Scientific and research activities as part of the educational process in higher education institutions

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Abstract: *The authors' goal is to show the need for students to participate in fundamental and applied scientific research to solve current problems by introducing and using innovative educational technologies, methods, and tools for training. The development of the Internet, expanding connectivity through social networks, the entry of artificial intelligence, augmented and virtual reality, 3D printing, etc., requires new knowledge and skills and leads to new challenges. Trained personnel in this modern world must have a solid professional background and developed systematic thinking, developed cognitive qualities and personal skills, which are formed on the basis of collecting and analyzing various information from diverse sources. The possibilities for training and real participation of students in projects, the development of which leads to the integration of knowledge acquired in different training courses, are considered. The report presents experiments conducted at Trakia University with students from the specialty Information Technology, who are trained through project work to integrate knowledge from various fields: Internet of Things (IoT); smart mobile applications; cloud computing; augmented and virtual reality; Big Data processing; smart sensors, etc. The hypothesis is that the knowledge and skills obtained will enable students to successfully implement themselves under the requirements related to the integration of Industry 4.0 technologies and the transition to Industry 5.0.*

Keywords: Education, Scientific research, Project-based learning.

1. Introduction

Scientific and research activities are a vital part of every university's mission. They are also essential to the educational process for students. High-quality education depends on creative development and the application of knowledge through students' scientific and research activities. In this way, scientific activity is a practical aspect of education. Only through research can education foster key qualities of an educated person—such as creative and critical thinking, flexibility, learnability, the ability to apply concepts in new situations, and engagement with public issues. Equally important is the role of scientific and research activities in enabling students to express their vision of significant problems and to utilize their innovations for social change (Farikhatul, 2024). Scientific and research activity is absolutely essential to the learning process for every student.

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Conversely, the growth of digital technologies and their expanding presence in various aspects of human activity create new demands for the quality of student education. Students must engage with emerging technologies driven by digital advancements—such as machine learning, artificial intelligence, virtual and augmented reality, remote control tools, network technologies, and autonomous systems. The adoption of innovative teaching methods is closely linked to providing the necessary infrastructure and equipment for both innovative instruction and research.

The thesis presents the possibility of applying the concepts of Research-based learning in a specific institutional context - Trakia University in Bulgaria. The authors aim to highlight the importance of training students to engage in innovative, fundamental, and applied scientific research in computer science, mathematics, and pedagogy. This training is crucial for addressing current challenges related to the adoption and use of new educational technologies, methods, and tools. The focus is on providing opportunities for students to participate in projects that synthesize knowledge from different courses. The overall goal is to enhance the quality of training and provide targeted preparation for young researchers in conducting scientific studies and participating in practical teaching activities.

In the experiments conducted at Trakia University, students of the "Information Technology" specialty are trained through project work to integrate knowledge from the areas of: "Internet of Things" (IoT); smart mobile applications (Mobile applications); cloud technologies (Cloud computing); augmented reality (Augmented Reality/Virtual reality); processing of large volumes of data through intelligent algorithms (Big data); smart sensors (Smart sensors); cybersecurity, etc. The knowledge and skills obtained will enable the students to successfully implement in accordance with the requirements related to the integration of Industry 4.0 technologies and the transition to Industry 5.0. Special attention is paid to students' experience and opinions on this type of training, and a specific experiment is presented through a real project.

2. Relevance and significance of the study

Digitalization is changing the way of life in every area of human activity. The demand for employees with digital skills is steadily increasing across the EU Member States and Bulgaria. At the same time, in the preparation of specialties, the updating of training is delayed, which must consider the new requirements for the competencies needed by IT specialists to be able to apply new technologies such as: virtual and augmented reality; artificial intelligence; introduction of remote-control tools; network technologies, connecting components; real-time planning and connectivity; autonomous systems, etc. Some of the indicated areas are considered in separate disciplines within the bachelor's or master's programs of certain Bulgarian higher education institutions (HEIs), which do not provide comprehensive, complex preparation of the necessary personnel.

A change is needed in how education and training systems adapt to the digital revolution to prepare computer specialists for industry, considering the needs of Industries 4.0 and 5.0 (Ross, 2017; Popchev, 2019). This includes not only creating up-to-date training documentation but also ensuring adequate training of teachers, learning content, teaching materials, and facilities. Last but not least, a change in the teaching method is also needed, related to project/problem-oriented learning, which will enable learners to adapt quickly in a specific research and real-world environment, to make effective decisions in complex, multifaceted, and real-world problems, to acquire knowledge, and to develop skills for independent analysis and problem solving.

Research activities at Trakia University are carried out in accordance with the university's scientific policy and the needs of public practice. The scientific policy is determined on the basis of:

- trends in the development of science, education, and technical progress;
- international, national, and university forecasts for the development of science, education, and the needs of public practice;
- international and national programs and projects for scientific research and the development of education;
- competitions of state bodies, companies, foundations, and other organizations for the development and/or implementation of scientific and research projects;
- proposals of units, teams, and individual researchers at the university;
- proposals of doctoral students, postgraduates, and students studying at the Trakia University.

3. Training students through work on scientific projects

Student participation in scientific project work is an important part of their education. We conducted an experiment with the students of the 3rd year of the Information Technology major at Trakia University, with specific research objectives set in the conducted study being:

- study of scientific materials – articles, reports, monographs, and books related to the subject area under consideration for analyzing the properties of mathematical or applied objects;
- acquisition of skills for modeling real processes, conducting experiments, and drawing analytical conclusions;
- support of the educational process by linking with scientific approaches and modern tools and technologies;
- presentation of the conducted experiments and analyses at scientific seminars, development of scientific articles, reports, etc.

During the experiment, the activities listed below were carried out in order:

– teams of teachers and students were created to study and investigate real, practical problems;

- materials were developed to assist students in conducting scientific experiments and presenting them;
- seminars and workshops were held with the participation of students, etc.

The participants in the scientific team come from diverse fields, providing an opportunity to conduct multidisciplinary research and obtain comprehensive results. The team members' scientific experience was used to select and describe the tasks, as well as to train students in working groups for research and teaching. The results obtained can be the basis for diploma theses and new scientific developments.

The hypothesis is that conducting scientific research will qualitatively improve the methodology for training IT specialists.

The following is a presentation of the pedagogical research conducted with a qualitative-quantitative (mixed) research design, implemented through an educational experiment. It has a descriptive-analytical and experimental nature, and its main goal is to study the effectiveness of project-based learning (PBL) as a method for integrating research activities in the education of students in information technology.

The study is oriented towards an analysis of the educational process in the conditions of digital transformation and an assessment of the impact of interdisciplinary, real projects on the formation of professional and research competencies. From a methodological point of view, the study combines: an experimental approach - by introducing an innovative training model; a case study approach - by working on a specific real project; an empirical approach - by collecting and analyzing data from training participants.

4. Conducting an experiment related to student work on a real project

An experiment was conducted to implement an innovative approach to student training by integrating quantitative analysis into fashion design research and education (Kazlacheva, 2025). The experiment has both academic and practical significance, demonstrating how data-driven methods can improve design analysis and student creativity.

The experiment employed a comparative analysis of historical and contemporary fashion design, utilizing quantitative methods and indices. The study was conducted and tested with design students as they worked on real projects. The originality of the study itself lies in the choice of data analysis methods. The most informative indicators of shape and color of contemporary and historical clothing were selected using the RReliefF, FSRNCA, and SFCPP methods. Feature vectors were reduced using latent-variable and t-SNE methods. The obtained data were used to group clothing by historical periods. Using Euclidean distances, the relationship between the clothing of contemporary designers and the elements of historical costume they used was established. This approach qualitatively complements existing research in this area. The study's results were subsequently used to train fashion design students.

We share the view that training should align with the requirements of the specialist market, on the one hand, and with trends in the development of information technologies, on the other. The curricula of the disciplines generally change more slowly and with difficulty. However, by working on real projects, one can stay up to date with modern technologies and the dynamics of their development. During their training, students work on a real project, applying the knowledge gained in various disciplines related to data collection and analysis, programming, and the application of software products in different application areas.

Project work involves the comprehensive solution of specific problems or practical tasks within a finite period, utilizing designated resources (Fajari, 2020). In the learning process, the individual tasks students perform must be well-formulated, incorporate knowledge and skills from the basic modules of the learning content, and involve integrating various activities. In (Crespí, 2022) they emphasize the positive impact of project-based learning on the development of certain thinking qualities, such as critical and creative thinking, motivation for learning, problem-solving skills, planning, experimentation, and evaluation, as well as teamwork skills and others. In addition, students must learn to respect copyright when using information from other sources.

In the conducted experiment, which involved students working in teams with teachers on real projects, we aimed to apply a project-based learning approach as a pedagogical model for interdisciplinary activities that address real-life problems. This is a challenge to students to construct, master, and consolidate knowledge and skills. Here, the goals of the training are related, on the one hand, to the project's problems and, on the other hand, to developing skills for working on a project. Through work on projects by students in teams, it is achieved (Di & Xuan, 2022; Rahmani, 2023):

- a stronger connection between training and practical needs;
- increasing the cognitive activity required of the student;
- assessing acquired practical skills, and not just the ability to memorize;
- overcoming difficulties in collaborative teamwork. Gradually, as they learn to solve problems together, students acquire teamwork habits.

The problem situations (case studies) presented to the teams must be well prepared and have a number of characteristics (Kilpatrick, 2018) such as:

- be broad-ranging - they must be related to a wide range of disciplines and topics, and involve making new associations;
- satisfy a specific goal, respond to a specific need, make sense, and require the application of skills;
- pose obstacles to overcome, create cognitive conflict, and resemble problem situations that will have to be solved in life;
- provoke the comparison of different points of view, lead to discussion, require the search for information from different sources, and do not imply a single answer.

Involving students in project work is crucial for engaging them in scientific work (Orozova, 2020). The scientific team that conducted the experiment included specialists from various fields, which enabled research across a wide range and achieved results in diverse areas.

Following the experiment with students from Trakia University in Stara Zagora, we conducted a survey to gather their opinions, asking: "What is your assessment of the work carried out and the results obtained on the implemented project?". The answers are: Strongly positive, Strongly negative, Rather positive, Rather negative. A total of 81% of the students showed a positive attitude, with 55% of the students expressing a strong positive attitude and 26% expressing a rather positive attitude towards this approach. While 18.5% chose a rather negative answer, there was no strongly negative answer. This shows a strong interest of young people in a research approach and the search for solutions to real practical tasks.

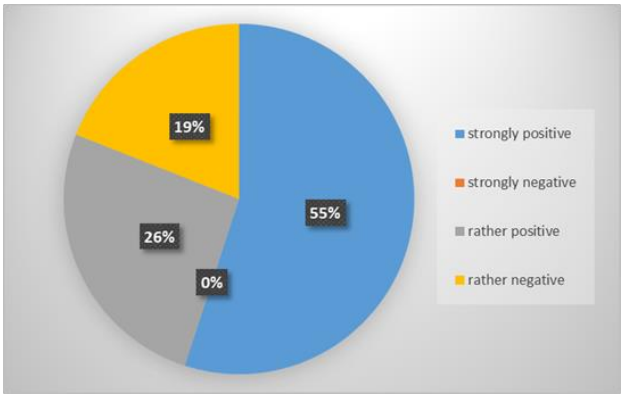

Figure 1. Diagram with results of the student opinion survey

We note that in the work process, students improved their interpersonal skills, teamwork, and leadership qualities, which are undoubtedly important skills in the twenty-first century. Additionally, the boundaries between disciplines are blurred, thereby enhancing students' ability to synthesize knowledge. The approach focuses on non-traditional research of a selected problem and requires the creation of a specific educational product that reflects a comprehensive system of knowledge, skills, attitudes, and personal qualities. Progress in real life provides opportunities to enrich the ideas of project-based learning with new information technologies and artificial intelligence, both of which are extremely dynamic.

6. Conclusions

Direct pedagogical observation was conducted during the project work, focusing on: the level of student engagement; teamwork skills; application of scientific and technical knowledge; communication between participants. Additionally, a qualitative analysis of informal feedback from students received during seminars, discussions and presentations was conducted, which complements the quantitative results and assists in their interpretation.

The study demonstrates the effectiveness of project-based learning for training IT specialists in the context of Industry 4.0 and 5.0. A methodological model for integrating scientific research into student training through real projects is presented. Existing research on PBL is expanded by incorporating modern digital technologies and AI into the educational process.

Highly qualified training requires creative development and experience of the knowledge taught through the scientific and research activities of the trainees. In this sense, scientific activity is part of the practical side of education. Through research activities, qualities of the educated person can be created, such as creative and critical thinking, flexibility, the ability to apply concepts in new conditions, engagement with public positions, etc. No less important is the role of scientific and research activities to express the student's vision for significant problems and use student innovation for social change. On the other hand, the development of digital technologies and their penetration into more and more areas of human activity impose new requirements on training. Trainees must master new technologies generated by the development of digital technologies - machine learning, artificial intelligence, virtual and augmented reality, remote control tools, network technologies, autonomous systems, etc. The participation of students in scientific research work to solve current problems through the use of innovative educational technologies, methods and learning tools is a practically useful approach.

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