

# 3D modelling for Individual Tasks in Descriptive Geometry

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**Abstract.** The article presents a new method of developing individual tasks (IHA) for solving positional-metric problems of descriptive geometry based on 3 D models, taking into account intensive control. The technique of effective self-study of methods of changing complex drawing with the use of visual 3D models is considered.

## 1 Introduction

Recently a contradiction has emerged in Russia between the high requirements of employers in technical fields, requiring high reliability of technical structures in vehicle design, construction and other areas of technology, to the knowledge of technical graduates in special disciplines of universities and their insufficient graphic training. Descriptive geometry is an important basic discipline of technical specialties, which requires high-quality graphic and geometric skills, developed spatial imagination. Weak basic training of applicants in drafting poses a challenge to teachers of graphic disciplines, which is aggravated by the reduction of teaching hours. In Far-Eastern Federal University (FEFU) there is no division of student groups into subgroups for practical classes, teachers have no time to assess students' graphic tasks due to increased workload.

The importance of the subject is clearly described by the author of the textbook on descriptive geometry. "The use of descriptive geometry is rational in the design of complex surfaces of technical forms with predetermined parameters, used in the aviation and automotive industries, in the creation of ship hulls and ship engines and in many other areas of engineering" [1].

The problem of weak drawing training is raised by many authors. "Pre-university graphic training is practically non-existent. As a result, at the end of the course of descriptive geometry, engineering and computer graphics, a significant part of students does not get the skills of three-dimensional thinking, reading and development of design documentation" [2].

When studying graphic disciplines, future engineers need to develop not only spatial imagination, but also logical, creative abilities as the basis of technical thinking. "Developed technical thinking is critically important in an engineer's field of activity. It

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allows you to understand the principles of structure and operation of various mechanisms" [3].

Descriptive geometry is the basic discipline for the teaching of special subjects. "Geometry is a basic skill to be mastered. It is important in architecture and design, in engineering and in various aspects of construction work" [4].

There are many researches on the development of spatial imagination of students in many countries. "As such, seeking ways to develop and assess learners' spatial thinking in 3D geometry is an important research area with one long-standing topic being how learners' reasoning is influenced by the ways in which geometric objects are represented" [5]. Mathematics in school should be taught with high visualization of graphical material. "In other words, it is important that teachers focus on visual materials by using different teaching strategies and material with effective body language and the use of using these kinds of visualized materials will help to develop students' spatial ability" [6]. Unlike the images studied at school, however, the images of graphic disciplines studied at university should have specific parameters to calculate other physical quantities and in form closer to the technical forms of areas of education.

There are many benefits of using computer technology in teaching to develop students' abilities. "Nowadays, integrating complete digital teaching became the main subject of educators and researchers." [7]. "The advent of personal computers, however, allows the necessary drawings to be created more quickly and accurately using computer-aided drafting and design (CAD) software" [8]. "The use of information and computer technologies develops creative abilities, activates cognitive activity, contributes to the improvement of practical skills and abilities, opens up new opportunities for the teacher in the presentation of the discipline" [9].

The great importance in the development of necessary qualities is played by students' independent work and its control. "The effectiveness of the educational process largely depends on the extent to which the teacher orients himself not only on the formation of students a certain baggage of knowledge, but also on the disclosure of their potential abilities to independent activity, their ability to find solutions in difficult life situations" [10]. "Along with the explanation of the material, teaching control is of considerable importance. Checking, diagnostics, joint discussion and parsing of errors allow students to expand their knowledge and skills, and teachers to cultivate students' interest in the subject, educate them the habit of analysis, prepare high level specialists out of them" [11]. The majority of authors suggest using modern computer technologies for presentations and for independent practical works to improve the quality of study of the discipline.

It is noted by the authors that there is a positive experience of using AutoCAD in the presentation of lectures and practical tasks of descriptive geometry. "The characteristics of the innovative course are visibility, efficiency and intensity, rationality, the formation of students' motivation to engage in scientific work and the undoubted usefulness of the course" [12]. The novelty of this research is the use of 3D modelling for students' independent study of drawing transformation methods and a new intensive method of development, the implementation of individual home assignments (IHA) students with the exact keys to control their decisions in contrast to the visual control. "As a result of building a model of their individual assignment students get the same section in four projections and can compare it with an example solution in a two-dimensional file" [13].

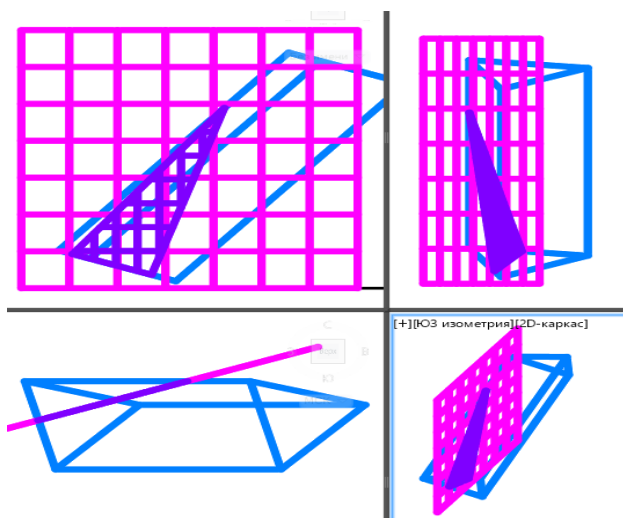
## **2 Objectives and methods**

The aim to research the application of 3D models to study methods of transformation of complex and drawing to intensify the development of IHAs, its solution and examination

was set to improve the quality of homework students studying transport process technology and automation of technological processes and industries.

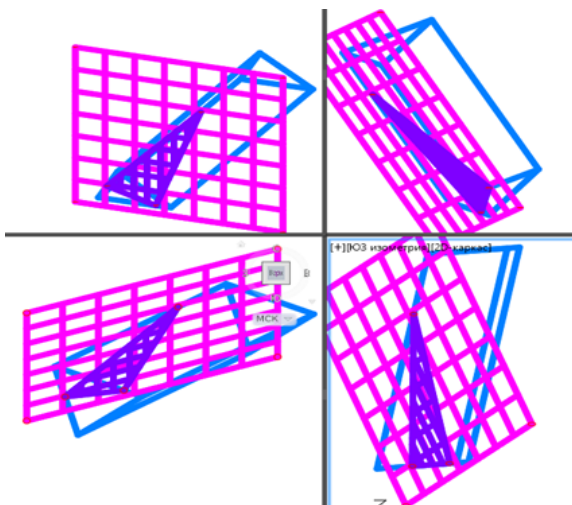
The research methods to be used were comparative, analytical, observational, descriptive. Comparative method was used in comparing the traditional method of training with the use of 3D models AutoCAD, comparing the coordinates of the projections and the area of full-scale section while controlling the students' IHA solutions and comparing the results of IHA passing for students of different majors. Analytical method was used to develop models of complex drawing transformations and new IHA. Observational method was used during consultations with students and assistance of advanced students to students not making satisfactory progress. Descriptive method was used in describing the algorithm for developing 3D IHA models and making tables.

The development of IHA begins with the use of four viewports of three projection planes and isometrics. "To build a 3D model, the workspace is divided into 4 screens using the "Viewports" command [14]. For the prism model, a horizontal polygon and a frontal edge are set, and the prism is extruded using the Extrude command and the Direction option. Then the prism is rotated using the command 3D rotation by a given angle to the oblique position of its base (Fig. 1), a horizontal line is set at a certain angle, and a horizontally projecting plane that intersects the prism is extruded from it. The teacher develops a key to assess the students' solution by executing the Intersection and 3D rotation commands, obtaining the full-scale view of the section. A copy of the prism, the intersecting plane, and the section are rotated to the oblique position (Fig. 2). Using the Coordinates command, the instructor gets another key to control the section projections in the students' solutions. Then, by measuring the coordinates of the vertices of the surface and the secant plane, the teacher creates a two-dimensional IHA in AutoCAD. Students solve the problem of constructing projections of the section and its full-scale size (FSS) by replacing planes of projections method. The teacher controls the solution by comparing the coordinates of the drawn projections of the section in the student's solution and the model. To control the FSS of the section, the command Area is used, which is compared to the teacher's key.

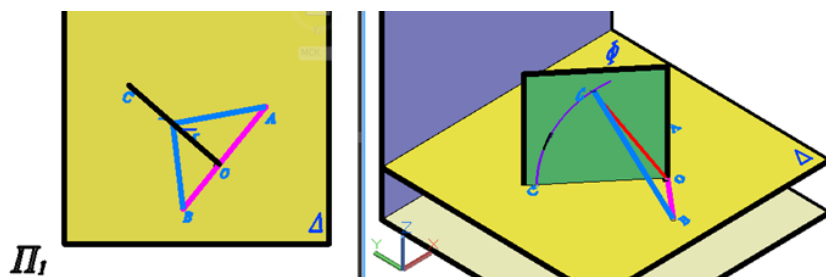


**Fig. 1.** Model of a prism with an inclined section.

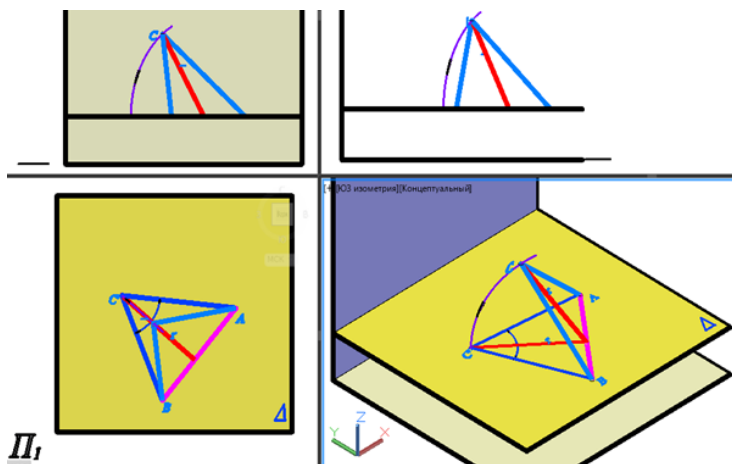
A new 3D models constructed using the algorithm of models for studying the replacement of planes of projections are used by students while solving the IHAS to determine FSS of distances and angles. "The 3D models were developed by student co-authors of the teacher to improve mastery of the topic of replacement of planes of projections, which were used to help students not making satisfactory progress" [15]. 3D model to study the method of rotation around the level line is made in three layers: layer 0 sets the oblique plane, layer 1 shows the point rotation, layer 2 shows the point rotation plane, (Fig. 3). layer 3 shows the result of the solution (Fig. 4), layer 2 is switched off to visualize the result of the solution.



**Fig. 2.** Model of a prism with an oblique section.



**Fig. 3.** Layers 1 and 2 with point rotation in the plane switched on.



**Fig. 4.** The result of the task solution.

### 3 Results

The results of the assessment of passing the IHA with the use of 3D models for the creation of the IHA and to the study of methods of transformation of the complex drawing are shown in the table. In the group of students studying the digital technology of mechanical engineering used the regular IHA and the models were not applied to study the methods of transformation of the drawing. Comparison of the results of the assessment of the student's IHAs shows the best results in the group where students were more active by developing models themselves.

**Table 1.** Evaluation of the results of IHA assessment.

| <b>Educational area</b>                   | <b>Number of students in the group, %</b> | <b>Number of students using the developed 3D models, %</b> | <b>Number of students who passed the IHAs, %</b> | <b>Number of students who passed the IHAs with excellent grade, %</b> |
|---|---|--|--|---|
| Transportation technology                 | 100                                       | 17   | 98   | 38  |
| Process automation                        | 100                                       | 20   | 100  | 57  |
| Digital mechanical engineering technology | 100                                       | 0  | 82   | 18  |
| Oil and gas midstream engineering         | 100                                       | 0  | 78   | 12  |

Protection of students' IHAs on the new tasks with control keys was 3 times faster than in the groups where the IHAs were solved by students on the regular tasks, which confirms the high efficiency of IHAs developed by the teacher using 3D models. According to the results of IHA access, the advantage of presentations with the use of 3D models showing the transformations of the complex drawing in comparison with the traditional presentation is obvious. That is due to the high visualization and dynamism, which contributes to the

development of spatial thinking and increase the effectiveness of mastering the material on the studied topic. The authors consider the goal of the study to have been achieved.

## 4 Conclusion

The study presents the developed and used 3D models to improve mastering of the topic of transformation of the complex drawing by methods of rotation around the projecting straight line and level line, the replacement of the planes of projections. The results of comparing the protection of IHAs by students of the four areas of education confirmed the high efficiency of the developed 3D models, the feasibility of their use in the study of this discipline. These models are useful for teachers in order to improve the visualization of the studied topic. The 3D models of faceted surfaces with intersecting oblique planes, and on their basis two-dimensional IHAs for students to solve metric-position problems in AutoCAD have been developed. Keys for exact and accelerated control of students' solutions have been developed. The effectiveness of the developed method for the development of spatial imagination, logical and creative abilities, which are the basis of technical thinking, has been proved.

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