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Formation of the Creativity of Students in the Context of the Education Informatization

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ABSTRACT

Information and communication technologies are an effective means of formation of the creative potential of future physics teachers, as with their science-based application in the educational process at the university they allow fully activating learning activities of students, provide conditions for their creative self-realization in the process of professional development. The article examines the scientific and methodological basis for the use of computer models, experiments and demonstrations, as well as virtual laboratory complexes in the formation of creative thinking of the future physics teachers. It is well known that the use of computer models of various physical processes and phenomena contributes to the effectiveness of students learning the physics course, allows them to comprehend the mechanisms of physical phenomena and processes. In this regard nowadays the International Kazakh-Turkish University named after Yasawi K. A. pays great attention to the development of the technical base of information and telecommunication technologies in training of future physics teachers, and electronic resources for using them in teaching physics are being developed. Using computer models, experiments and demonstrations, one can compensate for the lack of equipment in the physical laboratory, and thus teach students to independently produce physical knowledge in the course of physical experiments involving virtual models, i.e. there is a real possibility of the formation of students' creative thinking and enhancing cognitive activity in physics, particularly in optics.

KEYWORDS
information technologies, computer models, electronic resources, creative thinking, optics, training of future physics teachers

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Introduction

It is known that the traditional education in Kazakhstan is based on continuous and sequential assimilation of knowledge and relies on the reproductive capabilities without regard to personal creativity. The reality is that highly qualified modern specialists have to work in complex, rapidly changing

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conditions of scientific-technical progress, which requires constant updating of knowledge, erudition, combined with deep special knowledge, skills of conducting scientific research and creative attitude to their professional activities (Popova and Kruglova, 2011).

Modern young specialists with higher education must be prepared to deal with new challenges that require creative solutions, and be capable of creative self-development. And if the in-depth knowledge becomes a platform for training a new generation of competent professionals, the creative activity becomes a springboard which gives them an advantage in everyday activity, so at the moment the need to develop technologies shaping the creativity of students of pedagogical universities becomes mostly important (Ormanova, et al, 2013).

The need to develop students' creative abilities is fundamentally important, because it is this quality that ensures skills demanded by contemporary employers. This resulted in establishing organizations engaged in promoting a systematic approach to creative learning and cultural opportunities (e.g.: Creativity, Culture and Education (CCE)), in providing the Creativity, Culture and Education Literature Review Series dealing with the capabilities approach, creativity and creative learning. (McLellan, et. al., 2012).

Among works of foreign researchers in the field of creativity, we should mention the works by D. Leonard and W. Swap, (2010), Robinson, K. (2006), Lee&Kim, (2010). Gelade, (2002) and many others.

The issue of creativity touched upon in these works is multifacet. It is obvious that the definition of the creativity concept is represented in them. Thus, D. Leonard and W. Swap characterize creativity as "a process of developing and expressing novel ideas that are likely to be useful", "a goaloriented process ", on the one hand, and as a process which "involves convergent as well as divergent thinking", on the other. In their opinion, the convergent thinking is characteristic of the initial stage of the creative process. The divergent thinking is inherent to the later stages. It is explained by the fact that new original ideas are generated by divergent thinking. Then they are communicated to and evaluated by other people to decide whether they are really novel. Besides, the authors deal with misconceptions about creativity, the sequence of the creative process, steps for enhancing one's creative potential, etc.

Another definition of creativity is worth to be mentioned: "Creativity is a multidimensional ability that is influenced by various factors of specific social environments such as culture or language" (Gelade, 2002). The idea of connection of creativity with cross-cultural differences is of interest for researchers all over the world. Thus, Lee H, Kim K. investigated relationships between bilingualism and adaptive creative style, innovative creative style, and creative strengths among Korean American students. The results demonstrated that the degree of bilingualism was positively associated with creativity, creative style and creative strengths.

There exist points of view referring to the development of creativity in every learner. (D. Johnson) The explanation is that "creativity is no longer a "nice extra" in education". In his work D. Johnson presents his theory of multiple creative abilities. He dwells on strategies for assessing creativity, considers that everyone should become personally more creative every day.

At the same time, there are studies accentuating the urgency to foster creativity in gifted students (Gramond, 2005). B. Gramond presents the practical strategic series in gifted education, pays attention to curriculum compacting characterizing it as an easy start to differentiating for high-potential students. This guide provides basics for supporting creativity. The author considers that it is of paramount importance to enrich opportunities for gifted learners, to provide independent study for them, to use media and technology with these students.

The idea of evolving different ICTs in the education sector is developed in many studies in the field of creativity. The ICTs expand access to education, raise educational quality and help turn education into an active process with connection to real life (Safiul Hoque and Shafiul Alam, 2010).

A number of articles and books reveal creativity in teaching disciplines, and, namely physics, including high school physics (MacDowell and Michael, 2014; Sternberg, et. al., 2015; Jones and Richards, 2015; Carlile and Jordan, 2013).

It must be emphasized that the physics as an academic discipline has great potential in the formation of creativity. Firstly, this is due to the variety of physical disciplines (general, mechanical, molecular physics, electromagnetism, optics, quantum physics, etc), different methods and techniques which are used in studying them and provide wide opportunities to both teachers and students. Secondly, there are various forms of organization of educational activities in the study of physical disciplines that help to develop creativity (Dambueva, 2013).

The teaching experience and the results of our study show that learning and perception of the optics basics by the students are associated with some difficulties, due to abstractness of optical concepts, conflicting properties of light and low visibility of quantum objects under study; and some factors as follows:

- the imperfection of the contents of this section in existing programs of physics at the university;

- the use of verbal learning method by teachers as the main one at physics lessons;

- the lack of experimental support for optics teaching associated with impossibility of the full-scale experiment (not all optical phenomena can be shown at the school physics laboratory; the full-scale experiment is not always clear enough and mostly has a qualitative character; the devices are complicated and inconvenient in service), and the lack of necessary material conditions for it.

We also took into consideration another important fact that in the modern socio-economic conditions of society's development one of the important tasks of education is the development of personal qualities of future teachers, development of their creative thinking, creativity, values and attitudes. We assume that using new information technologies (NIT) in teaching physics, and particularly, optics will be a promising solution to these problems. There are several factors which cause their use at the present stage of training. First, many high schools have computers due to the social and economic achievements. The quantity and quality of ready-made physics software allows implementing various learning technologies. Secondly, the simulation with the use of any computer technology can give a good dynamic illustration not only of the observed physical processes and phenomena, but also of those processes that are not available for observation in a real experiment; and it also allows providing greater flexibility in conducting computational physics experiments and solving various experimental tasks. The computer with modern equipment connected to it gives us the possibility to conduct research of different studying processes on a high level. Accordingly, the use of new computer experiments (demonstration and laboratory) in training optics allows overcoming the mentioned related experiment problems. Moreover, the potential benefits of NIT give the opportunity to organize productive learning and make learning process personally oriented and the opportunity to set and solve both traditional and new educational objectives: the formation of model representations, information, communication and other skills of future physics teachers.

The theoretical basis of the study is represented by the works on the theory and practice of future teachers' professional training and the use of information and communication technologies in the development of personality of studentsfuture teachers. These are works by A. G. Asmolov, M. N. Berulava, B. N. Bezpalko,. Y. S Branovskiy, A. J. Vagromenko, S.G. Grigoriev, V.S. Ledneva, L.S. Podymova, N. S. Slastenin, N.G. Yaroshenko, etc. (Popkov and Korzhuev, 2004).

In the thesis titled "The use of information and communication technologies in the development of the creative potential of future physics teachers in the pedagogical universities" the author Amiraliyev A.D. examines the development of the creative potential of future physics teachers due to ICT in the pedagogical universities.

Thus, there are several major differences that emerged between the following concepts:

- the need for training and education of students' creative thinking and the lack of pedagogical technologies of formation of their creativity in physical disciplines learning;

- the requirements of modern society to the individual's creative ability to self-development in a rapidly changing conditions and insufficient attention in the educational process to the formation of the students' creativity in the study of physics and particularly in optics;

These contradictions made it possible to formulate the problem of research: to study pedagogical conditions and methods that facilitate effective implementation of the training process in order to develop the creativity of students – future physics teachers. Insufficient knowledge of the problem of creativity development and the relevance of solving the problem of its development by students in the learning process led to the choice of the subject of this study – formation of the creativity of students in the study of optics in the context of the education informatization.

Purpose: development of the students' creativity in the training course on optics **Tasks:** **- development of cognitive interests, needs and abilities;** **- formation of skills to make unconventional decisions;** **- creation of conditions to achieve students' personal potentia, their optimal self-determination and self-realization.** **Principles:** systematic character, consistency of conditions and purposes of the formation of creative pedagogical activity of students, the complex interaction of all subjects of training and education, awareness, students' autonomy and creative activity, unity
OPTIC TRAINING CONTENTS Light quantities,optical devices and systems, geometrical optics, wave optics, light quanta, elements of the relativity theory, atomic structure and atomic spectra

Teaching methods	Problem-based, developing, search, simulation, experiment, research, brainstorming, designing methods
Training tools	Tasks to encourage creative thinking, the use of ICT, simulation activities, problematic tasks, the creation and use of didactic tales and poems, statement of problematic chemical experiment
Forms of organization	Lectures, seminars, laboratory classes, out-of-class independent work
The effectiveness of teaching: the ability to handle the information independently; experience of experimental and scientific work; the formation of creativity and making a new creative product	

Figure 1. Model of the development of students' creativity in studying optics.

Materials and Methods

In order to formulate creative thinking we need to use the methods that are able to develop some operations of students' logical thinking, such as analysis, synthesis, abstraction and so on, teach students to set the problem, interpret information, express their own position, try to apply knowledge in a new environment, modify and alter the received knowledge. It has been established that the organization of the education is carried out in various forms: lectures, seminars, laboratory practical classes, extra-curricular activities, teaching practice and others.

All these forms of learning are interrelated and influence each other. With the aim of developing students' creative abilities we defined some disciplines, the content of which is most favorable for the development of creativity.

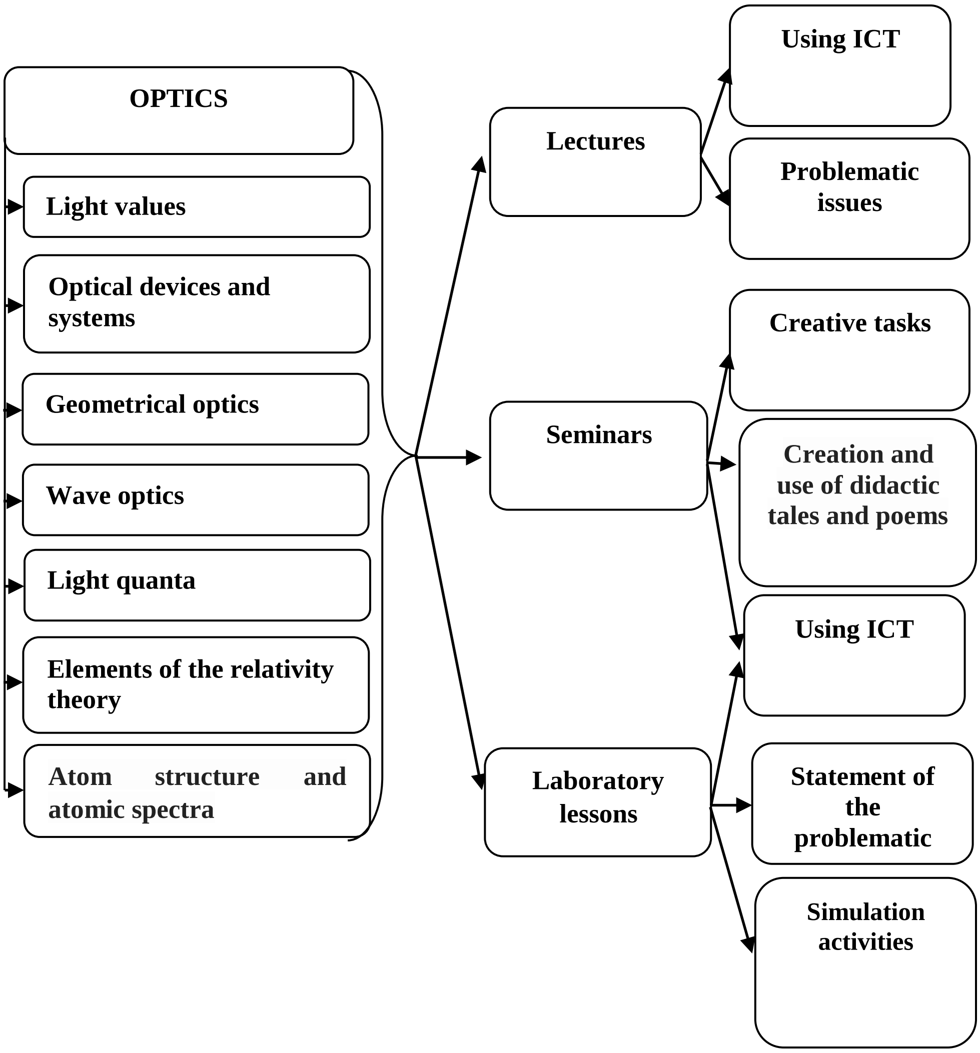


Figure 2. Organizational and methodical model of formation students' creativity

These forms of lesson organization can be used absolutely in all courses of optics studies at the university.

The content block includes systems of special tasks on various sections of optics with the use of ICT indicated in the pictures.

Here are some examples of such tasks:

1. The use of information and communication technologies of training.

In the modern world, information and communication technologies (ICT) are becoming the main tools of achieving the top educational goals (Hoque and Alam, 2010).

We assume that a promising way of students' creativity development is the use of new information technologies in teaching physics, in particular, in the study of optics. Their use at the present stage of training is determined by several factors. Firstly, there are computers in many high schools due to the social and economic accomplishments. The quality and the quantity of readymade physics software are on such a level that it allows implementing various learning technologies. Secondly, the simulation with the help of computer technology lets us get a dynamic illustration not only of the observed physical processes and phenomena, but also the illustration of those processes that are not available for observation in a real experiment; and it also allows providing greater flexibility while conducting computational physics experiments and solving various experimental tasks. The computer with associated modern auxiliary equipment allows carrying out high level investigation of the various study processes. Accordingly, the use of new computer experiments (demonstrative and laboratory), when teaching optics, allows overcoming the mentioned problems related to the experiments. Moreover, the potential benefits of information technologies give the possibility to organize productive learning and make the study process personally oriented, set and solve new educational tasks along with the traditional ones, such as: the formation of model representations, informational, communicative and other skills of future physics teachers (Berkimbaev, et al., 2013).

The university lecture continues to be one of the forms of presentation of the new educational material and there is a problem of using information computer technologies for improving the effectiveness of lectures. We have created an electronic textbook on optics, which involves a dialog mode for tutoring, performing training tasks, creative exercises, and also allows testing the level of the student's knowledge. In this textbook we developed the computer models of the optical phenomena in the form of animation, such as wave properties of light, interference, diffraction, polarization, and corpuscular properties of light – photoelectric effect, Compton effect.

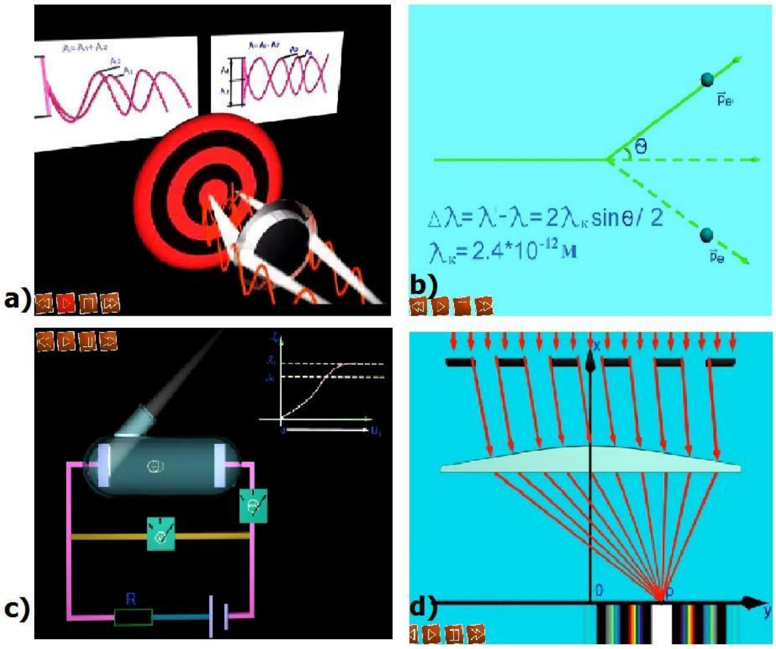


Figure 3. Computer animation optics models (Ormanov and Ramankulov, 2014) (a, d – Light diffraction, b – Compton effect, c – Photo-effect).

2. Creative tasks

This kind of tasks requires students to have a high cognitive activity and directly refer to the additional literature. We used the following types of creative tasks:

- Cognitive and non-standard tasks, which may have one correct answer for different solutions.
- Experimental research and design tasks.
- Tasks for the conversion and design of experiments.

- Tasks developing logical and combinatorial abilities, involving the search of the unknown by using analysis-by-synthesis.

- Special tasks requiring a non-standard logical approach in addition to the knowledge of the subject (Ramankulov, et al., 2015).

In the seminars, we use creative tasks requiring students to have a high cognitive activity and directly refer to the additional literature. In order to enhance the students' creativity, we have developed a workbook for students' self-study on optics with creative tasks. This workbook contains the following types of creative tasks: crosswords; tasks based on an experiment; tests of different types.

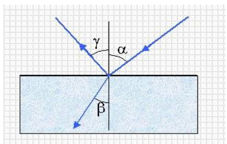
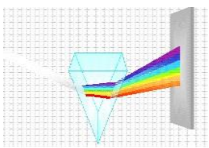
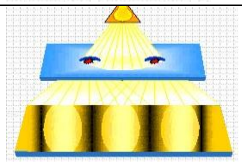
Property		Example	W aves	Pa rticles	Notes
Reflection, Refraction		 □□□ n□?	?	+	Both particles and waves obey the law of reflection Particles and waves both refract. *waves*□ *light* □□ $n_{2,1}$ □?
Dispersion			+	?	Waves naturally do this, particles do not
Interference			?	?	Waves naturally do this, particles do not

Table 1. Tasks for students for optics seminars.

3. Setting up the problem-based experiment

In the study of optics the experiment performs its heuristic, correcting, summarizing and research functions.

Therefore, at general workshops we use a problem-based experiment, grounded on the creativity of its implementation. Problematic nature of the experiment makes it possible not only to establish new facts, but also to correct errors in students' knowledge, clarify and correct understanding of certain issues in physics course. The implementation of laboratory experiments according to the instructions greatly reduces the degree of independence of students and makes it difficult to take into account their individual characteristics.

At the Physics Department a complete interactive physics course Open Physics has been arranged, which includes more than 80 virtual laboratory complexes, videos of experiments, sound explanations. They provide options for changes of initial parameters and conditions of the experiments, varying their time scale, as well as simulations of situations that cannot be simulated in real experiments (Berkimbaev, et al., 2013).

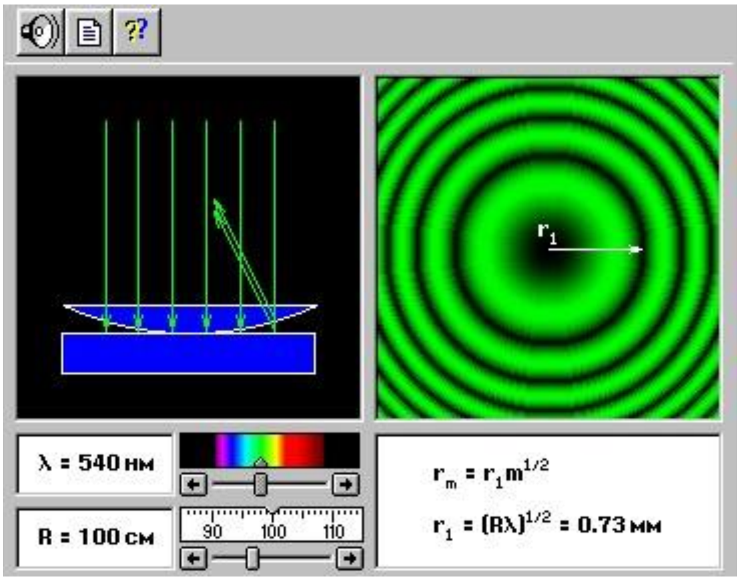


Figure 4. The fragment of the virtual laboratory work "Determining the radius of the lens curvature with the use of Newton's rings".

4. Problematic issues

The problematic situation occurs when students are encouraged to search for new knowledge, when there is a need to explain the observed experimental facts with the known theoretical propositions.

First, the students do know neither the original data, nor the results. In this case, knowledge is derived from specially designed experiments and logical reasoning of teachers and students. During the conversation a new concept or a proposition is made, the conclusion is drawn. In this case the learning objective is creative in nature. To create a problematic situation in the study of the section "Light quanta" the following questions can be asked:

a) Why are photographs developed, using the red light?

Answer: The red light does not affect the photo plate due to the low energy of photons of this light,

$\varepsilon = h\nu$, where the frequency ν is low.

b) Does the light produce more pressure on the white or black surface?

Answer: Bouncing off the white surface, the light produces the pressure equal to $p = 2I/c$. The light is not reflected off the black surface, in this case the pressure is equal to $p = I/c$. This shows that the light rays produce more pressure on the white surface.

Formulation of such a task is quite justified, because the students have a great store of knowledge in optics. However, the lack of knowledge on the issue raised makes its decision alternative. Students make both positive and negative assumptions.

5. The use of didactic fairy tales and poems

One of the most interesting and promising techniques for the development of students' creative qualities in the study of optics is the use of didactic fairy tales and poems. Those poems and fairy tales can be didactic that are written or chosen for the learning process and contain the information on the subject (Zinkevich-Evstigneeva, & Grabenko, 2003). In their use it is important to correctly motivate a student to search for new ideas and, as a result, to write a fairy tale or a poem.

Didactic fairy tales in the study of optics shall allow covering any of subjects, so the theoretical part, necessary for learning, is repeatedly read, analyzed, combined, compared by a student and only then it turns into a fairy tale. The use of such a technique is also useful due to the fact that even low achievers show great interest, and sometimes their work outperforms the work of the other students. At the beginning of the first lesson, students should provide an algorithm of writing stories, which will consist of the following:

- The introduction containing the information on the subject under study.
- Optical processes and phenomena.
- Appeal to the student. This is a final stage when it is necessary to find a solution to the situation.

For example: Reflection of light, its refraction,

Rectilinear propagation,

Imaging, these are all the issues that OPTICS considers.

6. Simulation activities

By this we mean the creation of such a learning environment in which the examples and assignments are directly related to the daily life of each student. For example, in the study of the light interference students are offered to study it on the example of the light interference observed in vivo, rainbow coloring of thin films (soap bubbles, oil spill and transparent oxide films on surfaces of hardened metal parts of annealing color) can illustrate this process. The formation of partially coherent waves interfering application occurs in this case due to the reflection of light falling on the film from its upper and lower surfaces. The result of interference depends on the phase shift acquired by overlapping waves in the film and depending on their optical path difference.

This formulation of tasks requires students to have a high cognitive activity and directly refer to the additional literature. Such situations contribute to the development of communicative and organizational pedagogic abilities and the development of creativity.

Results

The results showed that the present stage of the development of information and communication technologies is characterized by a large number of applications and software tools, the use of which for creating electronic resources does not require specialized training in the field of software (MS Word, MS Excel, MS Access, MS Power Point, Windows MovieMaker, FrontPage, Macromedia Flash, 3Dmax, etc.) (Kabylbekov, & Ormanova, 2006). The software tools especially valuable among them are the tools that allow creating multimedia electronic resources combining both static visual information (text, graphics) and dynamic information (speech, music, video, animation). Knowledge of the capabilities of such tools, having knowledge and skills to work with them shall allow a student to study creating electronic resources as a future teacher at the teachers training university (Berkimbaev, et al., 2013).

In the Khoja Ahmet Yassawi Kazakh-Turkish International University the group of authors created computer models of various physical processes and phenomena on the basis of the optics course and developed the methodology of their application. The elective course on the application of computer models and demonstration of various physical processes and phenomena "Technology of the application of computer models and demonstration in the study of optics" has been prepared. Thematic planning of the optics discipline has been prepared. The total labor of the discipline (one semester) includes 135 hours, classroom training – 90 hours (including lectures – 15 hours, practical classes – 15 hours, laboratory works – 15 hours), students' self-study involves 45 hours. An examination in the 1st semester is the final control. The syllabus, the methodical complex of the physics course have been compiled upon the credit education technology, introduced in the educational process and placed on the site of the University (www.turkistan.kz).

This course can be used by students studying at the faculties of Physics, Information Technology, Mathematics, Information Systems, Automation and Control, training in the physics discipline; the authors note the possibility of its use by teachers of universities, colleges, schools, gymnasiums, lyceums, working in classes with in-depth study of physics. Let us describe the content of the main sections of this course.

The first section "Introduction" contains a summary of the course under consideration.

The next section "Contents" contains detailed plans of lectures on the subject of optics, including the following units: geometrical optics, wave (interference, diffraction, polarization, dispersion) and quantum (photoelectric effect, Compton effect and thermal radiation) properties of light. Each lecture is complemented with a computer presentation with basic theory of the subject of a lecture, accompanied by a large number of computer models of experiments and demonstrations with the highest quality of animation.

The last section "References" contains the information about the bibliography cited in construction of computer models of experiments and demonstrations at the optics course.

The system of the students' research work (graduation thesis and term papers, etc.) has been developed applying electronic resources. The results of the study were used during the formation of creative thinking of future specialists in higher educational institutions.

The features of the organizational forms (lectures, laboratory works, practical training) and implementation of methods of training future specialists in electronic resources usage are as follows: methods of acquiring knowledge and skills; methods of formation of skills to apply knowledge in practice; control methods.

Electronic teaching manuals developed during the study and applied virtual laboratory complexes increase the quality of knowledge and improve the professional training, as well as contribute to the formation of creative thinking of future physics teachers by unifying theory and practice.

As a result of the conducted experimental work, methods of using computer models and experiments of various physical processes and phenomena, as well as virtual laboratory complexes, the levels of development of the components (fluency, flexibility, originality) under consideration and the levels of the formation of students' creative thinking (the beginning and the end of the experiment) have been determined (Table 3).

Components	Levels	Before experiment, %		After experiment, %	
		CG	EG	CG	EG
FLUENCY	High Average Low	16.3 48.6 35.1	19.4 38.8 41.8	13.5 56.7 29.8	33.4 55.5 11.1
FLEXIBILITY	High Average Low	27.1 37.8 35.1	27.7 25 47.3	13.5 56.7 29.8	38.8 33.3 27.9
ORIGINALITY	High Average Low	16.3 - 83.7	8.3 - 91.7	10.8 29.7 59.5	30.5 36.1 33.4

Table 2. Levels of the development of students' creative thinking applying electronic resources (by levels),% (CG – 37, EG – 36).

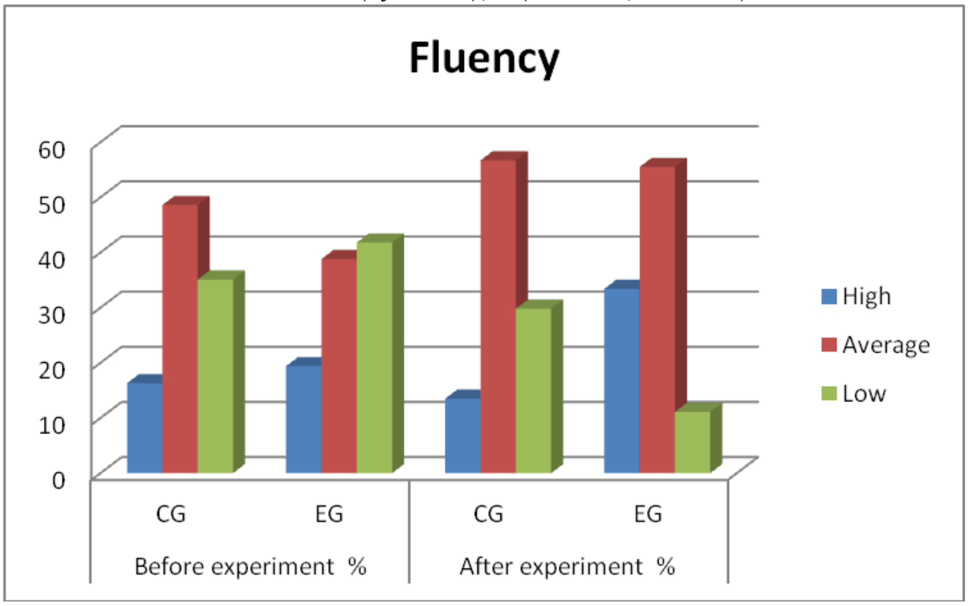


Figure 5. The dynamics of the formation of cognitive fluency (%).

At the final stage of the experiment a significant increase in students' creative thinking has been established as regards the use of information technologies. If in the course of the determinative experiment on the formation of cognitive fluency – 41.8 % of the students of the experimental group showed a low level, at the end of the experiment 11.1 % of the students demonstrated a low level; at the beginning of the experiment 38.8 % of the students showed an average level, while at the end of the experiment 55.5 % of the students demonstrated an average level; at the beginning of the experiment 19.4 % of students showed a high level of cognitive fluency, at the end of the experiment their number increased by 33.4 %.

Conclusion

As a result of the conducted experimental work, it was established that the formation of students' creative thinking with the use of computer models and experiments of various physical processes and phenomena, as well as virtual laboratory complexes, becomes successful when the following pedagogical conditions are observed:

- when the physical environment of the educational environment is organized in such a way that it increases the number of its quantitative diagnostic parameters (fluency, flexibility, originality);

- when the teacher is not only an administrator, but also an intermediary, assistant, stimulating and participating in the work of the others, and at the same time the teacher should be a model of a creatively thinking person;

- when creating such a program of formation of students' creative thinking, the content of directions of which, on the one hand, is conditioned by the content of components of creative thinking, and, on the other hand, the content is implemented in such a way that each of these directions complements the other directions, so the components of creative thinking become enriched as a whole.

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Disclosure statement

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