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VIRTUAL LABORATORY AS A FACTOR IN THE DEVELOPMENT OF COGNITIVE ACTIVITY OF STUDENTS DURING BIOLOGY LESSONS

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This article reveals the current topic of the development of cognitive activity of students during biology lessons using virtual laboratories. The results of the theoretical analysis of scientific publications and research devoted to the study of the essence and features of educational and cognitive activity of modern schoolchildren are presented. The purpose of the research was to study the influence of a virtual laboratory on the educational and cognitive activity of students in the biology subject. The criterion for the effectiveness of virtual laboratory work was a change in the success of learning and the development of cognitive motivation in the seventh grade students in their dynamics. The data of the mathematical analysis of the reliability of the obtained research results (error within $p > 0.01$) are presented. Significant differences were found in the relationship between knowledge quality, academic performance, motivation, and the use of virtual lab activities concerning the "knowledge quality" and "cognitive motives" parameters, as well as self-development motives. The analysis revealed a moderately high score on these scales in both the first group (control group) and the second group (experimental group) ($p > 0.01$). This suggests that the implementation of virtual lab activities has a greater impact on students' knowledge level and academic engagement. Based on the results of the study, the necessity of using virtual laboratory work as one of the factors in the development of cognitive activity of students has been justified.

Key words: *cognitive activity, virtual laboratory, cognitive motivation, academic success, biology.*

ВИРТУАЛЬНАЯ ЛАБОРАТОРИЯ КАК ФАКТОР РАЗВИТИЯ ПОЗНАВАТЕЛЬНОЙ ДЕЯТЕЛЬНОСТИ УЧАЩИХСЯ НА УРОКАХ БИОЛОГИИ

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Данная статья раскрывает актуальную тему развития познавательной деятельности учащихся на уроке биологии посредством использования виртуальных лабораторий. Представлены результаты теоретического анализа научных публикаций и исследований, посвященных изучению сущности и особенностей учебно-познавательной деятельности современных школьников. Целью исследования было определить степень влияния виртуальной лаборатории на учебно-познавательную деятельность учащихся по предмету биология. Критерием эффективности виртуальных лабораторных работ являлось изменение успешности обучения и развития познавательной мотивации у учащихся седьмых классов в их динамике. Приводятся данные математического анализа достоверности полученных результатов (погрешность в пределах $p > 0,01$). Достоверные различия по взаимосвязи качества знаний, успеваемости, мотивации и применение виртуальных лабораторных работ получены в отношении параметра «качество знаний» и параметра «познавательные мотивы», мотивы саморазвития. В результате анализа выявлен умеренно высокий показатель по этим шкалам как в первой группе (контрольная группа), так и во второй группе (экспериментальная группа) ($p > 0,01$). Это свидетельствует о том, что применение виртуальных лабораторных работ в большей степени влияет на уровень знаний и учебную

деятельность учащихся. На основании результатов исследования обосновывается необходимость применения виртуальных лабораторных работ в качестве одного из факторов развития познавательной деятельности учащихся.

Ключевые слова: познавательная деятельность, виртуальная лаборатория, познавательная мотивация, академическая успешность, биология.

ВИРТУАЛДЫ ЗЕРТХАНА БИОЛОГИЯ САБАҚТАРЫНДА ОҚУШЫЛАРДЫҢ ТАНЫМДЫҚ БЕЛСЕНДІЛІГІН ДАМУ ФАКТОРЫ РЕТІНДЕ

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Бұл мақалада мақалада виртуалды зертханаларды қолдану арқылы биология сабағында оқушылардың танымдық іс-әрекетін дамытудың өзекті тақырыбы ашылады. Қазіргі оқушылардың оқу-танымдық іс-әрекетінің мәні мен ерекшеліктерін зерттеуге арналған ғылыми жарияланымдар мен зерттеулерге теориялық талдау нәтижелері ұсынылған. Зерттеудің мақсаты виртуалды зертхананың биология пәні бойынша оқушылардың оқу-танымдық қызметіне әсер ету дәрежесін анықтау болды. Виртуалды зертханалық жұмыстардың тиімділігінің критерийі жетінші сынып оқушыларының оқу жетістіктерінің өзгеруі және танымдық мотивацияның дамуы болды (олардың динамикасында). Алынған нәтижелердің дұрыстығын математикалық талдау деректері келтіріледі ($p > 0,01$ шегіндегі қателік). Білім сапасы мен үлгерімнің өзара байланысы бойынша сенімді айырмашылықтар. виртуалды зертханалық жұмыстардың мотивациясы мен қолданылуы "білім сапасы" параметріне және "танымдық мотивтер" параметріне, өзін-өзі дамыту мотивтеріне қатысты алынды. Талдау нәтижесінде бірінші топта (бақылау тобы) және екінші топта (эксперименттік топ) осы шкалалар бойынша орташа жоғары көрсеткіш анықталды ($p > 0,01$). Бұл виртуалды зертханалық жұмыстарды қолдану оқушылардың білім деңгейі мен оқу әрекеттеріне көбірек әсер ететінін көрсетеді. Зерттеу нәтижелері негізінде виртуалды зертханалық жұмыстарды оқушылардың танымдық іс-әрекетін дамыту факторларының бірі ретінде қолдану қажеттілігі негізделеді.

Түйінді сөздер: танымдық қызмет, виртуалды зертхана, танымдық мотивация, академиялық жетістік, биология.

Introduction. The education system in the era of digitalization is becoming completely different, since it is becoming popular to actively integrate new information technologies into the learning model [1, p. 81]. The advent of personal computers and access to the global Internet has brought not only new technical, but also didactic opportunities to the field of education.

In this regard, the issue of the impact of the introduction of computer and telecommunications technology on the quality of the educational process is increasingly being considered. Virtual reality is one such technology that is attracting increasing attention in the academic and teaching communities. Over the past decade, the use of virtual reality in teaching and learning has increased dramatically and covers a variety of subjects.

G. Ioana, T. Lynch, M. Bratu, et al. have proven that using virtual labs, teachers can easily explain complex theoretical concepts through visual and immersive experiences that can simplify students' understanding of the subject. Virtual laboratories allow teachers to attract the attention of students and ensure their involvement and motivation [2, p. 23-25].

The specifics of the educational process with the introduction of new technologies are presented in the works of J.L. Guzmán., J. Babu [3, p. 5], M. Asbari, L.M. Wijayanti, C.C. Hyun, et al. [4, p. 229]. These studies are interesting because the authors described in detail the process of the influence of digital technologies on the components of the pedagogical process, the cognitive structures of the individual, his professional development.

Increasingly, the virtual laboratory is being used to acquire practical skills on various topics in biology. The virtual laboratory has gained important application in both secondary and higher education biology courses.

In the works of foreign authors such as G.G. Gerardo, C.R. Jiménez, J.A.M. Marín, et al. [5, p. 36], L. Daniela, A. Rüdolf [6, p. 192] it is reported that students have become more involved in the learning process due to exciting experiences, increased motivation to study in a virtual laboratory.

R. Prada, C. Hernández, A. Gamboa [7, p. 1388] revealed that virtual laboratories instead of real equipment helped to better cope with conceptual issues related to simple circuits and developed a greater ability to manipulate real components.

S. Affouneh, S. Salha, Z.N. Khlaif [8, p. 136] noted that virtual laboratories are advisable to use in the learning process and can improve student learning outcomes.

C. Whittle, S. Tiwari, S. Yan, J. Williams [9, p.313] revealed that virtual laboratories have an impact on the academic achievements of students and their mastery of the skills of the scientific process and the development of educational and cognitive activities.

J. Portillo, U. Garay, E. Tejada, N. Bilbao [10, p.135] have shown that the use of virtual laboratories provides many advantages for studying science helps students understand various scientific concepts and find the points of their misconceptions and correct them. It was also found that virtual laboratories develop students' abilities to design, evaluate and solve problems. In addition, the virtual laboratory increases the curiosity and positivity of students, as well as increases motivation to study the subject, which is relevant for all schools in the world.

In our reality, the requirements for the cognitive activity of schoolchildren are increasing every year, while the educational and cognitive activity itself is not growing [11, p. 37].

Goal and tasks. Since the problem of obtaining and assimilation of knowledge in the information society is one of the central ones for the development of the whole society, the purpose of our study was to study the influence of a virtual laboratory on the educational and cognitive activity of students in the subject of biology. The change in educational and cognitive activity was expressed through a change in the success of learning. This made it possible to solve the following tasks in the study:

- to identify the motives of educational and cognitive activity;
- to identify the level of academic success;
- to determine the reliability of the effectiveness of the influence of virtual laboratories on the cognitive activity of students in the study of the subject.

Theoretical aspects of the issue. In the modern understanding of the term "educational and cognitive activity" acquires an interdisciplinary and collective character. It includes not only the student's activity, but also his orientation, volitional regulation, motives, interests, as well as the learning tools used. Important components of this activity are the independence of cognition, the achievement of success in learning, the joy of discovering new things and meeting the educational needs of the individual [12, p. 69].

According to S.G. Vorovshchikov, educational and cognitive activities are interrelated. Educational activity is the basis for proper cognitive actions, and educational goals that arise in the process of solving cognitive problems are of an auxiliary nature and are aimed at solving them more effectively [13, p. 51].

B. F. Akhanov and G. B. Kunzhigitova consider cognitive activity as a desire for independent thinking, a search for their own approach to solving a problem or problem, a willingness to self-educate and form a critical attitude to the opinions of others, as well as independence in expressing their own judgments. At the same time, the activity of students may weaken if the necessary conditions for its development are not provided [14, p.33].

After analyzing the psychological and pedagogical literature, we have identified the main characteristics of educational and cognitive activity:

a) Educational and cognitive activity is an integral part of the learning process, next to teaching, and represents the active activity of the student.

b) Its essence lies in the perception and development of scientific knowledge, generalization of facts, consolidation and application of acquired knowledge in practical activities on the instructions of a teacher or in accordance with one's own cognitive needs.

c) The result of educational and cognitive activity is the formation of new forms of behavior and activity, the change of previously acquired knowledge based on cognition, training and experience gained.

d) The specificity of educational and cognitive activity lies in the fact that it is present at every step in life, in all types of activities and social interactions, but it is in the learning process that it gets a clear design: this is a conscious learning process by the teacher, in which the student becomes the subject of a specially organized activity.

e) Success in educational and cognitive activity depends on the awareness and assimilation of its structure in all its components, as well as on the activity of the student (educational and cognitive motivation).

Summarizing our understanding of educational and cognitive activity, we offer our point of view. In a broad sense, it is an independent sphere of life of modern schoolchildren, where they act not only as subjects of this type of activity, but also develop their personality and interact with other people. In a narrow sense, this is the activity of schoolchildren in the learning process, where they solve various tasks (both educational and cognitive), showing varying degrees of independence. It is important to note that the

educational and cognitive activity of a student is carried out under the guidance of a teacher, and the degree of assistance they receive depends on their activity, independence and competence. This affects the success of students in their cognitive activities [15, p. 53].

In the context of the above, it can be concluded that the changes that have occurred in the socio-cultural space have a significant impact on the attitude of modern schoolchildren to educational and cognitive activities, and it is important to take this factor into account. At the same time, it is necessary to take into account both positive and negative transformations in order to create optimal conditions for the development of positive aspects and correction of negative ones. It is important to provide modern schoolchildren with support and incentives for active participation in educational and cognitive activities, as well as to develop measures to overcome the problems associated with alienation, pragmatization and narrowing of the perception of education. This is the only way to ensure the harmonious development of schoolchildren and create conditions in which educational and cognitive activities will be considered as an important and valuable part of their lives, contributing to their personal growth and self-realization.

Materials and methods. The study involved 250 seventh grade students from 3 secondary schools in the Pavlodar city. The group consisted of schoolchildren aged 12-13 years. The type of group by gender is mixed.

In the process of conducting practical research, the following methods of theoretical research were applied: analysis, comparison, analysis of psychological and pedagogical literature. As an empirical method, we used a questionnaire, an analysis of academic performance according to completed tests and a method of mathematical analysis of the results of students' educational activities.

The textbook by Solovieva A. R. et al. is used as the main source of subject information. "Biology. Grade 7". The proposed laboratory work in this textbook has been redesigned for distance learning. The indicator of evaluating the effectiveness of the virtual laboratory was the success of the acquired knowledge of the students.

For students, it was proposed to conduct three laboratory work on the following topics: "Transport of substances", "Plant nutrition", "Plant respiration".

Performing each laboratory work involved completing a number of tasks aimed at identifying the level of knowledge on the topic of study.

The Adobe Flash Professional program was used to develop laboratory work, as well as a program for playing flash content – Adobe Flash Player. This choice of software is explained by the fact that Flash makes it possible to work with vector, raster and three-dimensional graphics. This program allows you to simultaneously use audio and video content playback.

The laboratory work in the Adobe Flash Professional program was posted on a one-page website created using a Google form. This made it possible for students of several classes to work remotely at the same time.

The data obtained with the help of tasks in laboratory work were subjected to careful processing. The empirical research data were processed using the SPSS computer data processing program and the Microsoft Excel program.

Our study assumed the identification of the influence of virtual laboratory work on the development of motivation and educational and cognitive activity. All participants were divided into two conditional groups: group 1 – students performing laboratory work virtually (experimental) and group 2 – students performing laboratory work on paper in the classroom (control). It was decided that section 1 is the ascertaining stage of the study, section 2 is the control stage of the study.

To perform virtual laboratory work, the subject teacher offered students detailed instructions. Following the instructions allowed students to understand the essence of the task being performed. The sequence for completing the work was established directly in the virtual laboratory work for those children who completed the work online. The same students who completed the laboratory work from the textbook were required to follow similar directions in the textbook. The text of the instructions was the same. The teachers did not take part in the direct implementation of laboratory work by students.

Upon completion of laboratory work, a questionnaire "The structure of educational motivation" (according to M.V. Matyukhina) [16, p.75-76] and a test to identify the level of acquired knowledge and further analysis of the results were conducted. A month later, after the virtual laboratory work was carried out, testing was conducted again on the same topics and using the same methods.

Results and their discussion. The results of the study, the ascertaining and control stages based on the questionnaire "The structure of educational motivation" (according to M.F. Matyukhina) were analyzed and presented in Table 1.

The results of the study revealed that in the control group of students who performed laboratory work in the traditional form, the indicators of motivation structure did not change. The cognitive motives of those who studied in the virtual laboratory underwent changes by 5%, from 15% to 25%, which, in our opinion, is due to the colorful and informative content of virtual laboratories, the ease of their perception.

Table 1 – results of the questionnaire "The structure of educational motivation" (according to M.F. Matyukhina), %

Motives	The control group		The experimental group	
	1st test	2nd test	1st test	2nd test
Internal:				
Cognitive	20	20	15	25
communication skills	40	40	40	45
Emotional	10	10	10	10
Self-development	30	30	20	30
The student's position	25	25	20	20
Progress	20	20	15	25
External	50	50	60	40

There were changes in the experimental group as well: communicative motives changed – from 40% to 45%. This indicates the positive impact of virtual laboratories on the desire of students to communicate with each other and due to their interest in the topic of communication. We see that students develop a desire to receive the necessary information on the topic of research, a desire to share information among themselves.

Emotional motivation in both the control and experimental groups did not change, and remained at the level of 10%. We believe that when performing laboratory work, receiving emotions is not decisive.

The motives for self-development have changed significantly: from 20% to 30%. Immediately by 10%. It seems that such changes are associated with informativeness, ease of perception, the development of computer skills in a child and awareness of the material being studied.

The motivation for achievement changed from 15% to 25%, and immediately increased by 10%. We believe that the students liked this format of studying the material and they enjoyed learning and learning something new and entertaining.

Extrinsic motivation, i.e. encouragement and punishment by the teacher decreased from 60% to 40%. Students have stopped being afraid of punishment, because they have lost relevance due to the growth of achievement motivation and self-development motivation, cognitive motivation. Encouragement remains a significant motivation for them in learning.

There were no changes in all motivation components in the control group. The absence of changes in the control group, in our opinion, is due to a stable motivation in this subject and an attitude towards such a format of laboratory work: traditional paper and textbook performance.

The results of the study of academic performance and the quality of knowledge at the ascertaining and control stages in their dynamics are presented in Table 2.

The results of the study were presented in Table 2.

Table 2 – Dynamics of academic performance and quality of knowledge (%)

Group	The quality of knowledge		Grade	
	1st test	2nd test	1st test	2nd test
Control	60	49,6	84	81,3
Experimental	67,2	65,6	85,6	88

The quality of students' knowledge during laboratory work in the experimental group was 67.2%, and in the control group – 60%.

When we repeated the cross-section a month later, the quality of knowledge in the experimental group was (65.6%), in the control group the quality of knowledge was significantly lower (49.6%).

Upon repeated verification, the quality of knowledge in the experimental group decreased slightly by only 1.6%, and in the control group by 10.4%.

This fact can be explained by the fact that virtual laboratory work was used in the learning process in the experimental group, which was vivid and memorable, which contributed to a longer retention of the studied material in memory. The visibility of the study of virtual laboratory work contributed to a better memorability of the educational material. The brightness and cognition of virtual laboratory work contributed to the development of educational motivation of students. The comparison and generalization of the results of the experimental work convincingly prove the effectiveness of the application of the methodological recommendations developed by us for the use of virtual laboratories in the learning process in biology lessons.

Analysis and processing of empirical data from psychological and pedagogical research (Microsoft Excel, Statistica, SPSS). We checked the reliability of the data obtained using a mathematical study of statistical data according to the Student's criterion.

Significant differences in the relationship between the quality of knowledge and academic performance, motivations and the use of virtual laboratory work were obtained in relation to the parameter "quality of knowledge" and the parameter "cognitive motives", motives of self-development. The analysis revealed a moderately high index on these scales in both the first group (control group) and the second group (experimental group) ($p > 0.01$). This indicates that the use of virtual laboratory work has a greater impact on the level of knowledge and educational activities of students.

Conducting laboratory classes virtually is not a full-fledged alternative to this important type of educational activity, but it allows you to solve certain tasks in conditions of the need for distance learning.

Conclusions. The cognitive activity of a person is based on his sensory, material activity. In the process of development, our knowledge becomes more specific and objective. The criterion and the only means of verifying the truth of our knowledge is practice.

The use of virtual laboratories is an accessible form of visual representation of practical biology classes.

The use of virtual laboratory work improves the quality of students' knowledge.

The revealed significant differences in relation to the "quality of knowledge" parameter in terms of identifying a direct relationship between this parameter and the use of virtual laboratories, the analysis result showed a moderately high indicator.

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