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APRESENTATION

"In this work 'Education: research and development vol.01,' we dive into a vast sea of knowledge and innovation in the field of education. This book is the result of a meticulous and comprehensive compilation of studies and collaborations from renowned experts, covering a wide variety of topics essential for the constant evolution of teaching and learning. Our journey takes us through the latest trends and discoveries in education, from innovative teaching methodologies to effective approaches to assessment and pedagogical intervention. Each chapter presents a unique and well-founded perspective on the challenges and opportunities currently faced by educators and educational institutions, providing valuable insights to promote a more effective and inclusive educational practice. This book is not just a book, but an essential resource for educators, researchers, and professionals committed to educational excellence. It serves as an inspiring source of ideas and reflections that have the potential to drive educational development and contribute to the building of a more informed, equitable, and prepared society for the challenges of the 21st century."

Good reading to one and all!

SUMMARY

CHAPTER 05
METHODOLOGY OF FUTURE NATURAL SCIENCES TEACHERS TRAINING TO USE SMART-TECHNOLOGIES IN THE PROFESSIONAL ACTIVITY

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ABSTRACT: The article deals with one of the possible ways of modernization of pedagogical education in Ukraine in order to train teachers of the new generation and to provide conditions for the formation and development of modern alternative models

of teachers' professional and personal growth on the principles of SMART-education concept. The problem of future natural sciences teachers training to use SMART-technologies in the professional activity as the condition for realization of the SMART-concept in education is actualized. The advantages of SMART-technologies use in the study of objects and phenomena of wildlife have been substantiated. They allow the formation of holistic thinking of both students and schoolchildren by combining figurative and logical thinking and strengthen the emotional and value perception of wildlife objects. Methods of formation of future natural sciences teachers' readiness to use SMART-technologies in the educational process, which involves the realization of a dual goal: the formation of the ability to use the resource SMART-concept in education to implement their own lifelong education and providing quality professional activities during teaching natural sciences school course have been highlighted. It has been substantiated the module content and the means of its learning by students. Tasks for the organization of independent work, tests, criteria and indicators of the level of students' abilities and skills formation to use the SMART-complex (motivational-value, cognitive, activity-constructive, reflexive and evaluative) have been developed. The effectiveness of the proposed methods on the basis of determined criteria has been proved experimentally. The pedagogical conditions for the effective use of methodology of future natural sciences teachers training to use SMART-technologies in the professional activity have been identified, namely: existence of vividly structured system of information and learning environment as the subject of the educational interaction with taking into consideration its hierarchical links to other components of the educational process in higher education institutions; purposeful training of students for the fluent operation of information and communication tools; improvement of the IT competence of research and teaching staff in the implementation of teaching methods based on modern information and computer technologies.

KEYWORDS: SMART-technologies; Schoolchildren/students; Future natural sciences teachers; Methods of teaching; Professional training; Pedagogical conditions.

1. INTRODUCTION

The problem statement. Reforms in education in the XXI century put forward new demands before the teachers. A teacher who thinks freely and actively, who foresees the results of his activities and accordingly models the educational process is a guarantor of solving the tasks set before the school. The quality of teaching staff is the most important component of the educational system. Realization of all other components of this system directly depends on the human resources with which it is provided. Teacher are responsible for the implementing new generation educational programs based on advanced pedagogical technologies, they are assigned the mission of preparing the younger generation for life in the future and educating a person with modern thinking, able to successful self-realization in life. Thus, the tasks of modern education vary in accordance with the requirements of the century by finding new technologies and modernizing the educational environment.

Present realities made us move to SMART-education concept. It involves complex modernization of all educational processes, as well as methods and technologies used in them. SMART-education means new knowledge and ideas generation, development of SMART-environment, SMART-society – an intellectual environment of people who are specially trained to implement the latest ideas and concepts. A lot of countries in the world, namely Korea, Japan, Australia, the Netherlands have claimed the SMART idea as a national idea of the whole society. According to UNESCO, the use of SMART-technologies provides an opportunity to significantly expand and improve learning opportunities, in particular in higher education institutions.

The analysis of recent studies and publications. The analysis of literary sources allows to confirm that understanding of SMART in the area of education ranges from the use of smartphones and other similar devices to deliver information to schoolchildren/students to the formation of an integrated intelligent virtual learning environment, including SMART devices. Our study is based on the complex considering of this problem.

Historically, the transformation of educational technologies has taken place within the chain: traditional – distance – e-learning – new information and

communication technologies (Smart). The use of SMART-technologies is aimed at achieving the following goals in the learning process: S (Self Directed) – providing opportunities for self-determination of what to learn and effective organization of self-learning; M (Motived) – motivation of active cognitive activity; A (Adaptive) – adapting the methods, place and time for learning for a specific subject who wants to gain educational services; R (Resource Free) – providing free access to educational resources; T (Technology Embedded) – permanent support of the learning process with modern technologies. V. Tykhomyrov briefly interprets the abbreviation SMART as: S – self-managed, M – motivated, A – adapted, R – resource-provided, T – technological [1].

According to O. Semenikhina [2, p. 42], the concept of SMART-education correlates with the latest educational trends voiced by FORBS magazine: distance education is becoming a leader in educational technologies – video lessons on YouTube or other services are mega-popular and in demand amongst the younger generation; personalization of learning – individual psychological characteristics of a person should become the basis for individual educational programs; gamification (introduction of game technologies in non-game situations) – reward technologies for what has been done can help to increase the learning motivation and improve its quality; interactive textbooks that should radically change the “traditional” presentation and interpretation of educational material; learning with the help of video games is a unique opportunity to provide knowledge about the real world through an interactive immersion in the virtual world.

The concept of SMART in terms of education contributes to the emergence of technologies such as SMART board, SMART screens, the Internet access from anywhere. Each of these technologies allows to building the process of content development, its delivery and updating in a new way. It is possible to learn not only in the classroom, but also at home and in any place: public places, such as museums or cafes. The main element which binds the educational process is active educational content, on the basis of which unified repositories are created, which allow to remove the time and space limits. Thus, SMART-education involves the use of smartphones, tablets, interactive whiteboards, other devices with Internet access, as well as all kinds of educational programs and applications for educational aims.

The scientists [1,2,3,4,5] consider that the goal of SMART-education is to ensure the most effective learning process by transferring the educational process to the electronic environment. Such approach provides an access to knowledge to anyone, expands the boundaries of learning. First of all, SMART-education provides flexibility (a large number of sources, maximum media diversity, the ability to quickly and easily adjust to the level and needs of the listener). It involves an active exchange of experiences and ideas, personalization of the course, saving time for refinement (editing existing material instead of creating it from the beginning).

The positive aspects of the use of SMART-technologies in the educational process include: the possibility of their use in the teaching of various disciplines; high efficiency of knowledge acquisition; increasing interest in learning among schoolchildren and students; modern technologies and understanding and perception of them as a natural component of young people, which makes their lives a convenient tool for creative development; ease of combining SMART-technologies with a communicative approach [6].

The analysis of literature sources proved that the problem of using SMART-technologies in the educational process has received some elaboration in the scientific achievements of such scientists as V. Abramov (2007), G. Ahmetova (2013), H. Bonch-Bruievych (2007), V. Bykov (2013), K Bucher, Yu. Hapon, L. Ivanenko, O. Zubova, Zh. Karaev (2013), R. Kozma (7) T. Kosenko (2007), A. Kushnir (2020), S. Muhambetzhanova (2013), T. Pozdniakova (2018), S. Pudova (2018), V. Tihomirov (2011), O. Semenikhina (2015), M. Sharples (2007) and others. Thus, modern SMART-technologies as a means of innovation and a factor of information development of society, which provide the transformation of the teacher from a translator of information to a facilitator of communication in the process of combined activities with students, have been analyzed in the works of A. Kushnir (2020) [5]. The effectiveness of the use of SMART-technologies in the educational process has been theoretically substantiated and it has been proved that the use of SMART-technologies diversifies the educational process, increases cognitive interest and motivation of students at the expense of visible, real result of their foreign language daily professional activity, allows to expand considerably traditional educational technologies, optimizes expenses on logistics, as well as provides access to a new level of quality of educational services. O. Semenikhina (2015) states in her studies

that the use of SMART approach in the preparation and development of educational materials testifies the learning process with the use of technological innovations. It provides an opportunity to obtain professional competence on the basis of a systemic multidimensional vision and study of disciplines, taking into account their multifaceted nature and continuous updating of content [2]. At the same time, it is universally recognized that future teachers should be fluent in using the latest information technologies, both at the technical and theoretical levels, through which the solution of any socio-pedagogical problems will be methodically correct, based on acquired knowledge, skills and abilities.

The issues concerning the use of information devices in the process of Biology school course studying were described in our previous paper [14]. However, the problem of future natural sciences teachers training for the introduction of SMART-technologies into the process of professional activity has not been properly studied yet. The **goal** of our study is to develop a methodology for forming the future teachers' readiness to use SMART-technologies in the process of Biology school course studying, verify its effectiveness and justify the conditions for its effective implementation.

The research was realized through the following ***tasks***:

To identify the specifics of the SMART-technology use in the process of Biology school course studying.

To develop a methodology for forming the future natural sciences teachers' readiness to use SMART-technologies in professional activities.

To substantiate conditions for the effective implementation of the proposed methodology.

2. RESEARCH METHODS

To achieve the abovementioned goal and tasks, a number of methods have been used, namely: theoretical – comparative analysis to find out different views on the problem, identify areas of study; modeling to develop a methodology for forming the future natural sciences teachers' readiness to use SMART-technologies in professional activities; designing – to develop a criterion apparatus of the research; systematization and generalization to formulate conclusions and recommendations for

improving the educational process during future natural sciences teachers training for the introduction of SMART-technology in educational process;

empirical – generalization of pedagogical experience, scientific observation, interviews, content analysis, questionnaires in order to determine the state of implementation of the problem in practice and to develop the content of experimental teaching methodology; pedagogical experiment, which provided verification of the effectiveness of the proposed methodology.

Experimental research has been carried out on the basis of Ternopil V. Hnatiuk National Pedagogical University and Sumy A. Makarenko State Pedagogical University. Summative experiment involved 212 biology teachers and 38 future biology teachers, who are now students of the second (master's) level of higher education. Forming experiment was held in two stages and lasted for four years (2019-2020 and 2022-2023 academic years). 1006 студентів participated in it.

The goal of the first stage of the forming experiment was to test the effectiveness of the developed methodology for forming the future natural sciences teachers' readiness to use SMART-technologies in professional activities. The goal of the second stage of the forming experiment was to justify pedagogical conditions for the effective implementation of the proposed methodology. The number of scientists and lecturers from higher education institutions who participated in the experiment was 292 and the number of students comprised 434.

3. THE RESULTS AND DISCUSSION

Preparatory stage, the aim of which was to determine the peculiarities of the SMART-technologies use in the process of Biology study preceded the development of an experimental methodology of forming the future natural sciences teachers' readiness to use SMART-technologies in professional activities. To do this, we analyzed the following factors:

the essence of SMART-technologies and the expediency of their use in the educational process of secondary schools and universities;

the peculiarities of the object of biological cognition (plant, animal organisms and humans);

the content of future natural sciences teachers professional and methodological training;

the content of Biology school course program.

The results of the conducted analysis showed that the peculiarities of the SMART-technologies use in the process of Biology school course studying are related to the object of its study – integral systems of wildlife in their hierarchical relationships and interdependencies, as well as the necessity to form emotional and value attitude of schoolchildren to the world of nature on the basis of bioethics. Due to emotional and value as well as figurative perception SMART-technologies make it possible to penetrate into the microworld of the cell, to model life processes in systems of different levels of organization, to demonstrate the manifestation of general laws of nature at the level of sensory-figurative perception, to reveal the beauty of wildlife in its uniqueness, diversity and interdependence of its systems, to highlight its self-value, universality and significance in our daily life.

Considering these peculiarities, as well as: the main objectives of training a highly qualified specialist who will show a desire for self-improvement and self-realization in his professional activity through a certain manifestation of self-efficacy, self-reflection and self-correction; expediency and need for integration of educational and self-educational activities in higher education; organization of research, dialogue, discussion, creative nature of relations of subjects of training in all paradigmatic variations of interaction with the help of SMART-technologies: “teacher – student”, “teacher – students”, “student – student”, “student – students”, “student – schoolchild”, “student – schoolchildren”, “student – student”, we have developed a methodology of forming the future natural sciences teachers readiness to use SMART-technologies in professional activities.

The proposed methodology involves a combination of the process of future teachers’ general and professional competencies formation through the use of SMART-technologies in the teaching of disciplines (skills are formed by imitation) and purposeful activities to train future natural sciences teachers to use SMART-technologies in professional activities. Herewith, students have an opportunity to study disciplines using electronic materials, watch lectures online or offline, sit tests, participate in telecommunication projects, share experience, improve their professional

level, spend more time for scientific experiments, save time, etc. They can do everything independently or using the technology of “flipped learning”.

The basis of the methodology of forming the future natural sciences teachers readiness to use SMART-technologies in professional activities is the subject “Methods of Biology teaching”, the structure of which includes the study of a special module (30 academic hours) on SMART-technologies. It comprises 4 academic hours of lectures and 8 academic hours of practical classes, as well as 18 academic hours of independent work. In particular:

Lecture №1. SMART-technologies and and their main possibilities in preparation for a Biology lesson. LEARNING APPS: features, functions, advantages and disadvantages.

The objective of the class: to get acquainted with the world experience of using SMART-technologies and the current state of their development in Ukraine; to identify the main possibilities of using information technologies in education; to provide a characteristic of the LEARNING APPS Internet resource, to single out its main functions and didactic possibilities.

Lecture №2. Modern possibilities of mobile application. The use of video-content in the pedagogical activities of a teacher. YouTube as a modern video hosting.

The objective of the class: to get acquainted with the concept of mobile learning; to determine the role of mobile applications in preparing and conducting a Biology lesson; to single out the kinds of video content in pedagogical activities and platforms for their application.

Now we would like to present description of the methods of conducting practical classes.

Practical class №1.

Topic: Mobile application as a part of modern Biology lesson.

Objective: to consolidate students’ knowledge of the use of mobile applications at Biology lessons; to make actual the basic principles of working with a mobile application; to conduct a lesson on the use of mobile learning; lesson analysis. The following *issues* should be considered: peculiarities of the use of mobile applications at Biology lessons; basic features of digital communication; platforms for working with mobile applications.

Students are given the following *tasks for classroom independent work*: presentation of a mobile application for work at a Biology lesson, the main educational possibilities, advantages and disadvantages of the work; compiling of the table arranging columns; mobile application, advantages and disadvantages of use, forms of work.

Tasks for out-of-class work: to prepare a lesson plan on the topic “The structure of modern ecology and its place in the system of sciences” using four exercises from the LEARNING APPS Internet resource at different stages of the lesson; compile and fill in the table (using 5 templates from the LEARNING APPS program) by columns: the name of the template, instructions for creating the exercise, form of work, example of use.

Practical class №2.

Topic: LEARNING APPS Internet resource in future natural sciences teacher preparation to the lesson.

Objective: to consolidate students’ knowledge on creating tasks for Biology lessons on the LEARNING APPS online platform; to get acquainted with various templates and additional functions of the resource; to conduct a lesson using SMART-technologies; to carry out analysis and self-analysis of the lesson. The following *issues* should be considered: main possibilities and functions of the LEARNING APPS Internet resource; types of exercises on the platform, their didactic possibilities; checking of out-of-class work from the previous lesson.

Students are given the following *tasks for classroom independent work*: conducting a lesson on the topic “The structure of modern ecology and its place in the system of sciences” using four exercises from the LEARNING APPS Internet resource at different stages of the lesson; to carry out self-analysis of the lesson; advantages and disadvantages of the lesson; group analysis of the lesson.

Tasks for out-of-class work: to prepare a lesson plan on the topic “Populations and their characteristics”; to create accounts for schoolchildren before the lesson using the LEARNING APPS platform and check their readiness to use them at a Biology lesson; to create four different tasks in the Internet resource for doing exercises independently and send them to schoolchildren’s personal accounts; to write down advantages and disadvantages of using the LEARNING APPS Internet resource in preparation for a Biology lesson.

Practical class №3.

Topic: Main functional potentialities of LEARNING APPS. Peculiarities of creating one's own class in the Internet resource.

Objective: to consolidate students' knowledge on creating tasks for Biology lessons on the LEARNING APPS online platform; technology of creating work accounts for schoolchildren; development of classroom management skills, statistics and general information; conducting a lesson using SMART-technologies; to carry out analysis and self-analysis of the lesson.

The following *issues* should be considered: basic requirements for creating exercises at the stages of generalization of material and systematization of knowledge using the LEARNING APPS platform; technology and instructions for creating one's own class, accounts for it and statistics; checking students' out-of-class work from the previous lesson.

Students are given the following *tasks for classroom independent work*: conducting a lesson on the topic "Populations and their characteristics"; analysis of the fulfilled tasks, their characteristics, didactic possibilities, feasibility of using; to carry out self-analysis of the lesson; advantages and disadvantages of the lesson; group analysis of the lesson.

Tasks for out-of-class work: to prepare a lesson plan on the topic "Biogeocenosis and its structure"; to prepare video content on the topic before the lesson; to create two new tasks in the LEARNING APPS Internet resource; to send assignments to the schoolchildren's accounts; to choose tasks on the ecological subject on this topic using a mobile application; to carry out a written analysis of the "Statistics" function; to describe the technology of using this application, the main features and advantages; provide a photo of the statistics from the previous lesson.

Practical class №4.

Topic: SMART-technologies as a future teacher assistant in preparation to Biology lessons.

Objective: to consolidate students' knowledge on the use of SMART-technologies in the future teacher's professional activities; to compare information technologies; to develop a modern lesson with an approach to working with SMART tools; to analyze the work and to carry out self-analysis of the results; to conduct questionnaires and testing to identify the formed students' knowledge.

The following *issues* should be considered: checking students' out-of-class work from the previous lesson; to carry out the comparative analysis of SMART-technologies.

Students are given the following *tasks for classroom independent work*:

conducting a lesson on the topic "Biogeocenosis and its structure"; to carry out self-analysis of the lesson; advantages and disadvantages of the lesson; group analysis of the lesson.

Tasks for out-of-class work: responding to a questionnaire with the aim to find out the effectiveness and feasibility of using SMART-technologies in preparation for Biology lessons; passing tests to identify the formed knowledge, skills and abilities in the use of SMART-complex and mastering the studied material.

With the aim of consolidation the acquired knowledge the students did corresponding independent work, developed lesson plans, created their own exercises in the LEARNING APPS Internet resource, reviewed the learning opportunities of mobile applications, carried out analysis and self-analysis of the work and created their own video lessons to implement them in video hosting for distribution and use in own educational practice.

The topic "Creating your own video lesson" was given to students for independent study. The aim of this activity was: to consolidate knowledge on creating one's own content; master the work with modern technologies; to form students' ability to create independently their own scientific material; to check the level of skills mastering acquired during the study of the module.

There were several requirements how to perform the task: a fragment of the lesson should be at least 8 minutes; the tasks from the LEARNING APPS Internet platform should be used during the lesson; a part of any stage of the lesson should be conducted; the theoretical material of the video must correspond to reality; the video can be used as part of a lesson; there should be creative and problematic tasks. Examples of some programs for video editing were given: inSchot. Sony Vegas Pro 15.0, Sony Vegas Pinacle. KineMaster, Movavi, Film Marcer, etc.

Questionnaires and tests were created to find out the effectiveness of the SMART-complex and the formation of key competencies in the use of information technologies.

Example of a questionnaire for students

– In your opinion, how effective is the use of SMART-technologies at biology lessons? For answers choose numbers from 1 to 5.

– How convenient and understandable was it for you to use a variety of technologies in preparation for biology lessons? For answers choose numbers from 1 to 5.

– During which type of lesson (acquisition of new knowledge, abilities and skills formation, reviewing and consolidation of knowledge, generalization, testing and correction of knowledge, combined) is the use of SMART-complex (LEARNING APPS, mobile application, YOU TUBE and other video hosting) the most efficient? Place numbers from 1 to 6, where 1 is the most efficient and 6 is the least.

– Have you been acquainted with SMART-technologies before? (Yes/No)

– In your opinion, what is more universal when preparing for a lesson? For answers choose numbers from 1 to 3, where 1 is the most universal, 3 is the least universal.

LEARNING APPS –; mobile application –; YOU TUBE and other video hosting –.

– How convenient is it to work using LEARNING APPS function “My Classes”? For answers choose numbers from 1 to 5.

– In your opinion, what stage of the lesson (actualization of basic knowledge and life experience of students, motivation of learning activities, learning new material, generalization and systematization of knowledge, lesson results, home task) is the most appropriate for the use of different technologies (LEARNING APPS, mobile application, YOU TUBE and other video hosting)? For answers choose numbers from 1 to 6, where 1 is the most appropriate, 6 is the least appropriate.

Examples of the tasks for testing students

Special blocks of theoretical questions on the studied material were developed to test students in order to check the level of competencies formation.

In general, the test includes 20 open-ended questions, which are divided into four blocks. Each question is evaluated from 1 to 5 points. In total, each student can get 100 points for the answers. We have developed special criteria for evaluating responses:

1 point – acquisition of theoretical knowledge is very poor, no completeness of the answer, no examples;

2 points – acquisition of theoretical knowledge is very poor, the answer is structured and logical, the student gives basic examples;

3 points – acquisition of theoretical knowledge is at the middle-level, the answer is structured and logical, the student gives examples based on his own experience of the work with information technologies;

4 points – acquisition of theoretical knowledge is at the sufficient level; the answer is clear, structured and logical; the student gives examples based on his own pedagogical activity and personal developments, the student analyses and makes conclusions;

5 points – acquisition of theoretical knowledge is at the high level; the answer is structured, logical and reliable; the student is able to answer problematic questions and finds ways to solve them; gives specific examples of the use of information technologies, which he used in preparation for the lessons; critical thinking, analysis and conclusions.

Block 1. Mobile application as a part of contemporary Biology lesson.

Characterize mobile applications and their role in the teacher's pedagogical activity.

M-learning: for/against.

Give specific examples of mobile applications and topics of lessons where they can be used?

Is it appropriate to use mobile applications during distance work with schoolchildren? In what forms of work do you think M-learning is most effective?

Block 2. LEARNING APPS Internet resource in preparation of the future natural sciences *teacher to the lesson.*

Name the main advantages and disadvantages of working with the LEARNING APPS Internet resource.

Characterize the main designation of the LEARNING APPS platform at Biology lessons.

Present a complete description of the list of LEARNING APPS templates. Create categories by which you could categorize the exercises and single out a series of highly versatile exercises.

In your opinion, is it possible to combine mobile learning with the technology of the LEARNING APPS platform?

Block 3. Main features of LEARNING APPS. Peculiarities of creating one's own class in the Internet resource.

Present a complete description of the main features of LEARNING APPS.

Describe instructions for creating one's own class using the additional function of the LEARNING APPS platform.

Statistics as an assistant in pedagogical work of the future teacher! Do you agree with this statement? Justify and give examples.

Conduct a comparative analysis of the use of the LEARNING APPS Internet resource and different types of mobile applications at Biology lessons.

Block 4. SMART-technologies as the future teacher's assistant in preparation for Biology lessons.

Significance of *SMART*-technologies in preparation and conducting Biology lessons.

Contemporary video hosting as a part of the educational process! Do you think that video training will become a part of the teacher's work in the future?

Advantages and disadvantages of using video training and video platform in the work of a Biology teacher.

Develop clear requirements for the creation of video content for educational purposes to conduct Biology lessons.

The data objectivity obtained during the forming experiment is ensured by the special conditions of its conducting:

38 students majoring in specialty 014 Secondary education (Biology and human health. Chemistry) took part in the pedagogical experiment.

The best possible acquisition of theoretical knowledge in natural sciences by the students (concepts, laws, regularities, their use in preparation for the lessons).

Sufficient level of modern information technologies mastering (PC, Internet, mobile applications, etc.).

Development of the author's program of mastering SMART-technologies (lectures, practical classes, independent work, literature, tests and questionnaires), which increases the reliability of the obtained results.

Students were assessed in accordance with the course plan "Methods of Biology teaching".

The criteria for identifying the level of students' abilities and skills formation to use the SMART-complex have been developed.

The scheme of students' knowledge and skills analysis during the pedagogical experiment:

Identifying the initial state of students' abilities and skills level.

Identifying the level of students' intellectual abilities and learning outcomes formation through observation, work analysis, assessing the students' readiness for practical classes, mastering the theoretical basis, passing special tests and questionnaires.

Identifying the change in the level of students' readiness to use SMART-technologies in teaching

Confirmation of the effectiveness of the SMART-technologies use at biology lessons using methods of statistical processing.

At the beginning of the pedagogical experiment we determined the level of students' understanding of the concept of "SMART-education" and their understanding of the role of information technology in pedagogical activities. The students were offered to answer the question "Have you heard of SMART-technologies before working with them?" Analysis of the results proved that 63 % of the respondents (24 students) were partially familiar with SMART-education technologies before and 37 % (14 students) began to use and got acquainted with them for the first time during experimental training.

During the pedagogical experiment students were taught according to the experimental methodology of forming the future natural sciences teachers' readiness to use SMART-technologies. Students were taught how to use an interactive whiteboard SMART Board and its various functions. Special exercises were developed using the LEARNING APPS Internet resource in preparation for lessons and then they were used during all the stages of the lesson. Students downloaded different mobile applications at various world software platforms and added parts of mobile teaching to the lesson plans, applying and testing the effectiveness at different stages of the lessons. Future natural sciences teachers performed tasks of independent work, where they created their own video lessons and considered the main possibilities of modern video hosting and its role in the educational process currently and prospects for the future. Performing tasks and during the preparation for lessons as well as during

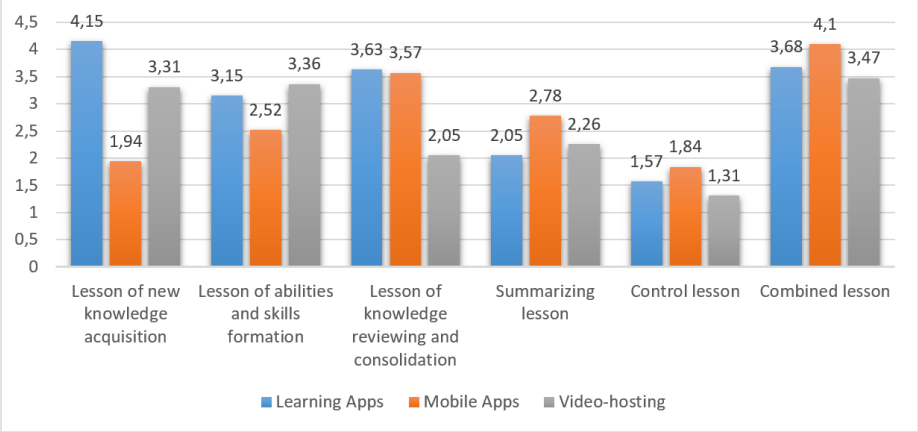
teaching practice students developed their own lesson plans, did author's tasks on the LEARNING APPS platform, introduced mobile learning technology in educational activities, recorded videos, passed tests, performed independent work, for which they received a certain number of points. Students' learning outcomes were assessed according to the criteria of the corresponding course, and the formation of intellectual skills according to three levels (middle, sufficient and high).

The use of SMART-technologies during the development of lesson plans contributed to increasing of students' activity and motivation to work, interest in teaching activities became noticeable and the level of preparation for lessons and works in writing changed. Students learned to use a SMART Board, create their own accounts in the LEARNING APPS Internet resource, author's exercises on this platform, personal video lessons, learned to use various video editing programs, improved personal skills of lesson planning and analyzed the effectiveness of information technologies use.

After the completing the training according to the experimental methodology, the students were offered to determine the most effective information technology in terms of its implementation in teaching. To do this, they were asked to determine the most effective technology considering their own experience by ranking them from 1 to 3. The results of the study showed that 41.3 % of the surveyed students chose the use of tasks from the LEARNING APPS Internet resource at Biology lessons as the most effective technology. Various video lessons as an effective tool in teaching were chosen by 35.5 % of future teachers. The third place was given to the technology of mobile teaching in the pedagogical activities. 23.3 % of students (future natural sciences teachers) chose this technology.

In the process of preparation for the lesson, modeling its plan, it is important to understand for what type of lesson you need to use SMART-technology. The students were offered to choose the most optimal type of lesson for each information technology. Future natural sciences teachers had to rate from 1 to 6 how it is effective the use of a particular technology at different types of lessons. Obtained results were presented in the table and the arithmetic mean of the index was defined (Fig. 1).

Figure 1: Efficiency of the SMART-complex use at the lessons of different types

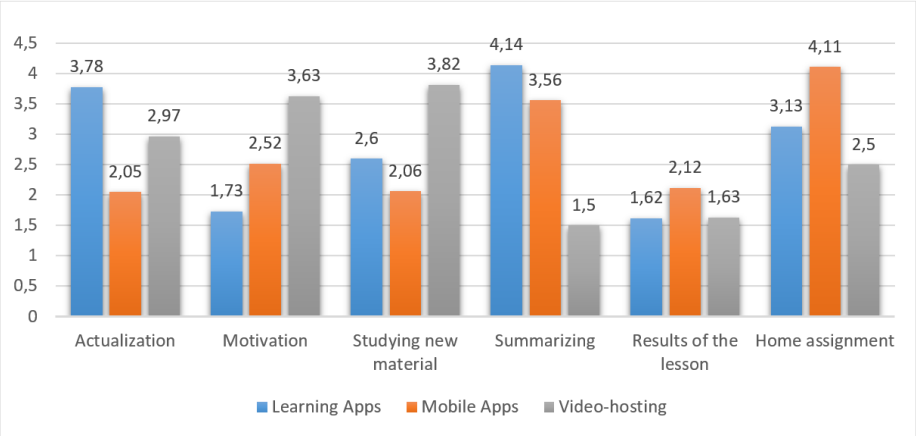


Source: The authors

We found that the technology of using the LEARNING APPS Internet resource was the most effective when it was used at the lessons of new knowledge acquisition. Students' response mean was 4.15. The least effective was the use of this information platform at the control lesson (1.57). Students recommend using of mobile learning at the combined lesson (4.10). The least effective and appropriate was the use of mobile applications at control lessons (1.84). The use of video materials at Biology lessons was the most effective during the combined lesson (3.47) and at the lesson of abilities and skills formation (3.36). Video hosting was less used at the control Biology lessons (1.31).

In the process of preparation for the lesson, it is important for the teacher to plan his work in the best possible way and divide the lesson into its stages most efficiently. Future teachers were offered to prioritize from 1 to 6 choosing the most effective stage of the lesson for the use of the SMART-complex technology. All the answers were presented in the table and the priority ranking mean was defined. These results are given in Fig. 2.

Figure 2: Efficiency of the SMART-complex use at different stages of a lesson



Source: The authors

At determination the efficiency of the LEARNING APPS Internet platform use at Biology lessons it was found that the most optimal use of technology was at the stage of summarizing of students' knowledge (response mean is 4.1) and the lowest mean of technology choice was given to the stage results of the lesson (1.57). The use of mobile applications by future specialists at Biology lessons is recommended and has the highest rate during the stage of home assignment and independent work of schoolchildren (4.15).

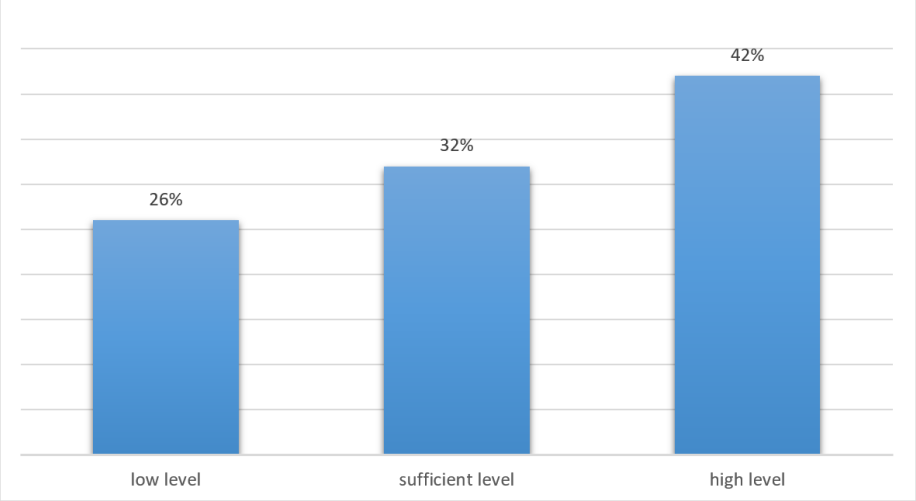
The work with the mobile learning technology is not effective at the stage of knowledge actualization and studying new material with the same response coefficient of 2.05. During the preparation of a lesson plan, the use of video-learning was noticed at the stage of studying new material and schoolchildren's knowledge, skills and abilities formation with the index of 3.73. The least use of video-hosting was observed at the stages of summarizing (1.52) and results of the lesson (1.68).

To determine the level of students' readiness to use SMART-technologies, we have developed the following *criteria*: *motivational-value* (awareness of the importance of mastering the theoretical foundations of information technology and prospects for their development, highlighting the main benefits of mobile learning in natural sciences teacher work, understanding the role and prospects of modern video-hosting use in pedagogical activities and self-education), *cognitive* (understanding: the

place of SMART-technologies in the educational process and methodology of their use in preparation for biology lessons; functional possibilities of electronic-interactive whiteboard for teachers at biology lessons), *activity-constructive* (creation of one's own account on the LEARNING APPS Internet platform, understanding and optimal mastery of all the functions of the Internet resource, the ability to create quality author's programs and technology of the own class with statistics to it in LEARNING APPS, the use of various platforms for downloading mobile applications, mastery of the methods of conducting a lesson using video materials and creating one's own fragment of the video lesson), *reflexive and evaluative* (the ability to analyze, draw conclusions, observe, compare and analyze the fulfilled work).

Having analyzed the level of future teachers' readiness to use SMART-technologies after the pedagogical experiment, we drew a conclusion that 26.3% of students showed a low level, 31.5% of students showed a middle level, and 42.2% of students showed a high level (Fig. 3).

Figure 3: Formed readiness of future Biology teachers to SMART technologies use



Source: The authors

In the process of developing the issue of substantiating the pedagogical conditions for the effective functioning of the proposed methodology (the second stage of the formative experiment), we considered our research, which proved that the relevant conditions should be understood as «the complex of motivational, content, didactic, managerial and technological resources and initial principles, creation and realization of which will contribute to the improvement of the process of future

specialists training» [15, p.186]. We interpret SMART-technologies as an element of information and learning environment (ILE). Therefore, we think that it is possible and reasonable to study the issue in a much broader context, namely the effective functioning of ILE.

We conducted a survey of both students and research and teaching staff with the aim to identify the pedagogical conditions for the effective functioning of ILE in higher education institutions. Students' answers to the question «Do you know the themes for your individual work?» proved that out of 440 respondents they are familiar to 35.5%, 45.5% are partially acquainted with them, and for 19.1% they are unknown. The quality of methodological support developed by teachers for independent work was rated by 438 students. Out of them 50.9% consider it to be excellent, 17.6% think that it is good, 22.8% consider it to be satisfactory, and 8.7% as unsatisfactory. The level of equipment of the classrooms with necessary tools for independent work was rated by 437 students. 20.8% of them evaluated it as excellent, 46.7 as good, 22.7% as satisfactory, and 9.8% as unsatisfactory. Herewith, out of 432 respondents, 12.7% do their independent work in the library, 18.1% in the classroom, 4.6% in the Internet cafe, 90.3% at home, 1.4% in the dormitory.

Results of the conducted questionnaire proved, that the readiness of electronic courses to ensure independent work, out of 432 students 9.3% evaluated as excellent, 48.1% as good, 25.5% as satisfactory, and 9.3% as unsatisfactory. Herewith, 36.8% of respondents give preference to printed resources and 63.2% prefer electronic resources. Search service Internet networks for independent work are often used by 86.5% of respondents, 11.6% use them sometimes, 1.9% of respondents use them rarely (430 answers).

Answering the question «How do you assess the level of readiness of the university for the introduction of distance learning?», out of 434 respondents, 34.3% consider it to be high, 52.3% – medium, and 13.4% – low. Out of 431 respondents, 50.6% have a positive attitude to distance learning, 29.7% – neutral, and 19.7% – negative. Herewith, 29.9% rated their readiness for distance learning (432 responses) as high, 56.3% as medium, and 13.9% as low. There are the following things that hinder the introduction of distance learning at the university: unsatisfactory state of the IT structure in the university (19.0%), teachers' non-readiness to work remotely (online) (44.4%), students' non-readiness to work

remotely (online) (39.8%), insufficient number of educational resources (46.9%), low quality methodological support (29.4%) (405 responses).

The results of teachers' survey showed that they use the following services for online classes: Google Meet (42.4%), BigBlueButton (16.9%), Zoom (79.7%), Viber (1.7%) (59 respondents). Herewith, 49.2% of teachers use the Moodle mobile application during their work with the electronic server, and 50.8% do not use it.

Answering the question «What digital tools do you use when conducting online classes?» 317 teachers said as follows: Google documents – 62.1%, Google questionnaires – 17.4%, Interactive whiteboards – 15.5%, presentations – 91.2%. According to the teachers, the use of such tools ensures the effective functioning of the ILE in higher education institutions. The level of use of educational resources of the electronic course server (Moodle) by students (160 respondents) was assessed as high by 43.8% of them, satisfactory – 49.4%, unsatisfactory – 6.8%.

The conducted analysis of the information support of the educational process shows that teachers, first of all, use educational and methodological complexes of disciplines in electronic format (text files, presentation files for lectures, methodological recommendations for practical and laboratory work, and independent work of students). Students are often offered electronic textbooks, but as the analysis of their format and content shows they are, in the main, electronic analogue of printed editions (mostly *pdf format), though they can be found on the web sites of departments, cloud storages, university repositories and they are placed there as electronic textbooks. Conversations with teachers prove that quite often users refer to digitized versions of paper books as electronic textbooks. Such attitude cannot be regarded as correct, since electronic textbook is not only an ordinary text that is given in a definite succession, but also additional determinants (for example, hypertext links), which are not common for a paper textbook.

Thus, the analysis of the practice of organization and support of the educational process in the training of students, normative requirements, scientific sources referring the outlined problem and our own pedagogical experience allowed us to single out such interconnected pedagogical conditions of the effective functioning of the ILE; existence of vividly structured system of information and learning environment as the subject of the educational interaction with taking into consideration its hierarchical links to other components of the educational process in higher education institutions;

purposeful raining of students for the fluent operation of information and communication tools; improvement of the IT competence of research and teaching staff in the implementation of teaching methods based on modern information and computer technologies.

We will reveal the essence of the identified pedagogical conditions for the formation of an effective ILE in higher education institutions, which are also relevant to our proposed methodology of future natural sciences teachers training to use SMART-technologies in their professional activity.

The first pedagogical condition is the existence of vividly structured system of information and learning environment as the subject of the educational interaction with taking into consideration its hierarchical links to other components of the educational process in higher education institutions. We will consider it on the example of the structure of the ILE of distance (online) learning in TNPU.

Its IT infrastructure includes modern hardware and software, including computer classrooms, digital laboratories, high-speed Internet connection, Wi-Fi, developed ILE, etc. The central component of the ILE s Moodle learning management system. Today the functions of Moodle are not limited only by providing access to electronic versions of our courses to the students. It is an e-learning portal of full value that combines administrative resources such as an information portal, a service for assessment the quality of training and educational programs, a service for free choice of disciplines, resources for final certification and conducting entrance examinations in the foreign language to the master's study program.

Integration with online communication services ensures transparent creation and joining the planned online events. The backup service ensures the preservation of data of the previous day, which allows, in case of unpredicted situations, resume the work quickly. Services that are deployed in the domain elr.tnpu.edu.ua are fully under the control of the university and the centre of distance learning, and the external services, which are being used, only provide flexibility and new opportunities in the implementation of electronic (distance) learning. The basis of the educational environment is the LCM Moodle educational resource management system with installed additional modules for integration at the system level of services for conducting online meetings, in particular Google Meet, Zoom, BigBlueButton.

The second pedagogical condition is a purposeful training of students for the fluent operation of information and communication tools. It is realized by developing and implementing student's individual educational trajectory, taking into account the study of mandatory and elective educational components. The purpose of their including in the curriculum is the formation of IT competence. In addition, a combination of formal, non-formal and informal education is desirable.

Taking into consideration activity of students in the network environment, in particular, in social networks and the use of various servers of Internet resources, it can be stated that students are ready to use information and communication technologies. This conclusion is confirmed by the results of a survey of students regarding their readiness for online learning.

Since I and II conditions have been more or less formed in modern higher education institutions, we will focus more on the details of implementation of the *III pedagogical condition* for the effective functioning of the ILE in higher education institutions. Namely: improvement of IT competence of research and teaching staff in the implementation of teaching methods based on modern information and computer technologies. For this purpose, we have developed a methodological system for improving the IT competence of research and teaching staff.

Conducted analysis of literature sources and practical work of modern higher education institutions proved that teachers can improve their qualification according to this direction in formal, non-formal and informal education. For example, attending trainings, workshops, webinars, interactive courses, engaging in self-education (active independent research and study of Internet resources, participation in conferences, preparation of scientific papers, etc.). However, scientists believe that the IT competence of a teacher as his basic competence evolves most effectively in the process of developing and implementing a holistic model of further training while studying modern information and communication technologies and digital technologies in order to use them in the organization of the educational process (planning, didactic tools, knowledge control and diagnostics of the levels of formation of information and communication technologies of those who study). This incited us to develop the methodological system for improving of the IT competence of research and teaching staff.

The following approaches are considered to be dominant in its construction: holistic, competence-futurological, andragogical and narrative-digital. The basis of competence-futurological approach constitutes the idea of the expediency of methodological system modelling based on the combination of key competences of the 21st century «4 C» (critical thinking, creativity, collaboration, communication) with digital competence and the ability to predict the possibilities of developing a modern learning environment in the future. The necessity of this very approach is caused by the entry of modern life into the so-called «regime with exacerbations» that demands projecting all the components of the model taking into consideration possible specificness of their modification in the future educational process according to the probable needs of professional activity.

Andragogical approach to methodological system modelling emphasizes that it is based on the andragogical principles of learning: independent learning priority; cooperative activity principle; the principle of relying on life experience; individualization of education; systematic learning; contextuality of learning; the principle of updating learning results; the principle of elective education; the principle of development of educational needs; the principle of reflectivity.

Narrative-digital approach makes it possible to apply digital narratives in the methodological system which represent integrated combination of the narrative (narration) and information and communication technologies. Development and use of digital narratives in the practice of teachers' professional activity takes an important place in the realization of this approach.

In the research we heeded the necessity to follow the most important methodological principles of cognition, namely holistic and systematic approach to the object of study. They demand to consider the problem not in isolation, but in the context of realization of the holistic educational process in modern higher education institutions. That is why we checked the possibility of the realization of the defined third condition through the development and implementation of the methodological system for improving the IT competence of research and teaching staff . It consists of goal-oriented, operational and content, activity-reflective and result-oriented components. Its system creative factor is the aim to increase the quality of mutually coordinated functioning of the subjects of educational activity. The basis of the methodological system is the introduction of a scientific and methodological seminar on the topic «The

Use of Activity Components and Online Communications of The Moodle System», which is considered an element of non-formal education of teachers. The final result is further training of research and teaching staff from different fields of knowledge on the plane of studying modern information and computer technologies in order to be able to use them in their professional activity.

Based on the theoretical analysis of the essence of the problem, the educational needs of students and teachers, we identified eight topics, the study of which should be included in the cognitive component of the suggested system, namely:

Conducting online training events. The use of LCM Moodle modules to ensure online teaching.

Didactic options of the module «Tasks» LCM Moodle.

Test control of knowledge by Moodle platform tools (Resource Test).

Digital tools for communication during the distance learning process (interactive online boards, Google documents, platforms for conducting online classes: Google Meet, Zoom, BigBlueButton).

Recording and publication of video lectures. Tools for editing video lectures. Converting of presentations into video lectures.

LCM Moodle game tools for organizing students' learning activities.

Digital tools for feedback during distance learning. Tools to conduct students questioning. Module Moodle Feedback.

Tools for interactive, adaptive teaching LCM Moodle.

To assess the quality of the proposed training classes, an integrated criterion of «didactic quality» was used, which was determined by the method of expert assessments. Indicators, according to which the main topics of classes had to be assessed, were agreed with this group of experts. As a result of collective discussion, the «weight» of each of the six selected indicators was determined. The results are presented in Table 1.

Table 1: The weight of indicators of the didactic quality of classes

№	Indicators	K
1	Possibility to reveal and apply the effective information and learning environment in higher education institutions based on the existing material and technical support	10
2	Significance for the holistic educational process organization	25
3	Significance for the organization of interactive pedagogical interaction of participants in the educational process	25

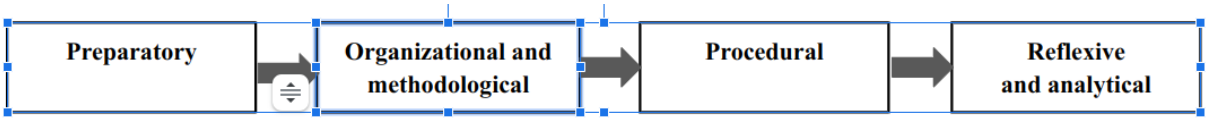
4	Accessibility for perception	10
5	Expediency to use during future teachers professional training	20
6	Correspondence to the life experience of research and teaching staff and students	10

Source: The authors

The results of the expert assessment convincingly showed the possibility and expediency of including the suggested methodological system of the constructed content of training classes in the cognitive component. According to the experts, they are available on the whole, for perception by research and teaching staff and are important for improving the quality of their IT competence.

We will characterize the stages of the experimental implementation of the methodological system for the IT competence of research and teaching staff of higher education institutions: preparatory, organizational and methodological, procedural, reflexive and analytical (Figure 4).

Figure 4: Stages of the implementation of methodological system



Source: The authors

Preparatory stage involves studying the needs of the subjects of educational interaction (students, teachers, the network subject of the educational process) in relation to the (ensuring) of the effective functioning of the ILE by means of questionnaires and analysis of educational information products (electronic courses). For ensuring the revealed needs we concentrated on the detection of the effective tool for improving the IT competence of research and teaching staff. Research criterion apparatus was also defined.

Organizational and methodological stage involved defining priorities in educational activity and conducting organizational actions on studying the suggested course as a means of continuing education for the formation of IT competence of research and teaching staff.

Procedural stage involved conducting an online scientific and methodological seminar with teachers of higher education institutions. In order to study the content of

classes independently, practice practical skills, video recordings of all classes were disposed at the bank of video lectures.

Reflexive and analytical stage of our research involved the analysis of the results of experimental training in terms of objective (number of developed electronic courses, level of course content, activity of use – working time in Moodle) and subjective (diversity of used platforms, types and kinds of tasks, self-analysis of the level of readiness to conduct distance learning by the research and teaching staff, analysis of the level of teachers' readiness to organize distance learning by students) indicators.

Comparative analysis of the results of introduction of the suggested methodological system for improving the IT competence of research and teaching staff of higher education institutions according to the determined objective and subjective indicators convincingly proves its effectiveness. So, as of December 2019 (before experimental training), 2085 electronic courses were developed in all and after the completion of the experimental work there became 2889 electronic courses, that is, the number increased by 804. The number of active courses increased by 126. Their number was 1322 before the experiment and after the experimental training their number increased to 1567.

In general, the teachers noted the following difficulties and shortcomings that arose during the experimental activity: technical ones, related to the unstable Internet connection; weak technical equipment of students with means of communication, which reproduces their video presence and reduces the level of communication; electricity cuts, technical problems during online classes; the study of certain topics referring the teaching methods of disciplines is not effective in the conditions of distance learning; lack of strong personal motivation among students, insufficient level of knowledge to prepare presentations for students; it is difficult to establish feedback with students during discussions, the teacher's interference into the process of performing laboratory work is limited or impossible, etc.

The results of checking the efficiency of the suggested methodological system for the improving of the IT competence of research and teaching staff according to subjective indicators are shown in Table 2.

Table 2: The level of the subjects of educational activity readiness for distance learning before (I examination) and after (II examination) of the forming experiment (160 respondents)

	Indicators/Level of readiness	**I diagnostic examination (%)**			**II diagnostic examination (%)**		
		I	**II**	**III**	**I**	**II**	**III**
1.	Level of teachers' readiness to conduct distance learning (self-analysis)	49,4	40,4	10,2	51,9	44,4	3,7
2	Level of students' readiness for distance learning (students' assessment)	20,2	65,5	14,3	24,4	70	5,6
3.	Level of students' activity during online classes	20,0	67,7	11,3	22,5	70	7,5
4.	Level of use of educational resources at the electronic course server (Moodle) by students	36,6	35,2	28,2	43,8	49,4	6,8

Source: The authors

Data from Table 2 demonstrate that the teachers assessed the level of their readiness to distance learning after the conducting of forming experiment much higher. Thus, the number of respondents with a high level of readiness increased by 2.5%, and those with a satisfactory level by 4.0%. The number of teachers who assessed their level of readiness as low decreased by 6.5%.

The fact that students assess the level of teachers' readiness to distance learning much lower than the teachers themselves turned to be rather interesting. The contrast between the levels of readiness, obtained on the basis of teachers' self-analysis and students' assessment is the following during the first examination: for the I level – 29.2%, for the II + 25.1% and for the III level + 1.9%. During the second examination the contrast is as follows: for the I level – 27.5%, for the II + 26.5% and for the III level + 1.9%. However, the tendency to improve the level of teachers' readiness to conduct distance learning according to students' assessment is maintained. Thus, the number of respondents who assessed the teachers' readiness at a high level increased by 2.2%, and at a satisfactory level by 4.5%. The number of teachers whose level of readiness was assessed by students as low decreased by as much as 8.7%.

The indicator of the level of students' activity during online classes has also increased: high by 2.5%; satisfactory by 2.3%. The low level decreased by 3.8%. The introduction of the suggested methodological system for the improving teachers' IT competence was also reflected on the level of educational resources of the electronic course server (Moodle) use by the students. Thus, the number of students who are on the low level decreased by 21.4%, and those on the high and satisfactory levels increased accordingly by 17.2% and 14.4%.

The given results allow to come to the conclusion about the efficiency of the suggested methodological system for the improving teachers' IT competence, in particular, and the expediency of constructing ILE in higher education institution taking into consideration singled out pedagogical conditions, in general.

CONCLUSIONS AND PROSPECTS FOR FURTHER RESEARCH

Summing up the results of the conducted pedagogical experiment, we can conclude that the obtained data demonstrate the place of SMART-technologies in the pedagogical activity of the future teacher. Peculiarities of their application in the educational process are related to the object of study (cognition) at school. In our study it is integral systems of wildlife in their hierarchical relationships and interdependencies, as well as the necessity to form emotional and value attitude to the world of nature on the basis of bioethics.

In the course of future teachers training it is expedient to combine the process students' general and professional competencies formation through the use of SMART-technologies by teachers while teaching disciplines (in this case skills are formed by imitation) and special training of future teachers to use SMART-technologies in professional activities. Herewith, students have an opportunity to study disciplines using electronic materials, watch lectures online or offline, sit tests, participate in telecommunication projects, share experience, improve their professional level, spend more time for scientific experiments, save time, etc. They can do everything independently or using the technology of "flipped learning".

We have found that the technology of using the LEARNING APPS Internet resource is most effective when used at the lessons of new knowledge acquisition. M-learning and video materials are recommended to use at the combined lessons. The least effective and appropriate was the use of mobile applications at control lessons. In general, the use of SMART-technologies in the educational process of future

teachers training, the formation of students' readiness to use them in professional activities increases the level of learning new material (it becomes more accessible and diverse), promotes increasing of interest and activity, the level of motivation to learning and forms cognitive interest to the learning process (cognition).

Implementation of the proposed methodology of future natural sciences teachers training to use SMART-technologies, taking into consideration the complex of pedagogical conditions, singled out in the study, allows us to activate parity subject-subject interaction of the educational process participants (students, lecturers) with modern information technologies, social networks, and Internet services. This leads to a cardinal change in the conduct and relations of participants in the educational process.

The mechanism of implementation of the pedagogical conditions is represented by the methodological system for improving the IT competence of research and teaching staff of higher education institutions. Its application allows ensuring of more effective mutually coordinated functioning of the subjects of educational activity within a holistic system of a higher education institution.

It has been established that to assess the content quality of the methodological system it is appropriate to use the «didactic quality» criterion according to the following indicators: possibility to reveal and apply the effective information and learning environment in higher education institutions based on the existing material and technical support; significance for the holistic educational process organization; significance for the organization of interactive pedagogical interaction of participants in the educational process; accessibility for perception; expediency to use during future teachers professional training; correspondence to the life experience of research and teaching staff and students. To assess the quality of teachers' IT competence formation within non-formal education it is appropriate to use subjective and objective indicators.

Organization of the educational process within non-formal education for the formation and improvement of teachers' IT competence allows improving the level of its formation considerably and increasing the quality of mutually coordinated functioning of the subjects of educational activity.

The synergy of the defined pedagogical conditions provides new opportunities for improving the quality of education, while ensuring the optimal pace of students work, the depth of content learning, and an adequate level of competence acquisition.

Widespread use of SMART-technologies in the process of future teachers' professional training will provide an opportunity to lay the foundation for successful professional activities and future career of higher education students.

The prospects for further study consist in finding the opportunities for the use of SMART-technologies in the formation of dichotomous, critical thinking of both students and schoolchildren, the formation of a holistic scientific worldview of students.

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