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Digitalisation of Bulgarian Secondary Education
Дигитализация на българското средно образование

ANALYSIS OF THE DIGITAL COMPETENCIES OF PHYSICS TEACHERS IN BULGARIA ACCORDING TO THE DIGCOMPEDU FRAMEWORK

Dr. Ivelina Kotseva, Assist. Prof.,
Dr. Maya Gaydarova, Assoc. Prof.
Sofia University "St. Kliment Ohridski" (Bulgaria)

Abstract. This article is a review of the reports delivered by Bulgarian physics teachers on the National Conference on Physics Education in the period 2007 – 2023 in the context of their digital competencies' development. Its main goal is to provide a comprehensive exploration of the integration of digital technologies in physics education, emphasizing their role in enhancing teachers' and learners' digital competence across various dimensions. The study emphasizes on the significance of digital technologies in fostering digital literacy, communication, collaboration, content creation, responsible use, and problem solving among students in alignment with the DigCompEdu framework. Digital technologies, including virtual labs, simulations, coding platforms, and mobile apps, offer students dynamic and interactive learning experiences, promoting information and media literacy and hands-on experimentation.

Keywords: physics education; digital technologies; digital competencies; DigCompEdu

Introduction

The main research objective of this article is to trace the development of digital competencies among Bulgarian physics and astronomy teachers in the period from 2007 to 2023. The primary research approach we will employ is the analysis and synthesis of the experiences shared by teachers at the National Conference on Physics Education. The National Conference on Physics Education is a significant and unique forum in Bulgaria, held annually, and it is the most representative in terms of the state of physics and astronomy education in primary, secondary, and higher education. The proceedings of the National Conference on Physics Education are published in print and, since 2018, in a digital format accessible on the website of the Union of Physicists in Bulgaria[1]. They are also included in the database of NACID – the National Centre for Information and Documentation[2]. Considering the fact that digital competence is a key competence that develops throughout one's life and was defined as a recommendation by the European Union as far back as 2006, we decided, in our analysis of the shared experience of teachers at all levels of education in Bulgaria, where we have references to digital technologies and development of digital competencies, to cover a broader period, starting precisely from 2007 up to the present moment. Proceedings from 2008, 2011 and 2015 are not available. Yet we explored more than 120 reports.

Table 1. Relative proportion of publications related to digital technologies and digital competences compared to the total number of reports in the reviewed proceedings of the National Conference on Physics Education, Bulgaria

National Conference on Physics Education	Total number of reports	Related to digital competencies and digital technologies	Relative proportion
"Experiment in Physics Education", Pleven, April 1 – 4, 2007	94	19	20 %
"Physics and Astronomy Education in the Context of the New Educational Structure of Secondary School", Ruse, April 2 – 5, 2009	70	13	19 %
"Physics – Culture – Education", Lovech, April 8 – 10, 2010	82	12	15 %
"Modern Goals in Physics Education in Secondary and Higher Schools", Gabrovo, April 5 – 8, 2012	74	5	7 %
"Challenges and Perspectives in Physics Education in Secondary Schools and Universities", Sofia, September 25 – 29, 2013	47	9	19 %
"Global Educational Standards, Comparative Measurements, and Physics Education in Bulgaria", Stara Zagora, September 8 – 11, 2014	50	8	16 %
"Informal Education in Physics and Astronomy", Yambol, April 7 – 10, 2016	66	7	11 %
"Experiment – the Basis of Physics Education", Sofia, April 6 – 9, 2017	72	13	18 %
"European Dimensions of Bulgarian Physics Education", Pleven, April 13 – 15, 2018	44	9	20 %
"Integrated Approach in Physics Education", Veliko Tarnovo, April 4 – 7, 2019	36	6	17 %
"Nuclear Physics and Energy in Physics Education", Sofia, October 2 – 4, 2020	27	2	7 %
"Physics in STEM Education in Secondary and Higher Education", Vidin, June 4 – 6, 2021	28	9	32 %
"Climate Change and Physics Education", Varna, June 2 – 5, 2022	27	5	19 %
"Education and Scientific Research in Physics – a Factor for Sustainable Development", Sofia, April 10 – 13, 2023	29	5	17 %
Total	746	122	16 %

Table 1 represents the relative proportion of publications containing references to digital technologies and digital competences compared to the total number of reports in the reviewed proceedings of the National Conference on Physics Education.

The DigCompEdu framework[3] encompasses 22 competencies categorized into six areas:

(1) Professional engagement (organizational communication; professional collaboration; reflective practice, digital continuous professional development);

(2) Digital resources (selecting digital resources; creating and modifying digital content; managing, protecting and sharing digital resources);

(3) Teaching and learning (teaching; guidance; collaborative learning; self-regulated learning)

(4) Assessment (assessment strategies; analyzing evidence; feedback and planning);

(5) Empowering learners (accessibility and inclusion; differentiation and personalization; actively engaging learners), and

(6) Facilitating learners' digital competence (information and media literacy; digital communication and collaboration; digital content creation; responsible use; digital problem solving).

There are two possible approaches to relating physics teachers' experience to the DigCompEdu framework. Following the first approach, we analyze each publication as a specific case, and seek for its intersection with the general framework of digital competencies. The second approach works in the reverse direction. For each digital competency, we look for manifestations and evidence. Both approaches allow us to track the development of digital competencies over time. However, the second approach is more systematic, while the first approach makes it easier to determine when a particular technology entering the Bulgarian educational space.

Digital competencies of Bulgarian physics teachers according to the DigCompEdu framework

We begin with the preliminary agreement that in many of the publications, more than one competence are evident, and the examples provided illustrate one competence but may also be relevant to others.

Area 1: Professional Engagement

In the realm of digital education, professional engagement is paramount, encompassing organizational communication, professional collaboration, reflective practice, and digital continuous professional development.

Organizational Communication

Organizational communication plays a crucial role in the adoption of digital technologies in education. Effective communication within educational institutions ensures that digital tools and platforms are seamlessly integrated into the curriculum. A good example of specific organizational communication is Astronomy education, where Internet is used on a massive scale. Due to the vast number of internet resources in the field of astronomy, the guidance of the teacher towards specific websites, archives, virtual astronomical observatories, and free access to the data of certain telescopes and satellites is necessary (Myglova, Stoev 2007).

As mentioned earlier, education in physics and astronomy, especially in the field of astronomy, largely relies on collaboration between teachers, specialists, amateur astronomers, and large international astronomical organizations and institutions. A weak point of the formal educational programs for the subjects of Physics and Astronomy in grades 7 – 12, as well as the Human and Nature subject in grades 3-6, allocate little space for astronomy. That is why attention should be directed towards informal education and new opportunities it provides through access to training and resources, including digital ones, for teachers and students in an informal environment. Typically, these opportunities are realized thanks to international projects, as we can see in the cases with the SMARTNET project for building a robotic telescope system (Kyurkchieva et al. 2009), the SID monitor for ionosphere observation (Kiskinova 2013), the GOLAB project (Djokin 2014), the SPACE AWARENESS project (Djokin 2018), and others.

The project EuSTD-web, approved, and sponsored by the European Commission under the Comenius 2.1 program is also presented (Epitropova, Solunov 2009). The target group includes teachers and their students from grades 1 to 8. The main activities of the project involve creating resources that support science education in a web-based environment, implementing and evaluating the created resources, and identifying, presenting, and disseminating best practices for the professional development of teachers in the field of natural sciences.

Another example where institutional organization is required is CERN's educational programs for involving students in real experiments conducted in a digital environment. One of CERN's initiatives is LHC World Wide Data Day, which took place on November 15, 2018. The aim of the event is to have students and teachers from around the world participate in the analysis of real data from two of CERN's major experiments: ATLAS and CMS. During World Wide Data Day, students and teachers become involved in the work of the scientists at the laboratory and have the opportunity to contribute their results to a shared digital spreadsheet. Through video conferencing, they can analyze and engage in discussions with scientists. Some of the participants are from grades 10, 11, and 12 at SU "Nikolay Katranov" in Svishtov, with guidance from Senior Physics and Astronomy Teacher Elena Ilieva and Senior Computer Science and IT Teacher Yordanka Ilieva. The students have been processing data from CMS, the detector with the participation of Bulgarian scientists at CERN. For this purpose, they use a specialized graphical user interface that visualizes particle tracks generated in specific events (Ilieva, Ilieva 2019). This example has a strong connectivity with Area 5: Empowering Learners.

Professional Collaboration

Professional collaboration is vital for leveraging digital technologies in education. Collaborative efforts among educators result in the development and sharing of digital educational resources.

The Municipal Center for Extracurricular Activities in the village of Baykal, Dolna Mitropolia Municipality, Pleven Region, serves as a place for informal education. This is where experienced teachers, not only in physics education but also in science education, participating in various national and international projects and educational programs introduce their colleagues to the opportunities for participation and qualification. Many lecturers are invited, roundtable discussions on various topics are organized, and training for working with various kits and equipment is conducted (Djokin 2016).

It is reported in the above-cited publication that through the SPACE AWARENESS project, in which the Municipal Center for Extracurricular Activities is one of 19 dissemination partners, a series of massive online training courses for teachers would be organized in 2016. Additionally, a summer school in Greece (under the Erasmus+ program) and an international workshop at Leiden University from October 10 to 13, with a one-day visit to the European Space Agency, are planned. It should be noted that the shared experience in this publication is an excellent illustration of the latest paradigm in natural science education – STEM education, and reflects European standards that define the framework for STEM as a global phenomenon.

The SCIENTIX project of the European Schoolnet Community (EUN) for science education in Europe offers navigation in all 24 languages of the European Union, a resource repository, on-demand translation of educational materials into the respective language. It also provides opportunities for uploading news and projects and other communication features are discussion, forums and chat rooms, news and events, teacher training opportunities through webinars, Moodle courses, newsletters, and social media presence including Twitter, and Facebook (Hristova 2016). Other similar projects are COMPASS (Hristova 2018) and INGENIUS (Hristova 2014).

The capabilities of Virtual Learning Environments (VLE) and project-based learning in physics within the context of Content and Language Integrated Learning (CLIL) are illustrated through the presentation of a project in physics education for grades 9 to 12 as part of the eTwinning activity under the EU Lifelong Learning Program. Bogdana Hristova, a physics teacher at the Joan Ekzarh Language School in Vratsa, Bulgaria, carried out the project from the Bulgarian side. The project's topic, goals, planning, and organization are described in her two reports (Hristova 2012, 2013). It is worth noting that the project's implementation involved the use of a digital workspace, which is specialized software installed on a server. This allowed students to access the workspace at any time from any computer connected to the Internet. Access to each virtual class was password-protected, and students were not allowed to share their passwords with their classmates. Each participating teacher had access to all the virtual classes for their students with a specific access password. Students from one class were grouped into pairs, and each pair joined a different international virtual class, with two students from Bulgaria, two from the Czech Republic, two from Sweden, and so on. The author also established assessment criteria, with skills such as internet research and information selection, as well as presentation skills, also being subject to evaluation. This example has a strong connectivity with Area 5: Empowering Learners.

In recent years, the Inquiry Based Science Education (IBSE) has become globally popular. The initial stage of implementing this approach involves research, which, in modern conditions, is largely conducted on the Internet. Marchev et al. (2013) and Hristova (2013) focus on this approach and various online resources. One of the goals of the PATHWAY project, as described by the authors (Marchev et al. 2013), is to gather and share best practices that have been tested in a real educational environment and are available online[4]. It is noted that dozens of Bulgarian science teachers have received training through seminars related to European general education projects such as COSMOS, PATHWAY, and LD-Skills.

Reflective Practice

Reflective practice is essential in the context of digital education, enabling educators to adapt their methods to students' evolving needs. Educators' reflection on the outcomes of digital teaching informs their instructional decisions and innovations. New digital technologies can enhance interaction between teachers and students and thus improve self-reflection, especially when combined with effective methods of assessment and collaboration.

It is very popular nowadays to use mobile applications for formative assessment and fast feedback. When using free web-based applications to enhance students' cognitive abilities in physics and astronomy, there are suggestions regarding Socrative, Bubbl.us, and Popplet (Trayanova 2014). An illustration of the Plickers technology for formative assessment combined with the Peer Instruction method is also available (Kotseva 2016).

The use of digital technologies for providing feedback and opportunities for reflection, leading to the improvement of teaching and learning practices for both teachers and students, can be achieved through an online platform for assessing group activities and student reflection. The platform, developed by Fabien Kunis, has the capability to offer students interactive collaboration in a digital environment. It is based on the PISA methodology from 2012 and 2015 for the assessment of team activities and it can track students' progress and provide assistance during their collaborative activities through appropriate interventions. In this way, it is possible to experiment and develop new forms and formats to support learning activities using digital technologies (Kunis, Gaydarova 2021).

Concept mapping tools support reflective practice, allowing educators to visually organize and connect ideas. Reflective educators use concept maps to evaluate their teaching strategies and adapt them for better student understanding. Mind maps facilitate the understanding of the relationships between concepts and quantities in physics (Gancheva 2018; Draganova, Tsoncheva 2019; Draganova-Hristova 2021). Creating mind maps is a process that is not only useful, but also enjoyable for students. Through them, students memorize content quickly, efficiently and through positive emotions (Filipova 2023). There are plenty of software tools available for their implementation, and physics teachers share their experience in this regard. Opportunities for creating mind maps through various programs - Drawing for Children, Kidspiration 2.1, Visual Mind 9.0, FreeMind (max) 0.8.0, Explain 1.5, ConceptDraw MINDMAP 4.5, and others, which were current at that time, as well as practical guidelines for their application in physics education, are shared (Todorova 2009; Trayanova 2014; Trayanova 2020).

Digital Continuous Professional Development (CPD)

Digital CPD is a dynamic process that empowers educators to enhance their digital skills continuously. Online courses and digital resources are important in educators' ongoing professional development. In 2008, the emphasis of the 'Lifelong Learning' program was placed on "the need to enhance and reinforce teachers' skills and knowledge to improve the utilization of the new opportunities created by ICT. Projects should focus on the development, testing, and implementation of materials, courses, and new pedagogical methods that enhance the use of high-quality materials in the teaching process in schools" (European Commission 2008, cited by Raykova et al. 2009, p. 122). The goals and expected results of the international project 'CAT: The effective use of computer-aided teaching and learning materials in science teaching – a teacher training course with a European perspective' are described. Bulgaria also participated in this project supported by the 'Lifelong Learning' program during the period 2008 – 2010.

The integration of digital technologies into education has transformed the learning landscape, making it more dynamic, interactive, and accessible. From laptops to smartphones, from classroom activities to e-learning and m-learning – all these rapid transformations reflect on the Digital CPD of teachers. The COVID pandemic accelerated these processes. From a research (2022) conducted on the effectiveness of e-learning among a group of teachers after the completion of fully remote learning, we understand that 60% of the surveyed teachers have long been applying information technology in education - more than 5 years. All of them use presentations with pre-prepared schemes (100%), and 80% of them have indicated that they use ready-made video clips. Nearly the same proportion (76.7%) use the whiteboard in the virtual classroom. Just over 1/3 of the respondents are proficient with a graphic tablet, and around 1/5 also use digital textbooks, educational games, and interactive exercises. Solving science problems during remote work in an online environment is primarily done through the whiteboard in the virtual classroom (80%), but a significant portion of teachers also uses a graphic tablet for this purpose (43.3%) (Raykova et. al. 2022).

As the saying goes, the new digital generation demands new models of education and, in its own way, dictates both reflective practices and continuous digital development for teachers (Radeva, Pavlova 2016). In summary, professional engagement in digital education is multifaceted and spans organizational communication, professional collaboration, reflective practice, and digital continuous professional development. Educators and institutions should rely on a range of digital tools, collaborative platforms, and reflective techniques to enhance teaching and learning in the digital age.

Area 2: Digital Resources

In the realm of education, the integration of digital resources has brought forth a profound transformation. Various digital technologies play a pivotal role in enhancing the learning experience. This summary delves into Area 2 of DigCompEdu, which revolves around selecting digital resources, creating and modifying digital content, and managing, protecting, and sharing digital resources.

Selecting Digital Resources

The adoption of digital technologies has empowered educators and students to access a vast array of digital resources. These resources are essential for enriching the educational experience and facilitating effective learning. Students can now easily access a wide range of educational content. This transformation enables learners to explore subjects beyond traditional textbooks. In addition, Web 2.0 technologies have enabled teachers and students to create and share content through collaborative online platforms, fostering creativity and self-expression.

Video clips are a priceless educational digital resource in physics education. They serve as a means of visualizing various physical effects, processes, and phenomena, and according to the authors Nancheva and Docheva (2007), they have their place and role for several specific reasons which are very well described in their publication. Of course, it is a common practice in schools to use YouTube channels like Khan Academy[5] for illustrating physics lessons or providing examples of applying physical phenomena and explaining cause-and-effect relationships. Many teachers and students utilize these channels. However, sometimes there may be gaps and inaccuracies in the presented visual information and its explanations. Here is the role of the teacher to select properly.

For conducting, demonstrating, or visualizing physics experiments (both real and virtual), a wide variety of software and hardware tools are used, as well as ready-made digital resources. This diverse range of tools and resources can include:

Simulation Software – programs that simulate physical phenomena and experiments, allowing students to interact with and observe these phenomena virtually.

The website of PHET Interactive Simulations[6] is freely accessible and has been maintained by the University of Colorado since 2001. It currently hosts over 1 billion simulations covering various subjects, including physics, chemistry, biology, mathematics, and Earth sciences. Over the years, it has gained popularity among physics teachers in Bulgaria.

Augmented Reality (AR) and Virtual Reality (VR) – AR and VR applications that immerse students in virtual physics environments or enhance real-world experiments with digital overlays. The AR technology is described by Raykova and Stoyanova (2013) and by Raykova et al. (2017), with one of the co-authors, Diana Stoyanova, having a dissertation on this topic. This technology represents a significant advancement in the field of visualization and virtual experiments.

Data Acquisition Systems – hardware and software that enable the collection and analysis of real-world experimental data, such as sensors, data loggers, and software like LabVIEW.

Online laboratories in GO LAB come in three types (Djokin 2014, p. 144):

Remote Labs – These physical laboratories can be operated remotely, allowing students to conduct real experiments and collect real data from a distance. The primary advantage is that students work with real equipment and techniques, rather than simulations. However, their maintenance can be costly, and they are more challenging to set up compared to virtual labs.

Virtual Labs – These are software-based simulations that mimic laboratory equipment. They range from simple illustrations of physical processes to precise simulations of experimental procedures. They are more cost-effective compared to remote labs.

Data Sets – These databases contain scientific data obtained from real experiments. For example, students cannot conduct experiments with equipment like the Large Hadron Collider (LHC) and the ATLAS detector, which are part of CERN's equipment. However, the public, including teachers and students, have access to the database collected during experiments at CERN. Relevant analysis programs (e.g., HYPATIA) that allow data manipulation accompany these data sets. Hadjiiska (2020) provides different opportunities and an example of a lesson based on data from the CMS of CERN.

The presence of built-in sensors and access to fast Internet has turned smartphones into a demonstrative and experimental tool in physics education over the last decade. Smartphones and apps for solving problems are employed both in the classroom and more often in extracurricular forms of education, in informal activities. Various capabilities of Arduino microcontrollers for conducting computer-based automation experiments are discussed in various publications (Tyutyulkov 2019; Angelov 2021; Pancheva 2021; Pancheva 2022; Kunis 2021; Gosheva, Raykovska 2022).

The combination of these software and hardware tools, along with digital resources, can greatly enhance the teaching and learning of physics by providing engaging and interactive ways to explore and understand physics concepts and experiments.

Creating and Modifying Digital Content

Digital technologies have provided tools and platforms for creating and modifying digital content. This not only applies to students but also to educators who construct interactive learning materials, making education more engaging.

An example of creating digital content is the development of a digital manual with eight laboratory exercises for 8th grade students, fully covering the requirements according to the curriculum of 2007 (Stoyanov et al. 2007). The instructional manual is designed for independent student work, both at home and in school. Each laboratory exercise includes one or two tests related to the respective educational content. The program allows for tracking the total time taken to complete the test and includes a built-in calculator that students can use.

The MOSEM project (Modeling and Development of Experiments Related to Electromagnetism and Superconductivity) aims to build a unified European educational space in physics by utilizing modern technologies (multimedia, video clips, computer modeling and simulation, distance learning) and pedagogical methods (Nancheva, Docheva 2009). The primary goal of the MOSEM2 project is to connect the experiments developed in the MOSEM project with modeling and simulations. Content based on Coach 6, Modellus, and Easy Java Simulation is developed.

Gravitational lensing is a phenomenon that cannot be studied through real experiments. In this case, virtual experiments are not only necessary but also an essential element in better understanding the physical properties of this object. A report based on the work of a student and her supervisor from an Astronomy club delivers a systematic process of creating a website for a virtual experiment (Takuchev 2007).

Raykova et al. (2013) describe an approach outlining the possibilities of organizing problem-based learning in the study of electromagnetic wave spectra in 9th grade using the platform HP Classroom Manager, PhET simulations, multimedia, and Internet. An attempt to highlight and track changes in the didactic structure of the physics lesson for new knowledge has been made.

The use of programming languages by students to create educational resources is particularly prevalent in professional high schools with information technology profiles. An example of creating animations is based on the Python programming language and open-source libraries to visualize complex physical phenomena. Developing mathematical models and simulations of physical phenomena is done by teachers in both physics and computer science, like Ventsislav Nachev from the National Professional High School of Computer Systems and Technology in Pravets. He shares his experience in the development of educational games (Nachev 2018).

Animations in physics education prove to be invaluable tools for facilitating visualization and, in turn, understanding various physical phenomena and functional relationships. The history of using animations in physics education is presented by Rabadzhiiska (2009), where the author has also shared methodological recommendations for creating animations. The goal of animations is "to illustrate physical processes that are difficult to explain and cannot be demonstrated." The author raises the question, "How can we help students master physics knowledge in an interesting and modern way by creating physics learning programs?" (Rabadzhiiska 2009, p. 209).

Some teachers create their own websites to expand the information resources available to students, who sometimes contribute to maintaining these websites (Manolova-Ivanova 2023). We have also included a publication in our analysis in connection with the technology Cinema4D for 3D modeling and animation (Yovcheva et al. 2013). Multimedia technologies like the one mentioned above, as well as Flash Macromedia (out of use nowadays), Adobe Animate, Maya, and Blender, are known in physics education, although they are not as commonly used. Nevertheless, 3D graphics software offers opportunities for the development of various ideas, such as physics educational programs in the form of computer games.

Managing, Protecting, and Sharing Digital Resources

The management, protection, and sharing of digital resources, as well as the organization of digital content that allows for easy and secure access while protecting sensitive and personal data, is a necessary condition for resource utilization. Most physics teachers participate in social networks where they share resources on online platforms, as well as personal or organizational websites/blogs. When sharing, it is essential to respect the copyright of the resources and any declared copyright limitations regarding use, reuse, and modification of digital resources.

For example, Karabaliev (2014) presents the possibilities of Google Apps for Education for organizing the educational process. Google Apps for Education is entirely free for schools and universities. In comparison, the platform Blackboard is a paid service, and Moodle is a formally free open-source system that requires financial resources for maintenance. Difficulties in using Moodle stem from the fact that it requires servers from the respective organization that will work with it and be administered by their administrators, making it impractical for small schools with limited resources.

Area 3: Teaching and Learning

In the context of digital education, Area 3 of DigCompEdu encompasses various facets of teaching and learning, including teaching methods, guidance for both educators and students, collaborative learning, and self-regulated learning.

Teaching

The use of digital technologies for their own professional development enriches teachers' professional experience and encourages the development of their digital competencies. This process intensifies when using platforms that offer activities for modeling processes and calculating specific values in the selected model. Some teachers continually seek new platforms and resources to diversify their teaching methods and are eager to acquire new ones. As an example, Gereva et al. (2022) highlight the use of the Wolfram Alpha platform7 in teaching quantum physics in high school. It is clear from this publication that "fast processing, the ability to input a large amount of data, as well as the construction of tasks with the parameters of real processes – all of this increases students' interest and activates their cognitive activities in the learning process. Furthermore, this platform can assist teachers in creating presentations, composing tasks, and obtaining graphical images when teaching these important and challenging topics".

There is an established practice in physics education in Bulgaria of creating digital resources that support and enhance the goals of teaching and learning, as well as of modifying existing digital resources to support and improve teaching and learning goals while respecting copyrights and licensing rules (e-textbooks and e-lessons as examples) (Yordanov 2018).

Guidance

The role of educators has evolved in the digital era. They guide and support students in navigating vast digital resources and content. Online learning platforms offer flexible and accessible education options, extending learning beyond physical classrooms.

"Developing high-quality online courses in natural sciences, and especially in physics, is a definite challenge... In the methodological construction of distance learning courses, due to their specificity, real laboratory exercises cannot be included. However, they should not be skipped. This would lead to a decline in the skills of students" (Exner et al. 2014, p. 65). The authors of this publication propose an alternative called "e-physics experiments". Each such experiment within the distance-learning course comes with methodological and practical guidance for its execution, and in some cases, a suitable video clip is added. Two examples from the "Molecular Physics" section are provided in the above-cited publication.

Digital lessons come in various forms, including those created by students. In these lessons, students utilize their knowledge of computer science and information technology to develop models of physics phenomena and processes. For instance, students create GIF animations depicting the flow of electric current in electrolytes and electrolysis. They use software like Paint and the PhotoScape application (Moncheva 2018).

Collaborative Learning

Digital technologies enable collaborative learning. Web 2.0 technologies empower students to create and share content through collaborative online platforms. Collaborative online document editing promotes teamwork and simultaneous contributions, improving group projects and assignments. Tools like Google Workspace and Microsoft 365 enhance collaboration among students, enabling shared document editing. Video conferencing tools facilitate real-time collaboration, document sharing, and discussions among students and educators.

The implementation of interdisciplinary connections between physics and IT in the 8th grade is a current topic, as discussed by Bozhanova (2009). In this context, the connection with ICT is realized through PowerPoint, Excel, and the Internet (searching for suitable animations). What the author suggests is the distribution of tasks among students based on their IT skills. The first team, formed by computer science students, will create a presentation on a specific topic related to the lesson. The second team, formed by mathematics students, will calculate the mass of the Earth and the value of gravitational acceleration using the formula for gravitational force. They will then plot the trajectories of spacecraft launched from Earth at different velocities using the Geonex software. The third team, formed by physics students, will research information on astronaut weightlessness and zero gravity on the Internet and present a pre-made animation on the topic of weightlessness to the class. The methods used in this approach include experimentation, teamwork, discussions, brainstorming, and situational analysis. According to the author, "teaching a lesson using IT significantly increases students' interest in physics. They enrich their knowledge by finding and using additional information and develop various practical skills related to drawing, data systematization, and creating multimedia products" (Bozhanova 2009).

Self-Regulated Learning

Online learning platforms and educational websites offer students a plethora of content, covering diverse subjects, allowing for self-regulated learning. Learning management systems help students manage their educational resources, assignments, and progress, promoting self-regulated learning. Digital platforms provide instant access to a vast array of educational content, encouraging self-regulated learning beyond the classroom.

Mavrova (2019) shares a practice regarding the use of QR codes for illustrating new material with appropriate short video clips, computer animations, or images, as well as for organizing independent learning activities at home. Students receive a card with the respective task, which is prepared for the lesson and is delivered online. This card includes a list of the necessary materials for conducting the experiment, the procedure, safety instructions if needed, as well as fields for filling in after conducting the experiment. While filling in the card, students are required to add photos and videos from the conducted experiment. After completion, they send the card for assessment and the students' work is stored in the cloud space.

Self-regulated learning requires digital technologies to enhance the learning processes and planning activities among students, promoting active and autonomous learning, making them more responsible for their own education. This shift focuses from teaching to learning. A practice at SPGE John Atanasoff, Sofia, requires students to create and record digitally an experiment at home. Home experiments are conducted without the intervention and control of the teacher during its execution. Students choose the Internet resource through which they will record, demonstrate, and popularize the experiment they have conducted on their own (Gosheva, Raykovska 2022).

In essence, digital technologies have transformed teaching and learning by offering flexibility, fostering collaboration, and promoting self-regulated learning, aligning with the principles of Area 3 in DigCompEdu.

Area 4: Assessment

Area 4 of DigCompEdu focuses on assessment, including assessment strategies, analyzing evidence, providing feedback, and planning for effective learning.

Assessment Strategies

Some of the so-called new means of control and assessment include: various types of tests; portfolio; development and defense of projects; presentations; exam with posters, graphics, diagrams, and models; open-book exam, idea analysis, thesis proof, thesis rejection; interactive board exam; peer assessment; self-assessment, and others. The MyTestX program offers various possibilities for creating and conducting monitoring in physics education. Some of these possibilities include test creation, personalized tests, assessment and analysis, data management, virtual learning opportunities (Ilcheva 2018). These features of MyTestX can be used to enhance the quality of physics education and facilitate the assessment and monitoring of the learning process.

Different strategies for assessment and criteria for assessing student portfolios with a self-assessment sheet referring content, technical execution, and reflective presentation and self-assessment are given also by Dimitrova (2021).

Analyzing Evidence

For example, learning analytics and data-driven approaches allow educators to analyze evidence effectively. These tools provide insights into student performance, helping to identify areas that require improvement.

In relation to Virtual Learning Environments using a set of tools provided by Learning Management Systems (LMS), there is a description of the development of a simulation laboratory within the Moodle environment (Aleksandrova, Nancheva 2007). The authors describe the structure of a simulation laboratory exercise along with clear instructions for students. There is an entrance test and a laboratory protocol that students must complete. Students have access through their accounts, and the system allows the use of various statistics on student activity, so we can see a connection to Area 5 as well. “The system generates detailed statistics and a report on the performance of the specific exercise for the entire group of students. This allows for the analysis of the distribution of responses and provides the opportunity to optimize questions – both the very easy ones and the very difficult ones can be changed or entirely replaced” (Aleksandrova, Nancheva 2007, p. 36). To avoid approaching the experiment as a ‘computer game’ in its remote implementation, the system is configured to record the purposeful activities of the learners, as well as the level of comprehension and understanding of the task based on the answers to test-type questions. It is necessary to fill in the appropriate values and draw conclusions for the specific task.

Feedback and Planning

Digital technologies facilitate instant feedback mechanisms and enable educators to plan and schedule assignments, assessments, and learning activities effectively, ensuring a well-structured learning environment. Another feature of digital platforms is personalized learning by adapting content and providing tailored feedback based on individual progress and performance. A good shared practice backed with two years practice on the LearningApps platform[8] is given by Pantaleeva-Kondova (2018). A variety of possibilities for feedback (Moodle, Web 2.0, CMS, etc.) addressing improvement of physics education is given by Hristova (2010).

In summary, digital technologies have transformed the assessment process by offering more efficient strategies, data-driven evidence analysis, and personalized feedback mechanisms, aligning with the principles of Area 4 in DigCompEdu. Educators now have access to a wide range of assessment strategies, including online quizzes, tests, and assignments that provide immediate feedback and automated grading. Analyzing evidence has become more data-driven, with learning analytics and digital platforms offering insights into student performance. Educators can identify areas that need improvement and tailor their teaching strategies accordingly. Feedback mechanisms are immediate and personalized, with online assessment tools offering real-time feedback to students. Learning management systems help educators plan and schedule learning activities effectively.

Area 5: Empowering Learners

Area 5 of DigCompEdu focuses on empowering learners, emphasizing accessibility and inclusion, differentiation and personalization, and actively engaging learners.

Accessibility and Inclusion

As we can see in many examples given above with the CERN, NASA and other institutions' initiatives, digital technologies have the potential to increase accessibility and inclusion in education by providing alternative formats for content consumption. Learning platforms and resources allow learners to access educational materials from anywhere, reducing geographical barriers and increasing inclusivity. In addition, in 5.3 we can see examples of initiatives held by BAS and the Ministry of Education and Science. Many NGOs can contribute to these guidelines as well, like the "Nikola Tesla Academy", Sofia, which is dedicated to the development and promotion of knowledge, innovation, and education, in honor of the renowned inventor Nikola Tesla (Pancheva 2022; Angelov 2021).

Differentiation and Personalization

Digital technologies offer opportunities for differentiation and personalization, allowing educators to tailor learning experiences to individual students' needs. Adaptive learning platforms adjust content based on student performance, ensuring that they receive appropriate challenges. According to Kostadinova (2023) "managing performance while considering the participants' temperaments when forming a team is an important aspect for creating lasting knowledge and fostering a range of qualities such as teamwork, tolerance, and planning skills during task execution." Combining project-based education with an understanding of temperamental characteristics would lead to the development of competencies fully, which are crucial for the future citizens of a modern European society. An interesting question is how digital technologies can support this.

Online learning resources provide a wealth of educational content, enabling students to explore subjects at their own pace and dive deeper into areas of interest.

Actively Engaging Learners

As we saw, digital technologies may actively engage learners in physics education through interactive simulations and animations. These tools allow students to visualize and experiment with complex concepts, fostering an active learning environment.

Gamified educational platforms motivate learners by turning education into an interactive and fun experience. These platforms encourage active participation and exploration. In extracurricular activities, an educational program of NASA called Sally Ride EarthKAM[9] is used (Djokin 2019). It is world widely available for students and teachers. Students can share their own photos and real-time images from the International Space Station (ISS) and request participation in virtual meetings with the ISS crew. Paunova and Tsvetanov (2010) give another example of an interdisciplinary educational program designed in the form of an interactive Web 2.0-based game.

In out-of-school activities, students are engaged in constructing digital devices, fostering both digital and science literacy. For example, creating a meteorological station using Arduino encourages hands-on learning. An initiative related to involving students in collaboration with monitoring institutions for data collection is the "Climate Box" project, funded under the "Education with Science" program by the Ministry of Education and Science. It is managed by IIKAV – BAS in partnership with the Geological Institute at BAS and three schools, two secondary schools in Sofia and Plovdiv, and the The High School of Natural Sciences and Mathematics in Burgas. In October 2020, all three schools held an outdoor, high-tech practical activity: "Drone Game – Meteorological Conditions and Fine Particulate Matter." This activity demonstrated ground-based and remote measurements using an automatic weather station and a mobile weather station mounted on a drone, equipped with sensors for temperature, humidity, atmospheric pressure, wind speed, and wind direction. Due to the pandemic, the project's lectures were delivered remotely through online platforms such as Shkolo.bg and MS Office Teams 365 (Vatralova, Bachvarova 2021).

Area 6. Facilitating Learners' Digital Competence

Area 6 of DigCompEdu focuses on facilitating learners' digital competence, encompassing information and media literacy, digital communication and collaboration, digital content creation, responsible use, and digital problem solving.

Information and Media Literacy

Digital technologies support information and media literacy by providing access to a vast array of online resources. Students can research and evaluate information, distinguishing between credible and unreliable sources. Online search engines and databases are powerful tools for students to locate relevant information quickly and efficiently. Yet, we think that despite the fact that physics teachers massively use information resources, targeted work on the information and media literacy of students is needed, providing them with guidelines for their independent work.

Digital Communication and Collaboration

The use of digital technologies in education encourages digital communication and collaboration. Many European and global associations are working to connect students' project work in a network, which requires students to communicate and collaborate using digital technologies. We referred to many examples in the previous sections of this article. Another excellent example is the programs of the European Association for Astronomy Education (EAAE). In addition, the educational program GLOBE (Global Learning and Observations to Benefit the Environment) is an international scientific and educational program that enables students and teachers from around the world to participate in data collection and the scientific process, significantly contributing to our understanding of the Earth's system and the global environment. Participants are encouraged to engage in local research covering five primary areas: the atmosphere, biosphere, hydrosphere, soil (pedosphere), and the Earth as a system. Measurements combine with data from automated stations to create a global resource for conducting scientific research. Some measurements serve as the primary basis for NASA's satellite data, such as clouds and soil moisture. The GLOBE data and information system contains over 130 million measurements from more than 10 million students in 113 countries worldwide since its inception in 1995. In early 2016, GLOBE expanded its participation beyond the official school environment to include individual citizens of all ages through the GLOBE Observer mobile application. Both the center in the village of Baikal and observatories in Varna, Stara Zagora, and others are involved in this network, sharing data and ideas for problem solving (Djokin 2019).

Digital Content Creation

Students are actively involved in digital content creation with software tools for text, image, audio, and video editing, presentations and spreadsheets. Another aspect of digital content creation is integration of coding and programming. Such activities foster creative problem-solving and digital content development and may refer to 6.5 below.

Responsible Use

Responsible use of digital technologies is a critical component of education. Based on reports we find it beneficial to broaden work on this topic in future time so that more reports refer explicitly to the responsible use of digital technologies.

Digital Problem Solving

Digital technologies enable students to apply problem-solving skills through interactive learning environments. Simulations and educational games promote critical thinking, experimentation, and problem solving, contributing to digital competence. The integration of dynamic software and online platforms supports digital problem solving. Tools like Moodle offer a flexible environment for students to tackle real-world issues and analyze evidence collaboratively.

Responsible use must be promoted through ethical and cybersecurity education, teaching students how to protect their privacy and behave ethically online. Digital problem-solving skills are fostered through interactive learning environments and platforms that encourage critical thinking and experimentation. In summary, digital technologies play a pivotal role in nurturing learners' digital competence, aligning with the principles of Area 6 in DigCompEdu.

Conclusion

This analysis based on the DigCompEdu framework and reports from the National Conference on Physics Education in Bulgaria in the period 2007 – 2023 provides an overview of the application of digital technologies in physics education and how they contribute to facilitating teachers' and learners' digital competence. It touches upon the readiness of teachers to use technology, evidenced by a substantial number of publications (around 16%) that reference digital technologies, particularly in the context of digital competence. Moreover, this trend remains stable over time, reflecting a tradition among physics teachers to share their experiences in the field of digital technologies.

It also discusses the need for a balance between real and virtual experiments, the benefits of digital technologies for student motivation and comprehension, and the importance of interdisciplinary STEM education. It also highlights the role of STEM centers and the ongoing development of digital resources and tools for physics education. The implementation of digital technologies in physics education is not a singular, monolithic approach but rather a dynamic and evolving landscape that encompasses various teaching methods, resources, and opportunities. The key lies in leveraging these digital tools effectively to enhance the learning experiences of students in physics education.

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NOTES

1. https://upb.phys.uni-sofia.bg/conference/index.html
2. https://nacid.bg/en/
3. https://joint-research-centre.ec.europa.eu/digcompedu/digcompedu-framework_en
4. www.pathway-project.eu
5. https://www.khanacademy.org
6. https://phet.colorado.edu/
7. https://www.wolframalpha.com
8. https://learningapps.org/
9. https://www.earthkam.org/

REFERENCES

ALEKSANDROVA, A.; NANCHEVA, N., 2007. The simulation laboratory exercise as an opportunity for conducting a remote physics experiment. *Proceedings of the XXXV National Conference on Physics Education,* pp. 33 – 36 [in Bulgarian]. ISBN 978-954-580-210-2.

ANGELOV, K., 2021. Some Applications of the 'Arduino' Platform in Teaching Physics: A Heuristic Approach. *Proceedings of the 49th National Conference on Physics Education,* pp. 78 – 83 [in Bulgarian]. ISBN 978-954-91841-6-7.

BOZHANOVA, S., 2009. Implementation of interdisciplinary connections between physics and information technologies in 8th grade. *Proceedings of the XXXVII National Conference on Physics Education,* pp. 205 – 208 [in Bulgarian]. ISBN 978-954-580-261-4.

DIMITROVA, N., 2021. Formative assessment as a component of STEM-oriented technology in the subject *Human and Nature* in the pre-high school stage. *Proceedings of the 49th National Conference on Physics Education,* pp. 90 – 96 [in Bulgarian]. ISBN 978-954-91841-6-7.

DJOKIN, I., 2014. The GOLAB Project and the Inquiry-Based Approach in Education. *Proceedings of the XLII National Conference on Physics Education,* pp. 144 – 147 [in Bulgarian]. ISBN 978-954-580-344-4.

DJOKIN, I., 2016. Municipal Center for Extracurricular Activities as a Venue for Non-formal Education of Science Teachers. *Proceedings of the XLIV National Conference on Physics Education,* pp. 27 – 30 [in Bulgarian]. ISBN 978-954-580-361-1.

DJOKIN, I., 2018. Results of the SPACE AWARENESS Project – (Awareness about Space). *Proceedings of the XLVI National Conference on Physics Education,* pp. 137 – 141 [in Bulgarian]. ISBN 978-954-91841.

DJOKIN, I., 2019. The Integrated Approach in Extracurricular Activities for Natural Sciences. *Proceedings of the XLVII National Conference on Physics Education,* pp. 28 – 38 [in Bulgarian]. ISBN 978-954-91841-5-0.

DRAGANOVA, T.; TSONCHEVA, A., 2019. Mind Maps as a Contemporary Method of Teaching and Assessment in Physics – An Integrated Interpretation between Physics and Geography. *Proceedings of the XLVII National Conference on Physics Education,* pp. 244 – 251 [in Bulgarian]. ISBN 978-954-91841-5-0.

DRAGANOVA-HRISTOVA, R., 2021. Practical STEAM Methods in Physics Education – 7th Grade. *Proceedings of the 49th National Conference on Physics Education,* pp.74 – 77 [in Bulgarian]. ISBN 978-954-91841-6-7.

EPITROPOVA, A.; SOLUNOV, H., 2009. EuSTD-web Project: Professional Development of European Teachers for Science Education in a Web-Based Environment. *Proceedings of the XXXVII National Conference on Physics Education,* pp. 129 – 131 [in Bulgarian]. ISBN 978-954-580-261-4.

EXNER, G.; TOSKOVA, A. & MARUDOVA-ZHIVANOVICH, M., 2014. Challenges in developing courses for digital and distance learning in physics – E-physical experiment. *Proceedings of the XLII National Conference on Physics Education,* pp. 65 – 68 [in Bulgarian]. ISBN 978-954-580-344-4.

FILIPOVA, M., 2023. Contemporary Science and its Motivating Communication in School. *Proceedings of the 51st National Conference on Physics Education,* pp. 123 – 128 [in Bulgarian]. ISBN 978-954-91841-8-1.

GANCHEVA, M., 2018. Mind Maps – An Effective and Engaging Method in Teaching Physics. *Proceedings of the XLVI National Conference on Physics Education,* pp. 189 – 196 [in Bulgarian]. ISBN 978-954-91841.

GEREVA, N.; PISANOVA, E. & RAYKOVA, ZH., 2022. Some ideas for using the Wolfram Alpha platform in studying elements of quantum physics in high school. *Proceedings of the 50th Anniversary National Conference on Physics Education,* pp. 105 – 110 [in Bulgarian]. ISBN 978-954-91841-7-4.

GOSHEVA, M.; RAYKOVSKA, G., 2022. The Integral Approach in Extracurricular Activities. *Proceedings of the 50th Anniversary National Conference on Physics Education,* pp. 82 – 87 [in Bulgarian]. ISBN 978-954-91841-7-4.

HADJIISKA, R., 2020. Open Lessons with Data from the CMS Experiment at CERN. *Proceedings of the 48th National Conference on Physics Education,* pp. 108 – 112 [in Bulgarian]. ISBN 978-954-91841-4-3.

HRISTOVA, B., 2012. Virtual Classrooms and Project-Based Learning in Physics within the Context of Content and Language Integrated Learning (CLIL). *Proceedings of the 40th Anniversary National Conference on Physics Education,* pp. 379 – 382 [in Bulgarian]. ISBN 978-954-580-313-0.

HRISTOVA, B. 2013. Project-Based Learning in Physics and Natural Sciences through Content and Language Integrated Learning (CLIL) and ICT: New Methods Revitalize Science in the Classroom (English & Science Conquer the New Spaces /CLIL Phenomenon Permeates Different Approaches). *Proceedings of the XLI National Conference on Physics Education,* pp. 75 – 78 [in Bulgarian]. ISBN 978-954-580-331-4.

HRISTOVA, B. 2013. Utilizing Research Methods (IBSE) to Enhance Physics and Astronomy Education. *Proceedings of the XLI National Conference on Physics Education,* pp. 148 – 151 [in Bulgarian]. ISBN 978-954-580-331-4.

HRISTOVA, C., 2010. E-learning and Web 2.0 tools as a means of improving educational outcomes and diversifying teaching methods. *Proceedings of the XXXVIII National Conference on Physics Education,* pp. 255 – 259 [in Bulgarian]. ISBN 978-954-580-279-9.

HRISTOVA, C., 2014. Modern Teaching Methods in Natural Sciences within the European School Network Project INGENIUS and Connection between Physics and Astronomy Education in Schools and Industry. *Proceedings of the XLII National Conference on Physics Education,* pp. 181 – 184 [in Bulgarian]. ISBN 978-954-580-344-4.

HRISTOVA, C., 2016. The Role of the European School Network, Project Resources of Scientix, and Educational Policies for Successful Work with Talented and Gifted Children, and Motivating Disinterested Students to Study Natural Sciences and Mathematics. *Proceedings of the XLIV National Conference on Physics Education,* pp. 262 – 265 [in Bulgarian]. ISBN 978-954-580-361-1.

HRISTOVA, C., 2018. Improving Physics Learning Outcomes using Investigative Approaches with Dynamic Software in Moodle Courses: COMPASS Project. *Proceedings of the XLVI National Conference on Physics Education,* pp. 120 – 122 [in Bulgarian]. ISBN 978-954-91841.

ILCHEVA, J., 2018. Opportunities of the MyTestX program for creating and conducting monitoring in physics education. *Proceedings of the XLVI National Conference on Physics Education,* pp. 167 – 170 [in Bulgarian]. ISBN 978-954-91841.

ILIEVA, E.; ILIEVA, Y., 2019. WORLD WIDE DATA DAY 2018 at

Nikolay Katranov High School in Svishtov. *Proceedings of the XLVII National Conference on Physics Education,* pp. 176 – 181 [in Bulgarian]. ISBN 978-954-91841-5-0.

KARABALIEV, M., 2014. Using the Google Apps internet platform for organizing the educational process in schools and universities. *Proceedings of the XLII National Conference on Physics Education,* pp. 73 – 76 [in Bulgarian]. ISBN 978-954-580-344-4.

KISKINOVA, N., 2013. Research Work by Amateur Astronomers with SID Monitor. *Proceedings of the XLI National Conference on Physics Education,* pp. 236– 239 [in Bulgarian]. ISBN 978-954-580-331-4.

KOSTADINOVA, S., 2023. Optimizing project-based approach based on participants' temperaments. *Proceedings of the 51st National Conference on Physics Education,* pp. 73 – 78 [in Bulgarian]. ISBN 978-954-91841-8-1.

KOTSEVA, I., 2016. Investigating the Peer Instruction Method's Impact on Skills in Dealing with Functional Relationships in Physics Lessons for 9th and 10th Grade. *Proceedings of the XLIV National Conference on Physics Education,* pp. 236 – 239 [in Bulgarian]. ISBN 978-954-580-361-1.

KUNIS, F.; GAYDAROVA, M., 2021. Opportunities and Practices in Implementing Teamwork in a STEM Learning Environment. *Proceedings of the 49th National Conference on Physics Education,* pp.134 – 141 [in Bulgarian]. ISBN 978-954-91841-6-7.

KUNIS, F., 2021. Using Mobile Devices in School Experiments for Physics and Astronomy in both Educational and Extracurricular School Activities. *Proceedings of the 49th National Conference on Physics Education,* pp. 60 – 67 [in Bulgarian]. ISBN 978-954-91841-6-7.

KYURKCHIEVA, D; GOLEV, V. & BONEV, T., 2009. SMARTNET - First Steps towards a Robotic Network of Small Telescopes in Bulgaria. *Proceedings of the XXXVII National Conference on Physics Education,* pp. 287 – 293 [in Bulgarian]. ISBN 978-954-580-261-4.

MANOLOVA-IVANOVA, R., 2023. Implementation of an Idea for Integrated Content in the Subjects of Physics, Astronomy, and Economics through Google Sites in the Year of Sustainable Development. *Proceedings of the 51st National Conference on Physics Education,* pp. 79 – 84 [in Bulgarian]. ISBN 978-954-91841-8-1.

MARCHEV, D.; RADEVA, V. & BORISOV, B., 2013. Good Practices in Science Education Based on the Inquiry-Based Learning. *Proceedings of the XLI National Conference on Physics Education,* pp. 127 – 132 [in Bulgarian]. ISBN 978-954-580-331-4.

MAVROVA, M., 2019. Use of Information Technologies in Physics and

Astronomy Education. *Proceedings of the XLVII National Conference on Physics Education,* pp. 218 – 221 [in Bulgarian]. ISBN 978-954-91841-5-0.

MONCHEVA, P., 2018. Interdisciplinary lesson – a strategy for increasing motivation for learning. *Proceedings of the XLVI National Conference on Physics Education,* pp. 130 – 132 [in Bulgarian]. ISBN 978-954-91841.

MYGLOVA, P.; STOEV, A., 2007. Sample Laboratory Work 'Solar Activity': Observational and Communication Opportunities in Teaching Astronomy. *Proceedings of the XXXV National Conference on Physics Education,* pp. 289 – 292 [in Bulgarian]. ISBN 978-954-580-210-2.

NACHEV, V., 2018. Mathematical and Simulation Models in Physics Education. *Proceedings of the XLVI National Conference on Physics Education,* pp. 142 – 144 [in Bulgarian]. ISBN 978-954-91841.

NANCHEVA, N.; DOCHEVA, P., 2007. Superconductivity – Experimentation and Visualization with the Help of Video Clips. *Proceedings of the XXXV National Conference on Physics Education,* pp. 55 – 60 [in Bulgarian]. ISBN 978-954-580-210-2.

NANCHEVA, N.; DOCHEVA, P., 2009. Project MOSEM - Opportunities and Perspectives. *Proceedings of the XXXVII National Conference on Physics Education,* pp. 177 – 180 [in Bulgarian]. ISBN 978-954-580-261-4.

PANCHEVA, V., 2021. Possibilities for Using Arduino in Educational Physics Experiments. *Proceedings of the 49th National Conference on Physics Education,* pp.147 – 152 [in Bulgarian]. ISBN 978-954-91841-6-7.

PANCHEVA, V., 2022. Measurement of the amount of precipitation. *Proceedings of the 50th Anniversary National Conference on Physics Education,* pp. 129 – 132 [in Bulgarian]. ISBN 978-954-91841-7-4.

PANTALEEVA-KONDEVA, A., 2018. Application of the LearningApps platform in the education of the subject "Man and Nature" in primary school. *Proceedings of the XLVI National Conference on Physics Education,* pp. 198 – 199 [in Bulgarian]. ISBN 978-954-91841.

PAUNOVA, E., TSVETANOV, S., 2010. Interdisciplinary educational program presented in the form of an interactive Web 2.0-based game. *Proceedings of the XXXVIII National Conference on Physics Education,* pp. 255 – 259 [in Bulgarian]. ISBN 978-954-580-279-9.

RABADJIISKA, R., 2009. Methodological Recommendations for Creating Physics Animations by Students. *Proceedings of the XXXVII National Conference on Physics Education,* pp. 209 – 212 [in Bulgarian]. ISBN 978-954-580-261-4.

RADEVA, V.; PAVLOVA, N., 2016. The new digital generation requires new models of education. *Proceedings of the XLIV National Conference on Physics Education,* pp. 281 – 284 [in Bulgarian]. ISBN 978-954-580-361-1.

RAYKOVA, ZH. et al., 2009. The Effective Use of Information Computer Technologies in Natural Science Education – European Project 'CAT: The effective use of computer-aided teaching and learning materials in science teaching – a teacher-training course with a European perspective'. *Proceedings of the XXXVII National Conference on Physics Education,* pp. 122 – 124 [in Bulgarian]. ISBN 978-954-580-261-4.

RAYKOVA, ZH.; TRAYANOVA, N. & STOYANOVA, D., 2013. Changing the Didactic Structure of the Physics Lesson for New Knowledge Using Some eForms of Learning. *Proceedings of the XLI National Conference on Physics Education,* pp. 178 – 183 [in Bulgarian]. ISBN 978-954-580-331-4.

RAYKOVA, ZH.; STOYANOVA, D., 2013. The use of Augmented Reality technology with mobile devices in the teaching process of the subject 'Man and Nature' in primary school. *Proceedings of the XLI National Conference on Physics Education,* pp. 184 – 189 [in Bulgarian]. ISBN 978-954-580-331-4.

RAYKOVA, ZH.; STOYANOVA, D. & NIKOLOV, S., 2017. Potential for using Augmented Reality technology to solve experimental tasks in physics. *Proceedings of the 45th National Conference on Physics Education,* pp. 107 – 113 [in Bulgarian]. ISBN 978-954-580-369-3.

RAYKOVA, ZH. et al., 2022. Some Trends in Changing the Technology of Science Education under Distance Learning Conditions in an Electronic Environment (Research on the Activities of Teachers in the Pre-high School Stage). *Proceedings of the 50th Anniversary National Conference on Physics Education,* pp. 43 – 49 [in Bulgarian]. ISBN 978-954-91841-7-4.

STOYANOV, D.; HRISTOVA, Y. & GEORGIEV, H., 2007. Digital Guide for Physics Laboratory Practices for 8th Grade. *Proceedings of the XXXV National Conference on Physics Education,* pp. 205 – 208 [in Bulgarian]. ISBN 978-954-580-210-2.

TAKUCHEV, N., 2007. Virtual Interactive Experiment with Gravitational Lenses. *Proceedings of the XXXV National Conference on Physics Education,* pp. 183 – 186 [in Bulgarian]. ISBN 978-954-580-210-2.

TODOROVA, D., 2009. Creating Mind Maps to Support the Learning Process in Physics and Astronomy Education. *Proceedings of the XXXVII National Conference on Physics Education,* pp. 147 – 150 [in Bulgarian]. ISBN 978-954-580-261-4.

TRAYANOVA, N., 2014. Using Free Web-Based Applications to Enhance Students' Cognitive Opportunities in Physics and Astronomy. *Proceedings of the XLII National Conference on Physics Education,* pp. 177 – 180 [in Bulgarian]. ISBN 978-954-580-344-4.

TRAYANOVA, N., 2020. Alternative Models of Teaching Atomic and Nuclear Physics in High School. *Proceedings of the 48th National Conference on Physics Education,* pp. 133 – 138 [in Bulgarian]. ISBN 978-954-91841-4-3.

TYUTYULKOV, K., 2019. STEM and Physics Education. *Proceedings of the XLVII National Conference on Physics Education,* pp. 86 – 97 [in Bulgarian]. ISBN 978-954-91841-5-0.

VATRALOVA, A.; BACHVAROVA, E., 2021. Science in support of STEM education: The "Climate Box" project – scientists, teachers, and students working together on climate, atmosphere, and water. *Proceedings of the 49th National Conference on Physics Education,* pp.14 – 19 [in Bulgarian]. ISBN 978-954-91841-6-7.

YORDANOV, B., 2018. Digital lessons in physics and astronomy in 10th grade, section "From the atom to the Cosmos". *Proceedings of the XLVI National Conference on Physics Education,* pp. 127 – 129 [in Bulgarian]. ISBN 978-954-91841.

YOVCHEVA, T. et al, 2013. Visualizing Processes for Modifying and Controlling the Adhesive Properties of Polymeric Surfaces. *Proceedings of the XLI National Conference on Physics Education,* pp. 215 – 218 [in Bulgarian]. ISBN 978-954-580-331-4.

Dr. Ivelina Kotseva, Assist. Prof.
ORCID iD: 0000-0003-2932-7069
Dr. Maya Gaydarova, Assoc. Prof.
ID (SCOPUS): 1400 7223 9000
Faculty of Physics
Sofia University
Sofia, Bulgaria
E-mail: iva_georgieva@phys.uni-sofia.bg
E-mail: mayag@phys.uni-sofia.bg