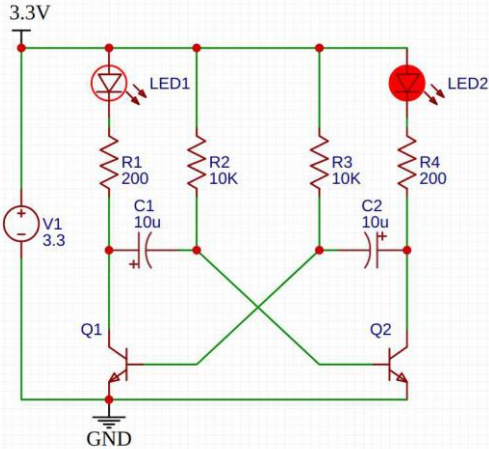

Figure 4.4. Schematic of Sch1 in easyeda.com
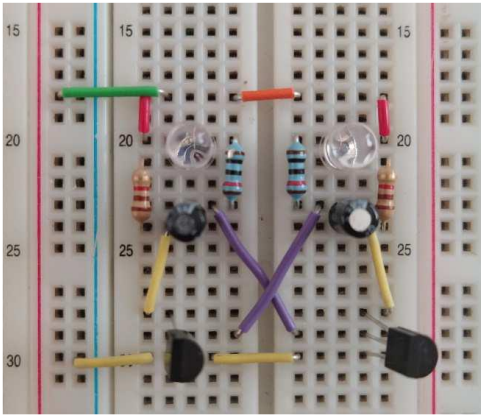
Figure.4.5. Schematic of Sch1 on the prototype board.

From the measurement made with an oscilloscope after applying a DC power supply of 3.3V to the schematic, we can see that the given circuit produces waveforms from charging and discharging the capacitors (Fig. 4.6).

Figure 4.6. Sch1 measurements from a Tektronix oscilloscope and schematic on the evaluation board.

Given a simulation evaluated at easyeda.com, we can see the same results shown in Figure 4.7.

Figure 4.7. Sch1 measurement in a purely numerical environment with simulation.

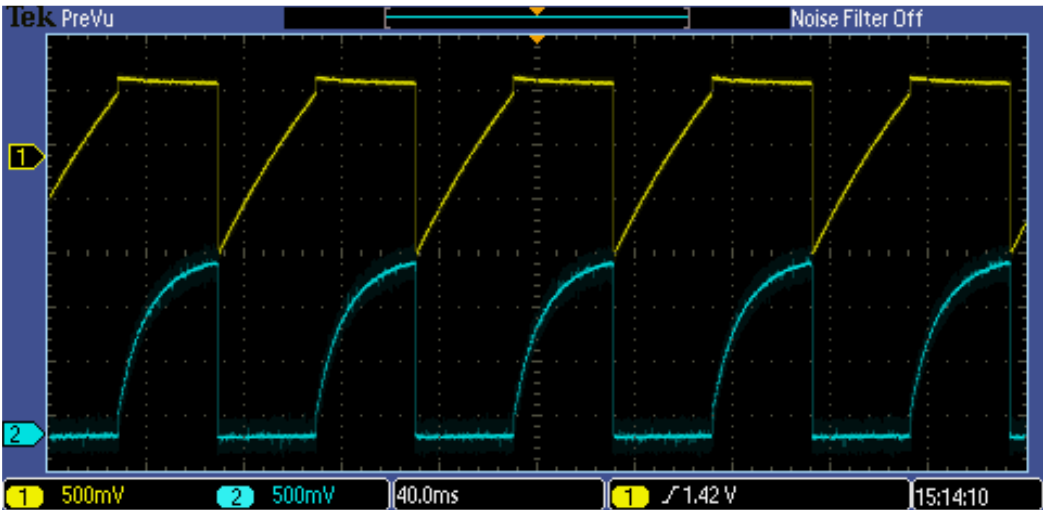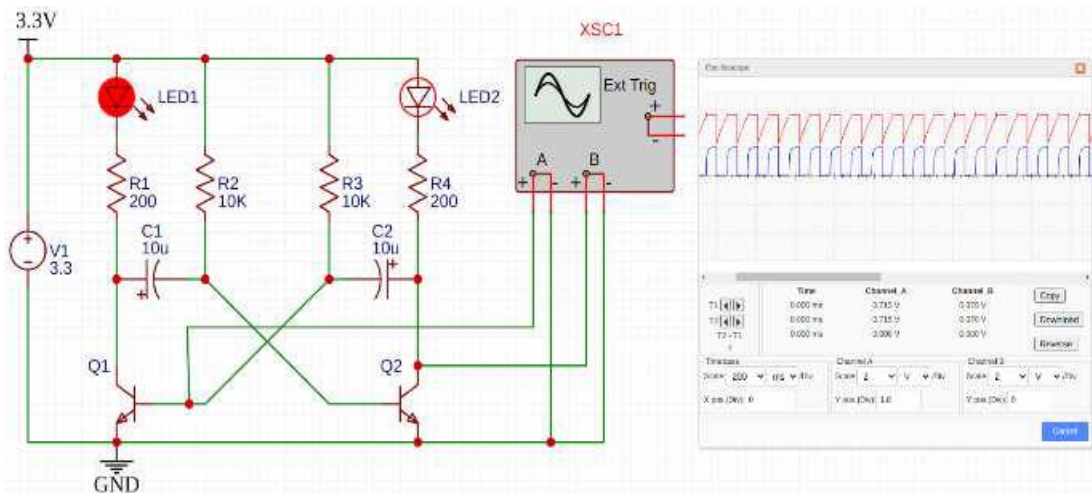Looking at Figure 4.6 and Figure 4.7, we can conclude that in some cases the use of simulation to test basic circuits and even complex is an excellent solution. This online simulator can be used both to measure the voltage and to reduce the voltage over the components, which is very useful to explain that in the real-world electronic components are not "perfect", there is a drop in voltages which are sometimes deposited from each other. For example, the voltage drop of the transistor can vary from 0.3xxV to 0.7xxV, and this depends on the way and technology that is used in production. This can be illustrated and explained. The second circuit represents a transistor as a switch; This is labelled Sch2. Figure 4.8 shows the scheme in the simulator. Figure 4.9 shows the real representation of the scheme.
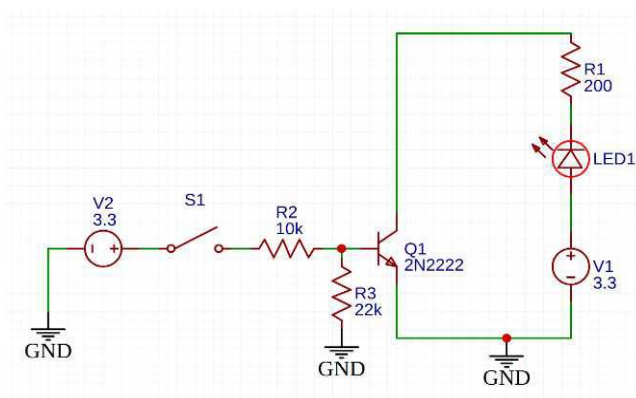
Figure 4.8. Sch2 in easyeda.com   *Figure 4.9. Sch2 on a prototype board.*
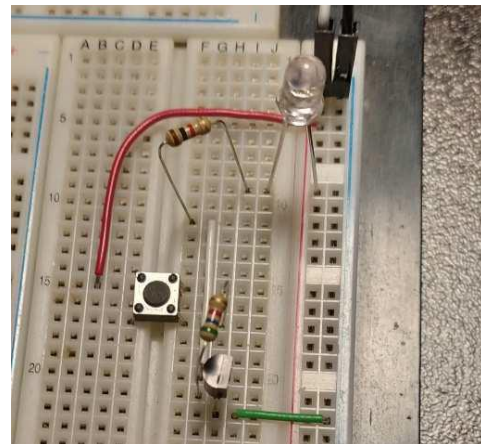
4.2.2. Conclusion.

As can be seen from the measurements and simulations made, distance engineering training is not entirely impossible. The measurements made prove that the simulations are close to the actual measurements and can be a reliable source of information for further research and production. In addition, we can say that due to the large set of libraries with different components in simulators, students can recreate many different schemes without the need to buy physical items that are difficult to access or dangerous to operate.

4.3. Sample lesson on the method of project-based learning combined with an innovative method Flipped classroom and use of Virtual Reality.

The presented lesson in Zooengineering shows the possibilities of project-based learning to increase the interest, participation and competencies of zooengineering students. The model of the project-based lesson is designed so that in the different stages of the lesson, different learning methods and technologies are additionally used. Table 4.1. contains the basic data for a project-based tutorial.

Table 4.1. Basic data for a project-based tutorial.

The Project-Based Lesson	
Professional field	Livestock farming
Specialty	Zooengineering
OCS	Bachelor
Discipline	Animal nutrition
Theme	Nutrition of growing calves
Number of participants / stage	16 / II year, IV semester
Stages of implementation of the project	Organizational, operational, productive
Other methods	Flipped classroom
Technologies used	VR/AR, Multimedia, Cloud Technologies

4.3.1. Organizational stage.

Set a project theme

With the help of a question, we introduce students to the topic ***"What do we need to raise a quality heifer?"*** Using VR/AR technology, we show in real size what the height and weight of calves should be during the different stages of their growth.

Cross-curricular links

Disciplines that relate to the topic of the lesson.

- Anatomy, morphology and systematics of forage crops;
- Introduction to animal husbandry;
- Anatomy of domestic animals;
- Technology of cattle and buffalo breeding;
- Fodder production, etc.

Purposes

General objectives – developing teamwork, tolerance and mutual assistance skills
Educational objectives – Development, enrichment and consolidation of the knowledge of feeding cattle; distinguishing the different stages of calf growth and the corresponding physiological needs; specifics of feed and supplements for cattle.
Currectional goals – the formation of creative thinking, tolerance and listening.

Teams

The students are divided into four teams.

Tasks

Research task of the teams.

I team – Study of the norms of proper nutrition and development of adolescent animals aged 4 to 6 months. Presentation of a report, presentation.

II team – Study of the norms of proper nutrition and development of animals in "puberty" at the age of 6 to 12 months. Presentation of a report, presentation.

III team – Study of the norms of proper nutrition and development of pregnant animals at the age of 12 to 22 months. Presentation of a report, presentation.

VI team – Study of the norms of proper nutrition and development of animals in a "close -up" at the age of 22 to 24 months. Presentation of a report, presentation.

Tasks distributed among team members.

I team

Name 1 – collection of information on the permissible limits of daily gain of the animal, in grams (e.g. – 1000 grams per day). Shaping the information into a report.

Name 2 – collection of information on daily ration requirements in MJ ME /kg (megajoule metabolic energy per kilogram) and crude protein intake in %. Shaping the information into a report.

Name 3 – collection of information on daily dry matter intake in % bw. Shaping the information into a report.

Name 4 - collecting information about the risk of excessive deposition of body fat and the consequences thereof. Assessment of the body condition of animals during the period. Shaping the information into a report.

In the specific project, each team follows repeats the tasks of the team members, as the task is to study daily rations, growth, risk of obesity during the different stages of adolescent calves. This implies a study of the same animal parameters, but different results, depending on the age of the calves.

Rules

The rules in the PBL process originate from the educational and educational objectives of the training. It is imperative to observe the right to: listening, open feedback, personal messages, constructive criticism, tolerance and willingness to compromise, frankness, responsiveness.

Plan of work and time frame

The project is implemented within 6 school hours.

4.3.2. Operational stage.

The teams carry out the main activities. Observations, collection and selection of information is the exploratory and analytical part of the stage. Work on the final product constitutes the practical concluding part of the operational stage. This is where we include the Flipped Classroom method, as students will carry out the activities outside of class. During this period, the teacher is available for questions and difficulties in the project work. In the classroom, the questions that have arisen during the research activity are discussed, a solution is sought. The teacher acts as a mentor, facilitator assisting, directing the activities of the

students, and not providing ready-made information. Thus, they themselves come to knowledge, through research, in order to solve the set task.

4.3.3. Productive stage.

The finalization of the final product is carried out through the presentation of the work done through presentations. In this particular case, we have chosen presentations, but the final product may be different, depending on the type of project.

Evaluation

The assessment is three-component – self-assessment, team assessment and teacher assessment presented in Table 4.2. The table contains the names of project participants by team and evaluation of project performance according to the following criteria: cooperation, distribution of tasks, content mastery, creativity, deadline, presentation. At the end, a total number of points is formed, obtained by summarizing the points according to all criteria.

Table 4.2. Scoring table to complete the project.

Team/Student	Teamwork			Distribution of tasks			Content mastery			Creativity			Keeping Deadline			Presentation			Evaluation	
	Self-estimation	Team	Teacher evaluation	Self-estimation	Team	Teacher evaluation	Self-estimation	Team	Teacher evaluation	Self-estimation	Team	Teacher evaluation	Self-estimation	Team	Teacher evaluation	Self-estimation	Team	Teacher evaluation	Total points	Final evaluation
I/1	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	35	6
I/2	2	2	0	2	2	1	2	2	2	2	2	2	0	0	0	2	2	2	27	5
I/3	2	2	2	2	2	2	2	2	2	2	2	2	1	1	0	2	2	2	32	6
…																				
II/1	0	0	0	2	2	2	2	2	2	2	2	2	0	0	0	0	0	0	18	4
II/2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	36	6
II/3	2	2	0	2	2	2	2	2	2	2	2	2	0	0	0	0	0	0	22	4
…																				

The table contains data on the students participating in the project, distributed by teams. The final assessment is formed on the basis of points by the teacher, the team and self-assessment according to the following criteria: cooperation, distribution of tasks, mastered content, creativity, deadline, presentation. The possible number of points is from 0 to 2 points. The transformation from points to score is in accordance with a six-point rating scale valid for Bulgaria (Table 4.3.).

Table 4.3. Scale for converting points to scores.

Criteria- points		Number of points	Evaluation
The criterion is covered	2 points	30-36	Excellent 6
		24-29	Very Good 5
The criterion is partially covered	1 point	18-23	Good 4
The criterion is not covered	0 points	12-17	Medium 3
		0-11	Skinny 2

Result:

The results of the conducted research show the potential of the project-based method for combining different innovative methods and technologies in the training process. The application of the method gives freedom of choice to the teacher and student in the educational process, which encourages creative thinking through creativity and innovation, helps to build the key competences of the 21st century.

4.4. Experiment: Application of project-based learning in school education.

The theoretical basis of PBL implies a variety of benefits for learners when properly applying the method. Acquisition of knowledge, skills and competencies enshrined in modern educational documents at national and European level – developing skills for self-organizing learning and project work, teamwork skills, problem solving, creativity, tolerance, taking personal and collective responsibility, etc. But in practice, these positive results are not always present. Several factors influence the successful implementation of PBL:

- socio-cultural characteristics of students;
- the education system in the country;
- the preparation of the teacher and his/her skills for motivation and management of the project;
- the willingness to participate in collective work and the effort of students (teamwork);
- the ability to compromise for the sake of the common good (the team) and others.

In order to verify and confirm the theoretically set benefits and results of PBL, an experiment was conducted in a real learning environment. The experiment was conducted at Druzhba School – Sofia during the academic year 2021 -2022 for a period of one month (February), in the subject Geography and Economics in Population sections; Villages; General government in 10A and 10B grades (24 16-year-old students). The implementation of the project work, communication, presentation of the results was supported by the Classroom application of Google Workspace for Education (Fig. 4.10.).

Figure 4.10. PBL in Google Classroom.

During the implementation of the PBL, the following problems were identified:

- direct refusal to participate in the project;
- refusal to work in a team and willingness to participate independently;
- failure to meet the deadline;
- refusal (concern) of presentation and public presentation;
- difficulties in the production of the final product (presentation);
- Not following the teacher's instructions.

As we have already explained above, PBL assessment is specific to the Bulgarian education system, which is rather theoretically oriented and the student's assessment is based on acquired knowledge rather than skills. The measurement of knowledge is done by written and oral tests, where the pupil reproduces the knowledge and skills he has acquired.

Figure 4.11. Submitted results from PBL in Classroom.

PBL is a method based on a competency approach to training, i.e. here skills and competencies acquired and shown by the student during his work on the project are evaluated. The final product is evaluated according to precisely defined criteria, but also the "way" by which the student has reached the final exact according to the applied criteria (Table 4.2.). New for the Bulgarian educational system is the three-component assessment – self-assessment, team, teacher. It implies skills of self-criticism and self-evaluation, at the expense of the student's final assessment. In the experiment, there was a tendency for maximum student self-assessment, regardless of the result achieved and the clearly unfulfilled criteria – such as meeting the deadline (Fig. 4.11).

The main advantage of PBL is the teamwork of students. In this particular case, the following problems related to teamwork were distinguished: refusal to work in a team, expulsion of a team member, non-fulfillment of the individual tasks of team members and taking them over by others, incorrect assessment of the team (in consideration with friendly and unfriendly biases), division into "capable and unable" coalitions of students, spoiling friendly relations and others.

Measures taken by the teacher, in this case in the role of mentor and facilitator to overcome the difficulties in the implementation of PBL are:

- further clarification of the nature and benefits of the project-based method;
- additional motivation, individual consultations and support;
- Conversation with a class teacher;
- risk of poor evaluation.

The problems encountered during the experiment were overcome and the training was completed successfully. This is confirmed by the positive assessment of the management of PSS "Drujba" – Sofia with their invitation to share good practices in school education to the pedagogical staff of the school in Sofia and the one in Plovdiv.

A key indicator of the benefits of implementing project-based learning is the higher results of learners shown in Figure 4.12.
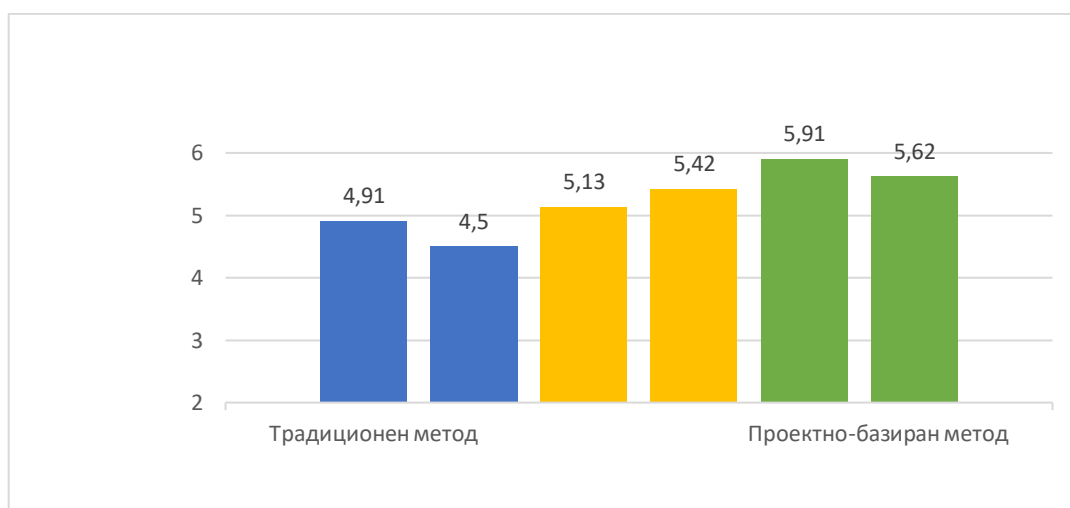

Figure 4.12. Average score from a written test in a traditional method and a project-based training method on the same section.

As I mentioned above, the experiment was carried out in the academic year 2021 - 2022 for a period of one month (February), in the subject Geography and Economics in sections Population; Villages; Government in two 10 classes.

Figure 4.12 presents data on the average score of six different 10th classes for the period of three school years placed on the specific section. The columns in blue on the chart represent the grades from the 2019-2020 school year, when the training was conducted using the traditional training method and the grades were obtained by written testing. The average score of both classes is in the range 4.50 – 5.00 (Good).

In the diagram in Figure 4.12, the columns in yellow represent the average marks from a written test, after completing the section taught using traditional teaching methods, but in an electronic environment in the 2020-2021 academic year. The average grade is higher than that of the previous year – in the range 5 – 5.50 (Very good). The increased average score may be due to e-learning during this period. Verification and control of knowledge in an electronic environment show a higher average grade in all disciplines in upper secondary education. This topic is controversial and is the subject of numerous studies, but in my opinion, a major factor for higher success in electronic exams is the low level of control by the teacher.

The last two columns of the diagram in Figure 4.12 present the average grade of two classes of project activity by the PBO method, after completing the section, in face-to-face form of education in the academic year 2021 – 2022. The average grade is higher than that of the previous two years – in the range 5.50 – 6.00 (Excellent). From this comparative diagram we can conclude that in this case, project-based training gives a better result, with a pronounced difference and trend ***Good – Very Good – Excellent*** (Figure 4.13).
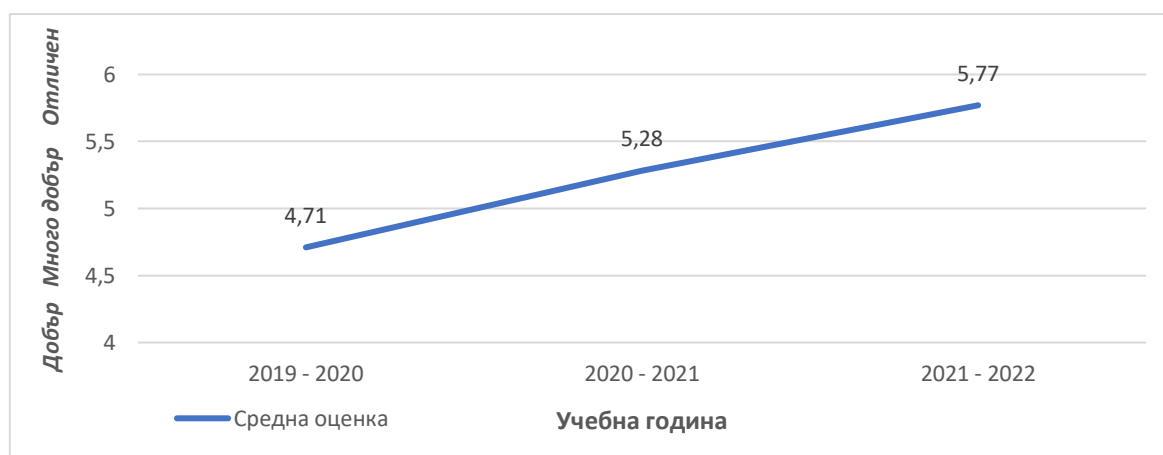
Figure 4.13. Average score from written testing in traditional method and project-based training method on the same section over three school years.

This upward trend in the average grades of the classes is maintained in the annual assessments. The average annual grades are over 5, in the column Very good and Excellent according to the six-point evaluation system. This shows that, even on just one section, project-based training carried out has an impact on the final annual assessment of learners (Figure 4.14).

33

Figure 4.14. Average annual assessment in Geography and Economics of 10th grade over a period of three years.

After the end of the experiment, an anonymous survey was conducted among students in grades 10A and 10B from the 2021-2022 school year, through Google Forms. The results of the survey showed (see Appendix 2 of the Dissertation):

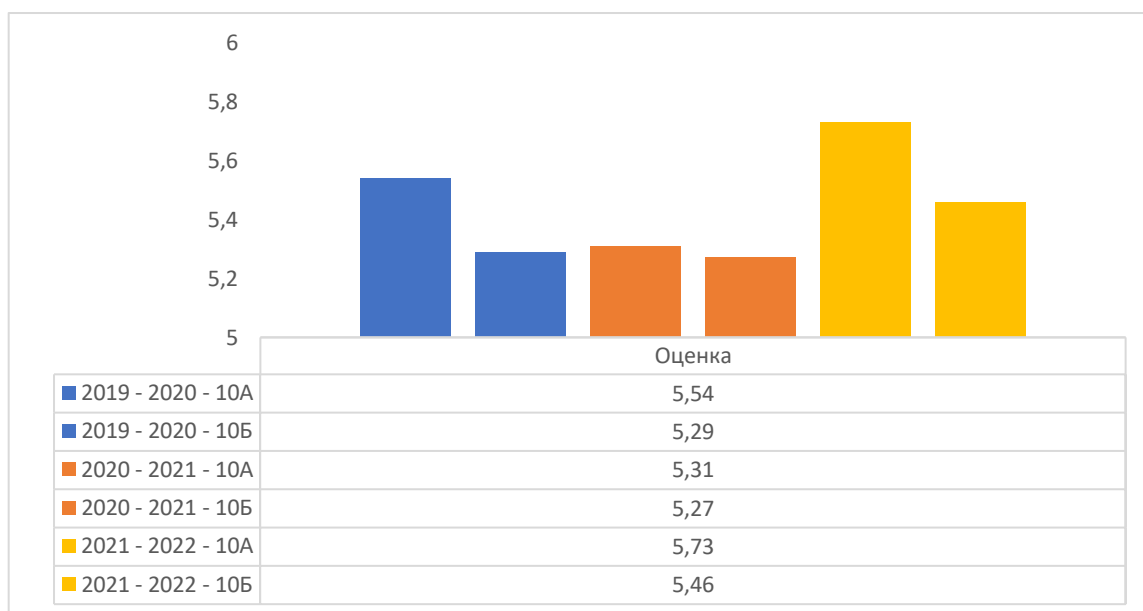•95% of students would study by the project-based learning method and by another subject (answer to question 2 of the questionnaire);

•The main advantage of PBL compared to the traditional one is its interdisciplinarity (answer to question 3 of the questionnaire – Appendix 2 of the Dissertation). While students are working on the project, they use knowledge and skills from many other subjects, such as Information Technology, Bulgarian Language and Literature, History and Civilizations, Biology and SA, etc.

•Project work implies the use of a larger volume of educational resources. In recent years, electronic resources have been preferred by learners. This is also shown by the survey, in response to questions 8 and 9.

• In project-based learning, the use of ICT is a basic necessity, as technology supports every stage of the planning, implementation and presentation of project work. We can even say that PBL is not only a competence-based method of active learning, but that it is also a technology-based method.

From the specific experiment we can conclude that all advantages of PBL can only be manifested when the method is correctly applied. Otherwise, these advantages can become disadvantages. The solution of the problems arising in the application of the method require rethinking and adaptation to a specific socio-cultural environment and educational system. This is largely the responsibility of the tutor and reflects his or her training, skills and willingness to apply the project-based method.

CONCLUSION

Information technology plays a major role in the development of modern education. The research and development carried out in the dissertation proves the wide application of ICT in every aspect of the educational process. Technology is at the heart of modern educational resources, innovative methods integrated into teaching and learning processes, overall administration and management of education. The use of information and communication technologies also changes the role of the teacher, as well as communicating and connecting with learners.

In the dissertation, research on basic problems in contemporary Bulgarian and world education was conducted. The discussed problem areas are related to the integration of ICT in the educational process - design and development of systems and educational platforms, ICT for the application of project-based learning, development of e-educational resources and technologies for e-education. Research and development in the dissertation contributes to supporting educators and improving the quality of the educational process.

A specialized web-based application platform for the project-based method has been developed. A specialized software architecture for the platform has been developed, which guarantees maximum performance, high safety and expansion and upgrade capabilities. The platform has developed and integrated an interactive assistant to support the work of teachers in the process of creating and managing project-based lessons, allowing the use of various digital resources and enabling the application of other educational methods and technologies in different combinations.

With regard to educational resources, three developments are presented. The first development is related to the creation of simulation models of robots and sensors. These models are open source and can be modified and applied in different courses. The second development presents the capabilities of stimulation software with application in electronics. It gives realistic results and is reliable to operate. The third development is a sample lesson based on PBL and upgrade capabilities. These resources can be used in various trainings and serve to create new project-based lessons.

Future research on the subject of the dissertation includes research and development of various ICT-based applications to improve other innovative methods and technologies in education.

Contributions to dissertation

In view of the work carried out in the dissertation and the results obtained in the course of the research and outlined above, the following scientific and applied contributions can be formulated:

- A model of a system for the implementation of project-based training has been developed, which allows to improve the skills of learners in a given subject area;

- A project-based lesson has been developed using an innovative method Flipped classroom and augmented reality, which allows a numerical assessment of the skills of the learners;

- A model of an automated interactive assistant integrated into the project-based learning application system has been developed, which assists teachers in creating project-based lessons;

- Digital educational resources for robot simulation and control have been developed, which are used in algorithm validation and testing and robotics training;

- An empirical comparison of learners' success with and without applying the developed model for project-based learning has been made. The results show an increase in learners' success in using the developed model.

Thanks

I would like to thank my supervisor prof. Dr. Dimitar Karastoyanov, for the fruitful collaboration, for all the advice and constructive criticism he made.

Thanks to Assoc. Dr. Denis Chikurtev for the methodological assistance, advice and recommendations, without which this dissertation would not have happened.

Bibliography

1. Aboud, F. (2020). The effect of E: Learning on EFL teacher identity. International Journal of English Research, 6(2), 22-27.

2. Al-Husseiny, N. (2019). Using ICT in inclusive learning programs for Persons with Disabilities and its impact on their lives.

3. Ametova, O. R., & Mustafoeva, N. I. (2020). The benefits and drawbacks of online education for law students in higher educational institutions. ISJ Theoretical & Applied Science, 12(92), 61-63.

4. Araújo, R. P., & de Medeiros, F. P. A. (2020, June). Requirements Elicitation and Specification for Educational Technology Development: A Systematic Literature Mapping. In 2020 15th Iberian Conference on Information Systems and Technologies (CISTI) (pp. 1-6). IEEE.

5. Ardiny, H., & Khanmirza, E. (2018, October). The role of AR and VR technologies in education developments: opportunities and challenges. In 2018 6th RSI International Conference on Robotics and Mechatronics (IcRoM) (pp. 482-487). IEEE.

6. Arora, A. K., & Srinivasan, R. (2020). Impact of pandemic COVID-19 on the teaching–learning process: A study of higher education teachers. Prabandhan: Indian journal of management, 13(4), 43-56.

7. Barak, M., & Yuan, S. (2021). A cultural perspective to project-based learning and the cultivation of innovative thinking. Thinking Skills and Creativity, 39, 100766. Bates, A. T. (2005). Technology, e-learning and distance education. Routledge.

8. Beier, M.E., Kim, M.H., Saterbak, A., Leautaud, V., Bishnoi, S. and Gilberto, J.M., 2019. The effect of authentic project- based learning on attitudes and career aspirations in STEM. Journal of Research in Science Teaching, 56(1), pp.3-23.

9. Bell, S. (2010). Project-based learning for the 21st century: Skills for the future. The clearing house, 83(2), 39-43.

10. Borissova, D., Ivanova, T., Buhtiarov, N., Naidenov, N., Rasheva-Yordanova, K., Yoshinov, R., ... & Garvanov, I. (2022, May). Application of Information Technology in the Teaching of Mathematics when Study of 2D Geometric Shapes. In 2022 45th Jubilee International Convention on Information, Communication and Electronic Technology (MIPRO) (pp. 638-643). IEEE.

11. Budnyk, O., & Kotyk, M. (2020). Use of information and communication technologies in the inclusive process of educational institutions.

12. Chikurtev, D, Rangelov, I, Yovchev, K, Chivarov, N. Communication system for remote control of service robots. IFAC-PapersOnLine, 52, Elsevier, 2019, ISSN: 24058963, 192-197

13. Chikurtev, D., 2020, October. Mobile Robot Simulation and Navigation in ROS and Gazebo. In 2020 International Conference Automatics and Informatics (ICAI) (pp. 1-6). IEEE

14. Chikurtev, D., Yovchev, K., & Chikurtev, E. (2016). Design and functionality of Web User interface for control of service mobile robot through the Internet. Problems of Engineering Cybernetics and Robotics, 67, 51-60.

15. Chikurteva, A., & Chikurtev, D. (2020, September). Model of project-based learning platform. In 2020 55th International Scientific Conference on Information, Communication and Energy Systems and Technologies (ICEST) (pp. 81-84). IEEE.

16. Choudhury, S., & Pattnaik, S. (2020). Emerging themes in e-learning: A review from the stakeholders' perspective. Computers & Education, 144, 103657

17. Collins, A., & Halverson, R. (2018). Rethinking education in the age of technology: The digital revolution and schooling in America. Teachers College Press.

18. Colvard, N. B., Watson, C. E., & Park, H. (2018). The impact of open educational resources on various student success metrics. International Journal of Teaching and Learning in Higher Education, 30(2), 262-276.

19. Costelha, H., & Neves, C. (2018, April). Technical database on robotics-based educational platforms for K-12 students. In 2018 IEEE International Conference on Autonomous Robot Systems and Competitions (ICARSC) (pp. 167-172). IEEE.

20. Danče, S. (2010). The influence of using the information and communications technology in primary education. Procedia-Social and Behavioral Sciences, 2(2), 4270-4273.

21. De Sousa, L., Richter, B., & Nel, C. (2017). The effect of multimedia use on the teaching and learning of Social Sciences at tertiary level: a case study. Yesterday and Today, (17), 1-22.

22. Dicheva, D., Dichev, C., Agre, G., & Angelova, G. (2015). Gamification in education: A systematic mapping study. Journal of educational technology & society, 18(3), 75-88.

23. Digital Education Action Plan (2021-2027): https://education.ec.europa.eu/focus-topics/digital-education/action-plan (accessed 27.10.2022).

24. Do Nascimento, L. M., Neri, D. S., do Nascimento, T., Yanaguibashi, E. A., Sá, S., & Gonçalves, L. M. (2019, October). sBotics: Simulation applied for the practical component of the Brazilian Robotics Olympiad. In 2019 Latin American Robotics Symposium (LARS), 2019 Brazilian Symposium on Robotics (SBR) and 2019 Workshop on Robotics in Education (WRE) (pp. 487-491). IEEE.

25. Domenici, V. (2022). STEAM Project-Based Learning Activities at the Science Museum as an Effective Training for Future Chemistry Teachers. Education Sciences, 12(1), 30.

26. Erihovna, K. S. (2016). Distance learning: Its advantages and disadvantages. International journal of professional science, (1), 71-74.

27. ESpark Learning: https://www.esparklearning.com (accessed 27.10.2022).

28. Esposito, J. M. (2017). The state of robotics education: Proposed goals for positively transforming robotics education at postsecondary institutions. IEEE Robotics & Automation Magazine, 24(3), 157-164.

29. Faisal, M., Ahmad, S. A., & Ansari, U. (2015). Information and Communication Technology in Dental Education: Benefits and Drawbacks'. International J. of Multidisciplinary Approach and Studies, 2(2), 147-155.

30. García, A. P., Fernández, G. V., Torres, B. M. P., & López-Peña, F. (2011, October). Educational autonomous robotics setup using mixed reality. In 2011 7th International Conference on Next Generation Web Services Practices (pp. 452-457). IEEE.

31. Gasni, D., & Chandra, D. (2022, March). Project-Based Learning in an Element Machine II Course: A Review. In 4th International Conference on Educational Development and Quality Assurance (ICED-QA 2021) (pp. 136-140). Atlantis Press.

32. Gatesichapakorn, S., Takamatsu, J., & Ruchanurucks, M. (2019, January). ROS based autonomous mobile robot navigation using 2D LiDAR and RGB-D camera. In 2019 First international symposium on instrumentation, control, artificial intelligence, and robotics (ICA-SYMP) (pp. 151-154). IEEE.

33. Gegenfurtner, A., Schmidt-Hertha, B., & Lewis, P. (2020). Digital technologies in training and adult education. International Journal of Training and Development, 24(1), 1-4.

34. Georgieva, D., & Valchev, G. (2020). SPECIFIC FEATURES OF INTERPERSONAL COMMUNICATION IN DEAF CHILDREN. Proceedings of CBU in Social Sciences, 1, 81-87. https://doi.org/10.12955/pss.v1.51

35. Georgieva-Lazarova, S. "Технология за изграждане на учебно съдържание чрез използване на електронни средства за обучение." Педагогически алманах 2 (2013): 134-162.

36. Gomez-del Rio, T., & Rodriguez, J. (2022). Design and assessment of a project-based learning in a laboratory for integrating knowledge and improving engineering design skills. Education for Chemical Engineers, 40, 17-28.

37. González, Y. A. C., & Muñoz-Repiso, A. G. V. (2017, November). Educational robotics for the formation of programming skills and computational thinking in childish. In 2017 international symposium on computers in education (siie) (pp. 1-5). IEEE.

38. Guajardo-Cuéllar, A., Vázquez, C. R., & Navarro Gutiérrez, M. (2022). Developing Competencies in a Mechanism Course Using a Project-Based Learning Methodology in a Multidisciplinary Environment. Education Sciences, 12(3), 160.

39. Gyurova, Viara. Why only pedagogical competence is not enough for the 21st century teacher? Online Journal "Educational forum" №3/2018, 1-16.

40. Hamidi, F. et al. (2011). Information Technology in Education. – Procedia Computer Science 3, 2011, p. 369 – 373.

41. Hernández, A. M. (2020). Online learning in higher music education: Benefits, challenges and drawbacks of one-to-one videoconference instrumental lessons. Journal of Music, Technology & Education, 13(2-3), 181-197.

42. Horváth, I. (2018, August). Evolution of teaching roles and tasks in VR/AR-based education. In 2018 9th IEEE International Conference on Cognitive Infocommunications (CogInfoCom) (pp. 000355-000360). IEEE.

43. Hrastinski, S. (2008). Asynchronous and synchronous e-learning. Educause quarterly, 31(4), 51-55.

44. Hrastinski, S. (2009). A theory of online learning as online participation. Computers & Education, 52(1), 78-82.

45. Hsin, C. T., & Wu, H. K. (2022). Implementing a project-based learning module in urban and indigenous areas to promote young children's scientific practices. Research in Science Education, 1-21.

46. Iqbal, H., Parra-Saldivar, R., Zavala-Yoe, R., & Ramirez-Mendoza, R. A. (2020). Smart educational tools and learning management systems: supportive framework. International Journal on Interactive Design and Manufacturing (IJIDeM), 14(4), 1179-1193.

47. Jones, C., & Ramanau, R. (2009). Collaboration and the Net generation: The changing characteristics of first year university students.

48. Jordens, X., Wilmart, R., Garone, E., Kinnaert, M., & Catoire, L. (2022). A Project-Based Learning Approach for Building an Affordable Control Teaching Lab: The Centrifugal Ring Positioner. IEEE access, 10, 4907-4918.

49. Kaewsaiha, P., & Chanchalor, S. (2021). Factors affecting the usage of learning management systems in higher education. Education and Information Technologies, 26(3), 2919-2939.

50. Kapur, R. (2019). The Significance of ICT in Education. IOSR Journal of Research and Methods, 7(3), 43-49.

51. Karastoyanov, D., Chikurtev, D., Gyoshev, S., Chikurteva, A., & Stoimenov, N. (2020, November). Advanced ICT for Access of Visual Impaired People to Computers, Knowledge, Education and Culture. In 2020 18th International Conference on Emerging eLearning Technologies and Applications (ICETA) (pp. 290-295). IEEE.

52. Karastoyanov, D., Stoimenov, N., & Gyoshev, S. (2019). Innovative Approach for 3D Presentation of Plane Culturally-Historical Objects by Tactile Plates for Disadvantaged Users (low-sighted or visually impaired). In MATEC Web of Conferences (Vol. 292, p. 03004). EDP Sciences.

53. Karastoyanov, D., Stoimenov, N., & Gyoshev, S. (2019). Methods and means for education of people with visual impairments. IFAC-PapersOnLine, 52(25), 539-542.

54. Kartika, R., Rahman, A., & Iswardi, I. (2022, March). The Effectivity and Efficiency of Project Based Learning in Achieving Student's Expected Learning Outcome (A Case Study of Vocational School Students). In 4th International Conference on Educational Development and Quality Assurance (ICED-QA 2021) (pp. 217-221). Atlantis Press.

55. Khetarpal, A. (2014). Information and communication technology (ICT) and disability. Review of market integration, 6(1), 96-113.

56. Khilya, A., & Korol, A. V. (2021, May). Features of the use of ICT in Speech Therapy Practice of Preschool Institutions. In SOCIETY. INTEGRATION. EDUCATION. Proceedings of the International Scientific Conference (Vol. 5, pp. 351-359).

57. Kholid, M. N., Pradana, L. N., Maharani, S., & Swastika, A. (2022). GeoGebra in Project-Based Learning (Geo-PJBL): A dynamic tool for analytical geometry course. JOTSE, 12(1), 112-120.

58. Koubâa, A. (Ed.). (2017). Robot Operating System (ROS) (Vol. 1, pp. 112-156). Cham: Springer.

59. Kryeziu, S. A., Avdiu, T. A., & Avdiu, A. (2021). Examining the Teachers, Administrators and Parents' View on Drawbacks of Technology Use in Education. Ilkogretim Online, 20(2).

60. Larmer, J., & Mergendoller, J. R. (2010). Seven essentials for project-based learning. Educational leadership, 68(1), 34-37.

61. Lazarov, L., & Georgieva-Lazarova, S. (2016). Education and Technologies.

62. Lazarov, L., & Georgieva-Lazarova, S. (2017). Internet Technologies in Education.

63. Lazarov, L., & Georgieva-Lazarova, S. (2017). Teacher preparation for a lesson using information and communication technology.

64. Littlefield, J. (2016). What's the difference between e-Learning and distance learning.

65. Loncke, F. T., Campbell, J., England, A. M., & Haley, T. (2006). Multimodality: A basis for augmentative and alternative communication–psycholinguistic, cognitive, and clinical/educational aspects. Disability and Rehabilitation, 28(3), 169-174.

66. Lopez, L. F., Ferrandis, E. M., Castillo, A. G., & Palomino, S. V. (2021). PROBLEM- AND PROJECT-BASED LEARNING IN CONSERVATION-RESTORATION TRAINING PROGRAMS. In ICERI2021 Proceedings (pp. 969-976). IATED.

67. Lucattini, P., Jayousi, S., Martinelli, A., Mucchi, L., & Lombardi, G. (2019, October). Social inclusion for children with disabilities: The role of ICT in play and entertainment activities. In EAI International Conference on Body Area Networks (pp. 281-300). Springer, Cham.

68. Maebara, K., Yamaguchi, A., Suzuki, T., & Imai, A. (2022). A qualitative study on the function of information and communication technology utilization in teaching students with intellectual disabilities: Implications for techniques of teaching/job coaching. Journal of Intellectual Disability-Diagnosis and Treatment, 10(1), 13-20.

69. Malin, Joel R., and Gul Muhammad Rind. "Making the case for project-based learning: An examination of research evidence translation and mobilisation in education." Review of Education 10.1 (2022): e3330.

70. Marín, D. P. (2014). Information and communications technology: In the 21st century classroom. Walter de Gruyter GmbH & Co KG.

71. Medina-García, M., Higueras-Rodríguez, L., García-Vita, M. D. M., & Doña-Toledo, L. (2021). ICT, Disability, and Motivation: Validation of a Measurement Scale and Consequence Model for Inclusive Digital Knowledge. International Journal of Environmental Research and Public Health, 18(13), 6770.

72. Mikkili, S., Panda, A.K. and Prattipati, J., 2015. Review of real-time simulator and the steps involved for implementation of a model from MATLAB/SIMULINK to real-time. Journal of The Institution of Engineers (India): Series B, 96(2), pp.179-196

73. Mirkholikovna, D. K. (2020). Advantages and disadvantages of distance learning. Наука и образование сегодня, (7 (54)), 70-72.

74. Mursid, R., Saragih, A. H., & Hartono, R. (2022). The Effect of the Blended Project-Based Learning Model and Creative Thinking Ability on Engineering Students' Learning Outcomes. International Journal of Education in Mathematics, Science and Technology, 10(1), 218-235.

75. Mustaji, Siti Masitoh, and Hirnanda Dimas Pradana. "Development of hybrid project-based learning in State University of Surabaya." Innovation on Education and Social Sciences. Routledge, 2022. 11-18.

76. Mustapha, I., Van, N. T., Shahverdi, M., Qureshi, M. I., & Khan, N. (2021). Effectiveness of digital technology in education during COVID-19 Pandemic. A bibliometric analysis.

77. Novak, A. M., & Krajcik, J. S. (2019). A case study of project-based learning of middle school students exploring water quality. The Wiley Handbook of Problem-Based Learning, 551-572.

78. O'Lawrence, H. (2005). A review of distance learning influences on adult learners: advantages and disadvantages. In Proceedings of the 2005 Informing Science and IT Education Joint Conference.

79. Paunova-Hubenova, E., Terzieva, V., & Todorova, K. (2019, September). The Role of ICT in Teaching Processes in Bulgarian Schools. In 2019 29th Annual Conference of the European Association for Education in Electrical and Information Engineering (EAEEIE) (pp. 1-6). IEEE.

80. Peachey, N. (2022). "Project-Based Learning", Oxford University Press, Retrieved from https://www.oup.es/sites/default/files/2022-03/OUP_Focus_Project%20Based%20Learning_%20highres.pdf

81. Petrov, P. D., & Atanasova, T. V. (2020). The Effect of augmented reality on students' learning performance in stem education. Information, 11(4), 209.

82. Petrov, P., & Atanasova, T. (2020). Developing Spatial Mathematical Skills Through Augmented Reality and Geogebra. In ICERI2020 Proceedings (pp. 5719-5723). IATED.

83. Petrov, P., & Atanasova, T. Digital Twins with Application of AR and VR in Livestock Instructions. Problems of Engineering Cybernetics and Robotics, vol. 77, pp. 39-50, 2021.

84. Peytcheva-Forsyth, R., & Yovkova, B. (2015). How students' experience in e-learning affects their judgements about the quality of an online course. International Journal of Human Capital and Information Technology Professionals (IJHCITP), 6(1), 14-25.

85. Podgórska, Marzena, and Iwona Zdonek. "Sustainable Technologies Supported by Project-Based Learning in the Education of Engineers: A Case Study from Poland." Energies 15.1 (2022): 278.

86. Pushpanathan, T. (2012). The role of a teacher in facilitating e-learning. Journal of Technology for ELT, 2(2), 1-4.

87. Ramirez-Montoya, M. S., Anton-Ares, P., & Monzon-Gonzalez, J. (2021). Technological Ecosystems That Support People With Disabilities: Multiple Case Studies. Frontiers in Psychology, 12, 633175.

88. Rudyk, O.Y. and Gonchar, V.A., 2020. The impact of the SolidWorks Simulation network quality on the accuracy of the calculations.

89. Rueda, M. M., & Cerero, J. F. (2019). Main barriers to ICT teacher training and disability. Research in Social Sciences and Technology, 4(2), 96-114.

90. Saad, A., & Zainudin, S. (2022). A review of Project-Based Learning (PBL) and Computational Thinking (CT) in teaching and learning. Learning and Motivation, 78, 101802.

91. Sagita, M., & Khairunnisa, K. (2020). E-Learning for educators in digital era 4.0. Budapest International Research and Critics Institute (BIRCI-Journal): Humanities and Social Sciences, 3(2), 1297-1302.

92. Santos-Hermosa, G., Ferran-Ferrer, N., & Abadal, E. (2017). Repositories of open educational resources: An assessment of reuse and educational aspects. International Review of Research in Open and Distributed Learning: IRRODL, 18(5), 84-120.

93. Schmid, E. C. (2008). Potential pedagogical benefits and drawbacks of multimedia use in the English language classroom equipped with interactive whiteboard technology. Computers & Education, 51(4), 1553-1568.

94. Shin, N., Bowers, J., Krajcik, J., & Damelin, D. (2021). Promoting computational thinking through project-based learning. Disciplinary and Interdisciplinary Science Education Research, 3(1), 1-15.

95. Skocheva-Antonova, M. S. (2020). Информационните технологии като средство и метод за овладяване на граматически правилна реч от децата в началното училище. Годишник на Шуменския университет „Епископ Константин Преславски ". Педагогически факултет, 24(1), 586-592.

96. Solomon, G. "Project-based learning: A primer." TECHNOLOGY AND LEARNING-DAYTON- 23.6 (2003): 20-20.

97. Spasova, N., Bogdanov, S., & Chikurteva, A. (2021, May). Opportunities for Online Engineering Training in Electronics. In 2021 12th National Conference with International Participation (ELECTRONICA) (pp. 1-4). IEEE.

98. Stendal, K. (2012). How do people with disability use and experience virtual worlds and ICT: A literature review. Journal for Virtual Worlds Research, 5(1).

99. Strobel, J., & Van Barneveld, A. (2009). When is PBL more effective? A meta-synthesis of meta-analyses comparing PBL to conventional classrooms. Interdisciplinary journal of problem-based learning, 3(1), 44-58.

100. Syvyi, M., Mazbayev, O., Varakuta, O., Panteleeva, N., & Bondarenko, O. (2022). Distance learning as innovation technology of school geographical education. arXiv preprint arXiv:2202.08697.

101. Terzieva, V., Paunova-Hubenova, E., Dimitrov, S., & Boneva, Y. (2018, September). ICT in STEM Education in Bulgaria. In International Conference on Interactive Collaborative Learning (pp. 801-812). Springer, Cham.

102. Toskova, A. T., Doychev, E. H., & Toskov, B. P. (2016). An idea for extension of the virtual educational space for lifelong learning. КОМПЮТЪРНИ НАУКИ И КОМУНИКАЦИИ, 5(4), 35-38.

103. Toskova, A., Toskov, B., Stoyanov, S., & Popchev, I. (2019). Genetic Algorithm for a Learning Humanoid Robot. Comptes rendus de l'Académie bulgare des Sciences, 72(8).

104. Totseva, Y. R. (2016). Project–based learning–technology and capabilities for use in Bulgarian schools. Reports Awarded with "Best Paper" Crystal Prize, 303-308.

105. Tsai, S., & Machado, P. (2002). E-Learning Basics: Essay: E-learning, online learning, web-based learning, or distance learning: unveiling the ambiguity in current terminology. eLearn, 2002(7), 3.

106. Turnbull, D., Chugh, R., & Luck, J. (2020). Learning Management Systems, An Overview. Encyclopedia of education and information technologies, 1052-1058.

107. Tzanova, S. S., & Radonov, R. I. (2019, September). Evaluation of Multimedia Learning Materials in Microelectronics. In 2019 IEEE XXVIII International Scientific Conference Electronics (ET) (pp. 1-4). IEEE.

108. Valchev, G. (2019). Готовност на подкрепящата среда (учители) за приобщаващо образование на ученици със специални образователни потребности в общообразователното училище. Педагогика, 91(3), 343-350.

109. Van den Heuvel, R. J., Lexis, M. A., Gelderblom, G. J., Jansens, R. M., & de Witte, L. P. (2016). Robots and ICT to support play in children with severe physical disabilities: a systematic review. Disability and Rehabilitation: Assistive Technology, 11(2), 103-116.

110. Vlasenko, L., & Bozhok, N. (2014). Advantages and disadvantages of distance learning.

111. Yordanova, M. (2021). Междукултурна комуникация и дигитализация в образованието. Чуждоезиково обучение, 48(1), 91-95.

112. Yusmaniar, Y., Sudrajat, R. T., & Mustika, I. (2022). The Effectiveness of Learning to Write Explanation through a Scientific Approach Using Project-Based Learning. Budapest International Research and Critics Institute (BIRCI-Journal): Humanities and Social Sciences, 5(1), 2717-2723.

113. Zhang, D., Zhao, J. L., Zhou, L., & Nunamaker Jr, J. F. (2004). Can e-learning replace classroom learning? Communications of the ACM, 47(5), 75-79.

114. Европейска квалификационна рамка (ЕКР)

115. Закон за предучилищното и училищното образование -2016 г.

116. Кирякова, Г., „Инструменти за създаване на образователни приложения с добавена реалност", Електронно списание „Педагогически форум" брой 4, 2018, ISSN: 1314-7986, DOI: 10.15547/PF.2018.026 10

117. Кожухарова, Г., Иванова, Д. „Дидактически модел за приложение на ИКТ в образованието" Електронно списание Педагогически форум, (2015) Брой 4, DOI: 10.15547/PF.2015.035

118. Лазаров, Л. (2011). Развитие на информационните средства за обучение. Педагогически алманах, (2), 94-103.

119. Лазаров, Л. (2016). Информационни системи в образованието. Universitetsko izdatelstvo" Sv. sv. Kiril i Metodiï".

120. Младенова, М., Брезин, Б, Предизвикателства при приложение на икт в обучението на „поколението на социалните мрежи", Управление и устойчиво развитие 4/2013 (41), 108 -113

121. Национална квалификационна рамка на Република България

122. Национална стратегия за въвеждане на ИКТ в българските училища – 2005 г.

123. Павлова, И. (2006). Информационните технологии в образователния процес: еволюция към ново качество на образованието.

124. Петрова, М., Петрова, И. "Интегриране на информационните и комуникационните технологии в началния етап на основната образователна степен." В. Търново 1 (2007): 225-229.

125. Стратегия за ефективно прилагане на информационни и комуникационни технологии в образованието и науката на Република България (2014-2020г.)

126. Терзиева, В., Тодорова, К., & Кадемова-Кацарова, П. (2016). Преподаване чрез технологии–споделеният опит на българските учители. In Сборник с доклади на межд. конф." Образованието в информационното общество", Пловдив, стр (pp. 185-194).

127. Трифонов, Р., & Павлова, Г. (2017) Приложение на методите на изкуствения интелект в роботиката Application of artificial intelligence methods in robotics.

128. Цанков, С., & Войноховска, В. (2014). Ролята на съвременните информационни образователни технологии за повишаване мотивацията на обучаемите. Научни трудове на русенския университе, 53.

129. Шопова, Т. (2011). Информационната грамотност–ключов фактор за ефективно обучение. Национална стратегия за въвеждане на ИКТ в българските училища. Достъпна на: https://www. president. bg/docs/1352306506. pdf. Посетено на, 30, 2021.