

Descriptive Geometry Exam: Testing or Traditional Form

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Abstract. The traditional syllabus of Descriptive Geometry provides a final examination, which includes some problems to solve. These problems cover the most important topics of this subject, as usual. Educational institutions of the post-USSR states were often accused of examinations results falsifications. To make cheatings impossible and to provide transparency of results, it was proposed to conduct computer testing examinations in graphical disciplines instead of the traditional practical type. This article summarizes the gained experience on the testing development, the advantages and disadvantages of testing as a type of examination, the conditions for its usage, and the requirements on the test base.

Key Words: Descriptive Geometry, testing, examination

MSC 2010: 97G80, 51N05

1. Introduction

The problem of graphical education development is one of the acute problems of modern engineering education. Problems of Descriptive Geometry teaching are well analyzed in the scientific literature, in Ukraine as well as worldwide [1, 3, 5, 6, 9, 10, 12]. Modern concepts and reforms [14] vary between an increase of mathematical components [13] and CAD-methods spreading into graphical education [2]. But the problems of knowledge control system development in general and testing as a form of final examination, in particular in graphical subjects, are not sufficiently presented in the scientific literature. Unfortunately, the traditional form of an Descriptive Geometry exam covers all course topics only partially and, usually, doesn't represent in adequate form the understanding of its theoretical base.

Testing as an examination type has been used since the early beginnings of the 20th century [7]. This method of knowledge control has its own advantages and disadvantages, especially for graphical disciplines [11, 12]. But testing with feedback produces the strongest positive effect on achievement and, due to this fact, is widely used for exploring the students' knowledge [4, 15].

Apart from the authors mentioned above, the collective of the Engineer and Computer Graphic Department of the Ivano-Frankivsk National University of Oil and Gas (Ukraine) has its own positive teaching experience [8], which is the basis of this work.

For the post-USSR states, testing became a new method to control student's knowledge with peculiarities of its usage, manifested in non-fully validity, standardization, objectiveness and representativeness of the developed tests.

Besides, educational institutions of the post-USSR states were often accused of falsifications of examinations results. Some of these impeaches for taking bribes were really reasonable. It is worth saying, that cheatings both for students and teachers were observed. So, computer testing was considered as one of the main approaches to provide objectivity and to increase the education transparency.

Testing as a final control cannot be used in graphical disciplines like Descriptive Geometry and Engineering Graphics for controlling the drawing skills of students. They get these skills only by performing drawings. With other words, testing is appropriate only for the control of theoretical knowledge, and its advantages can only be used partly, with some clauses.

The objective of this work is testing as a form of final exam in Descriptive Geometry; the goal is to compare it with traditional practical and testing forms of examinations for engineering students. This work summarizes the practical experience on online computer testing as a final examination in Descriptive Geometry, in particular: problems of tests' developments, advantages and disadvantages of graphical subjects testing, and the results of testing implementation in relation to the traditional examination. The authors focused on engineering students.

2. Descriptive Geometry course: syllabus and system of control

The course "Descriptive Geometry, Engineering and Computer Graphics", developed at the Ivano-Frankivsk National Technical University of Oil and Gas (Ukraine), is mandatory for engineering students. The overall credit hours are 240 (8 credits), taught in two terms. Lectures (36 h), tutorials (72 h) and CAD practices (at least 18 h in class + 21 h after class) are included.

The first part called "Descriptive Geometry" covers the theory of projection and its application, for example, solving some comprehensive geometric problems based on orthographic projection. "Descriptive Geometry" is presented in 9 lectures (18 h) and 18 practical sessions (36 h).

The second part, "Engineering and Computer Graphics", covers objects' drawing, freehand axonometric drawing, representations of work pieces, threaded structures of drawing and labeling, standard parts and representations of commonly used parts. In addition, detail drawing and assembly drawing are the most important contents in the second part. 18 practice sections (36 h) are closely accompanied by 9 lectures (18 h), which include a face to face instruction in instrumental drawing and CAD labs. The purpose of the practice sessions is to give students experience in freehand sketching, parts' measuring, disassembling and reassembling of assembly, instrumental sketching, CAD modelling, and design. Attendance in the practice sessions is obligatory.

Besides, 4 CAD labs are integrated into the second part with accompanying homework assignments on optimizing the representation of work pieces and producing a variety of drawings (planar drawing, 3-dimensional drawing, detail drawing, assembly drawing etc.). Homework problems (for both parts) are assigned after each lecture or tutorial, and they are timely corrected by the instructor (typically two or three days later). Students may discuss

together after the class, but they must finish the assignments independently.

The first part of the full Descriptive Geometry course is finished by a practical examination, and the second one, Engineering and Computer Graphics, is finished by a ‘pass-fail’ test.

3. Knowledge control and online examination system usage

The integration of Ukraine into the Bologna process caused changes in the national educational standards. Regarding Descriptive Geometry, it stipulates a decrease of total class hours and an increase of hours for individual work. It leads to students’ concentration on problem solutions instead of understanding all the theoretical material. Unfortunately, lectures are among the first events avoided by the students [10]. Therefore, the problem of a full and adequate control of students’ knowledge (including theoretical material) has arisen. A package solution of this problem is mentioned below.

First of all, the final mark on Descriptive Geometry depends on both examination and semester grades. It is defined as an average between the score, received during the semester, and the examination score multiplied with 1.1. During the semester, a student can receive 100 marks. The factor 1.1 aims to increase the significance of the examination in his/her total mark. When his/her semester mark has not been good, a student can improve the total mark by a better preparation for the examination.

The 100 marks, which students can receive during the semester, are distributed irregularly among 15 tests with multiple choices, classes and final tests with some problems to solve. The topics for class and control works are: location of a point, a line and a plane in the principal views, piercing points and planar intersections, perpendicularity relations, related views, revolution, intersection of a solid with a plane or line. They are graded from 3 to 10 marks depending on the difficulty of each work. Samples of students’ works are presented in Figure 1.

Intermediate tests are carried out at every lesson to control the students’ knowledge on

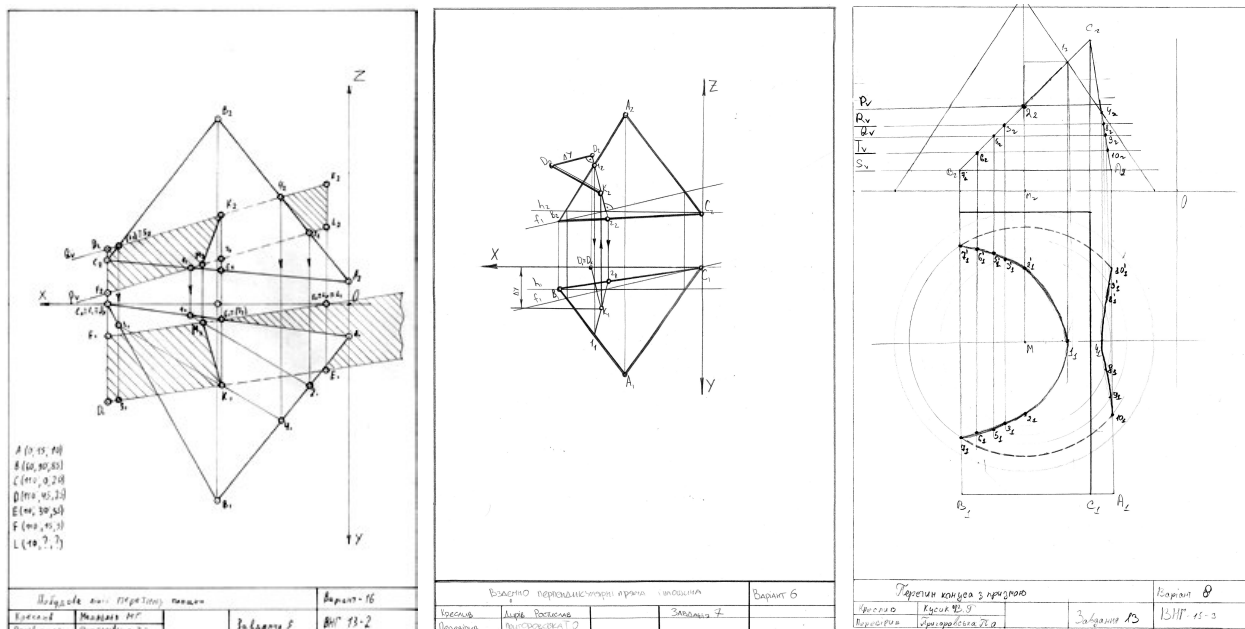
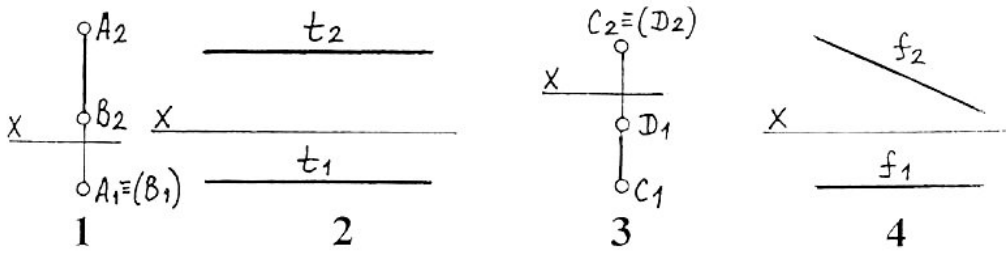


Figure 1: The typical students’ works

1. Which of the given sketches is the horizontal-projecting line sketch?



2. What figure presents the intersectional lines?

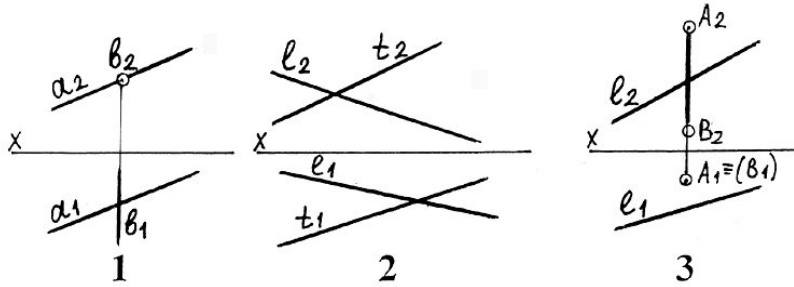


Figure 2: The standard theoretical tests

previous topics. Samples of these tests are presented in Figure 2. Each of them consists of 10 questions and grades in 3 marks.

The final examination in “Descriptive Geometry” is performed as an online computer test. Traditionally, this examination consists of 5 complex problems to be drawn by freehand:

1. Find the intersection of two planes, which are specified either by 3 points or parallel

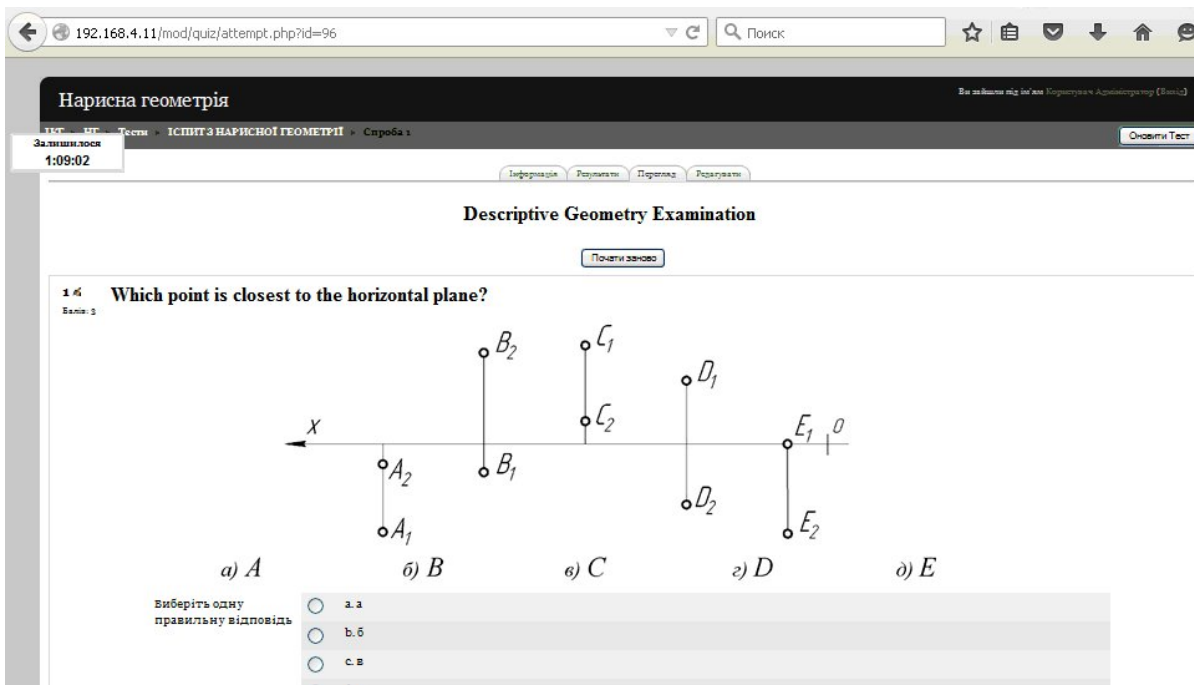


Figure 3: The screenshot of a test window

- lines, and to indicate the visibility ... 20 points.
2. Find the true length of the shortest distance between a point and a plane (to solve without auxiliary views) ... 25 points.
 3. Find the true shape of a triangle (to solve with auxiliary views) ... 15 points.
 4. Find projections and the true shape of the intersection between a solid and a plane ... 20 points.
 5. Find the intersection between two solids ... 20 points.

This approach has the following disadvantages:

- Impossibility to cover all the subject's topics during a 3-hours exam;
- Students concentrate only on performing the examination problems but ignore the theoretical base of the problems' solution;
- During the preparation for the exam, the students take into account only the examination problems;
- Possible cheating both from students and teachers.

So, the development of a computer test system was considered as a way to avoid the problems listed above. A testing system was developed on Moodle software, which includes a Quiz module. The password policy means that every student gets his/her login/password to start the online examination. The quiz is formed automatically and individually for each student by a random selection from a base, which includes 1600 problems. Every student gets his/her set of 30 problems to solve within 90 minutes (Figure 3).

The online examination system administrates the exam grading process, a total statistical data formatting, et cetera. It enables the administration of online examinations within the online classrooms.

Спроб: 190 (16 даної групи)

Показано оцінені та неоцінені спроби кожного користувача. Спробу, оцінка якої є фінальною, розміщено першою. Використано метод оцінювання - **Краща оцінка**.

Прізвище / Ім'я	Тест початий	Завершено	Затрачений час	Оцінка/100
Андрейчук Дмитро Михайлович	16 December 2015, 10:05 AM	16 December 2015, 11:06 AM	1 година 1 хв	76
Бобрик Максим Олегович	16 December 2015, 10:04 AM	16 December 2015, 11:13 AM	1 година 8 хв	66
Войчук Олег Яремович	16 December 2015, 10:05 AM	16 December 2015, 11:11 AM	1 година 6 хв	72
Гунда Юрій Васильович	16 December 2015, 10:03 AM	16 December 2015, 11:10 AM	1 година 7 хв	81
Данилюк Микола Олександров	16 December 2015, 10:04 AM	16 December 2015, 11:08 AM	1 година 3 хв	86
Дубина Богдан Богданович	16 December 2015, 10:04 AM	16 December 2015, 11:12 AM	1 година 8 хв	64
Заливаха Назарій Ярославович	16 December 2015, 10:05 AM	16 December 2015, 11:13 AM	1 година 8 хв	70
Карпа Роман Володимирович	16 December 2015, 10:06 AM	16 December 2015, 11:09 AM	1 година 2 хв	72
Козарський Ілля Романович	16 December 2015, 10:06 AM	16 December 2015, 11:12 AM	1 година 5 хв	86
Коцан Володимир Васильович	16 December 2015, 10:06 AM	16 December 2015, 11:00 AM	53 хв 26 сек	93
Нестеренко Владислав Сергійов	16 December 2015, 10:06 AM	16 December 2015, 11:14 AM	1 година 8 хв	82
Пришлюк Віталій Іванович	16 December 2015, 10:06 AM	16 December 2015, 11:14 AM	1 година 8 хв	62
Семак Мар'ян Романович	16 December 2015, 10:03 AM	16 December 2015, 11:10 AM	1 година 7 хв	77
Сільва Марія Сімоєш_Гомеш_Да	16 December 2015, 10:06 AM	16 December 2015, 11:14 AM	1 година 7 хв	34
Сулжик Христана Андрійана	16 December 2015, 10:04 AM	16 December 2015, 11:09 AM	1 година 5 хв	65
Фадхіл Омар Аббас_Фадхіл	16 December 2015, 10:06 AM	16 December 2015, 10:52 AM	45 хв 41 сек	33
Середнє по групі				69.94
Загальне середнє				56.68

Вибрати всі / Прибрати виділення / Видалити вибрані спроби

Figure 4: The screenshot of all students' statistics

The screenshot displays a web-based examination interface for Descriptive Geometry. At the top, there are navigation tabs: "Інформація", "Результати", "Перегляд", and "Розгадувати". Below these are sub-tabs: "Огляд", "Переоцінити", "Ручно оцінювання", and "Аналіз питань". The main title is "Descriptive Geometry Examination Trial No 1".

The first question (1) asks: "Which point, presented below, is placed on the down part of the horizontal plane?" It includes a diagram with a horizontal axis X and several points $A_1, A_2, B_1, B_2, C_1, C_2, D_1, D_2, E_1, E_2$ plotted above and below the axis. The answer options are: a) A, б) B, в) C, г) D, д) E. The correct answer is d) E, which is highlighted in green.

The second question (24) asks: "Through how many sides of a cube should you slice in order for the cross section to be a triangle?" The answer options are: а) 6, б) 9, в) 4, г) 3. The correct answer is г) 3, which is highlighted in green.

Below the questions, there is a summary of results: "correct" (green bar) and "incorrect" (red bar). The interface also shows a browser window with various tabs and a search bar.

Figure 5: The screenshot of total score, correct and incorrect answers

The examination consists of 30 multiple choice tests in which the candidates are asked to select the only correct answer out of the choices of a list. The testing system keeps record about time and total score for each student (Figure 4). Immediately after test program stops, the test result is available for the student as a list of correct and incorrect answers. The test results screenshot informs on the total score, the number of correct and incorrect answers, and the correct answers percentage. This percentage makes it easy to transform the test results

into a five-point assessment scale according to the requirements of the Bologna system. The test results are stored and may be printed for presentation.

4. Results and discussions

As far as the approach mentioned above has been used for 5 years, we can summarize our experience in using this testing as the main form of examination in Descriptive Geometry.

In the years 2010–2015, the Descriptive Geometry exam was taken by 138 students. During this time the following general trends were observed:

- the average marks increased from 3.2 in 2010 to 3.7 in 2015 (with respect to a five-point assessment scale);
- there is a good correlation between the marks obtained by students during semester and the exam marks.

For a sample of 30 random students, the ratio between the semester marks and the examination marks was close to 1.03–1.04. The only exception were students, who wanted to improve their marks from 3.7 to 4 or from 4.7–4.8 to 5, et cetera. The increase of the average mark from year to year ranged between 2.5 and 7%.

So, a proper testing increases the objectivity of knowledge evaluation by the following means of test's development.

In cooperation with practical lessons, by virtue of testing as a mean of knowledge control we are able to check creativity and to take arguments and non-standard ways of problem solving into account. By testing, a more comprehensive coverage of the theoretical material can be obtained if the total amount of problems covers all topics and herewith avoids the possibility of getting a correct answer by memorization. For this purpose, every year 100 problems were changed by teachers.

The problems reflect all topics, covered by the discipline, and they make possible to control not only the theoretical knowledge, but its practical usage. In particular, one feature of tests

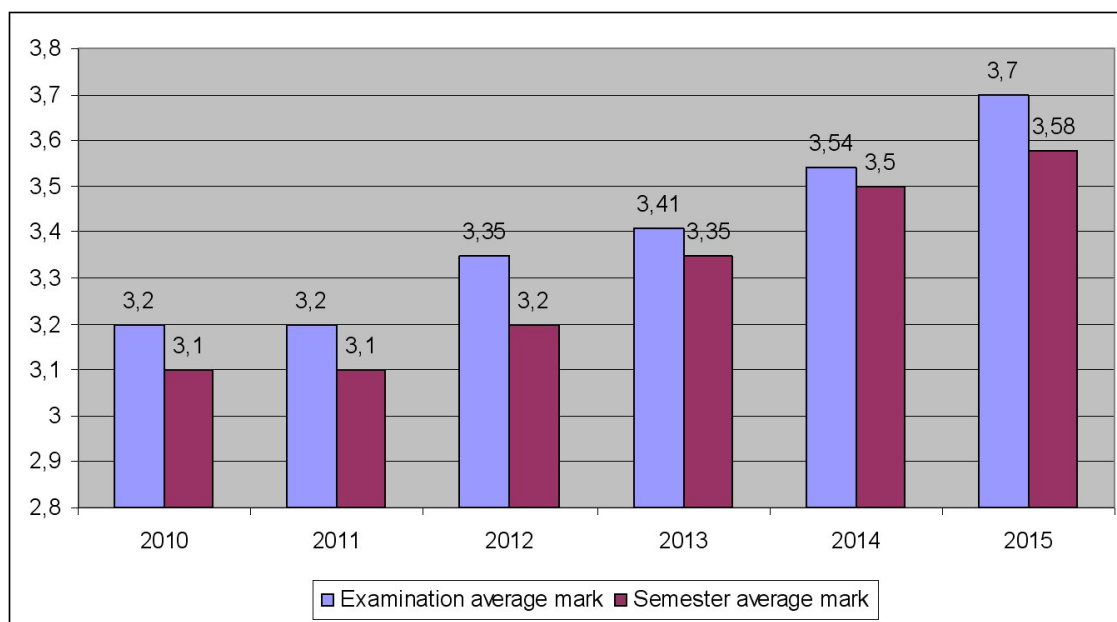


Figure 6: Ratio between semester average marks and examination average marks

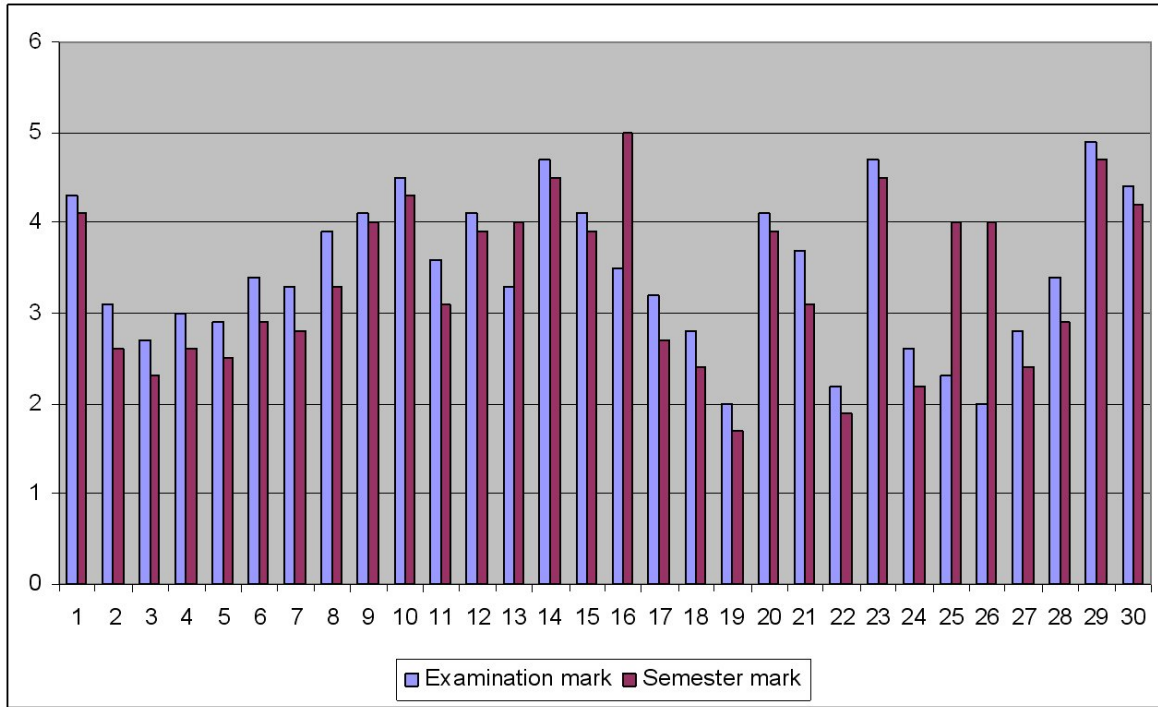


Figure 7: Semester marks and examination marks for sample of 30 students

in Descriptive Geometry is the prevalence of problems to define correct/incorrect solutions, for instance, to define the visibility of intersecting solids, et cetera. The sequence of problems in the test matches the sequence of Descriptive Geometry topics. At each problem, all proposed answers seem to be plausible and none of them is identical with a statement in the textbook in order to avoid correct answers obtained by guessing.

The full transparency of the examination process motivates students either to study during the semester and to prepare themselves for the exam. An indirect consequence of this fact was the increase of lectures' attendance and of the average mark in the discipline.

5. Conclusions

During the process of teaching, the positive and negative aspects of the teaching methodology are permanently analyzed, and necessary adjustments are made. Generally, the goals of transparency and study's motivation were achieved. But this form of examination is appropriate only together with performing drawings during the semester to get knowledge and skills of practical drawing. Obvious advantages of the final testing as a method of final control are the following:

- maximal covering of the Descriptive Geometry topics, including theoretical information;
- equal testing conditions for all students provide a fair control;
- the standardization of tests and testing procedures allows to evaluate the level of knowledge;
- the implementation and processing of the results provide an extremely convenient tool for monitoring the quality of the educational process within the framework of the quality management system;

- the analysis of test results can be used to make appropriate management decisions regarding the correction of the curriculum subjects, the choice of educational technologies, teaching of the discipline, et cetera.

But all these advantages can be reached only under the follow conditions:

- students need to perform drawings during semester to get knowledge and skills of practical drawing;
- the test base should contain enough problems to provide an individual set of problems for every student;
- a rotation of problems in the test base: every year new problems should be included to the base;
- the developed problems should be valid and cover all topics of the discipline;
- the result of testing should be an output, immediately after the completion of the test, and presented on the internet-site, available for everyone.

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