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COMPARATIVE ANALYSIS OF LABORATORY LESSON EFFICIENCY BASED ON TIME CRITERION

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Abstract
This article addresses the issue of increasing the effectiveness of laboratory classes in teaching physics in general education schools. Experimental lessons conducted using traditional equipment and newly developed modern laboratory kits were comparatively analyzed through the time criterion. The research results show that the use of innovative didactic tools provides an opportunity to perform experiments faster, more accurately, and more clearly, increases students' interest in science, and helps them consciously assimilate knowledge. This article substantiates ways to improve the quality of lessons and the effectiveness of the educational process by integrating modern technologies into physics classes.

Keywords: physics education, laboratory lesson, modern laboratory kit, traditional equipment, time efficiency, didactic tool, learning activity, innovative technologies, experimental analysis, student engagement

Introduction

In general education schools, laboratory and demonstrative experiments are considered one of the main types of learning activities in teaching physics. Through them, theoretical knowledge is reinforced by real experiments, and students develop skills to understand physical phenomena and relate them to real-life examples. Particularly, in explaining topics in the optics section, the importance of laboratory work is immense. Observing light phenomena directly and understanding them through experimentation is significantly more effective than mere theoretical explanation.

The primary goal of laboratory or demonstrative experiments is to deliver physical processes to students in a clear, concise, and understandable manner. With the help

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of experiments, students do not remain passive listeners but become active participants, observers, and analysts in the lesson. Therefore, laboratory lessons play an essential role as a didactic and pedagogical tool in teaching physics.

Scientific-pedagogical observations show that although traditional laboratory equipment and newly developed modern laboratory kits serve the same purpose for students, modern tools have advantages in terms of interactivity, visibility, and usability. Especially, mobile laboratory sets or computer-integrated measuring devices create significant opportunities to organize the lesson in a fast, engaging, and effective way.

One of the most crucial criteria in this regard is the time efficiency of performing experiments. Since the duration of a lesson is limited, completing laboratory work in a short time with high quality is of didactic importance. Saving time allows students to engage more in Q&A, analysis, and generalization stages. Conversely, complexities in setting up equipment, technical difficulties, and time wastage can reduce the effectiveness of the lesson.

Therefore, the main criterion for comparing laboratory classes based on didactic materials was chosen to be the time required to perform them. To assess the effectiveness of the developed modern laboratory kits, several laboratory works were conducted separately using both traditional and innovative equipment. The time spent by students to complete the experiments in both methods was recorded. This enabled a thorough analysis of the impact of modern technologies on practical lessons, particularly in terms of time efficiency.

Table 1. Comparative Analysis of Laboratory Efficiency Based on Time.

Grade	Lesson Title	Time spent performing the lab work (minutes)	
		Traditional equipment	Lab Kit Equipment
7	Practical lesson: Reflection of light from a flat mirror	18	10
9	Lab: Determining the refractive index of glass	21	13
	Demonstrative: Image formation using a thin lens	15	11
	Lab: Determining the optical power of lenses	25	15
11	Demonstrative: Light interference and diffraction	16	11
	Lab: Determining the wavelength of light using diffraction grating	23	19
	Demonstrative: Light dispersion. Spectral analysis	17	14
	Demonstrative: Polarization of light	12	9
	Lab: Relationship between illumination and light intensity	18	12

The analysis was based on the laboratory works listed in Table 1, focusing on experiments from the optics section of the 7th, 9th, and 11th-grade physics curriculum. For example:

- In grade 7: Reflection of light from a flat mirror;
- In grade 9: Determining the optical power of a lens, measuring the refractive index of glass, and forming images using thin lenses;
- In grade 11: More complex experiments such as interference, diffraction, polarization, dispersion, and measuring illumination were studied.

Each of these experiments was conducted using two different methods – traditional equipment and modern laboratory kits. In each case, the time spent by students, accuracy of the experiment, ease of observation, opportunities for analysis, and student engagement were assessed.

Results of the analysis revealed the following:

- The time required to conduct experiments was significantly reduced when using modern lab kits. This not only saved time during the experiment but also provided additional opportunities for discussing the results.
- Students showed higher motivation when working with modern tools, as the new technologies captured their attention and allowed them to operate the equipment independently.
- Traditional tools presented technical challenges, unclear visuals, and difficulties in classroom observation. In contrast, modern tools allowed multiple students to observe simultaneously.
- The teacher's workload was reduced as students could operate the equipment independently, allowing the teacher to focus more on pedagogical guidance.
- Students' lab notebooks were found to contain more meaningful notes, calculations, and graphs, indicating increased interest in the subject.

Thus, the overall conclusion drawn from the analysis is that experiments conducted using modern laboratory kits not only save time but also contribute to better understanding, active participation, and independent thinking among students. Simplifying the experimental process shifts students' attention to understanding the physical phenomena, which in turn leads to higher achievement.

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Conclusion

Enhancing physics lessons with modern laboratory tools is not just a technical update but a way to elevate the quality of the educational process to a new level. Therefore, in organizing laboratory classes in general education schools, relying solely on existing equipment is not sufficient. It is crucial to incorporate interactive and mobile laboratory tools.

In the future, integrating STEAM approaches, project-based learning, virtual laboratories, and digital simulations into physics classes using such tools can further improve the quality indicators of the lessons.

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