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## EXAMPLES OF ORIGINAL DESCRIPTIVE GEOMETRY TASK ITEMS

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**Abstract.** Now blended-learning is widely used in teaching descriptive geometry, which means that traditional teaching and e-learning are interspersed alternately within a single issue. For teachers the basic advantage is the possibility of efficient organization, while for the students the availability of learning materials at any time and place. For descriptive geometry the precise construction of the course is very important because of the hierarchical-sequential structure of the subject. Teaching-learning is here treated as a process, in which the individual stages and their interrelationships are carefully planned. In this process the consistency and compatibility of consecutive steps are very important as they should match the content and level of difficulty. Communication in descriptive geometry is performed through graphics, knowledge is mainly transmitted through drawing tasks. The selection of topics and their degree of difficulty are adequate to the stage and their function in the curriculum. The paper will present the concept of teaching descriptive geometry using Internet platform with short description of each component in the established system. Presented examples of drawing tasks and solutions are described by the profile of the task, which contains the most important characteristic from the teacher's point of view.

**Keywords:** Descriptive Geometry, didactics

### 1 Blended learning model of teaching Descriptive Geometry

The presented concept of teaching descriptive geometry is carried out for all majors at the Faculty of Civil and Environmental Engineering in Gdansk University of Technology. According to the curriculum of the subject during the course students learn how to use different types of projection to record 3D spatial objects on a drawing plane. During the course classical face-to-face methods of teaching are enriched with the forms of distance learning, which aim is not to replace the traditional teaching but to support and supplement it. This combination of multiple approaches to teaching-learning process resulted in blended-learning, where physical and virtual components are used. The main feature of the presented concept of teaching is the consistency of the whole system understood as the mutual suitability of its components. The system is not a closed learning environment, but it is in constant development and it is a subject to change as a result of self-evaluation and feedback. The individual modules of the course are applicable for various specialities within the faculty and can be upgraded.

Consistency and compatibility between the various components mean a close adequacy of the content and level of difficulty of successive sections in the structure of the course. Moreover, according to the theory of learning each stage of the course cause gradual extension of the zone of proximal development of the learner, which generates a much smoother transition from the lecture to the obligatory drawing task, and later from the drawing task to the final test. In the end, the effort of the learner is better distributed in terms of time and scope of knowledge, what in the case of descriptive geometry is very important because of the hierarchical structure of the subject. It should also be noted that

in presented approach, eliminating one of the stages may adversely affect the transition to the next stage, a typical example would be lack of initial knowledge from the relevant lecture and master task resulting in difficulty in completing the drawing task by a student. These types of cases are likely to be minimized when at the start of the blended course the important role of self-study components is thoroughly explained.

The descriptive geometry course for Civil Engineering covers 45 hours of lectures, exercises and design. As part of the compulsory subjects students perform 14 drawing exercises and one semester project integrating knowledge from a larger part of material. In order to increase the objectivity of the assessment the final test is uniform and at the same time for the whole year (Fig. 1).

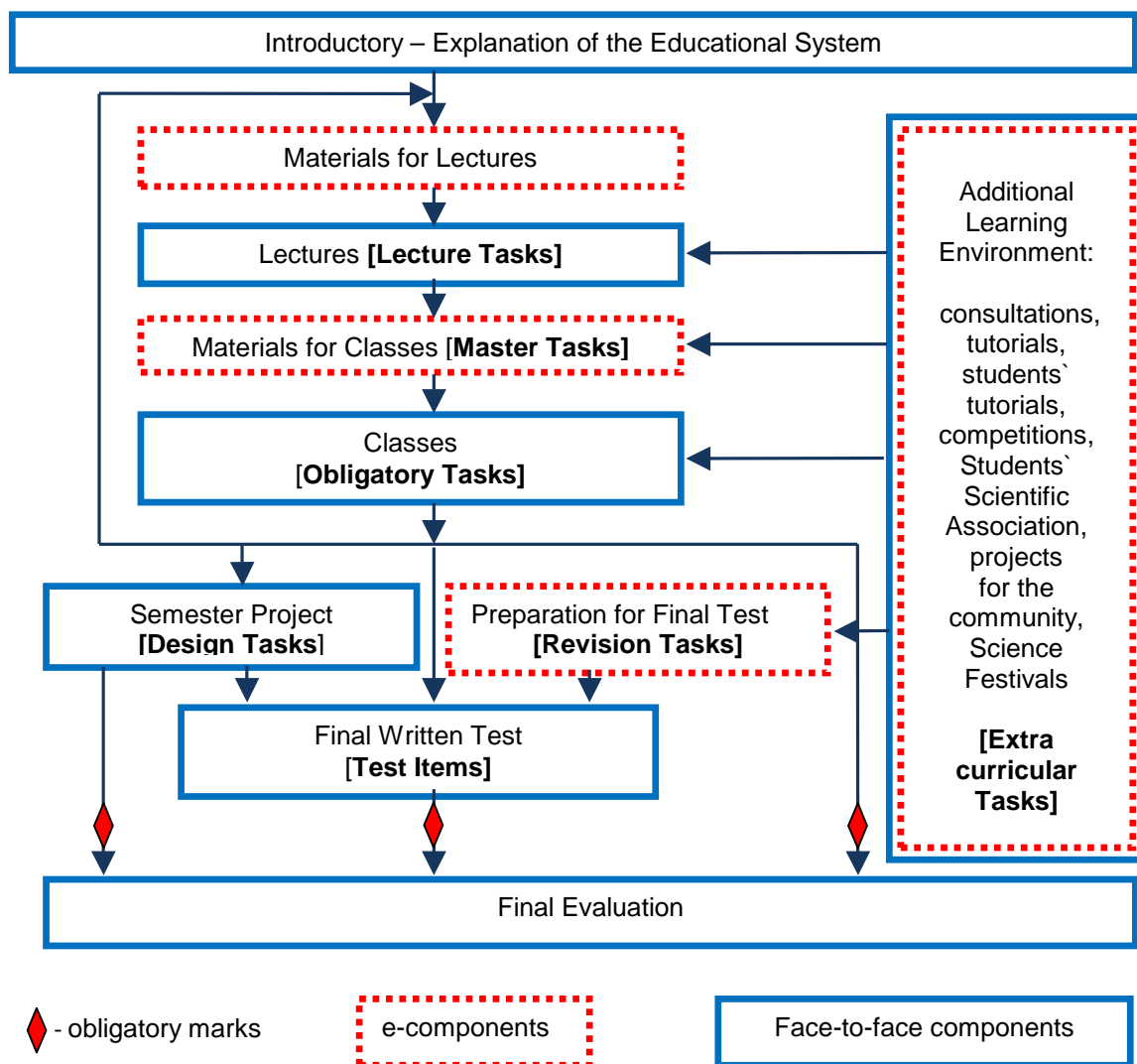


Figure 1: The model of blended-learning of Descriptive Geometry course

The traditional face-to-face components of the course:

- Introductory classes - the initial classes during which the concept of blended learning is presented, the special emphasis is put on self-study as an integral component of the overall program because this activity is carried out in uncontrolled phase of distance learning but at the same time greatly affects the effectiveness of learning. Self-study depends entirely on students` motivation therefore it is extremely important to encourage students take effort and further work.

- Lectures - conducted with the multimedia projector, step-by-step drawings are shown on a large screen.
- Obligatory tasks – a drawing tasks performed on the prepared sheets, the possibility of consultation with the teacher and other students.
- Design project - a larger task integrating knowledge from several lectures and classes, homework.
- Final test - consists of several task items of varying difficulty, it is simultaneous for all students, the test is evaluated with help of classical test theory.
- Final evaluation - students` results are obtained as the integration of formative evaluation throughout whole semester and summative evaluation during the final test.

The e-components of the course:

- Materials for lectures – A set of selected written and drawing materials prepared as a-basis to follow-up more complex constructions and personal notes.
- Master tasks - samples of tasks specifically designed for self-study before obligatory face-to-face classes. Virtual materials support the process of self-performance, allow individualization and flexibility of the learning process.
- Revision tasks - a set of drawing tasks of varying difficulty allowing to revise of most of geometric constructions from the course and to self-assess of required skills.
- Additional learning environment - a collection of additional physical and virtual materials, means and methods magnifying opportunities to learn.

## 2 Task construction

The task is an organized course of thinking, practical or verbal actions directed to use the acquired knowledge in practice requiring shorter or longer emotional activity and dependent on the will of the learner. While solving the student needs to consciously seek means by which the visible, but temporarily unavailable target can be achieved [4].

Writing tasks is often seen as a creative action close to art, so there may not be a set of rules that will give the guarantee of a good production test tasks [4]. However some practical tips for writing tasks, especially when they involve assessment [3]. Firstly, the content of the task should precede the form. The ideas can be drawn from both the content of education and observation of the difficulties students have to overcome. Thus initially the most important issue is to determine what action or sequence of actions is to be performed in the task. Secondly, the task form should not detract from its content and should not require any additional explanations. Building tasks needs more empathize with the situation of the student, not the situation of a teacher implementing the educational program. The tasks which are free of unnecessary rigidity are more likely to be motivating. Next, the text of the task should be clear and concise without unnecessary words or symbols. The language of the task should not be a barrier closing the students from independent thinking. Typical errors should be avoided - unclear commands, ambiguous expressions, unintended hints, etc. The foreseen time for the solution should be appropriate to sustain the motivation of students to its implementation.

In Descriptive Geometry both teaching and learning are being done by drawing. During lectures, classes, and other stages of the learning process the drawing tasks appear as the main form of transmission the educational content and at the same time as a basic mean of evaluating students' achievements.

Teaching Descriptive Geometry inevitably leads to designing tasks items. The modern teacher does not only refresh or edit old-school test items, but also constructs new topics, seeks for new ideas, adapts modern technology, keeps in mind the motivational factor [1].



Therefore the author in own teaching practice tried to avoid boring, stereotypical, needlessly time-consuming tasks or discouraging from studying the subject.

Table 1: The types of tasks in blended-learning of Descriptive Geometry course

Function	Objectives	Features of the task	Tips for the construction
<b>Lecture Tasks</b>	Study	- illustration of new issues discussed during the lecture, key tasks - often scheduled to be copied by students	- the solution shown step by step - visually perfect, not overburdened with details, - well illustrate the crux of the issue
<b>Master Tasks</b>	Self-study	- the link between the lecture and obligatory tasks - topics similar to Obligatory Tasks, high validity - typical topics, common settings and solids, - a complete solution enabling understand structure	- best topics, well illustrating the key issue - clear error-free solution; no overlapping lines or points - containing all proper notation which is required in Obligatory Tasks
<b>Obligatory Tasks</b>	Study evaluation	- issues arising from the syllabus, strongly correlated with the lecture, restricted time approx. 75 min - tasks with a higher degree of complexity, allowing to use the prior constructions, - consultations with the teacher or the group - motivating - a sense completing a difficult task	- a complete solution should well illustrate the problem, however lines, points may overlap - solutions should fit on the format and be accompanied by comments where appropriate - many variants of tasks for a large number of students - resistant to inaccurate drawing skills of beginner students
<b>Revision Tasks</b>	Self-study Self-evaluation	- range of topics of varying difficulty - solutions should enable self-assessment - the task should be prepared on a separate sheet of paper to resemble the test conditions	- not necessarily perfect, lines or points may overlap - available all possible correct solutions - information if the result can be obtained using a different approach
<b>Design Project</b>	Study evaluation	- complex multi-step design integrating knowledge, in a larger format - the task done at home, possible collaborative work - consultations before submission of the project	- problem solving task - possible multiple implementation of the same construction - many variants of tasks for a large number of students - topics changing in the coming years
<b>Test Items</b>	Evaluation	- set of test items forming achievement test, corresponding to standards - adequate test validity and reliability	- tasks resulting from the syllabuses - minimum lines, maximum content - faultless written verbal content, set score
<b>Additional Tasks</b>	Study Self-study	- complex multi-step design integrating knowledge, - optional formats - the task done at home, possible collaborative work - consultations before submission of the project	- creative new tasks, often not taken earlier by the teacher - in practice the result may be approximate - extracurricular requirements, diverse, often independently chosen by students

Creating the new Descriptive Geometry task begins with the decision on the tested skills and difficulty of the task. The strategy of task content building is related to the selection of:

- solution algorithm - one or many different answers, one or many different methods
- the order of the solutions algorithm - processing algorithm of a typical or reverse sequence

- setting of geometric elements – typical or special settings for the initial geometric elements.

The proper editorial and form of the task corresponding to the function in the educational system are of utmost importance in Descriptive Geometry tasks (Table 1).

### 3 The task evaluation - validity and reliability

The elements of educational system are subject of constant evaluation. According to the classical theory of tests, tasks which measure students' achievements are subject to qualitative and quantitative analysis. The qualitative analysis evaluates its validity while the quantitative reliability of measurement. Study and self-study tasks, which are not assessed statistically, are only analyzed for their validity.

Validity of a task or test as the measurement tool of students' assessment is considered to be the degree to which the tool measures what it claims to measure. In the paper the concept of extended validity proposed by Samuel Messick was adopted to Descriptive Geometry tasks. The appropriateness and social consequences are added to the construct validity and the whole construct is presented in the progressive table [2]. This approach created a possibility to preview various aspects of validity, including important consequential facets which influence the attitudes towards values and learning (Table 2). In the research the consequential aspects were not considered, also construct validity was skipped on the assumption that all task refer to Descriptive Geometry field of knowledge.

Table 2: The progressive table of construct validity of Descriptive Geometry tasks/ tests

	<b>Interpretation of Task/Test</b>	<b>Application of Task/Test</b>
On the basis of the collected evidence -test items and application	<b>Construct validity</b> - to what extent the task corresponds to the field of knowledge Aspects: - <b>identifying geometric problems</b> - <b>identifying complexity of geometric issue</b>	<b>Construct validity + Appropriateness and usefulness</b> - application in accordance with laws and educational programs Aspects: - <b>function in the teaching system</b> - <b>the aim of application</b> - <b>the course competencies</b> - <b>educational objectives</b>
Based on the anticipated consequences – opinions of teachers and students	<b>Construct validity + Shaping values</b> - short-term consequences of the measure for the students and their attitudes towards values and learning Aspects: - <b>motivating - encouraging students to learn and explore the subject</b>	<b>Construct validity + Appropriateness and usefulness + Shaping values</b> - the long-term effects on the students and the society Aspects: - <b>useful in their future engineering careers</b>

A task may be interpreted differently in various educational systems and among different students' groups. In terms of application aspect (appropriateness and usefulness) the task is evaluated in a particular teaching system. The research focused on four features of tasks applied in blended learning for Civil Engineering students (Table 2):

- function in the teaching system (the extent to which the task refers to the function in the teaching system: lecture, obligatory, revision tasks, etc.)
- the aim of application (the extent to which the task refers to the aim of application: study, self-study, evaluation, self-evaluation tasks)
- course competencies (the extent to which the task refers to the course-content: curricular, extracurricular, key tasks)
- educational objectives (the extent to which the task refers to the educational taxonomy: typical, problem-solving, etc.)



Reliability refers to the accuracy of measurement defined as reproducibility of the result and it is determined by statistical analysis. According to the classical theory of tests, both tests and complex tasks which measure students' achievements are subject to quantitative analysis, where the test results are interpreted. In the research assessment of reliability included 3 factors:

- reliability of measurement as accuracy of measurement, adequate high of reliability gives rise to statistical reasoning. (e.g. low reliability 0,5-0,79, reliable 0,8-0,89)
- task/item easiness– the ratio of points scored for the task by all students to a maximum (eg. 0,2-0,49 –difficult, 0,5-0,69-medium, 0,7-0,89-easy)
- task/item discrimination – distinguish students of higher and lower achievements (eg. minimal>0,2) [3].

The Final Tests for Civil Engineering students are annually the subject to evaluation and the actual values of the listed indexes are measured. In academic year 2014/15 and 2015/16 reliability index reached value of 0,64 and 0,62, both meant low reliability, but enabling to interpret task easiness and task discrimination [3]. Task easiness in the same years ranged respectively from 0,02-0,55, and from 0,25-0,55, which means that most tasks were difficult for students, only a few turned out to be of an average difficulty. Task discrimination ranged from 0,0-0,48, and 0,20-0,30, what means low discrimination items. Based on the statistical analysis of the results it is possible to distinguish among the tasks to what extent they served to evaluate students assessment.

#### 4 The profile of the tasks

The most important features of the task is in accordance with the phases of creation of the task gathered in a summative table (Table 3). The task plan guidelines relate to founded skills and the topic strategy. The aspects of validity included in the table refer to four points of appropriateness and usefulness of task application. They relate to the task assessment to what extent they have been used for the function in the system, aim of application, course competencies and learning objectives. The final overall brief evaluation is a compressed result of the previously described quantitative analysis or observation and experience.

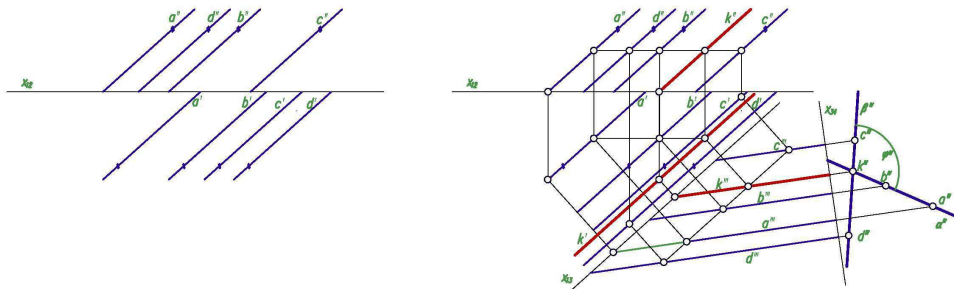
Table 3: The most important features of Descriptive Geometry tasks from the teacher's point of view

Task plan		Aspects of validity				Evaluation
Geometrical issue	Construction strategy	Function in the teaching system	Aim of application	Course competencies	Taxonomy of objectives	Measurement or experience
Auxiliary views	Processing typical algorithm of sequence	Lecture	Study	Key	Typical	Perfect
Dihedral angle	Processing reverse algorithm	Master	Self-study	Curriculum	Problem solving	Very good
Intersection	Typical settings for the geometric elements	Obligatory Task	Evaluation	Extracurricular	Creative	Good
Roof construction	Specific settings for the geometric elements	Project	Self-evaluation			Could be better
Rotation	Many different methods	Revision				Poor
Axonometry	Many different answers	Test Items				
Perspective		Additional				

By choosing the most appropriate features of the given task the table is reduced and called here a task profile. It seems that such profile can serve a quick interpretation of the task application.

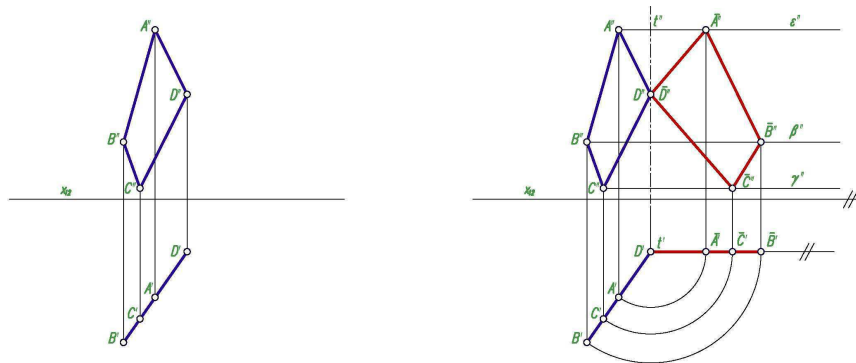
### 5 Examples of original task items

Below several tasks arranged by the author for students of Civil Engineering are presented together with their profiles [1].



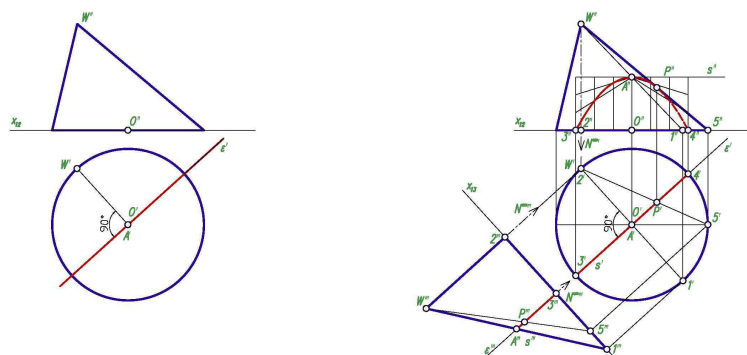
Task Plan		Aspects of Validity				Evaluation
Geometrical issue	Construction strategy	Function in the teaching system	Aim of application	Course competencies	Taxonomy of objectives	Measurement or experience
Intersection Dihedral angle	Specific settings for the geometric elements	Test item	Evaluation	Curricular	Typical	Very good

Figure 2: Task and profile: Draw the intersection line between planes  $\alpha = ab$  and  $\beta = cd$ . Find the true size of the dihedral angle between planes  $\alpha$  and  $\beta$



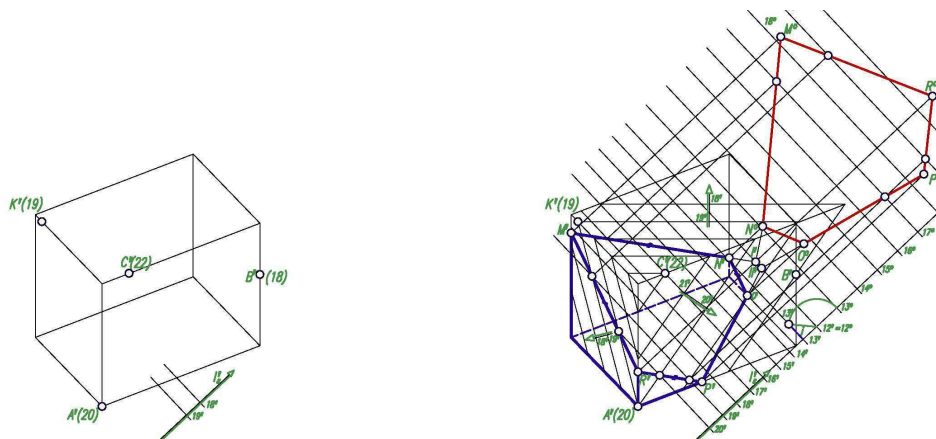
Task Plan		Aspects of Validity				Evaluation
Geometrical issue	Construction strategy	Function in the teaching system	Aim of application	Course competencies	Taxonomy of objectives	Measurement or experience
Rotation True size	Specific settings for the geometric elements	Test item	Evaluation	Curricular	Typical	Perfect

Figure 3: Task and profile: Find the true size of the tetragon ABCD by rotation



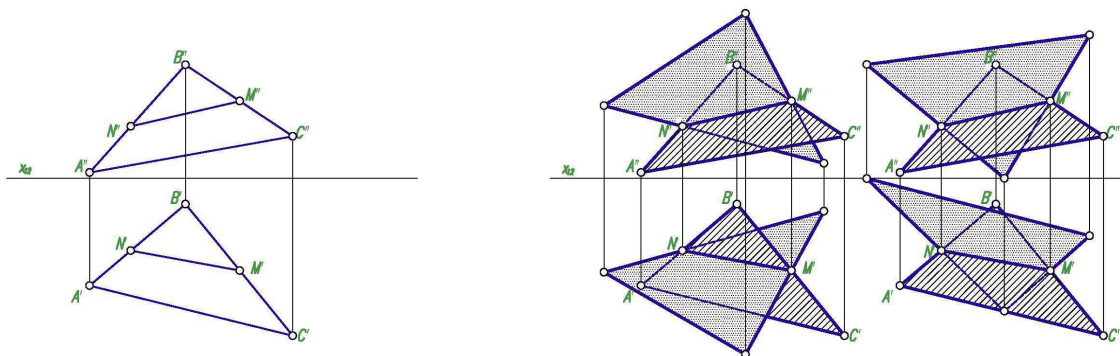
Task Plan		Aspects of Validity				Evaluation
Geometrical issue	Construction strategy	Function in the teaching system	Aim of application	Course competencies	Taxonomy of objectives	Measurement or experience
Intersection	Specific settings for the geometric elements	Test item	Evaluation	Curricular	Problem solving	Very good

Figure 4: Task and profile: Draw the intersection of the cone by plane  $\epsilon$



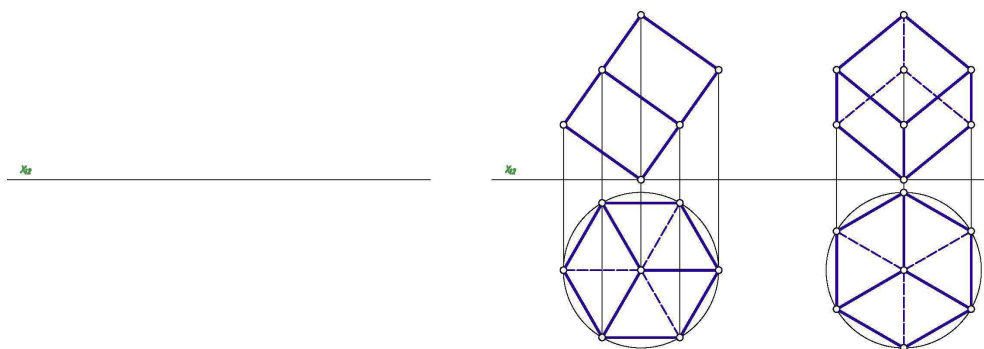
Task Plan		Aspects of Validity				Evaluation
Geometrical issue	Construction strategy	Function in the teaching system	Aim of application	Course competencies	Taxonomy of objectives	Measurement or experience
Intersection	Processing typical algorithm of sequence	Revision	Self-evaluation	Curricular	Problem solving	Perfect
True size		Test item	Evaluation			

Figure 5: Task: Draw the intersection of the polyhedron and find its true size



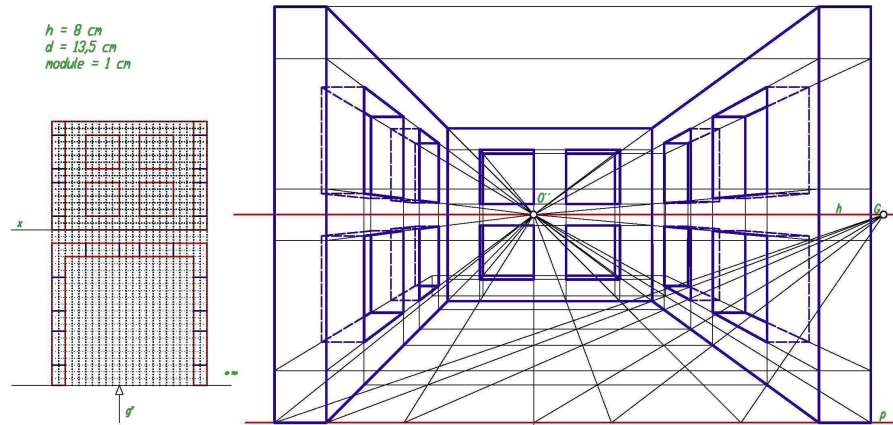
Task Plan		Aspects of Validity				Evaluation
Geometrical issue	Construction strategy	Function in the teaching system	Aim of application	Course competencies	Taxonomy of objectives	Measurement or experience
Intersection	Processing reverse algorithm	Additional	Self study	Curricular	Problem solving	Perfect
	Many different answers					

Figure 6: Task and profile: Draw the triangle intersecting with the given triangle ABC in line NM



Task Plan		Aspects of Validity				Evaluation
Geometrical issue	Construction strategy	Function in the teaching system	Aim of application	Course competencies	Taxonomy of objectives	Measurement or experience
3D construction	Specific settings for the geometric elements	Additional	Evaluation	Extracurricular	Problem solving	Perfect

Figure 7: Task and profile: Draw a cube whose horizontal projection view is a regular hexagon. The size of the edges and the setting of the cube are optional



Task Plan		Aspects of Validity				Evaluation
Geometrical issue	Construction strategy	Function in the teaching system	Aim of application	Course competencies	Taxonomy of objectives	Measurement or experience
Perspective	Processing typical algorithm of sequence	Additional	Study Evaluation	Curricular	Typical	Very good

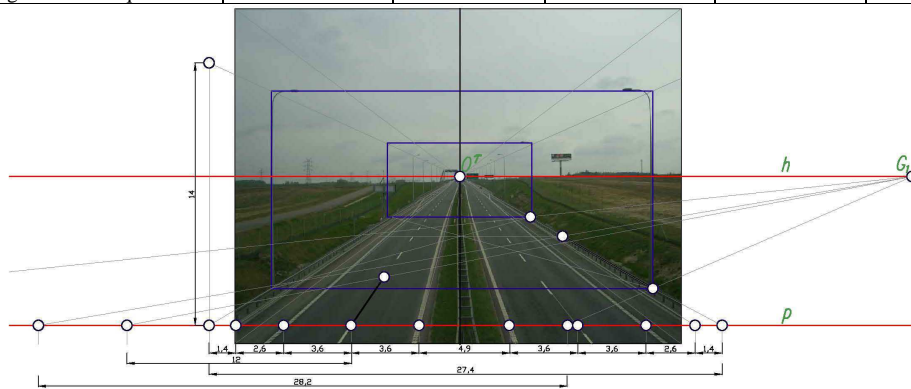
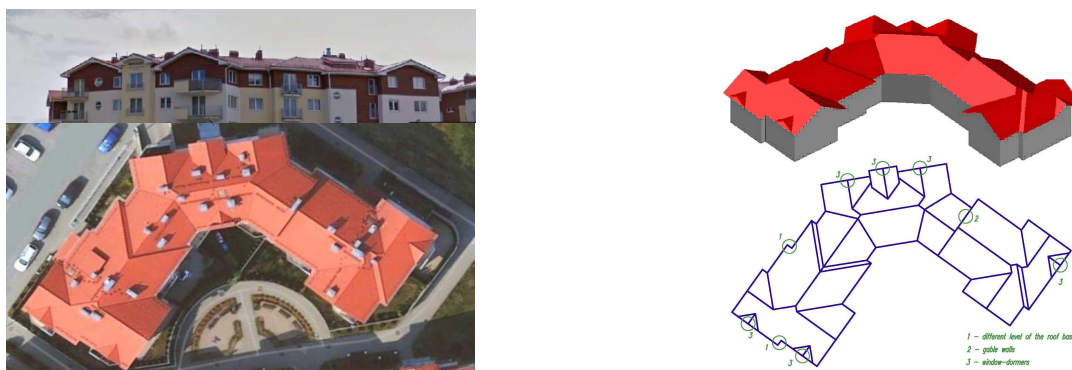


Figure 8: Task and profile: Draw the perspective view of the walls with 2 rows of windows

Task Plan		Aspects of Validity				Evaluation
Geometrical issue	Construction strategy	Function in the teaching system	Aim of application	Course competencies	Taxonomy of objectives	Measurement or experience
Perspective	Processing reverse algorithm of sequence	Additional	Study	Extracurricular	Problem-solving	Perfect

Figure 9: Task and profile: Measure the height and spacing of the road lamps in one-point perspective



Task Plan		Aspects of Validity				Evaluation
Geometrical issue	Construction strategy	Function in the teaching system	Aim of application	Course competencies	Taxonomy of objectives	Measurement or experience
Roof construction	Processing typical algorithm of sequence	Additional	Study	Extracurricular	Problem-solving	Perfect

Figure 10: Task and profile: Using the satellite photograph draw the construction of the roof

## 6 Conclusions

The article presents several Descriptive Geometry drawing tasks in context of the educational system. The tasks differ due to their relation to the topics, initial setting of geometric elements, or sequence of the planned solution.

An attempt was made to create the table of essential characteristics which could easily be transformed to the brief but useful profile of each Descriptive Geometry task. Such profile enables rapid interpretation of the task application. It is possible that it would be modified and mastered. It seems that since there are differences in curriculums among various universities the task profiles would allow teachers to spot them immediately.

Descriptive geometry teachers constantly prepare drawing tasks, construct new topics, seek for new ideas or technology to maintain students' interest. Some original topics are carried out in smaller groups or individually, often outside the obligatory classes. It is worth to share these experiences because new concepts and ideas may enrich teaching-learning process or become an incentive to creating entirely new tasks.

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## PRZYKŁADY ORYGINALNYCH TEMATÓW ZADAŃ Z GEOMETRII WYKREŚLNEJ

W nauczaniu geometrii wykreślnej obecnie wykorzystuje się blended-learning, gdzie tradycyjne nauczanie stosowane jest naprzemiennie ze zdalnym kształceniem w ramach jednego zagadnienia. Model ten zakłada etapy pracy obowiązkowej przeplatanej pracą własną w domu z wykorzystaniem witryny internetowej. W przypadku geometrii wykreślnej precyzyjne konstruowanie kursu jest bardzo istotne ze względu na hierarchiczno-sekwencyjną strukturę tematyki kształcenia. Nauczanie-uczenie się jest tu traktowane jako proces, którego poszczególne etapy oraz ich wzajemne powiązania w całym systemie są starannie zaplanowane. W tym procesie bardzo ważna jest spójność i zgodność poszczególnych części polegająca na ścisłym dopasowaniu treści i poziomu trudności elementów pośrednich.

W geometrii wykreślnej komunikacja odbywa się za pomocą grafiki, zarówno na wykładach, ćwiczeniach oraz pozostałych etapach uczenia się zadania rysunkowe stanowią podstawową formę przekazania treści. Temat i stopień trudności są adekwatne do roli jaką zadanie ma odegrać w przyjętym systemie kształcenia. W referacie zaprezentowano koncepcję nauczania geometrii wykreślnej z wykorzystaniem platformy internetowej wraz z krótką charakterystyką poszczególnych części składowych. Dla opisanej koncepcji przedstawiono typy zadań oraz ich pożądane własności ze względu na cel zastosowania w systemie. W artykule zamieszczono zróżnicowane przykłady tematów i rozwiązań. Zbiór najistotniejszych cech przedstawiono w ujęciu tabelarycznym pod roboczą nazwą profilu zadania. Wydaje się, że taki zestaw ważnych cech z punktu widzenia prowadzącego zajęcia może ułatwiać interpretację zastosowania prezentowanego zadania w danym systemie kształcenia.

