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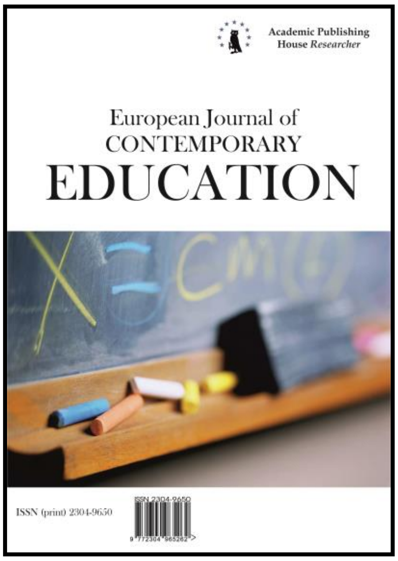

Assessment of Student Creativity in Teaching Physics in a Foreign Language

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Abstract

Multilingual skills tend to be an integral part of modern society because a specialist able to speak, read and write in multi-languages is able to meet competition. Given that all the latest discoveries and achievements in the field of natural science have been published in English, in accordance with the theme of our study, Physics teaching in English becomes one of the topical issues. However, experience has proven that a few students realize the importance of language integrated learning (LIL) that was confirmed by statistical data from questionnaire made among students of specialties 5B060400 and 5B011000-Physics, the Faculty of Natural Sciences, the Akhmet Yassawi International Kazakh-Turkish University. Realizing the value of gained knowledge is directly related to the motivation and result of learning process. It is assumed that the solution to this problem lies in the competitive organization of language integrated learning in teaching namely in appropriate choice of teaching methods. This is valuable in the context of modern practice-oriented understanding of learning. These technologies include the ICT and case study method which help to change the students' meaning of how the foreign language important from the point of view of their proficiency that was confirmed by statistical data. Some methodological aspects of the use of ICT and case-study in language integrated teaching as well as mechanisms of interdisciplinary coordination and cooperation between English teachers and Physics teachers that both contributed to the ICT and case-study integration in language integrated teaching as well as it is valuable for further research in this area. The staff of the Chair of Physics at the Akhmet Yassawi International Kazakh-Turkish University creates close ties worldwide and conducts extensive work in this direction. The theoretical and experimental studies that were carried out convincingly prove the need introduce into the educational process an innovative

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methods in the educational process as a case study and ICT for the formation of creativity of University students.

Keywords: Physics teaching, content language integrated learning, educational forms and techniques, case-study method, digital technologies, creativity of students.

1. Introduction

The revision of specialists' training system by the world's leading pedagogical universities resulted in new comprehensive specialties (Lorenzo et al., 2010), as well as system of supplementary education in the field of professional communication (Herppich et al., 2017), that was expected from the humanitarization of physical and natural science education and also reflects the need of society for specialists who are ready to work in the foreign language medium (Rezida et al., 2014).

The second language-integrated education of future Physics teachers and teaching of foreign Physics students in English in the world's universities are different methodological directions for any Physics teachers: both phenomena consider Physics teaching in a second language; however, one problem is the same: development Physics manuals in English as a second language (Roberto et al., 2017).

At the moment, the greatest attention of those who studies language integrated learning (LIL) is paid to the stage of pre-university training of foreign students in the world: the features of teaching approaches in other content subjects are considered (Singh et al., 2017). However, professionally oriented LIL and language-integrated competence of students in the universities (Ruiz de Zarob, 2008) were not also overlooked. Despite the lack of information concerning application of the language integrated method in Physics teaching there is the phenomenon like Physics teaching in a second language which is obviously considered as a single methodological issue.

While studying foreign literature, it should be noted that CLIL can be used as the latest technology for the development of subject-language competence. At a time when the importance of the topic of our study is of particular importance for the country, there is a noticeable lack of research in this area. The lack of research in the field of development of subject-language competence in the teaching of natural subjects, in particular, physics, unformed systematization of teaching didactics, lack of advanced technologies, textbooks and effective methods create difficulties for the development of this direction. The only way to overcome these difficulties is to combine IT-based management of education with Physics teaching in English.

The studies of Prather et al., 2011 and Klein, 2014 can be considered when talking about students' teaching in Physics through the digital technologies.

Despite this, second language integrated teaching of future educators and school Physics teachers through the digital technologies has been formed not as a unite system, but is still considered as an individual proposal.

Nevertheless, above studies are about the use of information and communication technologies in teaching of high students, but unfortunately, a fundamental scientific solution to the problem of implementing the development of subject-language competence of students in the conditions of IT-based management of education has not been found yet. There is a contradiction between the need to use digital technologies for the development of subject-language competence of students, the need for new technologies, methodological and computer software for its implementation and the lack of research in educational system based on the development of subject-language competence of students through the use of digital technologies.

The search for solution to this contradiction is mainly featured our research, that is, the development of subject-language competence in the process of Physics teaching in the way of IT-based management of education.

When a foreign language is used to teach certain subjects in this case there is one direction with the use of an intermediary language in which the language of teaching is a foreign language not only for student but also for a teacher. In our country and abroad, English is most often used as the intermediary language.

The second language integrated teaching is widely used in national and international high schools and according to studies conducted (Emadi, 2013) this is because of attraction of such English-based training programs from commercial point of view as well as personnel promotion, growth of the university competitiveness at an educational market, bring PhD expertise abroad etc.

According to the research carried out by the European Academic Cooperation Association, the European universities are encouraged to develop English-based training programs because of attracting both foreign and local students (providing the national labor market with highly qualified personnel with international experience) (Yemelyanova, 2014).

The second language integrated teaching of local and foreign students is seen to be insensitive by researchers but the interest in this matter has recently increased significantly. At the same time, according to S. Al-Shukri, M. Vakhitov and N. Filippova, second language integrated learning at national universities increases the level of requirements for foreign students because there is no language barrier between a student and a teacher; it develops internal competition and strengthens learning motivation as well as attracts teachers with fluent English (Al-Shukri, 2014). In such circumstances, learning of future teachers in the specialty Physics and English is seen as training of world-class specialists (Roehl, 2013).

Let's take a closer look at the approaches used both in training foreign students in a second language in our country and in training our students to make them able to work in a second language medium. It should be noted that an important feature of the CLIL is a simultaneous learning of the subject and language of instruction, i.e. the implementation of educational activities in conditions of imperfect knowledge of the language of instruction. The quality of training of foreign students in our country is directly dependent on the theoretical study of this issue, which is not reduced to the methodology of learning a foreign language, or to the methodology of teaching certain disciplines in pure form. In our opinion, the methodology of Physics teaching in second language should be considered as a complex of tasks and should integrate the methodology of Physics teaching with certain aspects of the methodology of English teaching (Usembayeva, 2015).

The problem of training Bachelors of Education in Natural Science in universities is seen to be relevant with a focus, on the one hand, to improve the scientific and methodological training of future Physics teachers, on the other hand, aimed at the widespread use of digital technologies in teaching, management of the educational process.

It is necessary to start fundamental research in order to make future Physics teachers ready for the use of digital technologies. An integral model of Physics teacher with additional specialization in computer science, based on an accurate forecast of trends in the development of the education system in general and computer science in particular, is a global problem, and its relevance is obvious.

We took into account another important fact that in the current socio-economic conditions of the development of society one of the urgent tasks of training is the development of personal qualities of future teachers, the development of their creative thinking, creative potential and value orientations (Leonard, Swap, 2010). 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.

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 (Lee, Kim, 2014).

There exist points of view referring to the development of creativity in every learner. (Johnson, 2015) 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.

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

We believe that the use of new methods as a case study in Physics teaching, in particular, in language-integrated Physics teaching is promising for solving these problems. It is needed to join interactive educational methods as case study with digital technologies while language-integrated Physics teaching. Their use in today educational system is stipulated by several factors. First, thanks to social and economic achievements, many universities have computers. The number and quality of ready-made software products in Physics help to realize various learning technologies. Secondly, computer modeling allows to obtain dynamic visual illustration not only actually observed physical processes and phenomena but those are unobservable in a real experiment and also allows for more flexibility in computational physical experiments and solving different experimental tasks in English. The computer along with update support equipment is used to realize various studied processes at a high level.

In his efforts the U.S. researcher Becker examines features of digital technologies in Physics learning. Mr. Becker proposes to change the way of use of digital technologies in Physics learning to meet actual requirements. Only then it will be possible to improve the quality of students' knowledge in Physics (Becker, 2001).

C. Angell, A. Guttersrud, E. Henriksen and A. Isnes in their efforts pay attention on the approaches in Physics teaching via digital technology. Their main concept is that Physics is very interesting although complicated science and teacher with students should improve the methodology of Physics teaching in accordance with modern requirements, to introduce information technology in the process of timely learning (Angell et al., 2004).

As well as some foreign scientists such as P. Klein, S. Greber, G. Kuehn and A. Mueller proposed to increase the interest of students by animated analysis of physical phenomena, using i-pad or a computer as a means of experiment. A. Rudolf, S. Leimin, E. Prazer based on the specifics of digital technologies in Physics teaching showed the importance of case study method in explaining of physical phenomena (Prather et al., 2011).

The thesis *Use of information and communication technologies in the development of creative potential of future Physics teachers at the university* written by A. D. Amiraliev considers development of creative potential of future Physics teachers using ICT and case study at the universities (Amiraliev, 2003).

In the case-study the key element is undoubtedly the case which also has a number of characteristic features that are important for this study. Based on the analysis of scientific papers which explain the meaning of "case" (Fischer, Casey, 2008), its characteristic features in the context of foreign language learning were identified and generalized: the case, consisting of authentic texts, has a communicative, dynamic, practical nature, since it involves the definition, discussion and joint search for solutions to urgent problems related to professional activities, and also has an interdisciplinary nature, since it is an information complex, which includes a range of related conditions from economic to socio-political ones. It is important to note that to solve the case it is necessary to take into account the full range of related conditions, to take into account relationship between presented areas of knowledge to obtain a complete picture and make the most correct decision. However, it should be emphasized that the case-study method is a tool to integrate related subject in second language medium and makes it possible to organize the process of the CLIL taking into account specifics of future professional activity by focusing on the formation of key skills of future specialist and also enables the student to see the diversity of interdisciplinary connections, because it is complex.

However, the use of ICT and cases is insufficiently covered in the development of creativeness of Physics teachers in the CLIL process.

The relevance and urgent need for practice in improving educational process to make future teacher ready for creative professional activity led to the choice of the line of our study.

2. Materials and methods

The following methods were used while study implementing:

- analysis of methodological, philosophical, psychological, pedagogical and methodical literature
- by means of various questionnaire, tests and reviews to elicit to what extent English is in-demand in schools of Turkestan region and find out the level of English proficiency
- review of advanced language acquisition technologies; consultations with scholars abroad
- analysis of case-study method in Physics teaching in English as second language
- review of IT education, elements of robotics and electronic digital resources
- selection of 3D and 4D computer programs needed to create digital resources
- creation of methods to build subject-language competence of future educators and school Physics teachers, and
- implement field activities, develop tests, using mathematical and statistical methods.

Experimental work was carried out at the International Kazakh-Turkish University and South Kazakhstan state University. The nearly 73 students were engaged in an experiment presented below in chronological order. 36 students at target (TG) and 37 students at experimental group (EG).

As part of the experiment, it was necessary not only to ensure the implementation of laboratory work in English and/or reports on the results of laboratory work in English by creating a foreign-language didactic environment and the development of foreign-language subject communication in the experimental group by the introduction of special teaching methods, but also to compare the results of training with a target group.

During the study, the diagnosis of the main qualities was carried out creativity: the ability to analyze and synthesize; fluency, flexibility and originality of thinking; the ability to develop a detailed hypothesis; the ability to detect and pose problems. Research methods: summary of estimated test the Buzın-Wunderlich; tests of creativity Torrance, E. P., adapted in the context of physics; the questionnaire creativity of Johnson (adapting E.E. Tunick). Distribution of students by levels of development of qualities of creativity was carried out by formulas 1 and 2.

Low score limit: $m - {}^{2}/_{3}\,\sigma$ (1)

High score limit: $m + {}^{2}/_{3}\,\sigma$ (2)

where: m – arithmetic mean, σ – standard deviation.

The reliability of the results obtained at the beginning and at the end of the experiment for each quality of creativity, as well as for the integral indicator is provided by the *Pearson's* chi-square test and *Student's t-test.*

To compare the distribution of students by levels of creativity in the control and experimental groups, the following hypotheses were formulated: H0 – there are no significant differences in the levels of creativity; H1 – there are significant differences(the results are shown in Tables 5 and 6).

The Akhmet Yassawi International Kazakh-Turkish University has created computer models of various physical processes and phenomena on the basis of *Optics in English* training course and has developed a method of their application. They have also elaborated an elective training course on the application of computer models and demonstration of various physical processes and phenomena *Application of computer models and demonstration in Optics*. The teachers' team has set up a curriculum on Optics course. It covers 135 hours per one semester totally including 90 hours of class work, that is divided into 15 hours of lectures, 15 hours of practice, and 15 hours of laboratory works as well as 45 hours take students' individual work. At the end of the semester student should take an exam. The teachers' staff has also outlined syllabus for Physics training course on credit transfer educational system, introduced it in the educational plan and placed on the website of the University (www.ayu.edu.kz).

This training course can be used by students studying Physics, Information technologies, Mathematics, Information systems, Automation and control. The authors note that this manual can be used by the teachers at the institutes, colleges, schools, gymnasiums and lyceums who teach in classes with in-depth study of Physics.

Students need to pass an exam at the end of the training course on Optics and they must to explain theoretical questions and solve a physical problem in English, and one of the criteria for successful completion of the exam is to show their speaking skills in English in the field of Physics.

Since English opens the way to the formation of creativity, we have evaluated the effectiveness of the methodology we have developed, through the evaluation of creativity.

3. Results

To successfully apply digital technology in language integrated Physics teaching it is required to clearly understand basic principles and techniques that contribute to the strengthening of future teachers' intellectual capabilities.

The structure and content of future teachers' professional training are undergoing significant changes today. Social order of training in modern professional school is focused on the development of thinking, creative inclinations of students, and their involvement in independent search activity, familiarization with the methods of scientific knowledge, formation of the ability to apply knowledge in new conditions. One of the ways to implement this direction is to organize students' productive and creative activity which, in turn, is a condition for the formation of their professionalism.

The problem of our research can be formulated as follows: what are the pedagogical possibilities of ICT and case-study method in the development of future teachers' creativity and appropriate educational conditions for their use in future teachers' training. Our research is aimed to find the solution of this problem. Below we offer didactic conditions for improving language integrated Physics teaching (Table 1).

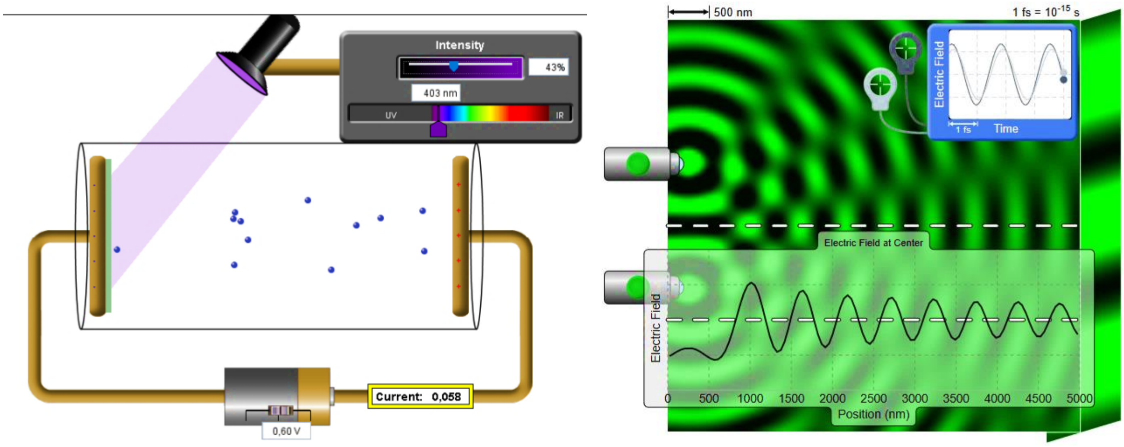
Table 1. Didactic conditions for Physics teaching in English

Prerequisites for the development of teaching physics in english	
1	2
Prerequisites	**Results**
To give theoretical underpinning of content and language (English) competence development of future teachers and school physics teachers by means of new information technologies use	Results of specified tasks solutions differ in a clear idea of theoretical bases of new information technologies use in content and language competence development. To set up didactic system content and language competence developmentof future teachers and school physics teacher; As a research result of the specified task the system of advanced technologies of physics in English development will be created and introduced in educational process.
Definition of General Physics study course content by means of information technologies	According to the didactic system created during solution of this task electronic textbooks and manuals will be published and introduced in schools and higher education institutions. Also the maintenance of the organization and holding facultative occupations at school will be defined.
The organization of upgrade training course for regional schools physics teachers	Physics teachers at the schools of Turkestan city department of education will complete upgrade training course, based on the best foreign practices, and will examine the maintenance of facultative lessons.
Start of the portal (website) "Physics education in English" in public and republican level;	Creation of electronic educational resources (electronic textbooks and multimedia programs, demonstration and virtual computer models), release of the manuals based on the advanced foreign methods and definition of use methods in the course of physics education.
Ensuring introduction of electronic educational resources and manuals at the rate of the general physics in republican schools educational process. Carrying out skilled and experimental works, creation of tests, use of mathematical and statistical methods	

Thus, below we consider the method of using these didactic conditions in any form of training.

At the university a lecture keeps on using to introduce new educational material, there is a problem of using digital technologies to improve the efficiency of lectures. According to D. Matros, D. Polev, N. Melnikova, N. Sokolova and A. Skripkin, lectures-presentations are one of the main opportunities for digital tools to be used in an educational process and the main idea behind of this is in applying computer technologies for visual presentation of the most important information on slides (texts, formulas, drawings, tables, graphic materials, etc.) (Moldabekova, 2013).

We have created an e-textbook on Optics, which provides for the use of an interactive mode for tutoring, performing training tasks, creative exercises and checking the level of students' subject knowledge in English. In this tutorial we have developed computer models of 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. Below are some of these models (Figure 1).



a) b)

Fig. 1. Computational models in Optics. (a– photoeffect, b – interference)

During the workshops we try to apply creative tasks that make students think critically and use additional literature. To increase students' creativity and individual work we have developed a workbook in Optics with creative tasks. The workbook includes different cases, puzzles, experiment-based tasks and various tests. Herewith are some examples from our workbook:

a) CASE #1

Maksat and Raushan decided to make a resistor for Physics. Maksat took a copper wire and Raushan took an iron wire.

– That's not a good idea to use an iron wire, a conductor is better to make from a copper wire, it is more valuable, – Maksat said.

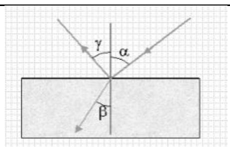
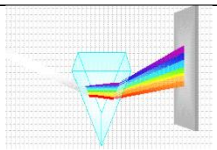
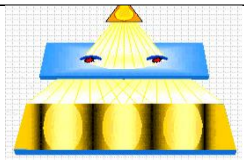
– I think the copper wire is hardly suitable because the resistance will be very low, – Raushan said.

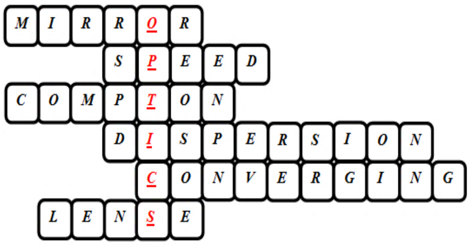
- Well, it depends on what wire is to take! – Maksat chuckled. – Mine's better.

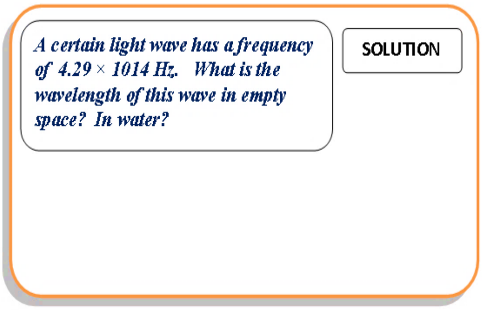
Questions to the case

1. Who of friends is right?
2. What characteristics should have the wire to make a resistor?
3. How to calculate the resistance of a resistor made of simple wire?
4. How to check if you are right?

Table 2. Example on Optics for students

Property	Example	Waves	Particles	Notes
Reflection, Refraction	 $\gamma = \alpha$ $n = \dfrac{\sin\gamma}{\sin\beta}$	+	+	Both particles and waves obey the law of reflection Particles and waves both refract. $\left.\begin{matrix} waves \\ light \end{matrix}\right\\} n_{2,1} = \dfrac{\vartheta_1}{\vartheta_2}$ Particles
Dispersion		+	-	Waves naturally do this, particles do not
Interference		+	-	Waves naturally do this, particles do not





1. ______are made from highly reflective metal that is applied to a curved or flat piece of glass.
2. When light is refracted its wavelength and _____ change
3. In 1922, Arthur _____ directed X-rays of known wavelength at a graphite target.
4. ______ – Newton proposed that different colors of light were actually different sized particles.
5. Lenses that focus light are called ______ lenses
6. ______ can be used to make visual representations, called images.

Fig. 2. Crossword from a students' workbook in Optics

Every teacher from the Department of Physics is also able to use full interactive Open physics course which includes more than 80 virtual laboratory complexes, video recordings of experiments with voice explanations. They provide options for changes in a wide range of initial parameters and conditions of experiments, varying their time scale, as well as modeling situations that are not available in real experiments.

Below is a fragment from a virtual laboratory work *Identifying the radius of curvature of the lens using Newton's ring"* (Figure 2).

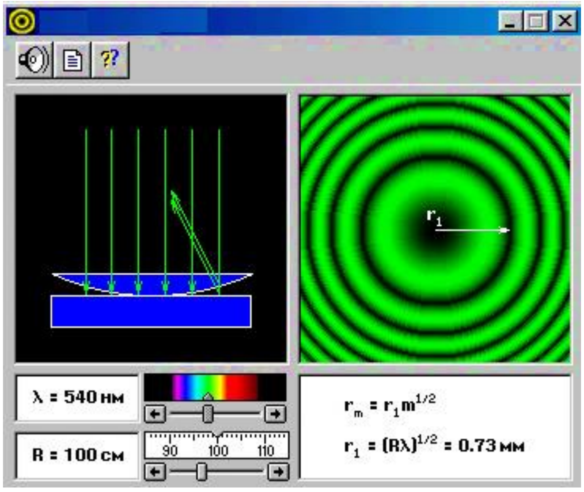


Fig. 3. A fragment from virtual laboratory work

Experimental verification of the effectiveness of educational and methodical complex in second language-integrated Physics learning is quite a difficult task, because usually such an experiment is to compare a new textbook with existing ones.

Since English opens the way to the formation of creativity, we have evaluated the effectiveness of the methodology we have developed, through the evaluation of creativity.

Monitor of the level of students' creativity involves the use of special techniques. There are a lot of scientific approaches to the problem of creativity research (J. Gilford, E. Torrence, D.L. Johnson and E. Tunick).

For our experiment, the most appropriate method is the method of creativity monitoring, proposed by E. P. Torrance, which is currently recognized as the most reliable and valid in comparison with other methods and is used for different age groups (Torrance, 2004).

The Table 3 below lists some criteria of creativity:

Table 3. General formation structure of future Physics teachers' creativity

Components	**Criteria and indicators**	**Levels**
Fluency Thinking	- quickly perform creative tasks - able to solve tasks fast - able to quickly recognize the new - able to act promptly - able to create several thoughts corresponding to the tasks; resourceful thoughts	Low Average High
Flexible Thinking	- tend to practice - be flexible to new problems - tend to solve the problem - be loyal to discussions - think beyond the borders of the task - be able to find more than one solutions - be able to give more than one right answers to new problem	Low Average High
Original Thinking	- have some original thoughts while implementing the task - be able to do the task by themselves - able to be sensible - offer original solution - use some individual elements in solution of new problem	Low Average High

Fluency, flexibility and originality of thinking were monitored by E. Torrance technique where verbal Physics-adopted subtests were used. The scores students had obtained passed through the quantitative and qualitative analysis. Table 4 shows changes in distribution of the level of creativity among students in target (TG) and experimental groups (EG) at the beginning and at the end.

Table 4. Comparison of the creativity level among future Physics teachers before and after experiment

Index of creativity	Level	Before experiment (the number of students)		After experiment (the number of students)	
		TG	EG	TG	EG
Fluency Thinking	High Average Low	6 18 13	7 14 15	5 21 11	12 20 4
Flexible Thinking	High Average Low	10 14 13	10 9 17	5 21 11	14 12 10
Original Thinking	High Average Low	6 - 31	3 - 33	4 11 22	11 13 12

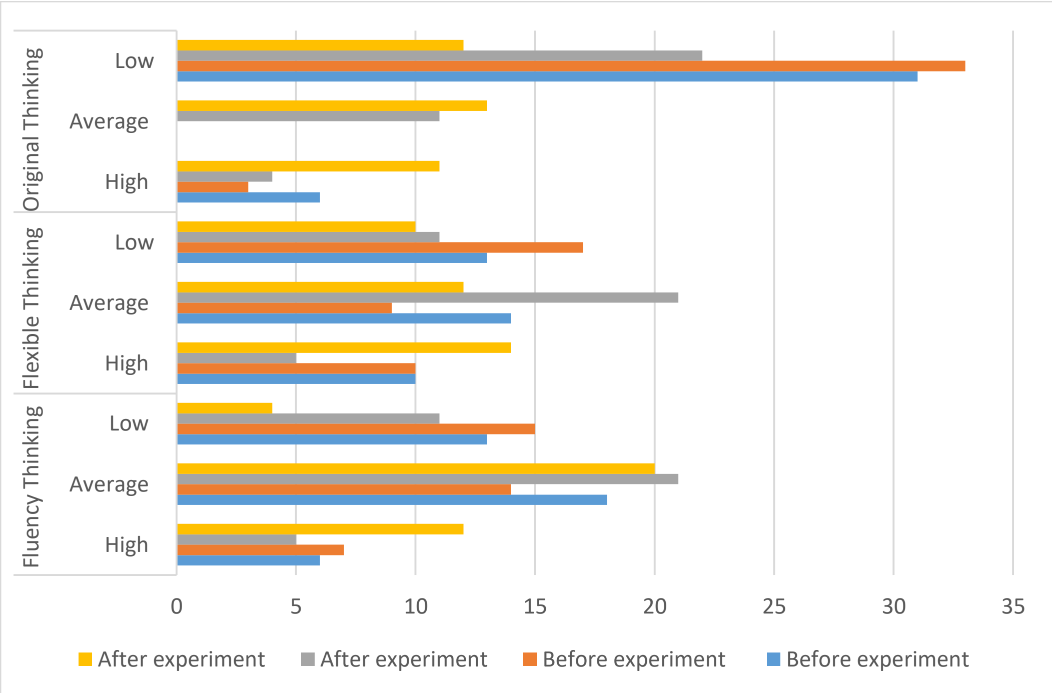


Fig. 4. Dynamics of students' creativity

Comparative indicators on creative properties of future Physics teachers before and after the experiment:

According to the data shown in Table 4, it can be noted that creativity is being developed uneven. In particular, 55 % of students in experimental groups have an average level of thinking fluency. In relation to the originality of thinking at the beginning of the experiment, students showed low and high levels of development, i.e. in the course of the experiment the students either did not exercised originality of thinking at all, or gave one answer, which could be considered as original. In general, experimental group has demonstrated higher level of creativity.

Thus, it can be seen that e-teaching aids and virtual laboratory complexes created in the process of our study improve the quality of knowledge and professional training, contribute to the formation of creative thinking of future Physicists by combining theory and practice.

4. Discussion

The reliability of results obtained at the beginning and at the end of forming stage for each criteria of creativity, as well as for the integral indicator is provided by Pearson criterion χ^2 and Student's t-test. To compare the distribution of students by levels of creativity in target and experimental groups the following hypotheses were formulated: No – no significant differences in the levels of creativity; N_1 – there are significant differences.

Table 5 shows the values of Pearson test $\chi^2_{эксп}$ on tested qualities on a quasi-professional level of physics teaching at the beginning and at the end of forming stage. According to the table of critical values for originality of thinking % $\chi^2 = 3{,}841$ (g=2, v = 1), in other cases $\chi^2 = 5{,}991$ (g = 3, v = 2).

Table 5. Values $\chi^2_{эксп}$ at the beginning and at the end of forming stage

Creative qualities	**Before experiment**	**After experiment**
Fluency Thinking	0,706	6,160
Flexible Thinking	1,606	6,753
Original Thinking	1,049	6,362

At the beginning of the experiment it is seen that $\chi^2_{\exp} < \chi^2 tg$ that means there are no differences between the development level of students' creativity from both experimental and target groups (hypothesis H_0). At the end of the experiment $\chi^2_{\exp} > \chi^2_{tg}$, that means there are significant differences in the development level of students' creativity (hypothesis H_1).

Values of t-criteria texp and ttg at the beginning and at the end of the experiment are shown in Table 6.

Table 6. values of t-criteria texp and ttg at the beginning and at the end of the experiment

Creative qualities	**t_{exp}**		**t_{tg}**	
	Before experiment	**After experiment**	**Before experiment**	**After experiment**
Fluency Thinking	0,070	3,127	2,007	1,994
Flexible Thinking	1,184	2,020	1,995	1,995
Original Thinking	0,213	2,389	1,999	1,996

According to the data from the table it is seen at the beginning of the experiment $\chi^2_{\exp} < \chi^2 tg$, and at the end of the experiment $\chi^2_{\exp} > \chi^2_{tg}$. In that way, in regard to development of fluency, flexibility and originality of the thinking the hypothesis H_0 is reasonable at the beginning and H_1 is just at the end of the experiment.

5. Conclusion

The experiment shows positive dynamics in students' understanding to what extent each several skills in English are important and open up new horizons to them. This confirms that the interdisciplinary approach to second-language indicated Physics teaching is not unidirectional: it is of interest not only in terms of the synergy of foreign language teaching and special subjects. Students able to present the results of the study can participate in international conferences and work with authentic scientific and technical literature gives students a range of opportunities for research activities at the international level, etc. Implementation of an interdisciplinary approach involves the development of strategic prospects both for the Faculty of Foreign Languages and the Faculty of Physics. The given interaction mechanisms can be successfully extrapolated to other areas of technical profile. The relevance of digital technologies and case study in the CLIL of Physics teaching was justified from theoretical and statistical point of view. The use of digital technologies and case-study helps to implement interdisciplinary and practical orientation of educational system today. The results received are valuable for further research in order to identify organizational features of second-language integrated learning of other technical subjects and build prospects for inter-faculty cooperation.

Research results make it possible to create and implement didactic system of second-language indicated teaching of natural subjects, namely Physics:

- transform educational system into a new model of economic growth through the technologies of accelerated second-language integrated learning of some subjects
- narrow the gaps between education in urban and rural schools by means of IT technologies; widen opportunities to improve human resources through fast English learning
- rise the quality of life by increasing of qualified English teachers
- develop high-tech product based on innovative technologies in educational process.

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