REPUBLIC OF AZERBAIJAN

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ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

METHODOLOGY FOR TEACHING THREE-DIMENSIONAL COMPUTER MODELS IN THE INFORMATICS COURSE OF SCHOOLS

Specialty: 5801.01 – Theory and methodology of training and
                 education (Metodology of teaching Informatics)

Field of science: Pedagogy

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GENERAL CHARACTERISTICS OF THE RESEARCH

Relevance and development of the theme. National leader Heydar Aliyev did not say in vain that "a state with a strong economy is capable of anything". Historical experience shows that some countries are enriched by their own economic resources and, as a result of rational management, effectively using these resources for a long time provides the well-being of the people. There are also countries that build and enrich the economy of these countries at the expense of the power of think tanks. In such countries, the role of education in the formation of the economy is exceptional. It is no secret that the main source of economy in such a country as Japan is human capital. It is here that the capital investment in the human brain has been going on for many years, since they can adequately assess the power of Science and education in the life of the people.

Although Azerbaijan is a fairly rich country from the point of view of natural resources, unfortunately, these resources are not used efficiently. Therefore, the role of education in the country's economy was played by the national leader H.Aliyev assessed it sufficiently and repeatedly emphasized the importance of carrying out education reform. For this reason, a document entitled "Educational Reform Program of the Republic of Azerbaijan" was issued by the former President's Decree No. 168 of June 15, 1999.

This document clearly states the purpose and principles of the reform: the main goal of the educational reform program is to preserve and develop the accumulated potential in preschool, secondary special, higher, bachelor's and post-secondary education.

The principles for achieving the stated goal are also reflected in the document. These principles include such important issues as humanitarian nature of education, practical orientation of reform, proportional development in education system, preservation of quality and competitiveness of education system, strengthening of relationship between education management bodies and other state bodies, implementation of management on the basis of state-public

principles, and, most importantly, establishment of new economic model of education system.

Despite the fact that 20 years have passed since the adoption of this document, we have not been able to achieve the desired results in our education.

Attempts to develop Azerbaijani education are also seen in other educational documents. One of them is the "Law of the Republic of Azerbaijan on education". The Law also includes the main principles governing the world education system:humanism, democracy, equality, nationality, quality, and most importantly liberalization and integration.

Another attempt was made to integrate Azerbaijani education into world educational standards. By the decision of the Cabinet of Ministers of the Republic of Azerbaijan dated October 30, 2006 No. 233, "General Education concept (National Curriculum) was prepared in the Republic of Azerbaijan. Of course, the views of the pedagogical and scientific community on the new educational program-curriculum are still ambiguous. Yes, it must be acknowledged that there are a number of aspects that are not necessary for the implementation of the curriculum. The influence of Soviet ideology in Azerbaijani society continues to remain, freedom in many spheres of our social life is not desired. All these are obstacles to the implementation of a new policy in education. A free family and a free society are still underdeveloped for the self-realization of the citizens of Azerbaijan. These shortcomings in the family and society, of course, had an impact on the school. Despite all these objective shortcomings, the curriculum has brought great innovations to our education. So, a new stage in the teacher-student relationship began, the teacher began to use not only the monologue, but also dialogue with his students, interactive training set foot in our schools. Significant changes have also occurred in the content of education. Already, students began to prefer to conduct analytical work on topics rather than memorizing topics, students were given the opportunity not to memorize the rules, but how to formulate these rules through generalization, conduct various mental operations on the text.

Achievements in education could not satisfy us at all, at least

because our achievements could not keep pace with the rapid pace of development of the time.

In this case, a new idea emerged: to develop an education strategy in Azerbaijan. For this purpose, by the Order of the president of the Republic of Azerbaijan dated October 24, 2013 "State Strategy on the development of education in the Republic of Azerbaijan" (hereinafter-the Strategy) was developed.

It is said in the strategy: "*Measures of the State Strategy for the development of education in the Republic of Azerbaijan*".[1] These areas include the creation of competency-based personality-oriented education content, the modernization of human resources in education, the creation of an accountable, transparent and effective management mechanism, the creation of a modern and lifelong education infrastructure and, finally, the provision of economic sustainability. The Republic of Azerbaijan and the world's leading education systems. Creating a financing model that meets the standards of the education system.It should be noted that the 'State Strategy for the development of education in the Republic of Azerbaijan" has not achieved its goals due to the lack of real, working mechanisms.

In addition to the documents listed above,by the №2815 Order of President of the Republic of Azerbaijan, Ilham Aliyev, dated March 28, 2013, 2013 was declared the "Year of Information and Communication Technologies". This clearly defines the position of the State in education policy.

The order contains an action plan to achieve the goal of information and "communication technologies". At the same time, specific work is entrusted to the relevant bodies to improve the regulatory legal framework and management to implement this plan.

Thus, the required document of the state of Azerbaijan on education envisages information communication technologies, its development and its use in accordance with the requirements of the time.

In the 10th grades, one educational unit was given related to the use of three-dimensional computer modeling in informatics in

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[1] Azərbaycan Respublikasında təhsilin inkişafı üzrə Dövlət Strategiyası // − Bakı, − 24 oktyabr, − 2013.− № 13. https://president.az/articles/9779@4

state standards and programs of general education. Although theoretical and practical realization of spatial figures by constructing models is envisaged here, resources and methods of its use for realization of the purpose set in the textbook do not meet sufficient requirements.It is shown to the standard that the student builds an information model of the object and describes its natural model.

We know that the process of modelling through three-dimensional computer graphics is used in many areas of human life. It is widely used in machine engineering and architecture for designing machines, in the development of special tools for three-dimensional modeling of games, in the development of installations and interiors, in the production of advertising and scientifically popular clips. Teaching three-dimensional computer modeling with new programs in secondary schools has become a necessary requirement of the time in order to carry out such high preparation.

Computer modelling should begin at the very first stage in the process of teaching computer science (A.G.Gayn, V.G.Jitomirski, E.V.Linetski etc.). The work on teaching modelling methodology and clarifying the content of training on this section was developed by N.V.Makarova and Y.F.Titova. Scheme of modelling stages, the definition of modelling object, consideration of concepts such as "object", "model", "system", etc. is one such case.

Y.F.Titova has developed a methodology for teaching two-dimensional computer graphics for high school students.Scholars such as L.A.Zalogova, M.Y.Monakhov, G.E.Monakhova, A.V.Kopiltsov, I.G.Semakin, and E.K.Khenner have developed elective courses in computer modelling and computer graphics for high school trend classes. O.Y.Ilyashenko developed a methodological system for teaching vector graphics and its implementation in the form of a special training course. The methodology of teaching three-dimensional modelling to use the latest set of basic forms for additional educational conditions belongs to V.V.Alexandrova.

In the research of E.Y.Tikhomirova, conditions were created to accompany the process of studying geometric materials by computer in order to develop students' general ideas about space. In her research work, the author developed a methodology that ehates a

three – dimensional computer model for students in grades 1-6 to master geometric material.

Studies on the use of a direct three-dimensional computer model in the Informatics and information technology course are practically low, but for schools this work is practically not developed at all. That is why teaching a three-dimensional computer model remains a problem in the Informatics course at school.

Object of the research it is the process of studying three-dimensional computer modelling of students in secondary school.

As a rule, the purpose of the study determines its **subject**, which is a methodology for teaching three-dimensional computer modeling when studying computer science in high school.

Purpose of the research: teaching senior students to use a three-dimensional computer model. At the same time, to create conditions for the use of knowledge acquired by students in computer science in the study of other disciplines.

The purpose of the study and the problems available to achieve this goal require the fulfillment of the following **tasks**:

1) To analyze the state of problems on the study of the section "computer graphics".A special place here is occupied by "Three-dimensional computer graphics", since the study of this topic in grades 10 and 11 is very important;

2) to choose the content of the educational unit "Three-dimensional computer modelling" in informatics at school;

3) determining the conditions of contact of this section with the subjects of technology, physics, mathematics;

4) to develop the methodology of teaching this teaching unit, taking into account the content of the subjects of technology, physics and mathematics;

5) to test the teaching methodology developed through pedagogical experiment;

6) processing of obtained results and conducting analysis on it.

Research methods. To perform the above tasks, the following methods were used:

- theoretical analysis of psychological, pedagogical, methodological and scientific literature on the study of the problem;

- conversation with teachers;

- to jointly use computer support in overcoming difficulties related to the solution of issues related to any subject;

- to conduct integrated lessons of mathematics and computer science using a three-dimensional computer model;

- conducting theoretical and practical trainings on informatics using the developed methodology;

- to observe the learning activity of students, to give them some recommendations in this process;

- talking to students, recording these conversations;

In order to fulfill the set tasks and achieve the goal of the research, the following hypothesis was made:the following will be achieved with the help of three-dimensional computer model training in the computer science course:

- development of students' ability to use a three-dimensional computer graphics environment.The formation of the second and third levels of creativity in most students;

- successful completion of training tasks in the field. If based on the use of three-dimensional computer modelling, they will focus on shaping students' thinking about space.The knowledge gained using a limited set of basic forms will help to carry out assignments in other subjects and develop creative abilities.

As a result of the research process, the following levels of development were determined during the use of three-dimensional computer graphics environment:

1. The student is able to independently perform the task given by the teacher with a step-by-step description.

2. The student is able to independently form a system of tasks or tasks and perform them on the basis of the environment presented.

The theoretical-methodological base of the dissertation is the scientific works done in the field of methodology (A.G.Palangov, A.M.Gasimova, M.A.Alishov, I.N.Ismayilov, N.A.Abishov, I.B.Ahmadov, H.N.Taghiyev, M.V.Abdullayeva; from the educators related to modern teaching methods F.A.Rustamov, I.N.Isayev, I.H.Jabrayilov, H.A.Alizade, E.Y.Golant, Y.K.Babanski, P.I.Pidkasisty, T.A.Ilyina, S.A.Smirnov, A.G. Pekun, A.A.Verbitsky, N.B.Borisova).

Scientific works of Kh.T.Novruzova, S.S.Hamidov, T.G.Vezirov, V.V.Laptev, M.P.Lapchik, I.V.Simonova, M.V.Shvetsky in the field of Informatics teaching methods and development of methodological systems; scientific works of V.A.Shtoff, L.M.Friedman, N.I.Kondakov, V.M.Kaziev on modeling research; scientific works of A.G.Palangov, K.F.Shirinova, A.M. Mammadov, I.V.Robert, N.I.Pak, S.M.Taneev, A.A.Stolyar, D.N.Kojevnikov, V.N.Dubrovski, V.V.Lapev, E.E.Nifantyev, L.M.Turanova about model in training and its use in modeling; scientific works of V.V.Aleksandrova, I.A.Kuznetsova, A.N.Kostikov, N.V.Makarova, N.Petrova, E.T.Selivanova, Y.F.Titova on computer graphics and computer modeling training; scientific works of N.S.Podkhodova, A.M.Sidtikov, Y.E.Tikhomirova, I.S.Yakimanskaya for research work on the development of spatial thinking and presentation; educational standards in Informatics also form a theoretical and methodological base.

The research work continued during 2019-2022.

In the first stage (2019-2020), a search and identification experiment was conducted. In the process of this experiment, an analysis of psychological, pedagogical, methodological literature was carried out, directions for the development of problems of modeling training in the school Informatics course were identified.The analysis of educational standards in Informatics allowed us to identify students' knowledge, skills and habits in three-dimensional computer modelling. The survey conducted with the teachers and the joint use of computer help in the lessons determined the type of tasks on the subject and subject areas of the appropriate subject.These are the types of assignments that are difficult for students to complete.Problems related to solving difficult tasks were identified.These problems were eliminated using three-dimensional computer modelling.Integrated lessons of mathematics and informatics were conducted.The object and subject of the research are determined.Its purpose, hypothesis, objectives are indicated. The method of solving these tasks is disclosed. Finally, the content of the training has been worked out.

In the second stage (2020-2021), a confirmatory experiment was conducted. In the process of the course of this experiment, the theoretical and practical components of training were tested, metho-

dological recommendations for teachers were identified, Levels of skills in using the 3D Studio MAX environment have been identified. Written surveys and interviews were conducted with students.The main goal was to reveal the interests of students and their learning achievements, to study the specifics of the difficulties encountered by students during the implementation of tasks in mathematics, drawing and technology, to group these difficulties and to find ways to overcome them. The main task was to identify the role of three-dimensional computer modelling in order to determine the level of students' thinking about space. For this purpose, students were tested according to I.S.Yakimansky's method. At the end of the experiment, the test materials were processed quantitatively and qualitatively. General conclusions were drawn on the conducted research.

Scientific novelty of the research: The necessity of introducing the educational unit "Three-dimensional computer modelling" into the informatics course in the upper grades of the secondary school is substantiated, the content of the theoretical and practical components of this training has been developed, the construction of the training methodology on the practical component was carried out in such a sequence:transition from training on development of models of objects on base form to application of knowledge, skills and skills gained in this field in other subject areas. It is aimed at developing students' thinking about space and their personal creative abilities.

The theoretical significance of the researchlies in this: It was considered expedient to identify two main components (theoretical and practical) in the content of training on "Three-dimensional computer modelling" unit. The conditions for the use of training methods in this section in the upper grades of basic education have been determined.This also applies to technological and physics-mathematics courses.

The practical significance of the research is as follows:

1) the teaching methodology of three-dimensional computer modelling has been developed in the lessons of interdisciplinary informatics. Teaching aids were prepared for pupils to strengthen teaching methodology;

2) A methodical recommendation has been developed for computer science teachers to study and teach the "Three-dimensional computer modelling" unit.

The main provisions for defense:

1. Theoretically justify the introduction of three-dimensional computer modeling based on the standards of the computer science course in the upper grades.

2. The state of teaching on computer science three-dimensional computer modelling educational unit:

a) the theoretical and practical components of this material can be realized in the teaching of technology, physics and mathematics;

b) in the conditions of basic education of a secondary school, only the implementation of the practical component is possible.

3. Three-dimensional computer modelling consists of this sequence on the practical component: transfer of knowledge, skills and habits acquired in the training of modeling objects based on the basic form into subject areas aimed at the development of spatial thinking of students and through it the development of personal creative abilities.

Approbation and application of the research. Results of the study it was published in 9 articles (including 3 articles abroad). In addition, the author gave a report on this at 4 international and 1 national scientific-practical conferences.

The dissertation was performed at **Ganja State University.**

Structure of the dissertation work. The dissertation work consists of an introduction, 2 chapters which includes 10 paragraphs, a conclusion, a list of references and appendices.

Introduction consists of 10 pages, 17303 signs, chapter I 59 pages, 103138 signs, Chapter II – 53 pages, 77581 signs, conclusion 2 pages, 3025 signs, proposals 1 page, 485 signs, list of used literature 16, appendices 8 pages, in total the dissertation work consists of 151 pages, 201532 signs.

MAIN CONTENT OF THE RESEARCH

The **"Introduction"** substantiates the relevance of the theme, the purpose and objectives of the research, its object, subject, basic hypothesis, methodological and methodological bases, scientific novelty, scientific-theoretical and practical significance are explained, the main provisions to be defended are defined.

The first chapter of the dissertation is called **"Three-dimensional computer modelling in secondary school teaching"**. This chapter consists of five paragraphs.

In this chapter, the problems of the development of students' knowledge, skills and habits on the educational unit "Three-dimensional computer modelling" are studied.The purpose of the study is that it is possible to solve this problem with the help of computer science.

In the first paragraph called **"Different views on the definition and explanation of the concepts of model and modelling"**, definitions given by world scientists to model and modelling were investigated and systematized. A.G.Palangov, L.M.Friedman, V.A.Stoffan, R.Mahmud-zade's views were quoted and analyzes were carried out. Model and modelling are universal concepts. They are the most powerful method of cognition in any field of specialization, in the system of cognition, to investigate processes and phenomena. At present, there is a system of concepts in the theory of modelling: object, model, information model, computer-graphic model and the relationship between these concepts. According to L.M.Friedman: *"A model is any object (system). Studying this object aims to gain knowledge about another object (original)".[2]*

If we refer to the words of V.A.Shtoff: *"The model plays a secondary role in relation to the object, it is deliberately created to understand that object. The methods chosen to construct the model are also the result of deliberate action and consist of specific theoretical considerations. Therefore, they consider it as one of the components of the scientific method. Thus, the model is a special epistemological*

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[2] Фридман, Л.М. Наглядность и моделирование в обучении. / Л.М.Фридман. – Москва: Знание, – 1984, с. 23.

image and, at the same time, a means of understanding".[3]

The second paragraph of the first chapter of the dissertation, entitled **"Stages of modeling and classification of computer models"**, as the name suggests, provides extensive and detailed information about the stages of modeling and classification of computer models.

In this section, as part of our research, we developed a three-dimensional computer modelling methodology in a 3D Studio MAX graphics model environment.

V.V.Aleksandrova's dissertation notes that: "*During three-dimensional computer modeling, objects are created according to certain base forms with the help of tools in the 3D Studio MAX program*".[4]

The graphic model is always preferred in research works. The graphic model has an advantage over others. For example, the advantage of analytical and physical models is that information writing is very closely reflected here and differs from visual point of view with its positive sides. Graphic symbols used when creating graphic models are more informative than the textual writing of information used in other models.

The graphic model is a model that embodies clarity in general. He expresses a general internal attitude to objects. The model opens the training material graphically.

The following tasks of the modelling problem were identified:

a) model constructing; b) model research; c) using the model.

All of the above tasks can be realized through the three-dimensional computer modelling methodology developed by us.The tasks for the construction and research of models are performed both during the study of objects with decorative plastic and objects in the field of things aimed at the development of spatial thinking of students.

In the third paragraph of Chapter I entitled **"Functions of model and modelling, visibility and modelling"**, based on the idea described

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[3] Штофф, В.А. Гносеологические проблемы моделирования: / Автореф. дис. докт. философ, наук. / – J1., 1964, с. 14.

[4] Александрова, В.В. Компьютерное моделирование пространственных форм в среде 3D Studio MAX / В.В.Александрова, И.В.Симонова, О.А.Тарасова. – СПб.: Анатолия, – 2003. – 319 с.

in the previous paragraph, "no matter how close the concepts of model and modeling are, there is a significant difference between them, because one refers to the name of the research operation as a whole, and the other to the sequence of this operation". For the reason we mentioned, the model and functions of modeling may not be the same, they are essentially very different from each other.

Properly constructed models are able to eliminate inaccuracies in the human language, can offer more useful, more active, more successful methods for communication. The advantage of the model over the method of communicating through words is that it is able to present the situation in a dense, precise form. The model makes the structure of the studied object more understandable and reveals important cause-and-effect relationships.

Models have always been used and will be used further in the application of training as a means of professional training. In particular, people who design natural models of spacecraft to train cosmonauts use the model to evaluate and control various random events (for example, people who develop natural models of spacecraft to train cosmonauts). This type of training simulators for training train drivers and business games for administrative training in firms.

In science, a model is used to study any object, event and process. It is used to solve various scientific problems or to obtain any information.Therefore, the model is defined as any object or system. In science, a model is used to study any object, event and process.

Oboyshikova I.G. defined the functions of modeling: "*These are administrative, systematizing, developing and scientific understanding method mastering functions. Modeling is a tool for creating problem situations. This also happens by developing students' mathematical abilities".*[5]

Kuznetsova I.A. writes: "*Modeling is the researcher building a model and studying this model in order to get information about the*

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[5] Обойщикова, И.Г. Обучение моделированию учащихся 5-6 классов при изучении математики: / Автореф. дис. канд. пед. наук./ – Саранск, 2002. – 9 с.

object - the original".[6]

The visibility of the models is based on these important regularities: the creation of material and ideal (figurative and sign-symbol) models is based on the creation of visual images of pre-thought models ─ modeled objects.More precisely, when building a model of one or another object, the subject creates in its own way an imaginary visual image of this object, and then the waste builds on its basis a material or image, a sign-smvolic model.The perception and mastery of the finished model goes in the opposite direction, that is, first they perceive the model as semantic (material, figurative, sign-symbolic), and then they build the corresponding mental model (visual image of the object being modeled).

The fourth paragraph **"Using a computer model in teaching secondary school subjects"** of Chapter I talks about the place of computer in teaching subjects in secondary school, how to use them correctly, and how to properly organize work in circulation. The effectiveness of training methods depends on various factors. Let's say that my teacher uses the question and answer method. In the first case, he/she asks pupils certain questions, and the pupils answer the teacher's questions based on the materials they have mastered first. In the second case, students not only answer the questions of the teacher, but also demonstrate new knowledge by creating new contacts based on these answers. So, in the first case, we are witnessing a reproductive method, and in the second case, we are witnessing a heuristic method of interviewing. We can see how skillfully and creatively we use training methods when we use other methods. It all depends on the teacher's ability and how to organize and equip the training.

Animations created on the basis of the three-dimensional computer environment enrich the learning process, help to make it more effective, and move the students' sense members to perceive the learning information.

In this case, the learning curve goes from a statistical form to a dynamic form, that is, it allows you to monitor the studied processes

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[6] Кузнецова, И.А. Обучение моделированию студентов-математиков педвуза в процессе изучения курса «Математическое моделирование и численные методы»: /Автореф. дис. канд. пед. наук. / – Саранск, 2002. – 18 с.

within a time frame. Given that it is not possible to demonstrate many of the events studied in the training room, it is not difficult to understand how important the above is. For example, children have the opportunity "to see" the atom and the nucleus inside it. There are other examples. When using three-dimensional computer models, students show not only external but also internal activity, which is based on feelings of curiosity and amazement. This presentation of the material has some advantages over traditional methods. Thus, students' attention increases, and because it is part of the system of figurative and emotional memory, the learning material is not erased from the student's memory for a long time.

The use of visual aids in teaching practice is combined with the teacher's verbal appeal to students:recitation, questions, etc. When using visual demonstration, the teacher creates visual images with the help of visual means observed with speech, and the mental activity of students in this case ensures a direct combination of the idea of concepts with perception.

We should not forget one more important issue. It is not always advisable to use a computer as a demonstration tool. Educators are well aware that the lesson is a teacher's creative space. There, the teacher uses the teaching aids according to the situation.

Given all of the above, we need to know that a computer is a component of a system of learning tools. It includes both traditional teaching aids as a quality provider of existing subject teaching. It is not enough to solve the problem of using a computer in the learning process, to act only from the functional capabilities of the computer and to use it in the teaching process. First of all, you need to know, what training tasks are performed with computer tools, what level of their effectiveness, like other didactic tools, and in general, what is applied or not. With the help of the computer, the training system can be effectively built, operated and developed only then, so that the pupils, as a whole, could achieve the achievements of the scientific and technical process to the fullest extent possible.

The last, fifth paragraph of Chapter I is entitled **"Theoretical bases of the use of three-dimensional computer models in secondary schools"**.

According to the theory of learning activities, it is possible to learn something, to master something only in the process of activity. As a result of the active activity of the subject, any mentally created, including graphic images are formed. It is very difficult to master any knowledge, understanding and movement in the process of live observation. The determination of the specific content of students' activities is based on laws studied by psychologists around the world. According to this law, the laws of imaginable activity lead to the creation of the image of a three-dimensional object presented on a two-dimensional plane. Thus, spatial imaginations are transferred from imaginary sphere to real graphic image.

In Informatics lessons from the point of view of modern educational standards, students should pay attention to the development of not only abstract three-dimensional models, but also models related to subject areas that are not related to informatics (eg: mathematics, drawing, biology, technology, chemistry). This may increase students' interest in the above subjects. At the same time, as a result, the general culture of students' thinking develops.Thus, it will allow students to consciously and deeply master the exact sciences.

Our analysis showed that modelling skills in a three-dimensional computer graphical environment allow the student to review all figures while teaching spatial figures at school. This opportunity is no less than the level of developing students' imagination and geometric thinking about space.

In modern pedagogy, preference is given to active methods of training.

It is students who grow as individuals thanks to the use of active methods. Active mental and practical activity of students in the learning process is an important factor for their effective understanding and practical assimilation of the studied material.

Game design, imitation training, role playing, analysis of specific situations and others are also included among active teaching methods. Proponents of cognitive psychology pay special attention to interactive methods. The use of this method is attributed to a list of characteristics. This list defines cognitive style of each of the learners. After that, it is possible to choose an effective technology of training. Interactive met-

hods include both traditional (lecture, open discussion) and innovative (reflection, imitation, debate, brain attack, etc.) is attributed.

N.V.Borisova conducted a classification of the method of active training as follows.
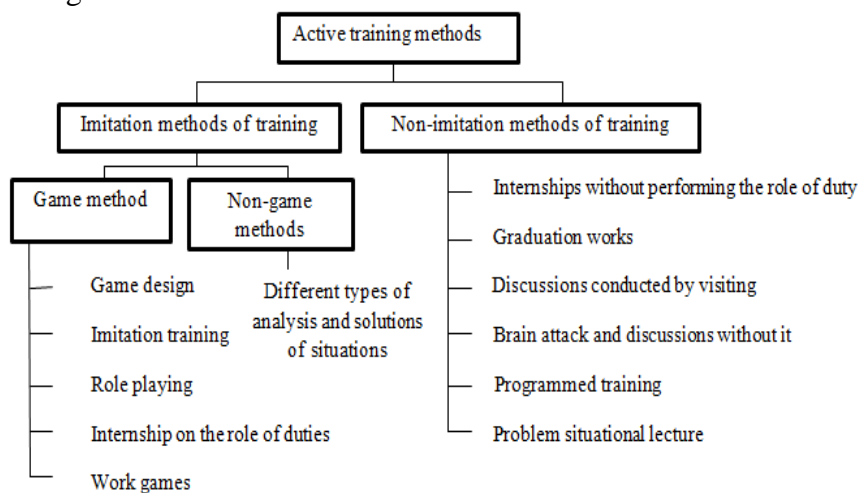
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                    ┌─────────────────────────┐
                    │  Active training methods │
                    └─────────────────────────┘
          ┌──────────────────────────┐  ┌──────────────────────────────┐
          │ Imitation methods of     │  │ Non-imitation methods of     │
          │ training                 │  │ training                     │
          └──────────────────────────┘  └──────────────────────────────┘
   ┌──────────────┐  ┌──────────────┐   ── Internships without performing the role of duty
   │ Game method  │  │  Non-game    │
   └──────────────┘  │  methods     │   ── Graduation works
                     └──────────────┘
   ── Game design      Different types of   ── Discussions conducted by visiting
                       analysis and solutions
   ── Imitation training   of situations    ── Brain attack and discussions without it

   ── Role playing                          ── Programmed training

   ── Internship on the role of duties      ── Problem situational lecture

   ── Work games
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Fig. 1. Classification of active training methods

A.A.Verbitsky notes that the application of active learning methods is not a new idea, but the use of forms and means of active learning in combination with traditional methods is rare.

In the course of the research, three-dimensional methods of computer modelling in computer science lessons were developed by us through the following:

1) Teaching three-dimensional computer modelling in a SketchUP environment;

2) To teach three-dimensional computer modelling based on the example of work in the environment 3D Studio MAX;

3) solution of applied issues from subject areas aimed at development of spatial thinking of pupils (mathematics, drawing and technology).

In the course of the research, experimental training showed that in a three-dimensional computer graphics environment, practical skills are acquired during laboratory work prepared by the teacher. This

includes creating three-dimensional computer models and completing core school assignments. In this case, the teacher should use methods that create positive emotions in students against learning activities. It must be able to implement the content, form and methods of this activity.This can be done by providing differentiated assistance to students in completing learning tasks with the same difficulty, rewarding learning, entertaining content, and creating a creative search situation.

The second chapter of the dissertation is called **"Methodology of teaching computer modelling in the course of computer science"**. The chapter talked about the content of training on modeling educational unit, methods, forms and means of training, menu items and characteristic of SketchUp program, methods of teaching teaching unit "computer modelling" and the results of the pedagogical experiment.

The first paragraph of the second chapter, entitled **"On the content of modeling training unit",** contains many issues.

Problems of three-dimensional computer modeling on the basis of full secondary education begin with the "Graph information model" of the content line "Information technology" in the 9th grade computer science course. Then it is continued in the 10th and 11th grades in the manner we mentioned above. In addition, practical questions related to computer graphics are considered in the content of the line "Creation and reorganization of information objects": 1) graphic information objects; 2) tools and technologies for working with graphs; 3) creation and editing of graphic information objects through graphic editors, presentation and animation systems. The analysis of the state education standard shows that the requirements for the level of preparation of students are given in the form of activities: not only "to know", but also "to be able to", "to be able to apply the acquired knowledge in solving problems related to our daily lives". The content of education is given personality, nature of activity and practical direction. The level of independence shown by students in solving various types of tasks allows them to determine at what level they will use three-dimensional computer graphics. It should be noted that the level of complexity of the tasks presented by

students should not be higher than the level accessible to them. Nevertheless, the transition to subject areas that are not related to computer science can create difficulties for some students.

The second paragraph called **"Methods, forms and means of training"** of the second chapter is classified the methods of training outlined in Chapter I, and as a result of the analysis, these classifications are completed. However, this completion is conditional, and as society changes and develops, new methods emerge. Completion work should be carried out in these classifications, taking into account the activity of students. The completed structural classification of Y.K.Babansky was completed by S.A.Smirnov.

Taking into account these classifications, we substantiate the use of the method of three-dimensional computer modelling in the methodology. In the course of the practical component of training, it is necessary to switch from the issues formulated by teachers in various subject areas to the issues formulated by students. This occurs at the expense of the development of students' creative abilities on the basis of the second, third, fourth and other methods described above.

The third paragraph of the second chapter of the dissertation called **"Menu items and characteristic of the SketchUp application program"** contains detailed information about the features of the program. Since older versions of the *SketchUp* software are accessible and free, the use and study of this purpose is advisable. Therefore, in order to use this program, it is necessary to first teach its tools and the features of the menu item.

Now let's take a brief look at the menu items in *Sketchup*.Since the commands of the file item are in other programs, we do not describe its submenu items. Let's take a look at some of the commands in this menu that are unfamiliar to us.

• *Preview in google earth*–used to do a preview on google;
• *Geo-lection* –used to determine geo location;
• *bulding maker*–to commemorate the building manufacturer or programmer;
• *3D Warehouse*–to search 3d warehouse;
• *Edit*– menu is almost partially familiar to us. What is new for

us, let's look at the commandments:
- *Undo Interact* – Returns the interaction;
- *delete guides*– to delete instructions;
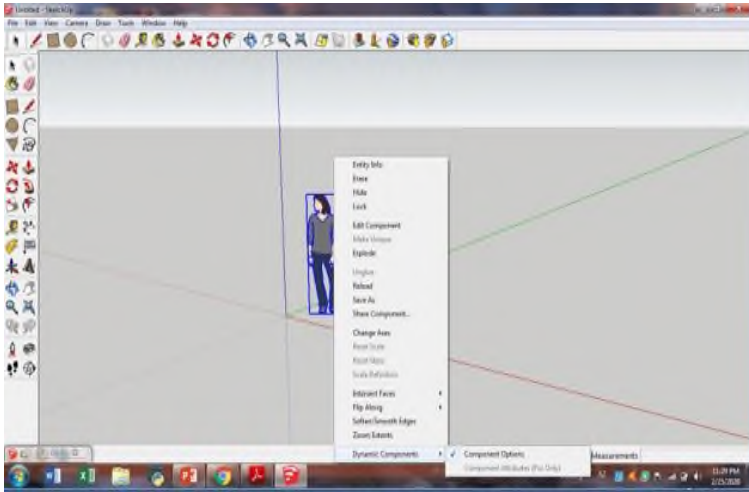- *Intersect face*–For crossed faces.
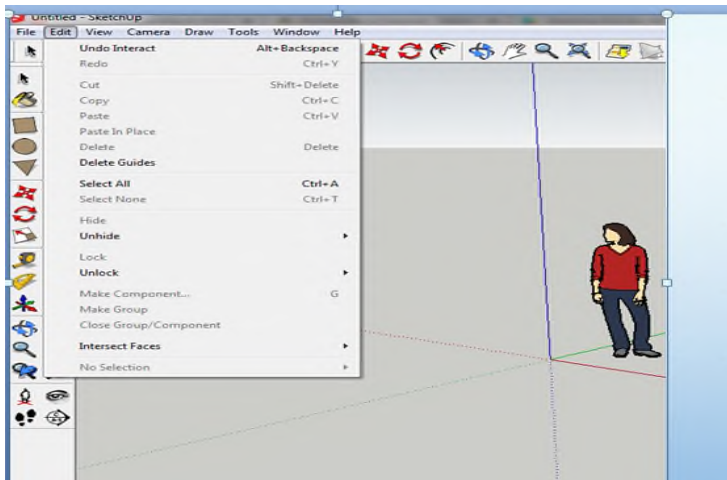

Fig. 2. View of *SketchUp's* context menu in software

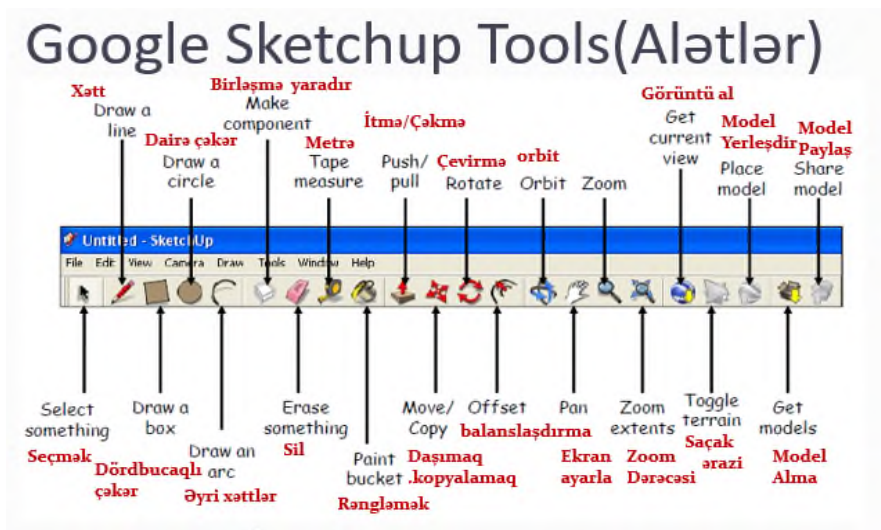**Fig. 3. The appearance in the program of the sub commands of the Edit menu of *SketchUp***

Fig. 4. SketchUp window menu tools

In the fourth paragraph called "**Computer modelling. Teaching methodology of the teaching unit"**of the second chapter, the issues mentioned below have been touched upon.

If we look at the existing textbooks, then in both the 10th and 11th grades, the topics of this teaching unit are mainly theoretical in nature. Most of them are devoted to the types and classification of models. Some topics have not been properly recommended for practical purposes. There is no logical sequence for the practical work of students here. This also makes the students' memory difficult and reduces their interest in the lesson. The method proposed by us differs from the one recommended by the authors of textbooks in two directions, eliminating this shortcoming. The first, according to us, is calculated on the fact that the Sketchup program is taught practically, and the second, preference is given to the logical sequence of topics. For this purpose, the number of hours allocated to the teaching unit is enriched with practical issues, a model-making programme (Sketchup) is perfectly taught.

So, in the first lesson, the most necessary part is taught from the theoretical material contained in the textbook, and then the following information is given about the Sketchup program. It is noted that this program was produced mainly for architects and engineers in 2001.

The last, fifth paragraph of the second chapter is devoted to the results of the pedagogical experiment. The paragraph is called **"Results of a pedagogical experiment".** In order to determine the level of knowledge of students in computer science in 10-11 grades on the unit "Modelling" in 2020-2021, a pedagogical experiment was conducted at M.Mehdizadeh Secondary School No. 4 in Ganja, and M.Isayev Secondary School in Agdash and R.Alihasanov Secondary School No. 1 in Masalli. The result of the experiment was to determine the level of knowledge of teachers and students in the teaching of "Modelling" in computer science in grades 10-11.

The stage of determining experiment. At this stage, the main goal was to reveal the real pedagogical situation. In the classes where the experiment will be conducted, meetings were held with pupils and teachers, facts were collected, preliminary provisions were determined. In the 10th and 11th grades, teachers' lessons on computer science on the "Modelling" teaching unit were heard. At this stage, a survey was conducted with teachers and students. The survey asked them the following questions:

Questions for teachers:

1) Are you satisfied with the knowledge of your students in computer science?

2) Are you satisfied with the content of the topics in the modelling unit?

3) What difficulties are there in teaching this teaching unit and can they be overcome?

4) What computer programs do you consider expedient to use in teaching the content of the modelling educational unit?

The students were asked the following questions:

1) How do you interpret and differentiate the concepts of model, modelling and computer modelling?

2) With what computer programs can you perform three-dimensional computer modelling?

3) How to model and classify three-dimensional figures in different situations (front, side, back, etc.)?

4) What do you know about 3D max and SketchUp programs?

5) What computer capabilities can be used to solve the problem?

6) Would you like to use 3D max and SketchUp to solve geometric problems using a computer?

Teachers'and students' answers were collected in the form of questionnaires.The survey found that 87% of teachers and students prefer to use computer technology in geometry classes.When analyzing the results of this survey, it turned out that the results of the survey are approximately the same in all classes. The result of this analysis fomented the idea that the content of this teaching unit is not adequate to the needs of students in textbooks. As a result of this, it is necessary to reconsider the content and teaching methodology. Thus, it is better to give preference to practical content in the content of topics included in this teaching unit. Therefore, the main part of its content should be devoted to building three-dimensional computer models. For this purpose, after giving information about the 3d max Studio program, its paragraphs and characteristics should be taught to build the SketchUp program. Then, in accordance with this theoretical material, a methodology for constructing models of various tricolor models should be developed.

By providing this methodology, it is necessary to prepare creative and medical works to demonstrate the effectiveness in teaching other neighboring subjects (problem, mathematics) as well as in studying informatics. In addition, the direction of independent activities of students should be given.

The students themselves initiated the construction of computer models through the SketchUp program, but practical skills have not yet been formed, since there is no practical work adequate to the main characteristic of the program and its reinforcement. Therefore, it is advisable to use a computer in the construction of drawings of three-dimensional figures and to perform calculations during the solution of the problem.

The second stage is called the learning experiment stage. The purpose here was to realize the hypothesis put forward. At this stage, experimental and control classes were traditionally chosen in schools. In the experiment classes, lessons were conducted using SketchUp on recording ounan classes and the capabilities of 3D max studio programs. For this purpose, the teachers who taught in those classes first got acquainted with the purpose and objectives of the experiment. In Grades

10, problems related to the calculation of the area and volume of the surface of a parallelopiped, a cube, a pyramid, a right tetraedrin were solved, spatial figures were displayed on the computer using 3D Max Studio and SketchUp software.The issues on textbooks and additional compiled in those classes were solved, and the most effective solution methods were discussed with the pupils. In Grades 11, it is devoted mainly to issues of constructing models of spatial figures and objects in SketchUp. Students have developed various forms of models of three-part shapes prepared in SketchUp program and the methodology of its use is shown. In addition, students were given independent tasks with the application of these programs, and the results were discussed in additional classes and discussions with the students.In control classes, teachers only got acquainted with the materials that were put into the experiment. At this stage, both experimental and control classes were presented to students with material consisting of tasks from the same questions. According to the results of the given tasks for each student, the assessments shown in the table below were obtained:

Table 1
**Schedule of assessment of pupils at the educational stage**

Points of pupils per unit of teaching modelling	For control classes (178 pupils)			For experiment classes (176 pupils)		
	I	II	III	I	II	III
5	29	26	24	45	39	42
4	49	46	40	51	53	50
3	93	101	106	76	80	81
2	7	5	8	4	4	3
Average point	3,56	3,52	3,44	3,77	3,72	3,74
The average score of all these three stages		3,50			3,74	

We can show the results of the assessment with the following diagrams:
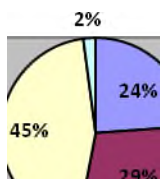
In control classes: In experimental classes:
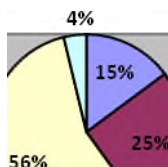
The diagrams show that the percentage of quality was 40% in the control classes and 53% in the experimental classes. Materials collected during the pedagogical experiment were tested in experimental and control groups and the results were compared. After the evaluation, it became clear that experimental graders received better results than control graders. The following formula was used to find the coefficient of beneficial effect obtained from the experiment:

$$X = \frac{E}{C}$$

Here E is the average score of the work done in the experimental, C - control classes. Taking into account the results obtained in the above formula, we obtain:

$$X = \frac{E}{C} = \frac{3,74}{3,5} = 1,06$$

Accordingly, the coefficient of effectiveness of the quality level in the experimental classes of students was 1.06 compared to the control classes. The teaching unit of computer science modeling using these 3D Studio MAX and SketchUp software enhances students' interest in computer science, helps them solve problems from mathematics to geometry. As a result, students are interested in studying the relevant educational units of both subjects.

At this stage, the results were discussed in the class where the experiment was conducted, and the opinions of teachers and students were heard. Positive and negative factors, shortcomings and the reasons

that caused them are disclosed in teaching functions and methods of use to update the content of the educational block of modeling in 3D Max studio and SketchUp in computer science lessons in grades 10-11.Obviously, when solving modeling issues, the use of 3D Max studio and SketchUp software is more effective. Our experiment gave us the confidence that a high school computer science course should start with a computer on a larger scale in 3D Max studio and SketchUp.

The results of pedagogical practice can be summarized as follows:

- modelling ability in experimental classes was higher than in control classes, with increased interest of students in the study of the modeling educational block.

The materials prepared by teachers for this purpose corresponded to the level of students in Grades 10 and 11, and the teaching methods of the teacher aroused the interest of students and created conditions for the development of logical, abstract, aesthetic and visual thinking abilities in them.

The third stage is the control stage held in the 2021/2022 academic year. At this stage, the results obtained at the previous stages are checked. Test and test classes were selected from 10 and 11 classes. In the experimental classes, more attention was paid to the practical application of the learning block on modeling than to the study of theoretical material.

Programs for building three-dimensional models, characteristic of which practical tasks are consistently improving, are currently more relevant here. For this purpose, geometrical content lines of mathematics were used. To solve this problem, conditions have been created to use the capabilities of computer technology. The lessons on the study of the SketchUp program were held sequentially. Students were presented examples of tasks given in the textbook and annexes.

At this stage of the experiment, modeling in schools consisted in the implementation of the proposed system for improving the quality and effectiveness of education through the knowledge, skills and abilities acquired in the learning process in the education department. At the same time, the following levels have been identified to increase the quality and efficiency of education:

- Application of students' knowledge, skills and abilities in the

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process of teaching the computer block of computer science modeling, improving the quality of mastering;

    - Level of development of student thinking by computer modelling from computer science using the capabilities of 3D max studio and SketchUp;

    - Mastering the concepts of modeling and modeling and the level of computer use in model building;

    - The level of development of students in terms of the development of modern programming in the process of teaching computer science.
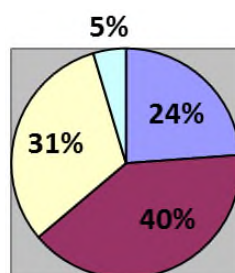
Table 2

Assessment schedule of students at the verification stage

Points	For control classes (133 pupils)	For experiment classes (130 pupils)
5	23	31
4	38	52
3	64	41
2	8	6
Average point	3,57	3,83

In control classes:
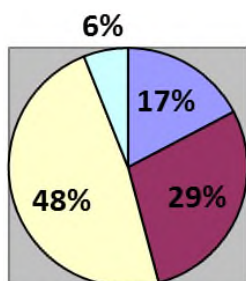
In experimental classes:

$$X = \frac{E}{C} = \frac{3,83}{3,57} = 1,07$$

It can be seen from the diagrams that the quality percentage was

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46% in the control classes and 64% in the experimental classes. This also shows that the enthusiasm of students to build models in the Modeling educational unit by using 3D max studio and SketchUp programs has changed in a positive direction.

The study allows us to come to the following **conclusions**:

1. The development of informatic skills of students should be at a focused level, in the future, an engineer, a technical worker should usually train a competent specialist. Therefore, it is necessary to take into account the factor that forms a wide variety of knowledge, skills and abilities in the teaching of Informatics and shows methods for implementing their application in various spheres of human activity. 3D max studio and sketchup programs should be used as a tool in the study of the Modelling teaching unit in research [1;6].

2. Currently, the methods developed and implemented in general schools on the Modelling unit of education are observed with very little processing.The developed methods do not cover all aspects of moodelization, either intended for additional education or pursue other purposes [4].

3. In the dissertation, the model and functions of modelling are distinguished from each other. As a result, students have no difficulty in distinguishing similar concepts, and therefore come from a critical thinking perspective in their perceptions of spatial concepts.They understand that when defining a concept, its most important qualities must be taken into account. Sometimes, when defining concepts incorrectly, they make appointments based on features that are not in those concepts. This is a fundamentally wrong approach [4; 5; 7;15].

4. Referring to L.M.Friedman, arguments have been made that the concepts of "feeling" and "visibility" are not the same.These arguments are practically demonstrated through pictures.As a result, students gain a broader understanding of objects whose identities seem real at first glance, but differ as a result of research [13; 15].

5. There is a serious need for three-dimensional computer modelling in the subjects taught by teachers [9;15].

6. Teaching students 3D computer modelling in informatics classes according to the methodology recommended by us allows using it in other subject areas. In this case, students themselves explore the object of study. This allows them to rise to a new level of visual-figurative-movement, and thus to make interdisciplinary communication [8; 10].

7. Teaching the modeling unit with the methodology we offer allows for the interdisciplinary integration of other subjects with the subject of computer science. Again, this helps students to learn the knowledge they have mastered and to memorize it for a long time [7; 9].

8. Preparation and teaching of topics on modelling training unit should be carried out in two directions (theoretical and practical [12].

9. When studying topics on the modelling educational unit, methods, forms and means of clarifying the activities of the student and teacher are identified. The necessity of applying these methods while teaching this section is substantiated [11].

10. It is appropriate to carry out the study of topics in the practical aspect on the modeling educational unit in the following sequence:

1) to start teaching modelling from objects based on base form;

2) to apply acquired knowledge, skills and habits in other areas of science (mathematics, drawing, technology), it is necessary to solve problem;

3) special creative ideas need to be realized in 3D max studio and sketchup [14].

It also creates the basis for the following **proposals to be put forward**.

1. Assessment of the results of training on the theoretical and practical component showed that it is advisable to increase the amount of hours allocated to the unit of training in the future.

2. Assessment of the results of training on the practical component requires drawing up tables at each stage of the selected computer graphics. Here it is recommended to take into account the teaching aid of the teacher in these classes by reflecting the independence of the students, the tasks performed, the difficulties and the time spent.

The main content of the dissertation is reflected in the following published scientific **works** of the applicant:

1. Novruzova G.S. İqtisadi fəaliyyətin modelləşdirilməsində metodologiyanın əsasları. Bakı: Bakı Slavyan Universitetinin Elmi Əsərləri, İctimai-siyasi elmlər seriyası, 2019. № 2, s. 65-70.

2. Новрузова Г.С. Области применения моделей динамических систем. Bakı: Elmi iş (humanitar elmlər üzrə aylıq beynəlxalq elmi jurnal), tədrisin metodikası, 2019. №10/49, s. 92-95.

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рования в познании мира. Gəncə: AMEA Gəncə bölməsi, Xəbərlər Məcmuəsi, 2019. № 4 (78), s. 125-129.

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5. Novruzova G.S. Modelləşdirmə yeni təlim metodu kimi. Bakı: Bakı Slavyan Universiteti, Humanitar Elmlərin Aktual Problemlərin Öyrənilməsi, 2020. №2, s. 234-238.

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9. Novruzova G.S. Məktəbin informatika kursunda "komputer modelləşdirilməsi". Bakı: Azərbaycan Respublikasının Təhsil İnstitutunun Elmi Əsərləri, 2020. cild-87. №1, s. 136-139.

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11. Новрузова Г.С. Методологические особенности применения компьютерного моделирования в начальных классах общеобразовательной школы. Министерство образования и науки Республики Дагестан, ГБОУ ДПО «Дагестанский Институт развития образования» ФГБОУ ВО «Московский педагогический государственный университет» Дербентский филиал Всероссийская научно-практическая конференция, Махачкала, Дербент, 2019, с. 213-221.

12. Novruzova G.S. Statistik məlumatları göstərmək üçün 3d modellərin üstünlükləri. BDU Mexanika-Riyaziyyat fakültəsi, Azərbaycan Xalqının Ümummilli Lideri Heydər Əliyevin Anadan Olmasının

97-ci ildönümünə həsr olunmuş «Riyaziyyat, Mexanika Və Onların Tətbiqləri» adlı Respublika Elmi Konfransı, Bakı, 2020, s. 64-65.

13. Новрузова Г.С. Связь обучения трёхмерному компьютерному моделированию с наглядностью // Северо-Кавказский горно-металлургический институт (Государственный технологический университет) I Международная научно-практическая конференция, Владикавказ: 2020, с. 33-36.

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15. Novruzova G.S. Modeling Analysis of Modeling Results Modern Situation and Perspective Development in Teaching Communication Technologies. The Journal for Educators, Teachers and Trainers (JETT), vol. 15 (2). 2024. p. 117-129.

The defense will be held November 01, 2024 at 12:00 at the meeting of the Dissertation council FD 2.15 of the Supreme Attestation Commission under the President of the Respublic of Azerbaijan operating at Azerbaijan State Pedagogical University.

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Dissertation is accessible at the Library and Information Center of the Azerbaijan State Pedagogical University.

Electronic versions of dissertation and its abstract are available on the official website of the Azerbaijan State Pedagogical University.

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