

E-TESTS IN DIDACTICS OF DESCRIPTIVE GEOMETRY AND ENGINEERING GRAPHICS

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ABSTRACT: In the current practice of teaching descriptive geometry and engineering graphics, the pressure is put on the skill of constructing drawings. In this way weak students often learn by heart planar solutions instead of trying to understand space relations as it is more efficient as far as passing the subject is concerned. In the authors' opinion the improvement of the described situation can come as a result of wider usage of tests in didactics of the subject. Each student can face considerably larger number of different spatial tasks during the time-limit provided for one constructional problem. The tests, in which the questions as well as the answers have the graphical form, are the most useful. The e-tests, based on computer technology, are the most effective in our times. They give the user immediate feedback information about the correctness of answers. E-tests can help developing competence and can become a useful tool for its assessment. Demonstration of e-tests related to didactics of descriptive geometry and engineering graphics are presented in the paper. The thematic scope of it includes basic problems such as: relation between a visual drawing and the set of orthographic views, construction of additional views, which are called auxiliary views, creating sections and dimensioning. The *Hot Potatoes* program is recommended to be used in order to construct the tests.

Keywords: Descriptive geometry, engineering graphics, technical drawing, didactics, e-learning

1 Current teaching problems

The authors of this article have an experience of over dozen years of work in the scope of teaching geometry and engineering graphics. Within all that period they have witnessed various difficulties in understanding spatial problems which are encountered by quite large number of students. There are lots of reasons for that situation, some of them are independent of the teachers and among them one can mentioned the following:

- educational policy carried out by the state, which aims at wide range of high level education, which causes inflow of young people with not good enough predisposition to study technical contents,

- limiting the number of hours of classes, which results indirectly from the current condition of the public finances.

Apart from these objective reasons, the other causes of failures are driven by outdated, unsuitable for changed needs and possibilities, ways of teaching geometry and graphics. The essence of teaching descriptive geometry is, and always should be, to enhance spatial ability among future engineers and to teach the students, mainly with the help of exercises, the ways to grasp spatial relations between three-dimensional objects and to use freely spatial relations. Exercises are directed to construct technical drawings, which will be used in a current

practice. Because of the small number of hours of classes at university, the students face the need to improve their skills by solving geometrical problems without the supervision of a teacher. In this way they are devoid of possibility of receiving feedback information, which is in practice a returnable answer containing the assessment for the correctness of provided solutions. If a student understands a certain problem not well enough, he/she gives up his/her self-education or solves the problem incorrectly being convinced of the accuracy of the proposed solutions. In many cases the students learn by heart planar answers instead of trying to understand spatial relations between 3D objects as this is more effective in context of being graded by the teacher.

Such a situation causes low efficiency of teaching. Large number of students set about passing the same part of material repeatedly while the grades they receive not always reflect their competence. The grades can award bonuses unjustly if they assess results of optical remembering the solutions. They are also unjust in case of the students who lack not spatial imagination but possess the ability to do neat drawings.

2 Using choice tests in the didactics of the subject

The improvement in the described situation can, in the opinion of the authors, come as a result of more extensive usage of the choice tests in didactics. Since taking a test does not require time-consuming drawing, a student can face bigger number of different spatial problems during the time which allows solving one problem in a classical way. It makes it possible to acquire experience. Tests in which the questions as well as the answers have a graphical form are particularly useful. Tests of choice as well as tests based on matching answers to questions can be created in this way.

Since the majority of mistakes made by students have reproducible character, an experienced teacher is able to prepare tests containing a correct answer and the answers with typical mistakes. It is important for the assessment of the competence of a student so that the number of questions in tests is big in order to minimize an influence of the random factor while choosing correct answers.

The choice tests are practiced in the teaching of geometry and engineering graphics and described widely in a scientific literature concerning the didactics of this subject. They are so-called *Mental Cutting Test (MCT)* [1] and *Mental Rotations Test (MRT)* [2]. A new and a very interesting test, which was called the *Spatial Imagination Test* has been described in [3]. The role of the mentioned tests is to assess the general spatial predispositions of a student. These tests measure what impact has studying graphical contents on the development of spatial abilities, than they do test the knowledge of rules of the graphical mapping used in particular methods of representations.

The use of the tests for verification of the detailed competence in the scope of individual problems of descriptive geometry and technical drawing is the authors' intention. The tests used in this way can be an effective tool for the assessment of the competence in a passive usage of graphical mapping. It is absolutely essential in every engineering job, in the opposite to the skill of making drawings, which is a domain of designers. The skill in the scope of comprehensive solutions of constructional tasks is assessed in the current practice. In case of failure, it is difficult to diagnose whether it has been caused by lack of spatial abilities or lack of proficiency of drawing.

In spite of convincing about virtues of the choice tests, the authors do not negate the role of constructional tasks and do not suggest that they could be replaced by the tests completely. They rather call for taking tests as a tool aiding the objective assessment of the competence of the student.

3 Advantages of the e-tests

Electronic tests so-called e-tests are the most effective forms of multiple-choice tests. They should be saved as HTML files aiming at being accessible to everyone, since reading of them requires only the computer with an operating system installed. E-tests are effective as an assessing tool and also, thanks to interactivity, successful as the means of the teaching. The student solving a choice test with the help of a computer, opposite to a classical book, has a chance to get an immediate returning answer (so called feedback information), which contains information about the correctness of his/her solution. In case of making wrong choice he/she may be given also additional commentary justifying the mistake.

The use of e-tests is possible in distance teaching (e-learning) as well as in traditional one in a computer lab. E-tests can be in both cases a fully reliable assessing tool. Graphical questions and answers, random selection of their order and creating a potentially complete base of tasks are the basic conditions for reliability of the assessment. Using the graphical mapping, which is difficult to verbal description, practically makes communication between students impossible, no matter if they are in direct contact with each other or not.

Using tests in didactics is a great benefit not only for the student but it also facilitates the work of the teacher. That is because of the possibility of automatic and immediate results of the test. Such aspects make tests applying important in the distance learning, which development seems to be sure, according to the lifelong learning principle promoted in the contemporary world.

To receive comprehensive advantages of e-tests one should put them into environment of the e-learning platform. Additional benefits of such a solution are the following:

- access to the tests can be limited only to persons registered as participants of the course,
- the structure of the course using e-tests can be well-thought-out so that the access to the next part of material is possible only after passing the previous one,
- the tests can contain a different combination of tasks generated on a base of the library of problems collected previously,
- criteria of passing tests can be modified by a teacher appropriately to the skill of students and according to experience gained using the tests.

4 Usefulness of e-tests in the didactics of individual problems

Technical nature limitations such as size of the monitor and resolution of the graphics card have influence on usefulness of the e-tests in didactics of individual problems of geometry and engineering graphics. It is coveted that a student making choice from different solutions has an opportunity to observe them on the computer monitor at the same time. However, technical conditions limit legibility of small size drawings, if their structure is extended excessively or if they are drawn with applying thin or broken lines.

In this way creators of the e-tests should be aware of the below limitations:

- drawings have to be not very complicated so that they could be legible on the computer monitor,
- variant answers cannot be diversified in a trivial way but the choice of the solution requires reasoning.

According to the authors of the paper e-tests can find their largest usefulness in shaping and verifying basic geometrical skills such as:

- mapping of the geometrical form of the object with the help of a set of orthographic views,
- reconstitution of such mapping,
- construction of the auxiliary view,

- construction of the section,
- correct dimensioning of objects.

Tables 1-7 show exemplary exercises of the scope of problems mentioned above. They have been made as single choice tests, multiple choice ones or tests to match up.

The structure of each e-test should be depended on its purpose. The test for the self-learning work should be constructed so that the level of difficulty of next tasks grows and is compatible with importance of solved problems. In case of test aiming at verification of knowledge of group of the students in the same time, it is not recommended to diversify the level of difficulty of exercises. That is because they are mixed in different way for each person passing test.

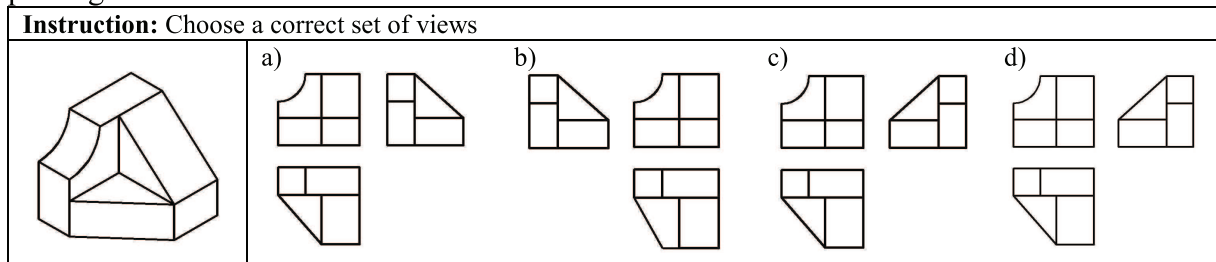


Table 1: Mapping the shape with the help of three orthographic views – single choice test

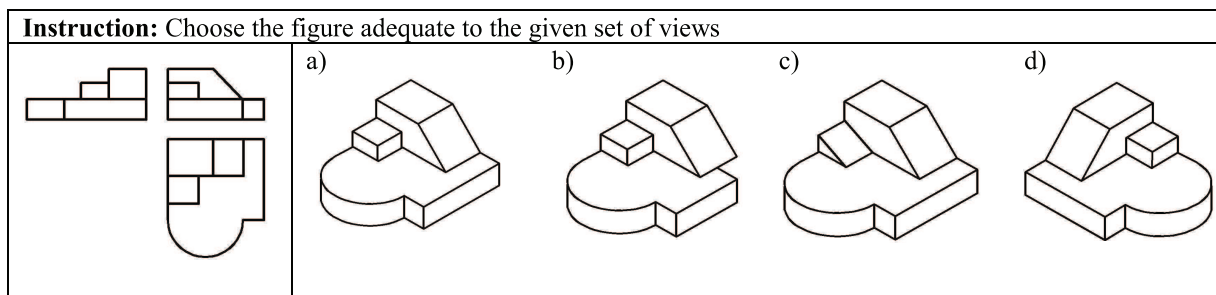


Table 2: Reconstitution of the set of orthographic views – single choice test

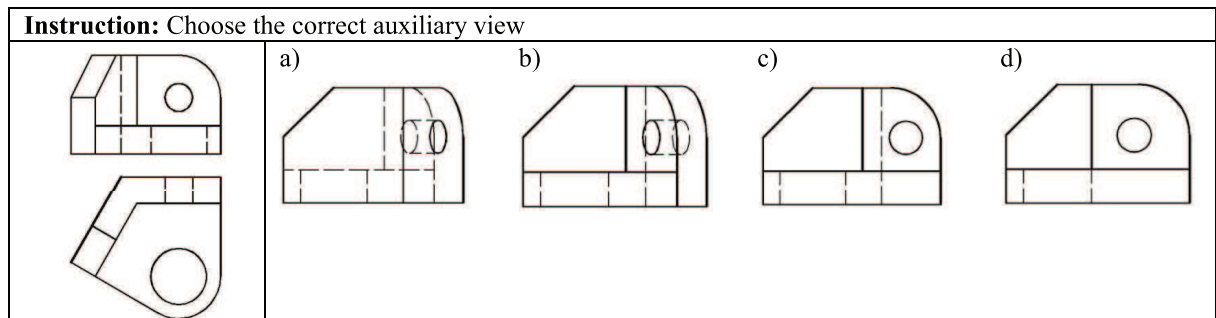


Table 3: Construction of the auxiliary view – single choice test

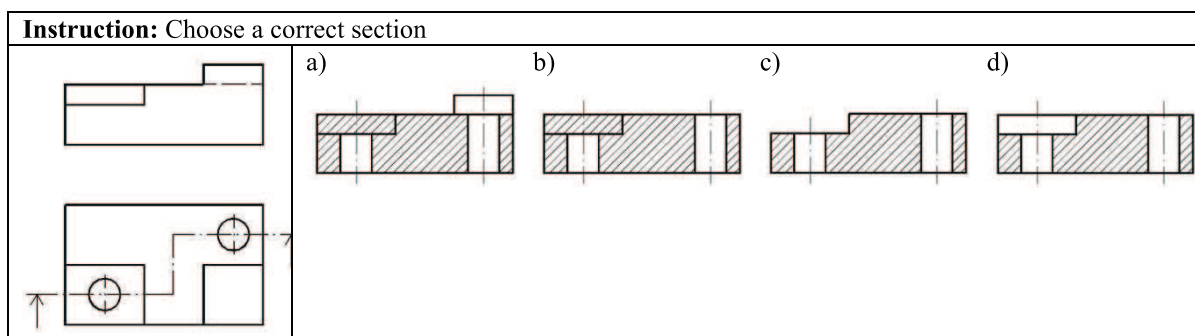


Table 4: Sections – single choice test

5 Computer software

The authors have used the *Hot Potatoes* program for preparing tests. This software is available free of charge on the [4] webpage and preparing widely available websites.

The *Hot Potatoes* package consists of six independent programs: *JCloze*, *JQuiz*, *JCross*, *JMatch*, *JMix* and *The Masher*. Possibilities of *JCloze* (for arranging tests consisting in inserting absent words), *JCross* (for arranging crosswords) and *JMix* (for arranging sets of questions, which examined gives independent answer on) programs in didactics of geometry and graphics are limited. They can be actually useful just for testing the acquaintance with the geometrical terminology. *JQuiz* (for arranging tests of single and multiple choice) and *JMatch* (for arranging tests to matching up) programs are in the authors' opinion the most valuable in the complete package. That is because of their possibility to present both questions and answers as drawings.

HTML files possible to open by any online browser are products of each of the above mentioned programs. *The Masher* program is assigned to compile websites containing sets of tasks prepared in programs different from the *Hot Potatoes* one. These tasks are next put into *Hot Potatoes* programme which is essential for arranging tests. The authors have used the *AutoCAD* software for creating drawings and turned them into JPEG files before putting into *Hot Potatoes* program.

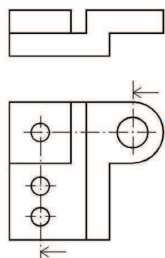
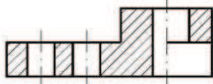

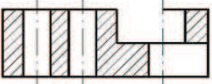

Instruction: Choose sections adequate to set of views				
	a)	b)	c)	d)
				

Table 5: Sections – multiple choice test

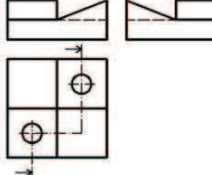
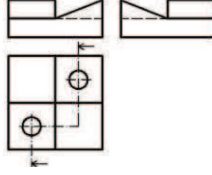
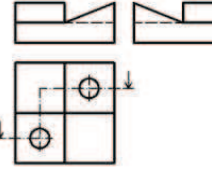
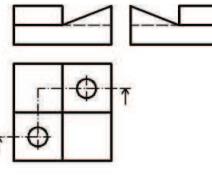



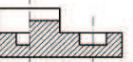
Instruction: Match sections to the adequate sets of views				
1)	2)	3)	4)	
				
a)	b)	c)	d)	
				

Table 6: Sections – test to match up

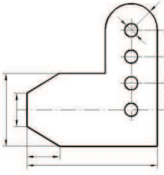
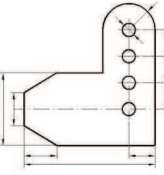
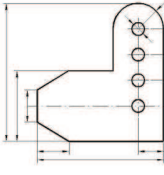
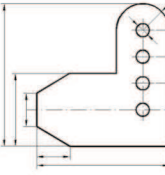
Instruction: Choose a correct set of dimensions				
a)	b)	c)	d)	
				

Table 7: Dimensioning – single choice test

6 The use of e-tests in practice

The main aim of using e-tests in didactic was finding out students attitude to that form of activity as well as assessing the effectiveness of e-tests as the tool for shaping and evaluating the student's competence. The first attempt has been taken by the group of 55 students of Civil Engineering Faculty which was also obliged to fill in anonymous questionnaire form. Students have solved 5 different tests formed as single choice tests with number of tasks enabling execution of all the work during 2 teaching hours.

The topic of questions was as follows:

mapping of geometrical form of the object with the help of the set of orthographic views,

reconstruction of the mapping,

construction of the auxiliary view on the base of the pair of orthographic views,

construction of the section,

correct dimensioning of the technical object.

Students had to choose only one correct answer from four given solutions. Results of the answers were calculated automatically in the following way:

the choice of the correct answer at once - 100%

the choice of the correct answer the second time round - 66%

the choice of the correct answer the third time round - 33%

the choice of the correct answer the fourth time round - 0%.

The result of the all test was calculated as average value from the results of all tasks in the tests. The effects achieved by the group of students solving the test have been shown on Table 8.

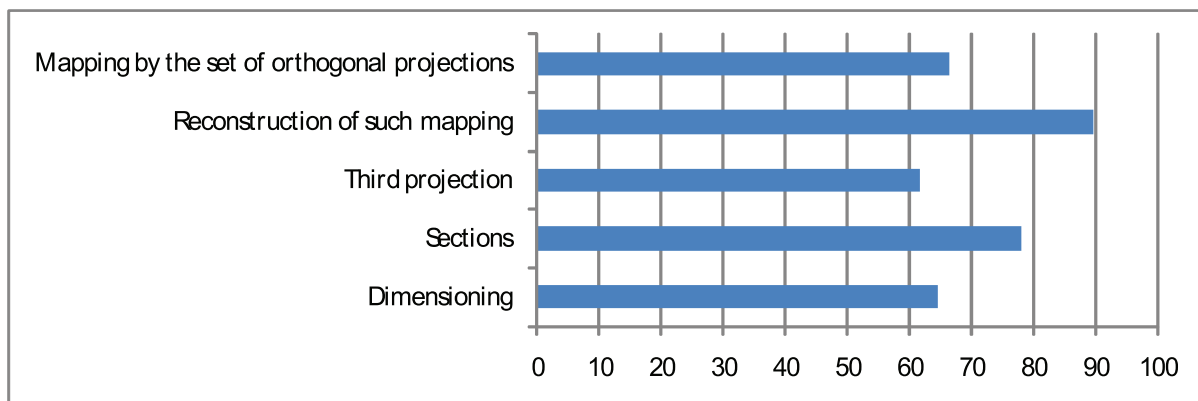


Table 8: Results of the tests

Taking into considerations the results of the students' questionnaires one can state that main advantages of the e-tests are:

immediate evaluation,

improving competence in the scope of geometry and graphics without drawing,

contact with a bigger number of different spatial problems in the time needed for construction of the single drawing.

Students had also possibility to define their own preference of applying e-tests as the assessing tool and help in self-education. Majority of them have chosen the second application only – the tool in self-studying.

7 Conclusions

The problem of applying e-tests in didactics of geometry and graphics, presented in the paper, is a part of wider vision of blended learning system teaching which have been discussed in

[5]. The E-tests that have been presented in the paper and prepared on the base on *Hot Potatoes* program, can be very useful in didactic of geometry and engineering graphics. Moreover they have turned out to be an educational tool approved by students. The main difficulties connected with using e-tests in didactics of geometry and graphics are on teacher's side and they concern inventiveness in selection of optimal tasks as well as construction of well-readable drawings. Acquired experience and satisfying results of tests summon the authors to future work on applying e-tests in didactics.

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TESTY ELEKTRONICZNE W NAUCZANIU GEOMETRII WYKREŚLNEJ I GRAFIKI INŻYNIERSKIEJ

W dotychczasowej praktyce nauczania geometrii wykreślnej i grafiki inżynierskiej nacisk kładziony jest na samodzielne konstruowanie rysunków. Słabi studenci uczą się w takim przypadku na pamięć rozwiązań planimetrycznych, zamiast starać się zrozumieć relacje zachodzące w przestrzeni, ponieważ okazuje się to skuteczne w kontekście uzyskania zaliczenia przedmiotu. W opinii autorów, sposobem na poprawę opisanej sytuacji jest szersze wykorzystywanie testów w dydaktyce przedmiotu. Student byłby wtedy w stanie zetknąć się z większą liczbą różnych sytuacji przestrzennych w czasie takim samym jak czas na rozwiązanie jednego zadania konstrukcyjnego. Najbardziej wartościowe są testy, w których zarówno pytanie jak i odpowiedzi mają formę graficzną.

Współcześnie możliwe jest przygotowanie i opracowanie takich testów w formie elektronicznej. Ich dodatkową zaletą jest możliwość dostarczania rozwiązującemu je studentowi natychmiastowej oceny poprawności odpowiedzi. Testy elektroniczne mogą być wykorzystywane zarówno do kształtowania kompetencji studentów jak i weryfikacji ich wiedzy i umiejętności. W artykule przedstawiono przykłady testów odnoszących się do dydaktyki geometrii wykreślnej i grafiki inżynierskiej jak również omówiono rezultaty ich zastosowań. Szczegółowa tematyka dotyczy relacji pomiędzy rysunkiem pogładowym obiektu a zestawem rzutów prostokątnych, konstrukcji rzutu dodatkowego, konstruowania przekrojów i wymiarowania. Oprogramowaniem polecanym przez autorów do przygotowania testów jest program *Hot Potatoes*.