Digitalization of School Biological Education: Problems and Solutions

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Abstract. In the article the use of digital technologies for the educational process in biology has been studied. The study has aimed at developing and testing the methodology for developing a block of educational tasks in biology by using digital educational resources. Surveys, testing, and the pedagogical experiment have been used as research methods. It has been determined that biology teachers need the methodology that allows the competent use of digital educational resources in teaching activities. In the article the methodology for developing educational tasks in biology by using digital educational resources has been introduced. It is based on the taxonomy of B. Bloom's educational objectives. The efficiency of the methodology has been confirmed by the results of testing students in the control and experimental groups: the level of development of students' universal learning activities (ULA) has considerably increased, and the rate of students with project skills has grown.

1 Introduction

In the 21st century, it has become habitual to use numerous electronic devices. Younger generations are also characterized by such peculiarities [1]. According to the theory of Neil Howe, modern students are the "Z" generation. In their lives, digital technologies and the virtual world are more important than the objective reality [2]. They are characterized by high learning ability, flexibility, energy, the desire for self-development and self-expression, and the tendency to form a teacher-student relationship that differs from the one older generations got used to [3]. Taking into account the students' peculiarities, it is also necessary to change the educational system and more actively use the expanding capabilities of digital technologies [4].

School education should be digitalized through the educational environment at its various levels: the educational environment of the school, the subject environment, and the individual environment of students. Further, the article contains materials of the study on the digitalization of the subject environment through the example of the subject *Biology* that uses digital technologies.

According to the well-known SAMR model, digital or information technologies can be used to solve various problems: from primitive "substitution" to the "transformation" and the

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solution of educational problems that cannot be solved without digital technologies. For the participants in the educational process to use digital resources at the level of "transformation", school biological education should considerably change [5, 6]. Currently most biology teachers strive to provide students with a large amount of empirical knowledge. Digital resources of the information search have become so accessible that they can be used to find the required biological facts so quickly that it is not so important to remember large amounts of these empirical data [7]. The most important results of biological education include the ability to solve practical life problems, universal competencies, and creativity.

In order to do this, teachers will have to learn how to efficiently apply the capabilities of digital technologies in the educational process in biology. There is a great variety of digital educational resources in biology (electronic manuals, programs, simulators, virtual simulations [8], etc.). It is rather problematic to navigate them, and, moreover, efficiently apply digital technologies in the educational process without special auxiliary instruments [2]. According to the studies, the use of digital technologies in the educational process depends, first of all, on the teacher [9]. This challenges teachers to develop their own competencies [10, 11].

The *problem* is related to the development of practice-oriented methodologies that enable biology teachers to correctly use the capabilities of digital technologies in their pedagogical activities. The study is dedicated to the creation of one of these methodologies. Its results are presented in this article.

The study *aims* at developing and testing the methodology for developing a block of educational tasks in biology by using digital educational resources.

The study *hypothesis* is as follows: the use of the methodology for developing a block of educational tasks in biology by using digital educational resources will improve the quality of biological education.

The *objectives* of the study included the following: 1. To identify the needs of biology teachers in the methodology for developing biology tasks by using digital educational resources. 2. To develop the methodology for developing a block of educational tasks in biology by using digital educational resources. 3. To experimentally verify the efficiency of using digital educational resources in teaching biology by using the developed methodology.

2 Methods

The methodology of the study included several scientific methods. Let us dwell on the most important of them. Biology teachers were *surveyed* to assess their ability to navigate digital resources, select, and apply them. *Testing* made it possible to determine the level of students' knowledge in biology and the level of development of universal educational activities before and after the pedagogical experiment. The *pedagogical experiment* made it possible to determine the efficiency of the methodology for developing a block of educational tasks in biology by using digital educational resources and its impact on the quality of biological education. The quality indicators included the level of mastering biological knowledge, the level of ULA development, and the level of project skills (according to the methodology of N.Yu. Pakhomova [12]).

The pedagogical experiment was based on the methodology for developing a block of educational tasks in biology by using digital educational resources. It enables the teacher to select digital educational resources that comply with each didactic unit in biology [13]. The methodology was based on: 1. The work program in biology. 2. Methodology for developing educational tasks offered by A.S. Ilyushina. 3. The taxonomy of B. Bloom's educational objectives. 4. The classification of digital educational resources made by S.V. Zenkina. 5. The hierarchy of objectives: remember, understand, be able to apply, analyze, evaluate, and

create [13]. The highest level – the ability to create – deserves special attention in this hierarchy. In order to develop it, it is necessary to have special pedagogical environment [14, 15]. According to the authors, this skill incudes the ability of students to be creative, the ability to create a "product" (thing or idea) characterized by originality, novelty, and other criteria of creativity.

The methodology for developing a block of educational tasks in biology by using digital educational resources is based on the universal algorithm of actions a teacher must carry out when planning a biology lesson (Table 1) [13]. Table 2 shows the example of a set of training tasks made by using this methodology [16, 17].

Table 1. Universal Algorithm of Actions

No.	***Actions***	***Explanations***
1	Goal	To understand the objective of the relevant chapter of the biology course
2	Tasks	To determine the tasks of a certain theme (a didactic unit)
3	Content	To study the basic content of the theme
4	ULA	To understand what ULA will be developed when studying the theme
5	Results	To define the project results when studying the theme
6	Digital resources	To select digital educational resources in accordance with the above five points
7	Tasks	To develop tasks by using digital educational resources

Table 2. Complex of Activities in Biology (Fragment)

Chapter "Animals". Theme "Habitats and Migrations"				
ULA	***Goals***	***Digital resources***	***Tasks***	***Expectations***
Retrieval and systematization of information	To remember To understand	Film *Great Migrations* by National Geographic, part 1	See the film and answer the questions	Students know what migrations are, understand their causes, remember examples of migrants
General educational and logical activities	To analyze To evaluate	Google Earth software	Find the habitats of one of the migratory animal species. Map migration routes, stops, obstacles to overcome. Make illustrations	Students can evaluate and analyze the peculiarities of animal migration, taking into account the geographical location, terrain and seasonality
Group work Moral and ethical assessment Project skills	To create	Yandex search QR code generator Photo editor Software for creating flash animation	Find out the impact of anthropogenic factors on animal migration. Create a flash animation about one of the identified problems in the group. Make a QR code to the work.	Students create their own unique creative projects in groups. There is a QR exhibition of students' works

The experimental and control groups (EG and CG) took part in the pedagogical experiment. In total, there were 200 students from grades 7 and 9. Working with the EG students, the teachers used the methodology of developing a block of educational tasks in biology by using digital educational resources. When planning their sessions, they used a variety of digital resources in each lesson. Working with the CG students, the teachers used traditional methods, while digital resources were used occasionally.

3 Results

According to the teachers' survey, 82 % of the respondents use digital technologies in their work, 40 % of them most often use a PC for typing, 19 % of them have been using digital technologies for over 15 years, 37 % of them are not sure that other teachers correctly use digital technologies, and only 22 % of them believe that they easily navigate in digital educational resources. Table 3 shows the changes in two important indicators – subject results in biology and the level of students' ULA formation before and after the pedagogical experiment. Table 4 presents the changes in the level of development of project skills in two groups of students (EG and CG) before and after the pedagogical experiment.

Table 3. Results of testing the students

Levels of students' results	***Number of students (%)***			
	Results at the beginning		***Results at the end***	
	CG	***EG***	***CG***	***EG***
Particular results				
Optimal	7.4	7.2	7.3	29.3
Admissible	39.1	41.5	43.9	48.8
Critical	46.1	41.5	43.9	17.1
Inadmissible	7.4	9.8	4.9	4.8
Universal learning activities				
High	0	0	4.8	58.5
Medium	29.3	27.9	34.1	33.9
Low	70.7	72.1	61.1	7.6

Table 4. Development of project skills

Levels of project skills development	***Number of students (%)***			
	Results at the beginning		***Results at the end***	
	CG	***EG***	***CG***	***EG***
High	0	0	5	48
Medium	29	28	49	41
Low	71	72	46	11

4 Discussion

Let us analyze the results of the study. According to the survey, a considerable share of teachers use digital technologies to replace outdated means for recording information. These data correlate with the corresponding indicators presented by the NAFI Analytical Center in 2019 [18]. The authors have determined the following problem: less than a quarter of the surveyed teachers believe that they can navigate in the variety of digital resources and apply them when teaching.

The results of testing the students before and after the experiment confirmed the efficiency of the methodology for developing a block of educational tasks in biology by using digital educational resources. In the EG, the number of students with the optimal level of subject results in biology increased, the level of ULA development grew considerably, and the rate of students with project skills increased. The impact of digital educational resources on the ULA development is confirmed by the studies organized by the Russian Foundation for Basic Research as part of the *Digital School Transformation* project [19].

Let us note the limitations of the results of this study and the areas to develop it in the future. Since the use of generalization in pedagogical studies is problematic [20], the authors consider the primary school age and possible inapplicability to humanitarian subjects as the limitations for applying the study results. The promising areas for the further study include: 1. The impact of digitalizing the educational process on the development of creative abilities of students of different ages. 2. The efficiency of distance forms to teach biology. 3. The development of a system for regulating the amount of time spent by students online. 4. Prospects for using VR technologies in the biological education.

5 Conclusion

The study has resulted in the creation of the practice-oriented methodology that allows biology teachers to correctly use digital educational resources in their pedagogical activities. The methodology for developing a block of educational tasks in biology by using digital educational resources has been tested. The assumption that this methodology improves the quality of biological education has been confirmed. The methodology is used by biology teachers in a number of schools where this study has been carried out. In the future, it is planned to study the impact of digitalization of the educational process in biology on a number of important aspects, for example, the development of students' creative abilities.

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