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Electronic textbooks and their impact on learning in Ukrainian schools

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ABSTRACT

The use of digital materials is a significant part of modern education. The article aims to analyze the impact of using electronic textbooks on students' academic achievements, motivation, and learning levels in Ukrainian schools. The realization of the proposed goal involved using a scientific survey and questionnaire method from two groups of students: experimental (n=125) and control (n=125). The experiment took place from September to December 2024. The study involves 7th-grade students. The results show that electronic textbooks for students demonstrated better learning outcomes than students in the control group. It is indicated that modern e-textbooks hosted on modern learning platforms have simple navigation tools and provide the ability to view structural elements, highlight text, and control knowledge. The study also points to the positive effects of using electronic textbooks. The conclusions state that well-designed and well-written electronic textbooks influence students' willingness to use them.

Keywords: Textbooks, Digitalisation, Learning, Surveys, Motivation.

1. Introduction

The active use of modern technologies significantly impacts the transformation of the educational process. Today, more and more educational institutions are introducing digital tools into the learning and teaching process. In modern schools, one of the key changes is the proliferation of electronic textbooks, which allow for interactive material, multimedia content, and personalized learning. The current scientific literature indicates that in Ukraine, this process is part of a broader strategy of digitalization of education, which is being implemented at all levels of the Ukrainian educational system. However, the problem of the effectiveness of using e-textbooks and comparing them with traditional ones requires more scientific attention [1]. Accordingly, the issue of the effectiveness of e-learning materials compared to traditional ones is still a subject of debate. Despite the identified advantages of e-textbooks, such as speed of knowledge acquisition, convenient access, multimedia, and interactivity [2], it is essential to determine their impact on student outcomes. The Ukrainian educational environment currently lacks a sufficient empirical basis for unambiguous conclusions about how effective e-textbooks are in improving students' performance, motivation, and learning speed. This study will address this research problem and allow for comparing the effectiveness of traditional learning tools with e-learning tools.

In addition, the main focus of the study will be on analyzing the role of electronic textbooks in the educational process in secondary schools in Ukraine. The focus is comparing the knowledge and performance levels of those who use electronic and printed textbooks. The study will also provide a detailed assessment of changes in student's attitudes toward the learning process depending on the textbook type. At the same time, the focus will also be on determining the impact of e-textbooks on the process of understanding and memorizing information.

Thus, this paper aims to analyze the impact of using e-textbooks on students' academic achievement, motivation, and learning in Ukrainian schools. The main research questions are as follows:

1. Have electronic textbooks improved learning outcomes?
2. Is there a difference in the speed and quality of learning between students using e-textbooks and printed textbooks?
3. Does the level of motivation (interest) in learning change when using electronic textbooks?

The study also formulated several hypotheses that will require confirmation or refutation.

H_0 (null hypothesis). The use of electronic textbooks does not affect students' learning outcomes.

H_1 (alternative hypothesis). Students who use electronic textbooks demonstrate higher learning outcomes.

2. Literature review

The proposed literature review aims to determine the state of development of using electronic textbooks in modern education, which is an essential component of understanding the transformations of modern school education in general. For a long time, school textbooks were rather conservatively affected by digitalization, which was only an auxiliary tool in the organization of the educational process. At the same time, the COVID-19 pandemic has demonstrated the high efficiency of digital technologies in education, which has radically changed the attitude towards e-textbooks in education. The current process of digitalization of education has a significant impact on the organization of learning. First, researchers note the importance of using digital platforms and online services that allow for a new way of organizing school classes. This allows for integrating the necessary material with accessible and engaging forms of teaching, which significantly motivates students to learn. At the same time, digital platforms are being integrated with textbooks in a necessary way, which, according to scientists, will be an important vector for the development of education in the future [3]. Today, gadgets are available to students and are actively used for entertainment, but the pedagogical potential of these tools allows them to interact with textbook materials and significantly expand them. This deepens the learning process, which is difficult to achieve by other methods except by using special software [4]. The relevance of e-textbooks confirms the importance of combining the achievements of digitalization and traditional learning.

Researchers have also evaluated the use of digital materials from teachers' perspective. It has been demonstrated that this approach is actively used in European countries, where the capabilities of e-textbooks are included in school education and are widely used at all levels [5]. In addition, this approach is essential not only from the point of view of learning in general but is productive for both humanities and technical disciplines, which opens up broad prospects for the further development of education in Ukraine [6]. Researchers also emphasize that the use of digital textbooks is in line with Ukraine's European integration, as this process will cover not only political or economic issues but also a wide range of social issues that will require regulation both by the administrative and managerial apparatus and by teachers who are directly involved in the organization of education [7]. Similarly, researchers have drawn attention to negative teacher experiences that have also become part of the organization of the learning process, as negative experiences can also be a source of valuable statistical or methodological information [8]. Such research findings are helpful in terms of generalizations and identification of problems on the way to further integration of digital textbooks into the educational process.

A separate subject for discussion was the issue of reforming Ukrainian school education, which was associated with the introduction of the New Ukrainian School and the corresponding changes in the system of educational components. Scholars considered specific difficulties and challenges on the way to transformation, which is a highly complex process that has been particularly negatively affected by the deployment of full-scale Russian aggression [9].

Using digital textbooks has become an important topic of discussion within the scientific community. Researchers have highlighted specific aspects concerning the regulation of digital textbooks in conjunction with traditional teaching and learning methods [10]. The degree to which textbooks incorporating a substantial digital component can be deemed digital has also become a topic of debate. [11], [12]. Researchers have drawn attention to the use of digital tools in teaching specific disciplines, including history and English [13], [14]. After all, the Ukrainian experience is significant in this regard. Traditional paper textbooks are declining as modern students prefer other learning methods. Modernizing the learning process using e-textbooks can increase its effectiveness. Starting in 2024, all textbooks purchased by the state in Ukraine must have electronic

applications. The main challenge is to create high-quality electronic content and an effective methodology for its implementation [15].

At the same time, along with the practice of European countries, an essential factor is the study of tools used in US schools, as some innovations in American education will require thorough attention in the future [16]. In addition, the authors note the peculiarities of using traditional textbooks, which do not lose their meaning in modern conditions but are effectively combined with existing digital materials and allow diversification of the learning process [17]. Some comparisons have been made with popular distance learning models, which do not deny the use of traditional textbooks but also emphasise the importance of synthesising older practices with modern digital technologies [18]. This material opens opportunities for further research with an emphasis on identifying potential vectors for developing electronic textbooks and determining their place in the modern educational process.

E-textbooks ensure the introduction of STEM technologies into the educational process, which helps students develop soft skills, particularly virtual and augmented reality, mobile and interactive learning, and virtual laboratories [19]. Researchers have analyzed various aspects of the use and role of electronic textbooks in modern education [20], [21]. However, further consideration will be required to address the issues related to studying the role of such learning materials in Ukrainian education. This issue lacks an empirical basis and specific calculations that would allow for broader generalizations about the further use of digital textbooks. Conducting a study based on specific survey statistics would allow us to further consider the difficulties of using digital textbooks, formulate specific recommendations for improving their use, or make amendments to the existing methodological system of their use.

3. Research method

3.1. Research design

The type of this study is quantitative, and it involved experimenting with 7th-grade students at secondary schools in Ukraine. Data from two groups of students, experimental and control, is planned to be processed. The experiment took place from September to December 2024. The authors chose this relatively long period because it was necessary to accurately and qualitatively process the students' results.

3.2. Sample and participants

The study used purposive sampling, including participants using explicit inclusion and exclusion criteria. Information about the experiment was distributed using corporate emails of secondary educational institutions in Ukraine and personal contacts. The study involved 7th-grade students from five schools. The choice of the indicated age level is because secondary school students already have some basic skills in working with electronic devices but are still not fully autonomous in learning. Accordingly, such parameters will allow us to assess the impact of electronic textbooks on their motivation and results. Thus, the main criteria for including participants are as follows:

1. Students in 7th grade of general education schools in Ukraine
2. Students must agree to participate in the study (with parental consent)
3. All participants must have technical skills
4. All participants must have the technical capabilities to use electronic textbooks at school, such as tablets, laptops, or computer access.
5. Students must study according to a single curriculum in schools. This is done to minimize differences in teaching subjects.
6. According to the conditions of the study, participants must be prepared to take tests, fill out questionnaires, or take an active part in the educational process.

At the same time, the exclusion criteria were related to a different age range and the unwillingness to take tests or fill out questionnaires. Accordingly, the exclusion criteria were as follows:

1. Students who studied in other classes were subject to exclusion
2. Students who had limited access to digital devices
3. Students who could not regularly use electronic textbooks.
4. Students with special educational needs that require individual approaches to learning.

5. Students studying in different curricula
6. Students whose parents did not provide informed consent for data processing and their children's participation in the study.

Accordingly, 250 students in-10 classes from 5 schools were involved in the study using the following inclusion and exclusion criteria.

3.3. Instruments and procedure

The study lasted one academic semester. In total, the study took place from September to December 2024. Students are divided into two groups:

Experimental group (125 students). This group used electronic textbooks and additional electronic materials exclusively throughout the semester.

Control group (125 students). This group used exclusively traditional printed textbooks.

The study will include an analysis of electronic textbooks in subjects such as math and physics. The authors selected these subjects because these disciplines have different specifics when presenting the material and require students to have critical and analytical thinking and memorization of facts.

The primary tool for the study was testing after the experiment, that is, after the students had studied for one semester. The authors developed the tests using model curricula, which are currently approved by the Ministry of Education and Science of Ukraine and are used in the 7th grade. The tests contained different types of tasks:

1. Multiple choice – to determine knowledge between facts
2. Gap filling – to understand terms and main events
3. Explanation of answers – to assess the general state of ideas and knowledge of students

The testing covered the main sections studied in mathematics (algebra and geometry) and physics (basics of metrology, mechanical movement, and forces). The testing had a precise time for completion – 30-40 minutes. This was done to avoid overloading students and make the process more familiar to typical educational control for children. During testing, it was forbidden to use external sources of information: exercise books, textbooks, Internet resources, etc.).

After testing, the results of each student were collected: the overall grades, the total number of correct answers, and the completion time were determined.

Another tool used in the study is student questionnaires. This was done to determine their level of motivation and satisfaction with the learning process. The questionnaire was designed to collect detailed information about students' attitudes toward learning. They could also reveal their experience of using electronic textbooks during their studies. The questions consisted of both open and closed questions. Some questions involved the use of a Likert scale (score from 1 to 5). Table 1 presents the main questions from the questionnaire.

Table 1. The main questions in the questionnaire

Section	Question
Age Determination	1. Enter your age
Group	2. Indicate your group: A) Used electronic textbooks B) Used printed textbooks
For those who used electronic textbooks	3. How long have you used electronic textbooks? A) Less than an hour B) 1-3 hours C) 3-5 hours D) More than 5 hours 4. Do you like learning with electronic materials? (Rate from 1 to 5) 5. Is it easier to learn with electronic textbooks than printed ones?

Section	Question
Attitude toward electronic textbooks	6. What advantages do you see in using electronic textbooks? A) Quick access to information B) Interesting presentation of the material C) Ease of use D) Many integrative elements E) The ability to work with the material outside the classroom
Level of motivation	7. Are you interested in studying in the 7th grade and studying subjects such as mathematics and physics? (score from 1 to 5) 8. Have you experienced an improvement in your academic performance this semester? (score from 1 to 5)

3.4. Data analysis

After collecting data from each student's testing, grades, number of correct answers, and execution time were processed using Microsoft Excel software. This software was chosen because it has sufficient tools for data processing: analysis of answers, average values, etc. After that, the average grades were compared between the experimental and control groups. The study also used statistical analysis to identify differences between the data in the experimental and control groups. Thus, the collected data were processed using the statistical analysis method in Microsoft Excel. In particular, the t-test method was used to compare the average performance values between the selected groups. The paper also carried out a descriptive analysis of the student's answers. Microsoft Excel capabilities were used to visualize the materials, and several graphs and charts were presented. The article also compared the obtained data with the results of other scientists.

4. Results and discussion

Most students understand the basics of metrology and research methods. They can apply them to explain the mechanical motion of bodies and describe the interaction of bodies and the nature of forces. However, 7th-grade students had problems with matching tasks. In the control group, 50 students out of 125 passed the test with 10, 11, and 12 points, 40% of success rate. At the same time, 12 students in the experimental group received successful scores (10%). Students in the experimental group spent an average of 35 minutes on the physics test. Students in the control group spent an average of 40 minutes on the physics test. Table 2 shows the history of test results.

Table 2. Key indicators of physics testing

Group	Number of students	Successful answers	successful outcome (%)	Average time to complete a task
Experimental	125	60	48	35
Control	125	50	40	40

Mathematics tests proved to be more difficult for both groups. While most students coped with the algebra tasks, they had difficulties with the geometry tasks. 40 people in the control group passed with 12, 11, and 10 points (32%). At the same time, in the experimental group, 60 students passed with high marks (48%). The average time to complete the task ranged from 25 minutes (Table 3).

Table 3. Key indicators of maths testing

Group	Number of students	Successful answers	Successful outcome (%)	Average time to complete a task
Experimental	125	60	48	25
Control	125	40	32	36

To compare the two groups, t-tests were conducted on two main criteria: time spent on tasks and the level of success in physics and mathematics. This made it possible to identify statistically significant differences between the groups regarding the use of traditional and electronic textbooks. In the experimental group, children completed physics tasks faster than the control group. The difference in task completion time between the groups was statistically significant ($t = 2.14$, $p = 0.036$). This shows that students who used electronic textbooks completed tasks faster. This demonstrates the effectiveness of using digital resources for learning. The difference in average task completion time was even more pronounced in mathematics. Students in the experimental group spent an average of 25 minutes completing tasks, while the control group spent 36 minutes. The difference was also statistically significant ($t = 3.50$, $p = 0.002$). Again, this showed that the students who worked with the e-textbooks could complete the tasks faster. Table 4 shows the main results of the t-test for the time spent on tasks.

Table 4. Results of the t-test for task completion time and performance analysis

School subject	T-Statistic	P-value	Conclusion
		Execution time	
Physics	2.14.	0.036	Noticeable individual differences in task completion times
Mathematics	3.50.	0.002	Noticeable significant differences in task completion times
		Success	
Physics	1.87.	0.070	The difference between the groups is not statistically significant
Mathematics	2.25.	0.030	There are some differences in the success of completing the tasks

As seen in Table 3, the number of students who successfully completed the task (received a score of 10, 11, 12 points) was determined to determine the level of success. For this purpose, a t-test was also conducted to compare the performance between the groups. In the experimental group, 60 pupils (48%) completed the physics task, while 40 pupils (40%) did so in the control group. Although students in the experimental group performed slightly better, the difference between the groups was not statistically significant ($t = 1.87$, $p = 0.070$). This shows that students who used e-textbooks performed slightly better, but the difference is not statistically significant and may be influenced by other factors. The difference in performance in mathematics tasks was more pronounced ($t = 2.25$, $p = 0.030$). These findings show that electronic resources can improve understanding in the digital age. The results also confirm the alternative hypothesis H_1, which is that electronic textbooks significantly improve learning outcomes. At the same time, hypothesis H_0 can be rejected, as the impact on learning outcomes is evident.

According to the survey, most students spent between 3 and 4 hours per week studying with e-textbooks (49%). Another 34% spent 3 to 5 hours a week; more than 5 hours - 12% of respondents. Figure 1 shows the primary data on the frequency of using electronic resources per week.

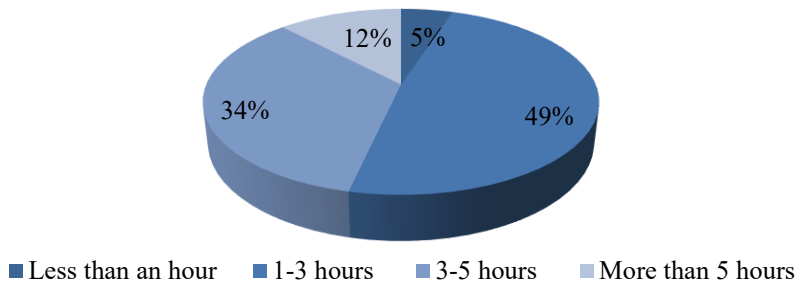

Figure 1. Data on the frequency of use of electronic resources per week

In general, 36% of respondents rated the work with an electronic textbook at 4 points on the Likert scale (36%). This shows that modern e-textbooks are interactive and have various multimedia applications, including immersive technologies for visualizing educational information and elements of game technologies. 28% rated

e-textbooks at three on the Likert scale. This also shows that modern textbooks should be more child friendly. Thus, these data show that textbook authors should develop e-learning products in the future. At the same time, 56% of surveyed students rated the process of using e-textbooks as convenient (scores of 4 and 5). At the same time, another 28% indicated that they were neutral about them. Another 28 percent believed they were not convenient compared to traditional printed textbooks. These students had some difficulties with e-textbooks. However, the survey showed that most students consider e-textbooks more convenient for learning. However, some students do not see a significant difference and have some difficulties in learning. Figure 2 shows the main ratings of students on the Likert scale.

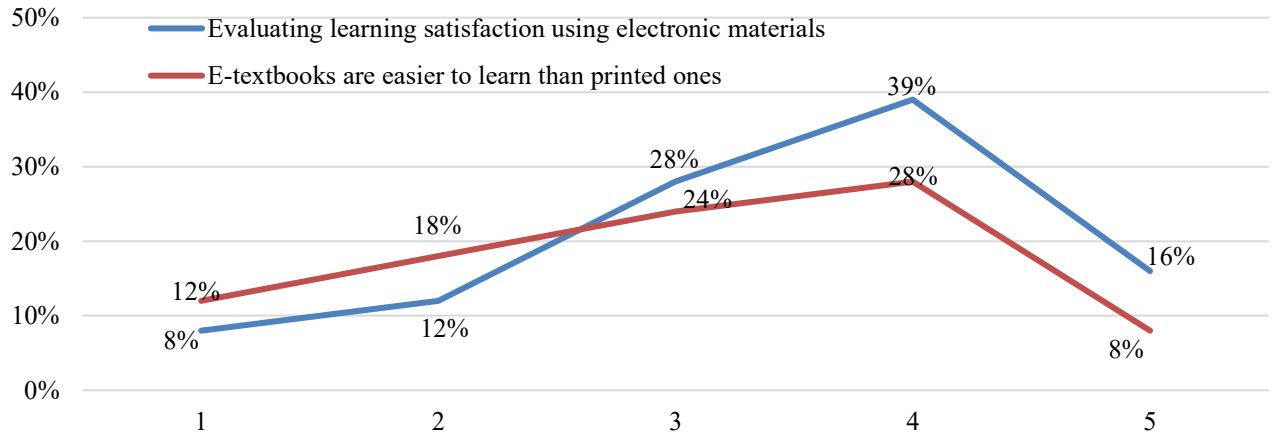

Figure 2. Convenience in using electronic textbooks

Acknowledging the main advantages of e-textbooks, 24% of respondents mentioned quick access to information. In addition, 28% of the respondents indicated that e-textbooks had an interesting presentation of the material and many interactive elements. This made their learning process more interesting and engaging. 12% acknowledged the convenience of using e-learning resources. At the same time, another 20% indicated that they could work with the material outside the classroom. The latter figure shows that today's students know the main advantages of current e-textbooks. Thus, an essential advantage of an e-textbook compared to a printed textbook is the possibility of interactive interaction between the user and the textbook's components. The interactivity of an e-textbook is the presentation of information in a form that facilitates a dialogue between students and the computer. In the experimental group, most students rated their interest in learning at 1 point and 5 points (40% and 12%, respectively). This shows a positive result from the use of e-learning materials. At the same time, the control group also has a predominance of 1 point and 5 points (52% in total). This indicates the effectiveness of the textbooks in mathematics and physics in grade 7. Figure 3 shows the level of interest in learning in grade 7 for the control and experimental groups.

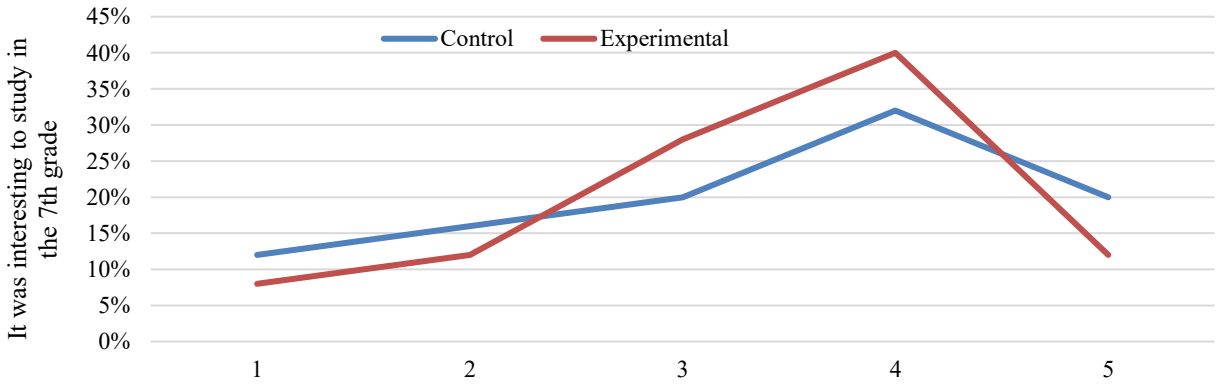

Figure 3. Level of interest in learning

At the same time, in the experimental group, 48% of students improved their performance (points 10 and 11). This shows the positive effect of electronic educational materials. At the same time, in the control group, fewer students (32%) gave high points (10 and 11). On the other hand, low points – 1 and 2 – account for 40%. This shows a less pronounced sense of improvement.

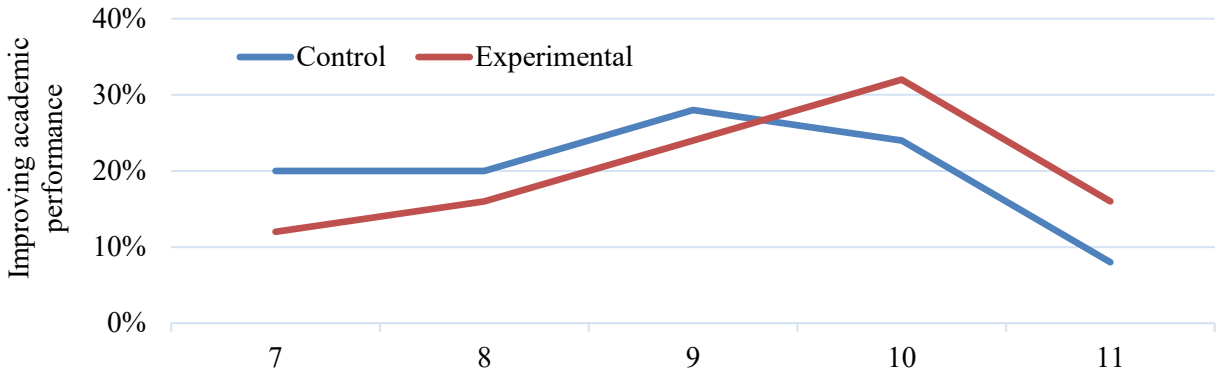

Figure 4. Improvement of results

Thus, the experimental group showed greater interest in learning (more points 10 and 11). Overall, this shows a positive effect of using e-textbooks. In addition, students in the experimental group felt that their academic performance improved more, as most of their points were higher (9 and 8). Students in the control group also experienced some improvements in their knowledge, but their results were less pronounced.

The first research question was whether e-textbooks improve student performance compared to traditional textbooks. It was found that students who used e-textbooks demonstrated better learning outcomes than students in the control group. In addition, it was found that students from the experimental group showed a higher percentage of successful answers (48% in physics, 48% in mathematics) compared to the control group (40% in physics, 32% in mathematics). Modern scholars also confirm these results, as they recognize that modern electronic materials for students are more interesting and motivate students to acquire knowledge [22], [23]. Other authors have also proved the importance of using digital technologies to provide an effective learning environment and recognized that modern digital tools make it possible to make learning more interactive and enriched with digital innovations [24], [25]. In general, this supports the hypothesis h_1 (alternative) that students who use e-textbooks demonstrate higher learning outcomes. At the same time, studies by other authors have shown that students read electronic texts much faster but retain information from printed materials better [26], [27].

The results show a difference in the quality of learning between students who use electronic textbooks and those who use printed ones. It was found that children in the experimental group completed physics tasks faster (35 minutes) compared to the control group (40 minutes). The difference in task completion time between the groups was statistically significant ($t = 2.14$, $p = 0.036$). At the same time, the difference was even more pronounced in the mathematics test. Students from the experimental group spent an average of 25 minutes completing the tasks, while the control group spent 36 minutes. The difference was also statistically significant ($t = 3.50$, $p = 0.002$). In addition, other authors have recognised the importance of the requirements for creating modern electronic learning materials [28], [29], [30]. To be effective, they must have various intrinsic contents. As for the requirements for the interface and design of e-textbooks, e-publications should have a coherent and intuitive interface, and the general background of the page should not distract from the text and images [31]. Thus, it ensures the concentration of attention on studying the educational material and performing various tasks. Studies have also recognised that modern e-textbooks hosted on modern learning platforms have simple navigation tools, provide the ability to view its structural elements, highlight text, and control knowledge [32], [33], [34] In addition, they provide essential information about the topic opened on the screen and contain instructions for completing tasks [35], [36].

The third research objective was to find out whether e-textbooks affect changes in motivation or interest in learning. The study found that the experimental group showed greater interest and motivation to learn (most students chose 4 and 5 score). This demonstrated the positive effect of using electronic textbooks. In addition, students in the experimental group recognized that their performance and results had improved. However, students in the control group also demonstrated a high level of interest in learning and showed some improvements in their knowledge, but their results were not as pronounced. In general, well-designed, well-written electronic textbooks influence students' willingness to use them. E-textbooks with interactive tasks and multimedia support are more engaging for students. This also correlates with the results of other researchers [37], [38], [39]. The research indicates that using the interactivity principle allows students to engage in the topic, involves them in active work, directs them to master the subject knowledge independently, and provides

the necessary information on request, which is especially important in the modern digital learning space. The study identifies the main advantages of using an electronic textbook, including the speed of obtaining information, convenience, interactivity, etc. However, other authors have drawn attention to other advantages, such as providing feedback to the student [40], [41]. Such feedback is provided due to the interactive nature of the student's interaction with the computer textbook environment and the availability of an automatic knowledge diagnostic system [42], [43], [44]. Thus, for the student, this affects the formation of the basic conditions for effective self-learning and self-control [45], [46]. For this reason, it affects the increase of their cognitive activity and motivation [47], [48]. Therefore, the study rejected the null hypothesis that e-textbooks do not affect students' learning outcomes but proved their importance in modern digital learning.

However, this study has certain limitations. We can point to the low number of respondents (250 people). This affected the results. Future studies are planned to involve a more significant number of respondents. In addition, the data obtained are limited by the regional factor (Ukraine). Therefore, these data are only based on students in Ukraine. This aspect should be considered when interpreting the data. These limitations open new areas for research. A broader experimental study involving students from Ukraine and other EU countries is planned to be conducted, allowing us to recognize the role of e-textbooks in modern educational institutions more accurately.

5. Conclusions

Based on the survey, the authors found that students who used electronic textbooks demonstrated better academic results than students from the control group. Important indicators were the increase in the percentage of successful answers compared to the control group in physics and mathematics. The experiment showed that students who used e-textbooks showed better results, although, in physics, the difference between the experimental and control groups was statistically insignificant. In mathematics, the effect was more pronounced. This confirms the alternative hypothesis about the positive impact of e-resources on learning outcomes and rejects the null hypothesis. It is important to note that physical tasks may require knowledge and experimental thinking skills, which are more challenging to develop with e-textbooks.

It is indicated that modern E-textbooks, placed on modern educational platforms, have easy navigation tools and provide the ability to view structural elements, highlight text, and control knowledge. In addition, they provide essential information about the topic open on the screen and contain instructions for completing tasks.

The study also indicated a positive effect of using electronic textbooks. Students from the experimental group admitted that their performance and results had improved. However, students from the control group also demonstrated a high level of interest in learning and showed some improvements in knowledge. However, their results were not so pronounced. In general, well-thought-out and well-written electronic textbooks affect the desire of students to use them. Electronic textbooks with interactive tasks and multimedia support are more interesting for students.

The introduction of a mandatory electronic supplement to a printed textbook starting in the 2024-2025 academic year will make it possible to use the positive aspects of both paper and electronic textbooks and improve the quality of the educational process.

In the context of the implementation of the Concept for the Development of Science and Mathematics Education (STEM Education), electronic textbooks provide didactic and methodological support for the use of immersive technologies for visualizing educational information, virtual laboratories, interactive and mobile learning, and contain additional cognitive and career guidance material that a paper textbook cannot contain due to the limited number of pages.

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