JOURNAL OF APPLIED SCIENCE AND SOCIAL SCIENCE
eISSN 2229-3113 pISSN 2229-3205
Volume 15 Issue 10, October 2025
Impact factor: 2019: 4.679 2020: 5.015 2021: 5.436, 2022: 5.242, 2023: 6.995, 2024 7.75

POSSIBILITIES OF USING MODERN TECHNOLOGIES IN TEACHING PHYSICS IN GENERAL SECONDARY EDUCATION

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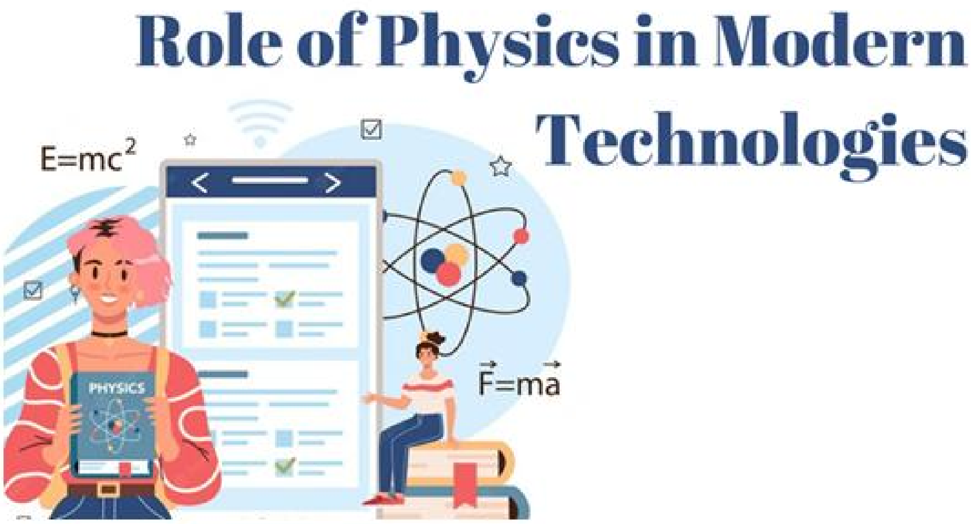
Annotation. This article explores the diverse possibilities of integrating modern technologies into the teaching of physics in general secondary education. It highlights how tools such as interactive simulations, virtual and augmented reality, digital data collection devices, online learning platforms, educational games, and collaborative software can enhance student engagement, understanding, and practical skills. The article also addresses challenges such as access disparities and the need for teacher training. Ultimately, it emphasizes the importance of technology as a means to enrich physics education and better prepare students for a technologically driven future.

Keywords: modern technologies, physics education, secondary education, interactive simulations, virtual reality (VR), augmented reality (AR), digital data collection, online learning platforms, gamification, educational games.

Introduction. Physics, often regarded as a challenging subject, is fundamental to understanding the laws that govern the natural world. In general, secondary education, effective physics instruction is crucial not only for fostering scientific literacy but also for developing analytical thinking and problem-solving skills among students. Modern technologies offer powerful tools to make physics more accessible, engaging, and meaningful. Their integration into teaching can transform traditional classroom practices, bridge the gap between theory and real-world applications, and inspire a new generation of scientists and engineers.



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One of the most impactful innovations in physics education is the use of interactive simulations and virtual laboratories. Modern technologies hold vast potential to enhance the teaching and learning of physics in general secondary education. From simulations and virtual labs to data analysis tools and immersive experiences, these technologies can transform abstract theories into tangible understanding. By embracing these tools, educators can foster deeper engagement, cater to diverse learning styles, and better prepare students for the demands of a technologically advanced world.

Literature analysis. The integration of modern technologies in physics education has been widely studied in recent decades, with numerous researchers emphasizing its potential to improve student engagement, understanding, and practical skills. This literature analysis reviews significant scholarly contributions concerning the use of interactive simulations, virtual and augmented reality, data collection technologies, online learning environments, and gamification in secondary physics education. A significant body of research supports the effectiveness of interactive simulations and virtual labs in enhancing conceptual understanding in physics. Wieman et al. (2008) argue that simulations enable students to visualize phenomena that are otherwise invisible or difficult to demonstrate, thus bridging the gap between abstract theory and concrete understanding. Similarly, Finkelstein et al. (2005) found that students using the PhET simulation suite demonstrated higher engagement and better conceptual grasp compared to traditional methods. Virtual labs, as highlighted by De Jong et al. (2013), provide safe and flexible environments for experimentation, allowing students to manipulate variables without the constraints of physical equipment. The studies also note cost-efficiency and accessibility benefits, especially in resource-limited educational settings (Makransky et al., 2016).

Recent advancements in AR and VR have sparked interest in their application in science education. Radianti et al. (2020) provide a systematic review showing that AR and VR improve spatial reasoning and increase motivation among students. In physics education specifically, Lee et al. (2019) demonstrated that VR environments enable students to interact with 3D models of physical systems, thereby improving comprehension of complex topics like electromagnetism and quantum mechanics.

However, some studies caution that the cost and technological barriers can limit widespread adoption (Cheng & Tsai, 2019). Additionally, teacher preparedness to effectively implement AR/VR remains a concern (Kavanagh et al., 2017).

Digital sensors and mobile devices have revolutionized experimental physics education by enabling precise, real-time data collection. Research by Rutten et al. (2012) shows that integrating digital tools like smartphone accelerometers into physics labs enhances students' ability to connect theoretical concepts with empirical evidence. Moreover, Logger Pro and similar software facilitate immediate data visualization and analysis, fostering scientific inquiry and critical thinking skills (Hofstein & Lunetta, 2004). The literature also highlights the importance of training students in data literacy to maximize these tools' benefits (Wilhelm & Beishuizen, 2003).

The rise of online platforms has introduced new pedagogical models such as flipped classrooms, where students learn content outside of class and engage in active problem-solving during class time. Bergmann and Sams (2012) advocate this model, reporting improved student achievement and engagement in science subjects.

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Platforms like Khan Academy and EdX offer customizable content that supports differentiated learning. However, studies emphasize the need for careful integration with face-to-face instruction to avoid student isolation (O'Flaherty & Phillips, 2015). Gamification, defined as the use of game elements in non-game contexts, has been shown to enhance motivation and persistence in physics learning (Dicheva et al., 2015). Physics-based games such as Kerbal Space Program have been used to teach mechanics and orbital physics through experiential learning, as noted by Arnab et al. (2015). Nonetheless, research warns that gamification should complement, not replace, traditional instruction and must be designed with clear learning objectives to avoid distractions (Hamari et al., 2014).

Despite these promising developments, the literature consistently points to challenges in technology integration. Access disparities, particularly in underfunded schools, remain a significant barrier (Warschauer, 2004). Teacher training is crucial; studies by Tondeur et al. (2012) suggest that without sufficient professional development, technology often remains underutilized or misapplied.

Materials and methods. Teaching tools for physics in general secondary education schools are far from being the most effective and engaging for students. Currently, the existing teaching methods are boring and fail to capture students' interest. Nowadays, students do not want to spend the entire school year just copying the same information at their desks. Physics is usually ranked as the most difficult subject among school sciences. Moreover, many students have low overall knowledge skills and abilities, which leads to several problems for physics teachers. These include how to increase students' interest in the subject, how to maintain their scientific curiosity regardless of the situation, and how to make this curiosity a part of their professional lives.

The main purpose of this article is to introduce innovative technologies related to theoretical and practical lessons into the education process in general secondary schools and to explore methods and approaches for increasing students' interest in physics.

To address this problem, the following means will be used:

- Analyzing existing methods and techniques during practical lessons;
- Analyzing methods used in theoretical research;
- Introducing unique innovative technologies;
- Conducting a comparative analysis of current and innovative methods for practical and theoretical physics lessons in educational institutions.

Currently, the physics course in general secondary education can be divided into two parts:

- Theoretical course;
- Practical course.

The theoretical course includes studying the theory, examining the inherent laws of processes, looking at examples of applying laws in real life, and many other things.

The practical lessons include solving problems based on the studied theory, observing physical processes, and learning to apply theoretical knowledge in practice.

All these parts of teaching physics in secondary schools are almost absorbed without any attention or interest from students. Modern students want to see more real and tangible things rather than just reading and copying all the information from books in almost every lesson.

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Therefore, there is a need today to introduce a completely new innovative idea for teaching physics in general secondary schools — to establish mini-laboratories (virtual laboratories) based on existing classrooms for conducting lessons.
These laboratories include specialized equipment such as:

- Computer devices corresponding to physical processes;
- Devices for conducting various physical experiments;
- Electronic boards.

Students find lessons more interesting when processes and laws are demonstrated on a computer rather than just perceiving information at their desks. Students subconsciously begin to develop a sense of responsibility for their actions. The laboratory environment around students creates an extraordinary, innovative, and professional image, which fosters interest in studying physics.
With such laboratories, by creating models of physical processes, students gain skills to understand and comprehend ongoing processes and develop new project ideas.
The current material-technical base for teaching theoretical and practical physics courses in secondary schools cannot be sufficiently provided by laboratories. Classrooms are almost empty except for desks and wall boards. Conducting lessons under the same conditions in such classrooms does not allow students to fully understand or change laws. New and innovative solutions are needed to learn physics effectively.
A modern, well-equipped laboratory would be the best of all possible innovative solutions to attract students' attention and desire to learn.
This solution fits well in unique and modern conditions for several reasons:

- Modern laboratory lessons create more opportunities for studying the theoretical aspects of physics;
- A modern equipped laboratory classroom can provide more opportunities for learning the practical course of physics;
- Students feel part of the learning process and directly participate in solving assigned tasks;
- Laboratory lessons represent a new innovative project in teaching school physics.

Modern laboratories in the material-technical base of existing physics classrooms in general secondary schools allow students to directly participate in performing physical phenomena and tasks, calculating, experimenting, solving, and observing. None of the existing physics lessons provide such opportunities. Therefore, this idea can be called unique and innovative in solving the issue of teaching physics in lyceums.
In computerized laboratories, you can easily display text, photo, and video materials. Students no longer have to flip through books and get lost among the pages.
Table 1: Modern technologies and their applications in teaching physics in secondary education

Technology	**Description**	**Educational Benefits**	**Challenges**
Interactive Simulations	Computer-based models that simulate physical phenomena	Enhances conceptual understanding, safe experimentation	Requires teacher facilitation; access to computers
Virtual and Augmented Reality	Immersive 3D environments or overlays to visualize concepts	Improves spatial reasoning, student engagement	High cost, infrastructure demands, teacher training

Technology	Description	Educational Benefits	Challenges
Digital Data Collection Tools	Sensors and mobile devices for real-time experiment data	Connects theory to practice, fosters inquiry skills	Needs data literacy training; equipment availability
Online Learning Platforms	Websites and apps offering instructional content and exercises	Enables personalized, flexible learning	Risk of student isolation; requires integration
Gamification and Educational Games	Game-based learning environments for physics concepts	Increases motivation, supports experiential learning	Must align with learning goals; potential distractions
Collaborative Tools	Cloud platforms for communication and group projects	Enhances collaboration, supports peer learning	Dependence on internet access and digital skills

Moreover, educational technologies must align with curriculum standards and pedagogical goals. The TPACK framework (Mishra & Koehler, 2006) is frequently cited as a model guiding effective technology integration by balancing content knowledge, pedagogy, and technological proficiency. The literature unequivocally supports the positive impact of modern technologies on physics education in secondary schools, highlighting improved engagement, conceptual understanding, and practical skills. However, successful implementation depends on addressing challenges related to access, teacher training, and pedagogical alignment. Future research should focus on longitudinal studies assessing technology's impact on learning outcomes and on developing scalable teacher training models.

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