PERCEPTION OF VIEW – HOW TO DEVELOP SPATIAL IMAGINATION

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Abstract: The concept of design work, presented in the article and undertaken in the course of „Engineering Graphics" conducted for the students of Environmental Protection course at the Faculty of Power and Environmental Engineering of the Silesian University of Technology, is a part of studies related to the analysis of the role and importance of the physical model in teaching subjects referring to spatial imagination, such as „Engineering Graphics", „Geometry" and „Engineering Geometry". The authors justify the introduction of a physical model into teaching of „Engineering Graphics" by the application of one of the oldest teaching principles – the principle of direct vividness, formulated in the nineteenth century by Pestalozzi[1]. The design tasks which are presented in the article is an extension of the idea of basing the teaching of „Engineering Graphics" in certain justified cases resulting from, among others, the specific field of study or particular needs of students, mainly on design tasks directly referring to direct vividness.

Keywords: geometry, engineering graphics, models, didactics

1 Introduction

The way, in which a man constructs any image to be a picture of a reality or a fact, has been a problem under consideration by the representatives of various areas of science. However, all sensations associated with surrounding us objects or events have always existed in time and above all in space.

The human eye is the most perfect optical organ ever created. Therefore, vision is the primary spatial sense. Thanks to it, we can see the shapes and colours of spatial objects. It provides the most obvious and the most prosperous perceptual information. Moreover, vision dominates and is the most important for any kind of understanding of space. Plenty of information, that we do not need to realise, arrives from an eye to a brain. They are stored in the consciousness. Thus, if we look at something, the image is stored, even if we do not attempt to.

The perception of an object, recreating its shape, size and distance in which it appears, defines the concept of perceptual constancy, where we distinguish the following:

- colour brightness constancy – perception of an object in its natural colour (regardless of the season, daytime and the saturation of the light)
- shape constancy – perception of an object in its natural form (regardless of the viewing angle)
- size constancy –perception of an object in its natural size, regardless of the distance,

[1] Joachim Heinrich Pestalozzi (12.01.1746 – 17.02.1827) – Swiss pedagogue and educational reformer. His educational methods were child-centered and based on individual differences, sense perception, and the student's self-activity. His motto was "Learning by head, hand and heart" [2].

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- location constancy– keeping the position of the observer, regardless of motion [1].

Figure 1: Colour brightness constancy - the human mind and eyes are able to recognise the shape of tree on these pictures and the colour changes

Figure 2: Shape constancy - the observer recognise the shape of bird even pictures present them in different views

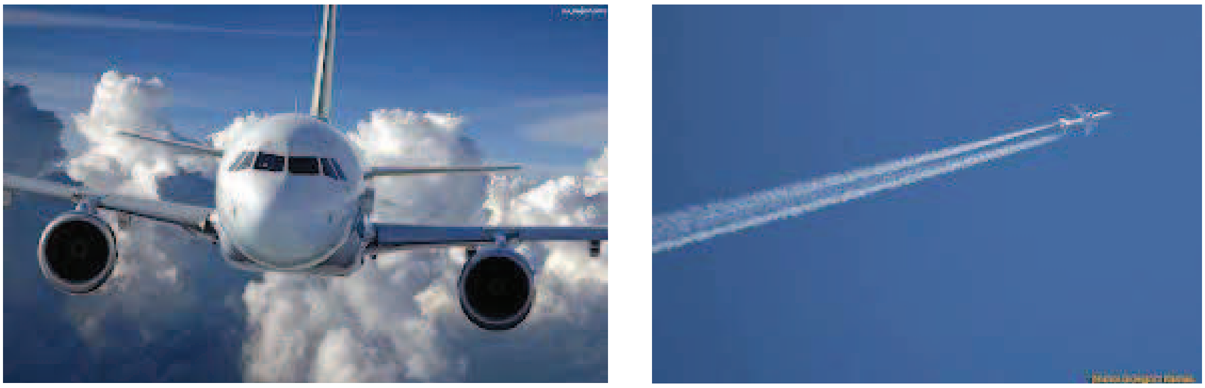

Figure 3: Size constancy - the observer is able to recognise, that pictures present such huge object as plane even with such different sizes of views

So it is possible to say that, the ability to perceive the environment in three dimensions is a relationship between the vision and the experience of space and spatial objects that man has acquired during the learning process. Another type of capability associated with the perception of space is spatial imagination - ability to create in the mind an image or object compliant with its actual shape and location. The man has a spatial imagination, if on the ground of a drawing, model or description he can imagine, analyse, extend and describe the shape and position of geometric objects [4]. Today no one needs to be convinced of the importance and the role of spatial imagination in engineering work. An ability to operate a flat (2D) representation of three dimensional (3D) object is a common phenomenon for designers. Flat, for example geometric, representation is a global way to pass strict and unambiguous information about the object. This is an engineering language. But how to encourage young beginner students - the future practicing engineers to learn new and sometimes, difficult language?

The oldest learning rule formulated in the nineteenth century by Pestalozzi was based on the theorem saying that sensory cognition is the foundation of knowledge. A particular importance was attributed to the method of ascertaining the element from general to specific, so as to make the teaching educational which will develop the ability of independent thinking. In this way the principle of vividness was born, which requires reliance of the whole science on ascertaining the reality itself, and thus the concrete things, phenomena and processes. There are two types of vividness:

- direct cognition of the phenomenon such as observation of naturally occurring phenomenon,
- indirect cognition referring to the imagination produced on the ground of previous observations of the object (a real model or teaching tool in the form of model, image, diagram, chart or other) [3, 5].

The principle of vividness is most relevant in the teaching of geometry, descriptive geometry, and subjects referring to geometry such as engineering graphics, because it significantly influences the growth and development of spatial imagination. One of the methods in the process of proper associating and development of spatial thinking is the use of models as means of indirect representation of reality. A model according to a definition is a pattern, which facilitates the development of spatial imagination. The use of models at the beginning by watching, building, bonding and then making their projections, sections or drawing of axonometry allows for flexible operation in the development of spatial thinking. Such thinking may be understood as an exercise to see; present and process information, and a

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chance to achieve the desired success can be increased by the use of various illustrative means. They implement many functions (explaining, verifying, imitating), but also help in creation of the spatial image.

While working with our students at the courses of Descriptive Geometry and Engineering Graphics often there is a problem of an approach to the problem of space, its development and reproduction. This raises the question – whether to stay with traditional education methods involving mainly the use of a drawing as a means developing spatial imagination? After all drawings require the ability to read their contents and the ability to make drawings, so that content created in the author's mind could reach the recipient? Or, maybe one should strengthen the emphasis put on the model formation, using physical models, both for reading and creating technical drawings? Selection of appropriate and effective teaching methods becomes extremely important when the time for the implementation of the classes program is small and issues are presented to the students of the so-called „non-design" courses and provide them with a complete novelty.

2 How to develop spatial imagination – new concept of teaching graphics classes

Since 2008 at the Faculty of Energy and Environmental Engineering of the Silesian University of Technology there is conducted a branch of study - Environmental Protection. Graduates of this branch of study are to be professionals prepared for working in the field of development and protection of environment and should be prepared to work in environmental protection inspectorates, centres of research and environmental development and in research laboratories. The program of the first year of Engineer's degree studies includes the following principal subjects: Chemistry (120 hours), Mathematics (105 hours), Biology (75 hours), Physics (75 hours), Information Technology (30 hours), Engineering Graphics (30 hours) and speciality subjects such as: Ecology (90 hours), Environmental Protection (60 hours), Law and Economy in Environmental Protection (105 hours), Industrial Technologies (15 hours), The Risk of Civilization and Balanced Development (30 hours), Hydrobiology (45 hours) [5]. Engineering Graphics course includes 15 hours of lecture and 15 hours of design classes. The course object covers such issues as the orthographic projection in the mapping and reconstruction of parts of space, axonometry as a basic form of creation of illustrative drawings (freehand sketch), the main forms of graphic recording recommended by the standards (projection, section drawings, dimensioning), marking projection as a method of recording used in the design of terrain, urban drawing. The main objectives of the course were:

- development of skills to make technical drawings prepared in a variety of techniques,
- knowledge of the principles of preparing technical drawings using standard symbols,
- development of skills to read the contents of the technical drawings,
- development of spatial imagination.

Therefore that Environmental Protection course does not belong to the so-called „design" courses (graduates of which are not likely to work as designers), and the drawing for students of this course is not a commonly used way of conveying information, a lot of emphasis in the classes was placed on presenting practical aspects of the subject – trying to convince students that "one picture – drawing is worth a thousand words". Experience gained by the author in the course of teaching such subjects as Engineering Graphics, Technical Drawing, CAD Mappings carried out for various technical courses allows to state that one of the most difficult issues for the students learning forms of graphic recording is an orthographic projection. While many courses of Engineering Graphics and Technical Drawing, conducted by the author, this issue was presented to students during the lecture on the example of axonometric drawing of three-dimensional object, which was then mapped in orthographic projections. Subsequently, students in the design classes were solving individual tasks based on the same assumptions, i. e. three-dimensional object shown in the axonometric drawing had to be mapped in orthographic projections. The greatest difficulty for students was appropriate reading of the object's shape represented in the axonometric drawing and the correct mapping of these parts of the object that had been hidden behind object. Equally difficult task was to correctly represent the edges which were invisible in a projection.

The design task in this shape required the students to refer to a spatial model constructed in the imagination. Therefore it met the demand of indirect vividness, but in itself it didn't contain direct vividness – student didn't have the possibility of direct observation of the model, manipulation of it and observing its positions relative to the projection plane. Gained teaching experience of the authors has inspired to introduce the physical model as a part of facilitating the study of the principles of graphic mapping of spatial elements. Described earlier design task was changed and divided in three parts: homework, class work and final test.

The first task - homework was an introduction for the next. Students in the homework made individually designed physical models of spatial elements according to certain presuppositions such as the shape and size of the basic block and a number of cutting planes. The physical model was then mapped in orthographic projections according to the standard rules (students made six projections/views of the block including the invisible edges) and in two axonometric projections recommended by the PN (Polish Standard) – in isometric projection and in oblique dimetric projection [6]. Working with hand-made model, whose shape was designed by the student, significantly facilitated the graphical mapping of the spatial component on the plane of the drawing, whether it was in orthographic or in axonometric projections. The possibility of physical manipulation of the model, conducting a survey of the changing positions of the elements of spatial object against projection plane significantly facilitated the understanding of the principles of the orthographic projections and the essence of the positions of the projecting spatial elements such as edges and planes against projection plane. The students' work done this way was a direct cognition of this phenomenon – thus fulfilled the postulate of direct vividness cited in the introduction.

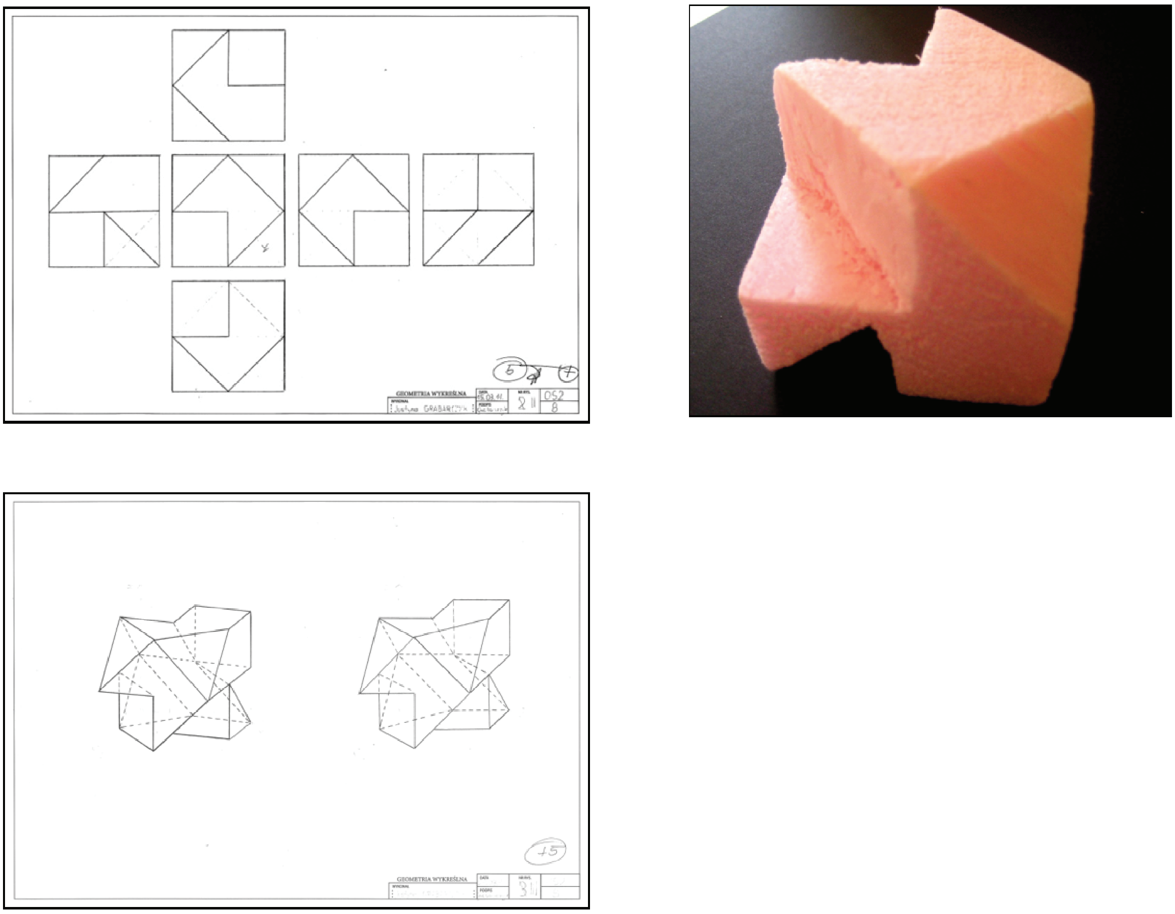

Figure 4: The example of student's homework - physical model, orthographic views and axonometric projections

The second task - class work was divided into three main stages:

1. construction of a model with a number of ready-made polyhedral forms,
2. mapping of the model in a parallel projection - axonometry,
3. mapping of the model in orthographic projection.

Drawing part of the task was performed as a freehand drawing and design drawing. Similar to the homework, in the view of the authors, fully met the demand of direct vividness [3]. Composing their own spatial structures with ready-made polyhedral forms, students were able to make multiple observations of the model. Practical use of a central plan in the form of digital images made by students, presenting the previously constructed models, to create their own inventory records of works performed, became significant and very important in the context of further research part of the design task.

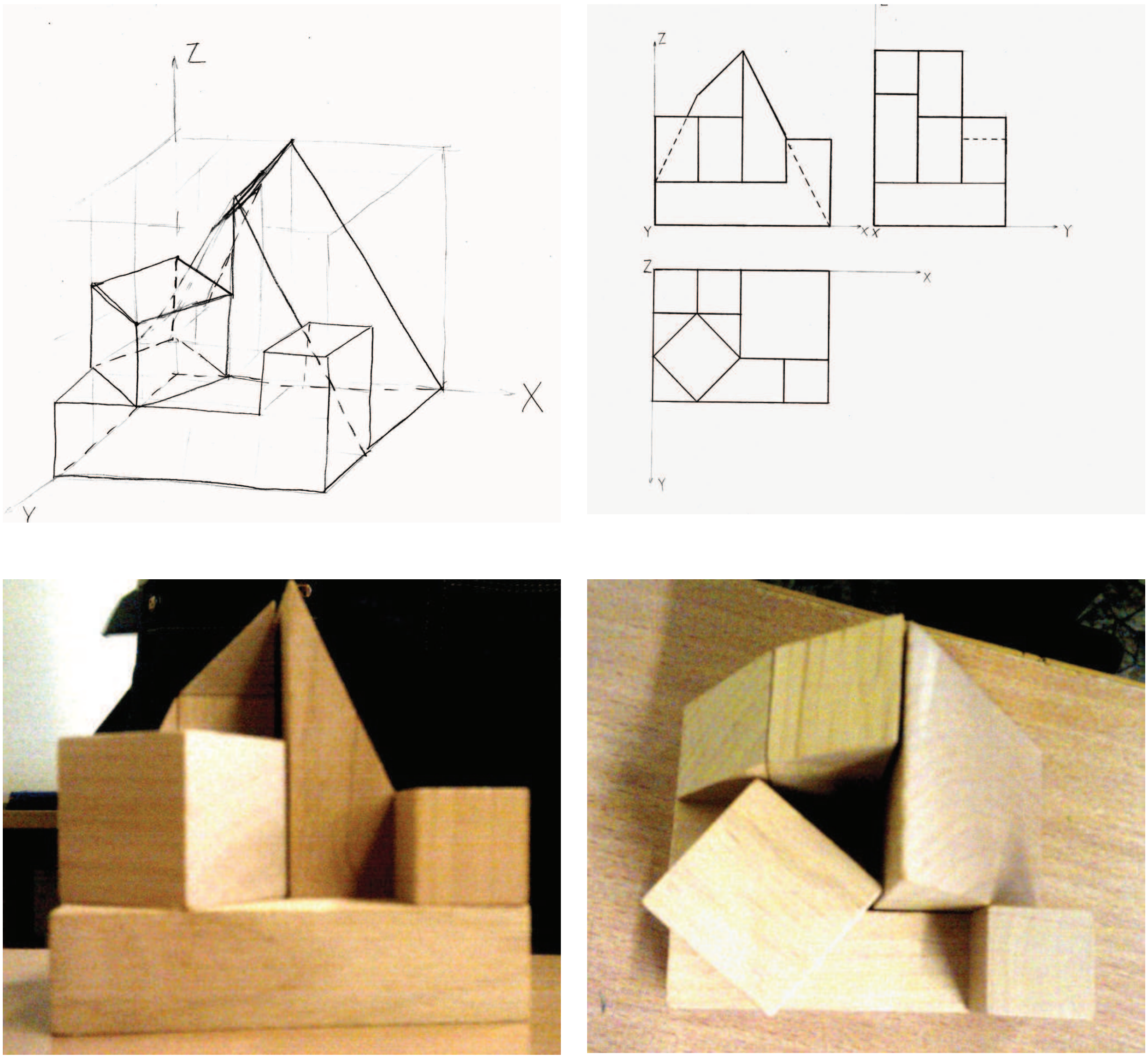

Figure 5: The example of student's class work

In the final test students had to map in orthographic projections spatial object which was drawn in axonometric view. The solution of the final test based on the preceding homework and class work was an indirect cognition of the phenomenon referring to the imagination created on the ground of previous observations of the object – it fulfilled the postulate of indirect vividness. It appears to be purposeful in the mind of the authors a further development of the task with the part to be solved with the use of CAD software – the students in the later part of the task would develop a digital block model of the spatial element designed by themselves, making further observations of graphical mapping in the virtual space.

3 Conclusion

The possibility of physical manipulation of the model both in homework and in the class work fulfilled the postulate of direct vividness in the course of engineering graphics. Such tasks gave students experience, which was needed to solve final test - drawing task prepared in traditional way.

A new concept of classes, especially design exercises, in general have changed the concept of student's work in the class - a method of student's work was more like a workshop than traditional technical drawing classes.

This year's final test results show that the new concept of classes' works - 32 people (80%) of the 41-person group of students passed the final test at the first attempt to test. The last year final test results were a little bit different - 30 people (50%) of the 60-person group of students passed the final test at the first attempt to the test.

An additional advantage of the new concept of design classes had the opportunity to present students the practical application of a central projection in the form of photographic documentation carried out by students.

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PERCEPCJA WIDZENIA - JAK KSZTAŁTOWAĆ WYOBRAŹNIĘ PRZESTRZENNĄ

Przedstawiony w artykule koncept pracy projektowej realizowanej w ramach kursu „Grafiki Inżynierskiej" prowadzonego dla studentów kierunku Ochrona Środowiska na Wydziale Inżynierii Środowiska i Energetyki Politechniki Śląskiej stanowi część badań związanych z analizą roli i znaczenia modelu fizycznego w dydaktyce przedmiotów odwołujących się do wyobraźni przestrzennej, takich jak „Grafika Inżynierska", „Geometria Wykreślna" i „Geometria Inżynierska". Zasadność wprowadzania modelu fizycznego do dydaktyki „Grafiki Inżynierskiej" autorki opierały na jednej z najstarszych zasad nauczania - zasady poglądowości bezpośredniej, sformułowanej w XIX w. przez Pestalozziego. Zadanie projektowe, które jest przedstawiane w artykule jest rozwinięciem idei oparcia dydaktyki „Grafiki Inżynierskiej" w pewnych uzasadnionych przypadkach wynikających np. ze specyfiki kierunku studiów lub szczególnych potrzeb studentów, w głównej mierze na zadaniach projektowych odwołujących do poglądowości bezpośredniej.