THE METHOD OF FORMING SPATIAL REPRESENTATIONS AND IMAGINATION, CONSTRUCTIVE AND GEOMETRIC THINKING OF STUDENTS WHEN STUDYING DISCIPLINE "COMPUTER ENGINEERING GRAPHICS"

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ABSTRACT
The article describes the experience of application of method of formation of spatial representation and imagination, constructive and geometric thinking within the discipline «Computer engineering graphics», studied at a college. It describes the methods, methodological support and training element for the formation of a tentative scheme of steps of the learners for the typical graphics tasks organized during independent work. It describes a pedagogical experiment, analyzes the results of the experiment and gives recommendations for the implementation of the methodology.
Keywords: Computer engineering graphics, spatial representation and imagination, constructive and geometric thinking, a tentative scheme of action, modular approach, training element, pedagogical experiment.

INTRODUCTION

The purpose of the discipline "Computer engineering graphics" at a college is the development of spatial representation and imagination, constructive and geometric thinking, determining capabilities of the students to the analysis and synthesis of spatial forms and relations on the basis of graphic models of space, practically implemented in the form of drawings of spatial features and dependencies.
The task of studying the discipline "Computer engineering graphics" is the learning of methods for obtaining certain graphic models of space based on orthogonal projection and the ability to solve by these models the tasks associated by spatial forms and relations.

LITERATURE REVIEW

The objective of our study is the experimental approbation and devising methods of formation of spatial representation, imagination and constructive and geometric thinking in training sessions on discipline "Computer engineering graphics" and in the course of organized independent work that would allow students to form the creative level of graphic solution of problems in analysis and synthesis of spatial forms and relations based on the methods of transformation of graphic models of space. The study applies the methods of organization of educational work in the educational program of a college and during the pedagogical experiment.

We believe that it is possible to allocate three levels of development of spatial representation, imagination and constructive and geometric thinking: reproductive, productive and creative.

At the reproductive level learners are able to solve typical tasks of receiving graphical models of space based on orthogonal projection (level of reproductive abilities).

At productive level, learners are able to apply the methods of transformation of graphic models of space using the existing skills of solving typical problems of reproductive level for obtaining graphical models space based on orthogonal projection (level of productive skills).

On a creative level learners are able to solve creative tasks of the analysis and synthesis of spatial forms and relations based on the methods of transformation of graphic models of space, tasks of searching methods of transformation of spatial models depending on individual spatial objects (level of creativity).

We believe that the formation of spatial representation, imagination and constructive and geometric thinking is possible in two stages. At the first stage, students acquire an approximate scheme of action for solving typical graphical tasks of reproductive level during the independent study of a training element. At the second stage, learners solve graphic tasks of productive and creative level depending on the complexity of a topic. In the process learners follow an approximate scheme of action, practiced during independent work.

We believe that such training is possible to use with the subject modular approach to the organization of educational process on discipline "Computer engineering graphics", which is described in the works of M.Choshanov, N. Erganova, ets.

In this case, according to P. Juceviciene a module is the logically completed part of an educational discipline that corresponds to one topic.

It is developed suitable methodical support for lectures and practical classes, independent work of learners, and monitoring the level of formation of spatial representation, imagination and constructive and geometric thinking for each module. The structure of a methodical support of the module on the topic consists of lecture material that is accompanied by a multimedia presentation, a training element, reflecting the methodology of implementation of a typical graphic task and serving as a means of forming an indicative basis for the activity during independent work, the package of graphic assignments of creative level, designed to perform for students on the seminar. The primary means for independent work of students is a training element. The training element is a booklet that consists of a coordinating part, information and activity part and controlling part.

The coordinating part is designed to coordinate trainees in the field of the objectives of the study of a training element, equipment and tools necessary for its study, and also in the list of training elements prior to this training element. The example of the coordinating parts of the training item shown in the picture.

Information and activity part of the training element consists of two columns: the left column contains completed text paragraphs which are the algorithm of the assignment and on the right side each text paragraph is aligned to reference pattern illustrating the step of the algorithm described in the paragraph. The example of information and activity part of the training element shown in the picture.

The controlling part of the training element is a list of control tasks with forms of responses that the learner fills in after learning the educational item, and a sample of completing the graphic tasks described in the training element. The example of the controlling part of the training element on the theme is shown in the figure.

The educational process in the study of each module is included in the general system classes in high school and has a gradual organization.

At the first stage of studying the topic it is two hour lecture. In the first hour of the lecture it is considered the theoretical position on the topic using multimedia systems as well as revealed the practical application of the studied educational material.

In the second hour of the lecture in detail worked out the training element, oriented to perform typical graphic task on the subject matter.

The second stage is that during independent work students learn a training element and execute typical graphic task by the method described in the training element. It is recommended the following sequence of work with the training element:

1. Read the learning objectives of the training element, to prepare the necessary drawing tools, sheets of paper in the specified format.
2. Based on the summary of the lecture, to learn the appropriate training material in a textbook, proposed by the teacher as the primary on the subject.
3. Refer to issued training element. The trainee is encouraged to consistently study the text material presented in meaningful paragraphs of left part of the training element, simultaneously with the study of the text material it is proposed to analyze the illustration corresponding to the studied paragraph and to establish the correspondence between textual content and its graphic reflection in the right part of the training element.
4. To close the test part of the training element and to restore the meaning and method of implementation of graphical task by the illustrations given in the right part.
5. To take the prepared sheet of paper in the proper format, to prepare the drawing tools given in the description of the equipment on the coordination page of the training element.
6. To close the right (illustrative) part of the training element and to perform the graphical task of the training element using the methodology of the work described in the text part of the training element.
7. After completing the job, to compare received graphical image with the image given in the controlling part of the training element, to identify errors, and to correct them focusing on the illustrative part of the learning element.

8. To turn to questions for self control, given in the controlling part of the training element and to answer them by filling out a response form.

The standard graphic tasks and forms with responses performed using the training element shall be passed to the Department to check by the lead teacher in strictly defined time, usually within seven days after the lecture on the subject matter.

The third stage aims at the formation of the creative level of graphical tasks' implementation and it is implemented on the seminar. At the training seminar each student gets their own variant of the implementation of creative learning task to image various graphic objects in drawings. Performing creative tasks activates the intelligence capacity of the learner, forcing him to seek solutions to non-standard tasks using approximate scheme of action acquired during learning the training element.

Thus, during the third stage the trainees perform creative graphic tasks, which leads to the formation of their abilities to think outside the box and to apply existing knowledge and skills in new practical situation, the development of cognitive activity and creativity, and, ultimately, helps to the formation of creative perception of space and the development of spatial representation, imagination and constructive and geometric thinking.

RESEARCH METHOD

Experimental testing of the described method of forming a spatial representation, imagination and constructive and geometric thinking was conducted during the training on the discipline "Computer engineering graphics" and has been used in Russian State Vocational Pedagogical University in preparing teachers of vocational training and in the Ural Institute of State Fire Service of EMERCOM of Russia in specialty training "Fire safety".

In the experimental testing were involved four groups of students of Russian State Vocational Pedagogical University and four groups of cadets of the Ural Institute of State Fire Service of EMERCOM of Russia. The total number of participants of the experimental approbation was 180 persons.

In experimental approbation have been developed criteria of an estimation of level of formation of spatial representation, imagination and constructive and geometric thinking of students, and in particular:
- reproductive level was estimated in the range from 0 to 10 points;
- productive level was estimated in the range of 0 to 20 points;
- creative level was estimated in the range from 0 to 30 points.

The range of scores was identified for assessment of the completeness and correctness of fulfillment of graphic tasks.

The experimental approbation included ascertaining, forming and control stages.
On ascertaining stage of the experimental approbation using the test methods and the package of control tasks there were identified the initial level of formation of spatial imagination of the four groups of students and four groups of cadets and calculated the average value of the level of formation of spatial representation, imagination and constructive and geometric thinking of students and cadets. According to the results of the findings there were generated two control groups and two experimental groups with a similar level of formation of spatial representation, imagination and constructive and geometric thinking.
A comparative experiment was conducted over one semester. In the course of the experiment there were studied such topics as:
- "Projection of straight lines";
- "Projection of planes";
- "The methods of conversion of projections";
- "Axonometric projection of lines and planes";
- "The projection of geometric solids. Scanning of the surface of geometric solids";
- " The intersection of the geometric solids. The construction of the lines of intersection by the method of auxiliary clipping planes"
- "The intersection of the geometric solids. The construction of the lines of intersection by the method of auxiliary intersecting spheres".

In the control group the classes were conducted on traditional lecture and seminar techniques of teaching in a college. Learners listened to the lecture material and there were conducted seminars using the graphical tasks for the creative level of formation of spatial representation, imagination and constructive and geometric thinking. The independent work of the learners was to prepare for seminar, to study textbooks and lecture notes.

In the experimental groups classes were carried out according to the method described above using the training elements for forming an indicative basis for the activity during independent work of students.
In the control phase, the learners of the control and experimental groups were offered integrated graphic work with graphic assignments of reproductive, productive and creative level. According to the results of integrated graphic work there were calculated the average score for each student.
The results of the experiment are shown in figure.

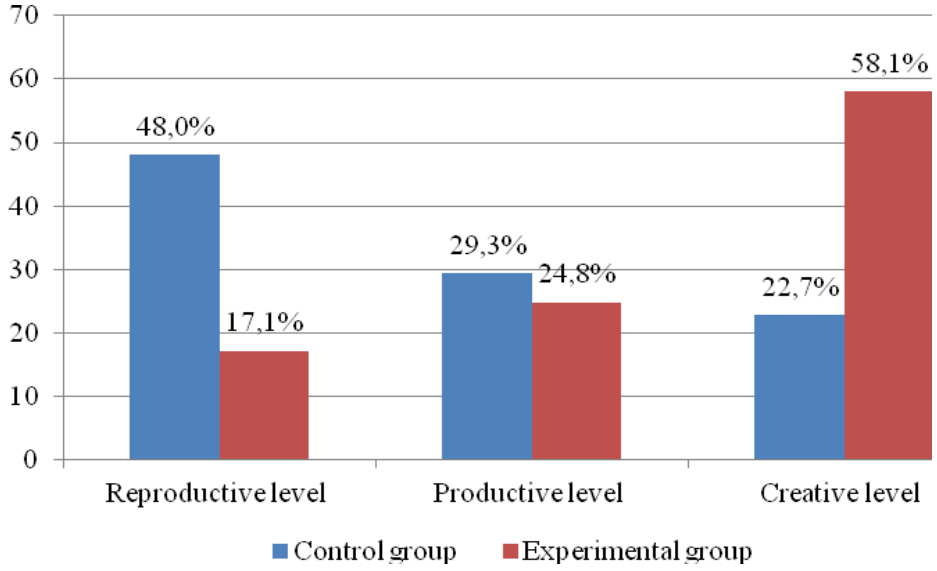

Figure1. Experimental results

The results of the experiment show that in the control group 48 % of students had performed integrated graphic work on the reproductive level, 29,3% - on the productive level and only 22.7 % on the creative level, almost half of the learners were unable to rise above the reproductive level of formation of spatial representation, imagination and constructive and geometric thinking. In the experimental group only 17.1 % of the learners were unable to rise above the reproductive level. 24.8 % of the learners had reached productive level of formation of spatial representation, imagination and constructive and geometric thinking. More than half (58.1 percent of the students) had reached creative level.

DISCUSSION AND CONCLUSION

The analysis of the experimental results confirms the high efficiency of the developed method of formation of the indicative schemes of action through the use of training elements as part of an organized independent work of students in the study module on the topic. We can assume that the use of the developed methodology and methodological support can significantly increase the level of formation of spatial representation and imagination, constructive and geometric thinking that determine the capabilities of students to the analysis and synthesis of spatial forms and relations on the basis of graphic models of space, practically implemented in the form of drawings of specific features and dependencies. Extrapolating the experimental results to other technical disciplines we can assume that the technique will also be effective in the study subjects, the content of which requires the solution of standard engineering problems, and the development of productive and creative level in the design and engineering of the subject.
The examples of such disciplines may include: theoretical mechanics, theory of mechanisms and machines, machine elements, mechanics of materials, materials, equipment industry, etc.

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