Descriptive Geometry: Innovative Approaches to Training Students in the Specialization "Industrial and Civil Engineering"

Nina Krasovskaya[1], *Alla* Feoktistova[1], and *Irina* Nordman[1,*]

[1]Industrial University of Tyumen, 625000, Volodarskogo-str., 38, Russia

Abstract. The article deals with problems of the organization of individual creative students' independent work in the conditions of informatization of education. The importance of innovative approaches for the development of comprehensive information culture of the future specialist in the specialization "Industrial and civil engineering" in the area of "Construction" is stressed. The possibility of applying of synergistic approach in specialists' training is discussed. Ways to develop highly effective methodological materials when teaching Descriptive Geometry are shown.

1 Introduction

In the future professional activity, the graduates of the construction high school in the specialization "Industrial and civil engineering" have to perform quite creative work related to the design of buildings and structures, as well as to the development of various designs, including the unique ones. Therefore, it is important to organize the educational process in the given area so, that the students form a permanent motivation to acquire knowledge in the field of design and construction throughout the entire training period, starting from the first year. Currently, scientific and educational activities in the higher school is organized taking into account the logic of stage of scientific and technological revolution. Its distinctive feature is the social determination of goal sets. Engineering activity is increasingly turning into a social-engineering one. In this context, the main objective of the teacher is to choose modern high-performance and innovative teaching approaches, in order to create conditions in the learning process not only for the formation of general professional competencies, but also for enhance the creative learning activities, student' independent work for searching the new knowledge and formation of a research thinking style.

In this context, the teacher will have to develop special individual tasks of problematic nature as well as non-traditional tasks and exercises of increased complexity for identifying of creatively gifted students. As person creative abilities are originally built-in; it is required to awaken them and stimulate to develop. It should be done already in the first study year, in order the students are able to demonstrate understanding of the objects of

* Corresponding author: nordman.i@inbox.ru

their future careers and develop their abilities in the field of non-standard approach to space-planning decisions on subsequent courses, being studied in the direction "Construction". From among students, groups for participation in the scientific and educational project groups as well as students' research associations can be subsequently formed. As years of the authors experience show, these creative people participate in the senior years in the development of large general education project to the specific point with great interest and have the possibility of its presentation as a final project for graduation. Development of creative abilities of students activates also the interactive teaching methods: business and didactic games, dialogues, discussions, round tables, project method [1], used for many years for students in the specialization "Industrial and Civil Engineering".

The innovative assessment methods of students' knowledge and skills play an important role in enhancing of learning efficiency. Thus, for example, a multi-stage system of knowledge control is used for students in the area "Construction" at the Industrial University of Tyumen. Firstly, each training manual contains questions for self-control on the subjects; in the work books, all subjects have multiple-choice tests, in addition a short five-minute test is held at the beginning of each practice session and at the end of the lecture. This is the first stage of the effectiveness evaluation of the cognitive activity of the student. The second stage of evaluation is the intermediate testing for separate modules of discipline. And at the end of studying the discipline, the third stage of evaluation is the final testing. The second and the third stages of testing are carried out on the basis of score-rating system. It is a more advanced form of control, as it stimulates the activation of independent cognitive activity of students and ensures their systematic work throughout the entire training period, which contributes to a better assimilation of acquired knowledge [2]. It is important to understand that at the time of effectiveness assessment of students' educational activity the quality assessment of teaching activity takes place.

Modern educational activity of higher schools is increasingly based on new technologies, including the information ones, that can ensure the high quality of training, the higher labor productivity of students and teachers as well as the maximum satisfaction of their information requests. Among others, these technologies include conducting classes using computer presentations, as well as variety of audio-visual media. These technologies make it possible to intensify the development of not only students'space-visual thinking, but also the analytical one, to increase significantly the information content and efficiency of lectures [3] as well as solve common tasks, transformable to classroom conditions. Wherein the fine combination of cognitive and emotional learning is achieved. New information technologies of training help to achieve one of the main goals of the high school strategy – improving the quality of users' labour intelligence and maintainance of high professional skills and information culture in their work.

Currently, basic means of learning are both new teaching materials, meeting the modern requirements, and modern equipment including computer technics. The computer performs many design decisions automatically, easily and imperceptible connecting us to databases formed in all life spheres. Computer information technology do not only radically affect the entire form of acquiring knowledge and professional skills, but also refer to the deeper areas of the development and indication of personality, absolutely individual person features.

However, the ability to obtain large amounts of information easily and quickly changed at the same time the development and expression technology of students' creative abilities, as in these conditions, problems in the perception occure due to retreat from the traditional criteria and standards. Today there is no need to study thoroughly the traditions, schools, styles, to provide the scientific perception. Even the graphics packages, originally created for the full and rapid implementation of creative abilities, suppress mostly today these

creative start by abundance of ready solutions. The best hardware and software only help to create the necessary atmosphere and the most important resource is still the "human factor". Formation of professional abilities and skills system of future specialists is impossible without mentality training and flexibility of thinking. In addition to the core courses, it requires from the teachers special knowledge and experience in psychology.

Modern education is simply forced to integrate the functions of the missing public institutions previously set the desired depth of the creative person development. Modern assessment of the students' creative possibilities is based on the dominant and logic of knowledge of the course program, but does not include the element of its creative application. However, the reality is increasingly demanding the ability to improvise with the acquired knowledge, skills and to generate scenes and professional ideas [4]. The knowledge on the subject is only the instrumental background of the creative process, so the most actual problem in the application of information technologies is the lack of the their application culture. In addition to the basic expression forms, it is necessary to have a sense of the optimal number of the original information abundance in relation to the creative beginning in solving practical problems. This is achieved by introducing of adjustments, differentiating the implementation and the creative process in the course of disciplines. This allows the formation of the future specialist as a potential leader and founder.

In this regard, in recent years more than ever new technologies in educational process are researched aimed at overcoming the problem of their adequacy to the objectives of the development of creative abilities [5 – 7]. Among such innovations synergy is considered (from the Greek word "synergetikos" – "joint action", "cooperation"), which increasingly find application in the educational theory. It is a mode of study, where the knowledge and efforts of several people can be organized in such a way that they are mutually amplified repeatedly and accurately [8].

The essence of synergy effect is a combination of performance efficiency as result of the integration, the merger of separate parts into a whole system due to systemic emergence effect, namely the irreducibility of the individual elements' features to the properties of the entiry system [9]. The synergistic effect in education involves several components, including also the possibility of cooperation teacher – student as well as student – student, and the possibility of creating an integrated system that includes both teachers and students, teaching methods, methodological and logistical support, etc. An example of a synergistic approach can be a "project method" that brings together students with different levels of individual abilities. The result of this teaching method is the activation of the latent creative potential of each project participants. At the same time, students get more freedom on the timing and volume of training material, on the use of literature on other disciplines and other fields of knowledge, so, the integration of disciplines takes place in conditions of synergetic approach [10 – 12]. Synergy brings together disparate scientific facts, fragmented in various disciplines, and offers a qualitatively new generalized scientific worldview – a synergetic one, instead of fragment studying of the scientific worldbuilding. Thus, a synergistic education allows to stimulate individual, may be not displayed, hidden developmental lines. It is a way of opening of a new reality, searching ways to understand themselves and the ways in the future [13]. Synergetics as a universal methodological paradigm, formulated in the areas of natural knowledge, where complex systems, the phenomenon of self-organization and evolution of complex systems are studied, relying on the principles of openness, nonlinearity, structural heterogeneity, is increasingly used in the humanitarian sphere, including the education theory [14]. Synergy technologies coming out from creative and scientific teams are included in the educational institutions and easily traced in greater depth of joint studies of teachers and students.

However, the mere conducting classes using the new information systems will not be effective without a special methodical support, because even in the current conditions, the main teaching medium is still a learning edition – printed or electronic one. As one of the approaches of use and development of students' creative abilities and enhance the effectivness of the educational process in educational institutions, the development of modern innovative and effective accompanying educational materials is particularly important. It play in the pedagogical activity the same role as the work equipment in any manufacturing process. Therefore, all the educational-methodical materials should not only help students in mastering the discipline, but also ensure the achievement of a steady training results with minimal time and efforts on their part as well as on the part of teachers. Developed workbooks and albums release students from monotonous routine work while taking notes during lectures and allow more detailed audio-visual perception of teaching material. Preparation of any teaching edition should include careful selection of educational information, its rational distribution according to the units (modules), development of an optimal presentation form of teaching material. Development of various educational and training materials for improving the efficiency of perception [15], for example, graphics information and optimal organization of independent cognitive activity of students should be carried out in accordance with one of the basic principles of didactics – the visualization.

2 Methods

Authors of the paper developed new training materials with a high illustrative degree to study Descriptive Geometry by students in the area of construction. Before that authors had carried out a special scientific and pedagogical research to determine the optimal variant of form and of mentioned training materials. One of the research problems was to obtain statistical data on methodological specifics of the current training manuals. The following working hypotheses have been advanced:

- "weak" points in researched materials would show themselves as lack of assimilation of the relevant block of educational information by trainees;
- mastering level of educational material would be higher in the experimental group than in the control one;
- if the optimum efficiency level of researched teaching material would be reached, an average score of residual knowledge of students would not decrease in Descriptive Geometry, despite the decrease in the number of classroom hours devoted to their study.

Several training materials have been researched, including a training manual developed in the form of a workbook on the discipline "Descriptive Geometry", which was intended for students of engineering and construction specialties as a training manual, allowing to organize optimally students' classroom and independent work, as it contained basic course definitions and provisions, visual illustrative material (251 figures), workpiece blueprints both for note-taking of a lecture material, and for solution of classroom tasks and self-tests. Plan of research included following steps:

1. Development of an original version of illustrated teaching material.
2. Experimental use of material during the educational process.
3. Controlling of the mastering level of the educational information by students at the end of studying the discipline.
4. Checking the level of residual knowledge at the end of the year.
5. A students' questionnaire survey about the quality of teaching material.
6. Statistical analysis of obtained data.
7. Analysis of the obtained results.
8. Finalization of training materials, changes and new effectiveness research according to the plan.

At the first stage two experimental groups of students were chosen, which used the above mentioned training manual, and two control ones, in which it was not used. Learning efficiency was tested during the semester by special tests. The expert group consisted of 6 teachers. The answers were evaluated on 12 criteria, which were the main identifiers for experts. Assessments were recorded in special expert sheets and average indicators of mastering level were calculated. The coefficient of mastering the educational information was calculated for each student by the formula (1):

$$K_j^i = \frac{\sum \% \text{ over all descriptors}}{M\,L}\ C \tag{1}$$

where:
M - number of descriptors;
L - number of tasks in the test card;
C - number of correctly solved problems according to the expert assessment;
j - ordinal number of the student in the registration book;
i - expert number.

The form and content of the workbook were also assessed by questionnaire among students and teachers.

3 Results and discussion

Results of the initial research stage showed that the mastering level of educational material in experimental groups proved to be 7.4% higher than in control ones. It did not suit the authors of the research. "Weak" points of the teaching manual were revealed (for example, difficulties for students on determination the lines visibility as well as in the description of algorithms for tasks solving, incorrectly formulated questions in the tests for self-control and others.) At the same time the survey showed that 92% of students considered the use of such workbook compulsory and most of respondents (83%) evaluated these teaching materials as "good".

At the second research stage, the mentioned teaching manual was revised based on the results of experiment and questionnaire at the first stage, and an optimal variant of its content was created, which was confirmed by results of testing and questioning of students. As control groups were taken those ones, which used the old version of the training manual and as experimental groups those, which used the revised version of the mentioned training manual. Students used the new version got a higher average testing score than students of control groups. Experimental results showed that the mastering level of learning material in experimental groups at the second stage is by 9.3% higher than in the control ones. It is also higher compared to control groups at the first stage by 16.7%. From mentioned above it can be concluded that the second variant is more efficiently than the first. The same was confirmed by checking the residual knowledge of students of experimental and control groups. Thus, on the basis of the statistical data the main research hypotheses were confirmed by the experiment, and the revised version of the training manual was adopted as the optimum for the respective training stage. And it has been already used in the educational process on Descriptive Geometry during recent five years.

4 Conclusion

New learning technologies develop alongside the traditional ones, enriching them with innovative approaches, among others with the synergetic one. It is important to understand

that all of the structural elements of the learning process need to update: the training and methodological support, forms of conducting classes, teaching methods and efficiency assessing of cognitive activity results. By introducing information technologies, special attention should be paid to the development of creative abilities of future specialists.

References

1. V.G. Ivanov, S.V. Barabanova, M.F. Galikhanov, L.T. Miftakhutdinova, Engineering Education. Immanuel Kant Baltic Federal University. **20**, 9-14 (2016)
2. N.I. Krasovskaya, A.A. Feoktistova, Proc. of the international scientific-practical conference SWorld. **9**, 81-83 (2012)
3. S. Svetsky, O. Moravic, J. Stafankova, P. Schreiber, Proc. of the 22nd International DAAAM Symposium, **22(**1), (2011).
4. M. Piczak, A. Heidebrecht, Proc. of the Canadian Engineering Education Association (CEEA) (2015)
5. URL : https://peer.asee.org/engineering-education-in-russia-traditions-experiences-challenges-and-opportunities
6. S.I. Koryagin, K.L. Polupan, Engineering Education. Immanuel Kant Baltic Federal University. **17**, 7-13 (2015)
7. Y. Cao, Proceedings of the Canadian Engineering Education Association (CEEA) (2015)
8. A.A. Feoktistova, *Proc. of the international scientific-practical conference SWorld.* **11(**2), 6-8 (2013)
9. K.A. Meteshkin, O.I. Morozova, *Automobile transport*: Coll. of researched papers. Ukraine, Kharkiv, 149-154 (2015)
10. G.S. Dyakonov, Vysshee obrazovanie v Rossii. **12**, 35-40 (2013)
11. Ya.A. Barlukova, Bulletin of the Buryat State University, 15, 39-42 (2010)
12. V.A. Karambirov, Society and Law, **2 (44**), (2013)
13. URL: https://infourok.ru/sinergetika-kak-osnova-integracii-778703.html
14. S.V. Krivykh, *Professional Education Academy,* 12 (54), 3-13 (2015)
15. S. Urdarevik, Proc. of the Conference *Synergy in STEM*: *Bringing Mathematics, Physics and Engineering Together.* Brooklyn, New York (2009)