Electronic Physical Education Textbook: Effective or Not?

Experimental Study

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Svetlana Kubiyeva (✉), Aiymgul Akhmetova, Klara Islamova
Aktobe Regional State University named after K. Zhubanov, Aktobe, Kazakhstan
Kubieva_S @mail.ru

Nurolla Mambetov, Alpysbay Aralbayev
Atyrau State University named after Kh. Dosmukhambetov, Atyrau, Kazakhstan

Gulnar Sholpankulova
Eurasian National University named after L.N. Gumilyov, Nur-Sultan, Kazakhstan

Abstract—It is very important for a modern specialist to be aware of information technologies and effectively apply them in their professional activities. Thus, the use of electronic learning tools contributes to the motivation of students and allows them to more deeply master the learning material through video and audio files compared to a paper textbook. The purpose of the study is to evaluate the effectiveness of the introduction of the experimental electronic textbook in physical education classes. The proposed textbook consists of 7 modules. The goal, objectives, as well as the tasks for their implementation and test tasks to consolidate the material learned, have been developed for each module. During January-May 2019, at Aktobe Regional State University named after K. Zhubanov, there was a pedagogical experiment to introduce an electronic textbook in physical education. The experiment involved 28 young men. The results showed that the introduction of an electronic textbook in the experimental group has a more positive effect on physical fitness compared to the control group.

Keywords—Efficiency; electronic textbook; information technologies; physical education.

1 Introduction

Students and physical education teachers have been asked to effectively apply information technologies in the classroom [1-4]. On the one hand, electronic textbooks are available in educational institutions and on the Internet. However, there are questions related to the algorithm for using information technologies; the sequence of their implementation; the relationship that they have with the course material; the criteria for evaluating the effectiveness of the IT introduction.

Domestic and foreign scientists highlighted the following aspects of the problem under study.

***The use of information and communication technologies in teaching and training*.** The results achieved by the experts are listed below:

a) The ways physical education teachers and trainers can use information technologies to accumulate and store relevant information in order to use it when solving educational and scientific problems have been proposed [5]
b) The recommendations for training basketball students and assessing the digestion of the material provided have been developed; the practice of filming classes and competitions has been introduced [6,7]
c) A program to teach karate techniques, to assess skill mastery, and to carry out mathematical data processing has been introduced [8]; d) a methodology to perform and record a technique and its individual elements in order to compare the performed parameters of the technique with its standard indicators has also been developed [9].

***Information technologies in the training of future specialists*:** Specialists offer the following recommendations:

a) The effectiveness of the IT implementation is mainly manifested through knowledge and mental skills; the presence of interest; improved physical performance; activation of internal values; intensive participation in different areas of physical activity [10]
b) Computer technologies should be implemented in such aspects as: assessment of the knowledge gained through adequate training; understanding of the techniques and tactics of the elements studied; correct spelling of terms with an adequate display of the movement technique; content of the biomechanical structure of movements [11,12]
c) The problems associated with the implementation of computer technologies include the fact that there are modern technical capabilities for using such technologies, but there is no proper methodological support for their practical implementation in physical education and sports [13]
d) Successful training of future physical education teachers is determined by the level of expertise in the theory of computer technologies; practical experience of their application; interest in certain methods; sensitivity to working on a computer [14].

***The use of computer technologies to implement various exercises and games*:** The researchers give the following recommendations:

a) For people with heart diseases, a program for the brachial muscles has been implemented through a minicomputer; it allows determining the duration (in minutes) of the number of movements performed and their orientation [15]
b) Based on the analysis of the use of computer technologies, the authors recommend the prospects for their implementation to improve the motor activity of individuals taking into account their physical fitness and psychological state [16,17].

***The use of computer technologies in the development of a virtual representation of the motor activity types*:** The authors developed:

a) Virtual computer programs that can simulate various types of locomotion [18]. This is implemented through various types of interaction (by commands, body actions, coordination of signals with hands) [19]
b) Computer methodologies used for creating the identity of preparedness of the physical condition of individuals, which includes identity formation methodology; accumulation of primary materials; creation of the algorithm of sequential activity; control mechanism for managing all components [20].

***The impact of information and communication technologies on youth health*:**The following results have been identified: the most common diseases included cervical spine load; negative changes in the pectoral muscle performance and lumbar spine. In order to correct these negative effects, the physical activity aimed at increasing the movement amplitude of the body parts was proposed [2].

***The attitude of teachers and students towards the use of information technologies*:** Specialists revealed the following information:

a) Although male and female teachers had relatively different opinions regarding computer technologies, there was a consistent pattern indicating the absence of a particular difference in their position [21]
b) Undergraduates consider it important to master the basics of computer technology and implement them at a more professional level in their future activities [22].

The use of information technologies in the educational process: The following recommendations are proposed in this direction:

a) To further improve the use of computer technologies in physical education classes, it is necessary to introduce various modifications offered on the Internet, which should be adjusted to the tasks solved in the educational process [23,24]
b) The conceptual apparatus and the dominant elements of the methodology for the analogy implementation have been characterized. In addition, real tools for creating and applying analogies in industrial and educational activities have been presented [25]
c) The development allowing watching movements in three positions: from the inside, outside and in motion is recommended. These attitudes form an image of performing a motor action in students, which is later transformed into a motor skill through practical implementation [26]
d) A computer program that takes into account student's differentiated characteristics and allows mastering the theoretical, physical, and technical components of the proposed material with the help of adequate tools has been developed [27]
e) A methodology based on the use of computer technology, called “turned upside down physical education audience,” has been proposed. It provides students with the algorithm for doing independent exercises that they will perform outside the institution through the use of the Internet and other computer-based tools [28].

The purpose of our research is to scientifically substantiate the introduction of an electronic textbook "Physical Education at University" in physical education classes based on the use of a pedagogical experiment and mathematical statistics methods.

Thus, the following tasks have been set:

1. To develop an electronic textbook "Physical Education at University".
2. To conduct a pedagogical experiment to introduce an electronic textbook "Physical Education at University" in physical education classes.
3. To substantiate the effectiveness of the introduction of the electronic textbook in physical education classes at the university.

2 Methods

2.1 Research design and sample

The study was conducted in three stages during the 2018-2019 school year. At the first stage (September-December 2018), the analysis of the scientific and methodological literature was carried out in order to form the scientific apparatus of the study. At the second stage (January-May 2019), a pedagogical experiment to introduce an electronic textbook "Physical Education at University" in physical education classes was conducted. At the third stage (June-August 2019), we developed a mathematical apparatus that made it possible to substantiate the reliability of the introduction of the electronic textbook in physical education classes at university.

The recommendations of Zheleznyak and Petrov [28] were used to conduct the pedagogical experiment. The purpose of the experiment was to substantiate and experimentally evaluate the effectiveness of the electronic textbook "Physical Education at University" in physical education classes. We chose a parallel type of experiment.

The criteria for evaluating the effectiveness of the introduction of the electronic textbook included:

1. The level of theoretical knowledge (theoretical knowledge in the "basketball" section evaluated in points according to the credit technology);
2. The level of technical skills (slam dunk technique that is evaluated in points);
3. The level of physical fitness (standing long jump evaluated in centimeters).

The study was conducted at Aktobe Regional State University named after K. Zhubanov (Kazakhstan). It involved 28 young men: there were 15 people in the experimental group and 14 people in the control group).

2.2 Survey

The level of theoretical knowledge was assessed based on the tests available in the electronic textbook.

The students were asked to solve the following test tasks:

1. What is the distance between the basket projection onto the court and the three-point line in basketball: a) 6.00 m; b) 6.25 m; c) 6.10 m; d) 6.15 m; e) 6.75 m.
2. How long does a shot last: a) 20 sec; b) 30 sec; c) 22 sec; d) 25 sec; e) 24 sec.
3. Does the game continue if it ends in a tie:

   a) Yes, until the first point is scored
   b) No, the match ends in a tie
   c) Yes, there are free throws awarded to the team
   d) Yes, there is an extra quarter
   e) Yes, there is an extra five-minute period.

4. In what cases is the three-second rule applied:

   a) If the defender is in the paint
   b) If the attacker with or without the ball is in the paint
   c) If there are frequent shots
   d) If it takes the player more than 3 seconds to shoot the ball
   e) It is time for a free throw.

5. The arrow on the scorekeepers' table is used for:

   a) Stopping the game time
   b) Indicating the direction of movement of the team
   c) Determining which team receives the ball after the held ball
   d) Which team can make substitutions and take a timeout?
   e) Indicating that the team has 4 team fouls.

2.3 Data analysis tools and statistical processing

To justify the theoretical knowledge improvement in the experimental group compared to the control one, we used the White's criterion [29]. To justify the technical skills improvement in the experimental group compared to the control one, we applied the Pearson criterion [29].

To determine the physical fitness improvement in the experimental group compared to the control one, we used the Student t-test [29].

The Borland Delphi 6 programming environment and the Microsoft Office Front Page 2003 program were used to develop the electronic textbook.

3 Results and Discussion

We have developed an electronic textbook “Physical Education at University” [30].

The sequence of working with the electronic textbook “Physical Education at University” is as follows: download the textbook from the disk; there is the electronic textbook icon on the desktop. When the program is opened, an image appears on the screen, which changes into the main program window after pressing the key.

When "Start" button is clicked, the student log on window appears on the display. It consists of the following elements: last name, first name, year of study, faculty, specialty. After filling in all these parameters, it is possible to switch to the next window by clicking the "ok" button. Then a student sees a window that includes the following sections: "Lectures", "Practical assignments", "Independent student work", "Testing", "Video lectures", "Extra materials".

In the "lectures" section, there is a theoretical material on 7 modules: 1) sprint; 2) long- and middle-distance races; 3) a methodology for teaching the technique of long jump; 4) a methodology for teaching the technique of throwing a small ball, grenade; 5) basketball; 6) volleyball; 7) gymnastics.

In the "Practical assignments" section, there is practical material to consolidate the modules. The "Independent work" section includes topics that students should study independently. The "Testing" section contains tests on a variety of topics ("Athletics", "Basketball", "Volleyball", "Gymnastics") and different practical exercises ("Athletics", "Basketball", "Volleyball"). The student has to select a test or an exercise that they need to pass. There is a window with a test question on the selected topic ("Athletics") and answer options.

There are also "Previous Question" and "Next Question" arrow buttons. The questions of the test change; each test contains 15 questions; however, there are 30 questions in total. When the test is completed, the student will see the "Test completed" message and the result table. The "Save Result" button saves the test result as a text file.

The "Video lectures" section allows choosing one of the five presented video files (basketball, volleyball, gymnastics, athletics). In the "Extra materials" section, the student will find presentations on various sections of the course material. The "?" button in the upper right corner provides the information about the program: author, year of creation, development environment, as well as the instructions for using the electronic textbook.

During January-May 2019, a pedagogical experiment to introduce an electronic textbook in Physical Education classes was conducted at Aktobe Regional State University named after K. Zhubanov. The experiment was carried out as follows. In accordance with the tasks noted above, the initial level of theoretical and technical knowledge, as well as physical fitness was first determined.

Table 1 presents the data on the initial level of students' theoretical knowledge.

Table 1. Indicators of the initial level of students' theoretical knowledge

Experimental group		**Control group**	
Score (points)	***Assessment***	***Score (points)***	***Assessment***
72.3	Good	69.8	Satisfactory

Table 1 shows that the experimental group scored 72.3 points and received a "Good" assessment. In the control group, the result corresponded to the "Satisfactory" assessment (69.8 points).

Table 2 shows the initial level of students' technical skills.

Table 2. Indicators of the initial level of students' technical knowledge

Experimental group		**Control group**	
Performed	***Failed to perform***	***Performed***	***Failed to perform***
8	13	2	14

According to Table 2, before the pedagogical experiment, there were 8 successful cases of performing the slam dunk technique and 13 failures. In the control group, 2 students out of 16 succeeded and 14 students failed.

Table 3 shows the initial level of students' physical fitness.

Table 3. Indicators of the initial level of students' physical fitness.

Experimental group			**Control group**		
Result, cm	Grade	Assessment	Result, cm	Grade	Assessment
225.3	C+	Satisfactory	213.2	D+	Satisfactory

Table 3 shows that in the experimental group, the average standing long jump result was 225.3 cm, which corresponds to the C+ grade and is considered "satisfactory". In the control group, the average standing long jump result was 213.2 cm, which is the D+ grade and is also marked as "satisfactory". At the beginning of the pedagogical experiment, there was a seminar to teach physical education teachers and students to work with an electronic textbook.

The technology of introducing an electronic textbook to study Physical Education is as follows. A module for review is selected in accordance with the planned course material. At one of the four classes per week, students work with the electronic textbook in the computer classroom for 25 minutes. They are expected to acquire theoretical knowledge in the course material and visual sensations of performing motor actions (when familiarizing themselves with the methodology for performing exercises). In the gym, students' visual sensations are gradually transformed into motor skills that can be implemented in the practice of Physical education.

To substantiate the effectiveness of the introduction of electronic textbooks in "Physical education", we developed three working hypotheses.

1. **Hypothesis N1:** The introduction of an electronic textbook in the experimental group has a more positive effect on the theoretical knowledge level compared to the control one, and it will demonstrate better results.

To apply the White's criterion, we arranged all the data in ascending order (Table 4).

Table 4. The ascending scores obtained by each student of the control and experimental groups in theoretical testing

No.	**Experimental group**	**Ranks,** R_e	**No.**	**Control group**	**Ranks,** R_c
1	82	15	1	65	1
2	85	16.5	2	66	2
3	85	16.5	3	68	3.5

4	86	18	4	68	3.5
5	87	19	5	70	5.5
6	88	20.5	6	70	5.5
7	88	20.5	7	71	7
8	89	22.5	8	73	8
9	89	22.5	9	74	9
10	90	24	10	75	10.5
11	91	25	11	75	10.5
12	92	26.5	12	78	12
13	92	26.5	13	79	13
14	93	28	14	80	14
15	94	29		Rank sum, $\sum R_c$	105
	Rank sum, $\sum R_e$	330			

Thus, $\sum R_e + \sum R_c = 330 + 105 = 435.$

the sum of the ranks was calculated based on the formula (where n is the total number of the participants):

$$\sum R_{total} = \frac{n(n+1)}{2} = \frac{29 \cdot 30}{2} = 435.$$

The coincidence of the rank sums indicates correct data ranking.

The control group rank sum (105) was compared with the tabular value, where $T_{table} = 164$ at p = 0.95. 164> 105, $T_{table} > T_{actual}$. Therefore, hypothesis N1 is accepted. Indeed, the introduction of an electronic textbook in the experimental group has a more positive effect on their theoretical knowledge compared to the control one; in addition, students in this group demonstrate better results.

2. **Hypothesis N1:** The introduction of an electronic textbook in the experimental group has a more positive effect on technical skills (slam dunk technique) compared to the control group. The students from the experimental group have fewer failures compared to the control group.

Let us apply the Pearson's criterion. We have compiled a four-field table of results (Table 5).

Table 5. Four-field table of slam dunk results

Experimental group	$E_1 = 15$	$E_2 = 6$	$n_e = E_1 + E_2 = 21$
Control group	$C_1 = 5$	$C_2 = 11$	$n_c = C_1 + C_2 = 16$
	$E_1 + C_1 = 20$	$E_2 + C_2 = 17$	

Given that one of the values in the four-field table is 5, we used the following formula to calculate the empirical value of the Pearson's criterion:

$$\chi^2_{emp} = \frac{N\left([E_1C_2 - E_2C_1] - \frac{N}{2}\right)^2}{n_e n_c (E_1 + C_1)(E_2 + C_2)}$$

We compared the obtained value χ^2_{emp} with a critical value χ^2_{cr} at the number of degrees of freedom v = C -1 and the significance level p = 0.05, where C is the number of categories.

In our case, C = 2 as there are two categories; therefore, v = 1. $\chi^2_{cr} = 3.8$ at p = 0.05.

$$\chi^2_{emp} = \frac{(21+16)\left([15\cdot 11 - 6\cdot 5] - \frac{21+16}{2}\right)^2}{21\cdot 16\cdot 20\cdot 17} = 4.4$$

4.4> 3.8; therefore, hypothesis N1 is statistically accepted, i.e. the introduction of an electronic textbook in the experimental group has a more positive effect on technical skills (slam dunk technique) compared to the control group; the students from the experimental group have fewer failures compared to the control group.

3. **Hypothesis N1:** The introduction of an electronic textbook in the experimental group has a more positive effect on physical fitness (standing long jump) compared to the control one, and the students from this group will demonstrate better performance.

We used the Student's T-test. Table 6 presents the experimental results for the calculation.

Table 6. The results of each student from the control and experimental groups in standing long jump

No	Experimental group	No.	Control group
1	240	1	210
2	235	2	215
3	230	3	211
4	231	4	205
5	232	5	208
6	238	6	200
7	236	7	204

8	234	8	201
9	239	9	206
10	238	10	209
11	236	11	212
12	231	12	213
13	232	13	211
14	236	14	217
15	230	15	212

The sequence of calculating the significance of the differences by the Student's T-test.

1. The arithmetic mean values $\bar{x}$ for each group were calculated separately according to the following formula:

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n},$$

where x_i is the value of a single observation; n is the total number of observations in the group.

Thus, we get:

$$\bar{x}_e = \frac{240 + 235 + 230 + 231 + 232 + 238 + 236 + 234 + 239 + 238 + 236 + 231 + 232 + 236 + 230}{15} = = 234.53;$$

$$\bar{x}_c = \frac{210 + 215 + 211 + 205 + 208 + 200 + 204 + 201 + 206 + 209 + 212 + 213 + 211 + 217}{15} = = 208.71.$$

The comparison of the arithmetic mean values shows that in the experimental group this value is higher than in the control one. However, in order to prove that the experimental group participants perform a standing long jump better, we should make sure that the differences between the calculated arithmetic mean values are statistically significant. To do this, let us proceed to the next step.

2. In both groups, the standard deviation σ was calculated based on the following formula

$$\sigma = \frac{x_{i\max} - x_{i\min}}{K},$$

where $x_{i\max}$ is the greatest indicator, $x_{i\min}$ is the lowest indicator for each of the groups, K is the tabular coefficient.

Let us substituting the values in the formula:

$\sigma_e = \frac{240 - 230}{3.47} = 2.88$ for the experimental group,

$\sigma_c = \frac{217-200}{3.41} = 4.99$ for the control group.

Let us proceed to the third step.

1. The standard error of the arithmetic mean value (*m*) was calculated using the formula $m = \frac{\sigma}{\sqrt{n-1}}$, as the number of participants in each group is fewer than 30.

$$m_e = \frac{2.88}{\sqrt{15-1}} = 0.77; m_c = \frac{4.99}{\sqrt{14-1}} = 1.39.$$

2. The average error of the difference was calculated according to the formula

$$t = \frac{\overline{x_e} - \overline{x_c}}{\sqrt{m_e^2 + m_c^2}} = \frac{234.53 - 208.71}{\sqrt{0.77^2 + 1.39^2}} = 16.25.$$

Based on the special table, the significance of the differences was determined. For this purpose the obtained value was compared with the boundary value at a 5% significance level ($t_{0.05}$) at the number of the degrees of freedom $f = n_e + n_c - 2$, where n_e and n_c are the total number of individual results in the control and experimental groups, respectively. In our case, the number of the degrees of freedom $f = 15+14-2 = 27$, $t_{0.05}$ = 2.05, $t_{0.01}$ = 2, 77. The calculated value *t* = 16.25 is greater than the tabulated values of *t*; therefore, the differences between the arithmetic means of the two groups are considered significant. Hypothesis N_1 is accepted, i.e. the introduction of an electronic textbook in the experimental group has a more positive effect on physical fitness (standing long jump) compared to the control one, and the students from this group demonstrated better performance.

Kozina and Putanets [30] conducted similar studies. Thus, visual dynamic cartoons designed in "Macromedia Flash MX 2004" were presented in order to help students master technical and tactical elements in sports games. At the same time, the authors developed a symbol library consisting of various elements (sound accompaniment of the execution of technical elements, etc.). The content of the electronic textbook that we developed is different in terms of the assimilation of the material proposed: students are offered video lectures, which clearly demonstrate the technique of performing technical actions.

Before the pedagogical experiment, there were 8 successful cases of performing the slam dunk technique and 13 failures. In the control group, 2 students out of 16 succeeded and 14 students failed. For comparison, in the work by Muhammad [31], the number of correct double steps before the experiment was 11.9 in the experimental group and 3.98 in the control group; after the experiment, it was 13.8 and 3.37, respectively [31]. Our data differ as before the experiment this indicator was 8 cases in the experimental group, and 13 cases in the control group.

Before the experiment, in the experimental group, the average standing long jump result was 225.3 cm, which corresponds to the C+ grade and is considered "satisfactory". In the control group, the average standing long jump result was 213.2 cm, which is the D+ grade and is also marked as "satisfactory". Temchenko [32] studied the influence of the implementation of information technologies on the physical fitness of students, for whom the single sport methodology was introduced (based on the example of football). Due to the implementation of the methodology, the results of standing long jump in the experimental group increased from 2.51 m to 2.63 m.

4 Conclusion

We have developed an electronic textbook "Physical Education at University", which includes the following sections: "Lectures", "Practical assignments", "Independent student work", "Testing", "Video lectures", "Extra materials". The proposed textbook consists of 7 modules: 1) sprint; 2) long- and middle-distance races; 3) a methodology for teaching the technique of long jump; 4) a methodology for teaching the technique of throwing a small ball, grenade; 5) basketball; 6) volleyball; 7) gymnastics.

Before the pedagogical experiment, it was revealed that the level of theoretical knowledge (computer testing on the theory of basketball) and the performance of "standing long jump" were "satisfactory". In terms of technical skills, there was a greater number of students who failed to perform a slam dunk.

By applying the White' criterion, the Pearson's criterion and Student's t-test, we proved the working hypotheses about the positive impact of the use of electronic textbook "Physical Education at University" in physical education classes on the level of theoretical and technical skills, as well as physical fitness of students.

In our study, we have relatively expanded the data on the existing developments in the field of creating electronic Physical education textbooks; features of their implementation in the educational process; substantiation of the mathematical reliability of their implementation impact on the level of theoretical and technical skills, as well as physical fitness of students.

The materials can be used to complement the existing developments in information technology in the field of Physical education of students, namely, the creation of electronic Physical education textbooks.

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6 Authors

Kubiyeva Svetlana Sarsenbaevna - Candidate of physical and pedagogical sciences, docent of the Physical Culture and Sport Department, Aktobe Regional State University named after K. Zhubanov, Aktobe, Kazakhstan.

Akhmetova Aiymgul Utegulovna - Candidate of physical and mathematical sciences, Associate Professor of the Department of Mathematics, Aktobe Regional State University named after K. Zhubanov, Aktobe, Kazakhstan.

Islamova Klara Islamovna - Candidate of pedagogical sciences, Associate Professor of the Department of Ecology, Aktobe Regional State University named after K. Zhubanov, Aktobe, Kazakhstan.

Mambetov Nurolla - PhD in Pedagogic sciences, Acting Professor of the Department of Physical Culture and Basic Military Training, Atyrau State University named after Kh. Dosmukhambetov, Atyrau, Kazakhstan.

Aralbayev Alpysbay Seitkaliyevich - PhD in Pedagogic sciences, Head of the Department of Physical Education, Atyrau State University named after Kh. Dosmukhambetov, Atyrau, Kazakhstan.

Sholpankulova Gulnar Kenesbekovna - Candidate of pedagogical sciences, Acting Professor of the Department of Social Pedagogy and Self-knowledge, Eurasian National University named after L.N. Gumilyov, Nur-Sultan, Kazakhstan.

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