Geometry – aims, tasks and methods, in other words does looking mean the same as seeing

(the role of descriptive geometry in education and activities of an engineer)

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Abstract - **We can state it even today that important information about geometrical space which is coded in a form of projections of points and geometrical figures is essential for work of not only an engineer but also a doctor, an artist etc. The problem which can be seen at that moment refers to the aspect of correct reading of 2D picture which codes information about 3D space (not only geometrical information but also this which describes physical features of a pictured object).**

The ability to verify geometrical features done on the basis of object picture forms not only a characteristic of our geometrical intuition but quite often it results from mental analysis of consequent, logical reasoning about geometrical space.

At this moment of our considerations let us ask the following questions:

In what rational way do we prepare people for correct reading of picture information?

Do we mean the same by 'looking' and 'seeing'?

What level of geometrical knowledge do we consider as the base for shaping the profile of a contemporary engineer?

Wouldn't it be worth rereading extracts from G. Monge's lecture, which he gave in Ecole Centrale (Paris, 1794), where he defined aims, tasks and methods of descriptive geometry?

Isn't it time to recollect what descriptive geometry has been and is it for?

Naturally, there are more such questions and they refer to a broader topic which is the answer to the question what education is. In our opinion education is what is left in a man when he forgets what he was taught. If we forget about what role imagination plays in shaping the profile of a contemporary engineer then in a short time we will be turning people into semi-machines prepared for robots' service.

PREFACE

For many contemporary engineers the notion *descriptive geometry* does not mean anything interesting, or even worse, it has no meaning for them because in the teaching process (we think that academic educational process has, unfortunately, been changed to teaching) such a subject has not been taught. However, we are talking about basic issue which refers to the **principles of engineering reasoning, basics of designing and reading engineering picture information.**

2. INTRODUCTION

Some of the main features of the surrounding world are its geometrical features and there can be included:

- shapes of solids which occur there
- location of solid in the space
- the effect of solids' penetration
- light and shadow play
- shapes of plane and slanting figures
- plane and slanting curves
- other features

Basic, technical perception of the world refers to the world of geometrical solids and figures, the world of surfaces and curves. That is the way we have recognized the environment since we were born. It is a child who by its experience of the presence of solids, curves and surfaces gets to know the world. The same kind of environment is for an engineer, who in his professional career conceptualizes various objects and technical processes. Nevertheless, they are first created only in his mind.

The phase of technical realization of an idea involves cooperation of many people and therefore, the information about its innovation must be realized in a comprehensible and understandable way for a broad spectrum of society (production decision makers, direct creators and contractors). Hundreds of years of practice proved that indispensable elements here are: conventional geometrical drawing and mature geometrical terminology.

To sum up, the following stages can be differentiated:

- a creator has an innovative idea
- idea conceptualization
- drawing information
- the process of idea's approval
- technical design of innovation (technical and descriptive documentation)
- design verification
- working technical documentation of a design

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At all these stages geometrical model of a design dominates (or is at least present) **which is presented by means of words or pictures.** Also in geometrical notions a fact is described (way or form) of virtual existence and then of a real object. Therefore, geometrical terminology plays decisive role in creative engineering process of designing and **which subject in engineering teaching deals with this issue?**

Who deals with the development of reasoning of geometrical space?

Geometrical descriptions are very often accompanied by drawings (axonometry, Monge's projections, and less frequently central or marked projection). This **drawing is made on the basis of suitable constructions and agreements** but since 1794 we have had mutually unequivocal way of information record of space (Gaspard Monge, *Geometrie descriptive* (Paris, 1799)). It means not only that:

an engineering object conceptualized in 3D Euclid's space can be orthogonally projected into two or more auxiliary planes

But also that

this projection/drawing can be decoded and information can be obtained about the original (a designed solid) with the same precision as the genuine one

And finally such a question can be asked:

is the reading of essential information from an engineering drawing an intuitional activity or it has to be learned ?

2. XXI CENTURY – THE ERA OF PICTURE COMMUNICATION

It is not without reasons that XXI century has been called picture communication century. We can state it even today that important information about geometrical space which is coded in a form of projections of points and geometrical figures is essential for work of not only an engineer but also a surgeon, a biologist, an artist etc. The problem which can be seen at that moment refers to the aspect of **correct reading of 2D picture which codes information about 3D space**

This information is not only geometrical information but also it describes physical features of a pictured object. However, it must be reminded that almost 40 years ago we forgot about the contents of such subject as *descriptive geometry.*

One of the aims of descriptive geometry is education and developing abilities of reading information about location and geometrical features of an object, determined by its projection/projections (parallel projection, Monge's projection, axonometry, central projection=snap shot picture). Constant rejection of this fact leads to the situation when the ability to read technical picture information carefully is based only on intuition, skills and experience of a person who does the reading. Similarly, as with computer aided designing we rely on test and error method, which gives positive effects but is time consuming and lacks general method of teaching.

As a result many notions of mature geometrical knowledge have been forgotten and for many years new rules have been rediscovered which had been known for more than 200 years. Such notions as for example 3D picture or three dimensional image have been created and are commonly used when they are well known axonometry or perspective. A picture is by its nature two dimensional and it goes without saying.

Finally, let us pay attention to the fact that reading of information about geometrical space is not enough because **in the process of technical or scientific work this information must be verified.** Why? Simply because our way of seeing is with illusion error whose occurrence we usually do not predict. Therefore, in the process of creating our images of space, generated on the basis of flat geometrical pictures we have to have means/tools which would prove the truth of our images. It is geometry which can supply these means because the evaluation of location and topology of an object pave the way of construction optimization.

The ability to verify geometrical features done on the basis of object picture forms not only a characteristic of our geometrical intuition but quite often it results from mental analysis of consequent, logical reasoning about geometrical space. Naturally, life experience of a person who recognizes the space and genetic predispositions have important influence here.

At this moment of our considerations let us ask the following questions:

1. In what rational way do we prepare people for correct reading of picture information?
2. Do we mean the same by 'looking' and 'seeing'?
3. What psychological processes enable decoding of picture/drawing information
4. What is the knowledge of people teaching descriptive geometry or fundamentals of CAD technology and creators of computer aided design software
5. What level of geometrical knowledge do we consider as the base for shaping the profile of a contemporary engineer?
6. Wouldn't it be worth rereading extracts from G. Monge's lecture, which he gave in Ecole Centrale (Paris, 1794), where he defined aims, tasks and methods of descriptive geometry?
7. Isn't it time to recollect what descriptive geometry has been and is it for?

8. Isn't it worth developing space imagination in its geometrical aspect and how to do it systematically and in a system
9. Do scientific revolutions change the paradigms of science or make the achievements of previous generations fall into oblivion?

Naturally, there are more such questions and they refer to a broader topic which is the answer to the question what education is. In our opinion **education is what is left in a man when he forgets what he was taught.** If we forget about what role imagination plays in shaping the profile of a contemporary engineer then in a short time we will be turning people into semi-machines prepared for robots' service. Then, a handful of talented people, scientific elite, will govern the global community, conflicts between social classes will get bigger and bigger and it may result in a disaster of global sedition. This is the threat of neglecting educational needs of a man with his intellectual ambitions. It is becoming more and more visible that people and societies are seen as recipients of excessive number of commodities, which should be condemned and seen as contemporary slavery.

In this situation of a contemporary man it seems that his only defence is to invest in good education which facilitates development of his imagination and thus increases his value on the market

Therefore, teaching process (at all levels) must ensure good education with its elements consciousness and geometrical knowledge.

CONSTRUCTIVE PROPOSAL OF TEACHING MODERNIZATION

Our experience tells that for over 30 years CAD technology has been developing and that the process of drawing engineering designs has been significantly automated. However, **the processes which take place in engineer's imagination have not been automated, neither the methods of design conceptualization** and therefore it is still done in an engineer's mind (also engineering inventory is proceeded by mental process). It can be easily noticed that only few engineers are creators of new technical solutions, majority of them in fact manage production. Nevertheless, both of them **have to master the basic and universal language of technology i.e. standard geometrical drawing,** which is required by social communication. Hence, let us present the following statement on developing predispositions to engineering designing and abilities to use engineering drawing:

1) computer workstation (computer, operation system and CAD program) with suitable input/output tools constitutes **basic tool** for introducing modern technology of engineering designing;
2) basic stage covers **geometrical modelling**:
   - consolidation of basic terms and notions, on the basis of geometrical situations presented by a picture or snap shot
   - introduction of Cartesian space in accordance with a kind of space implemented in CAD system (laevo–rotary or dextrorotary space)
   - basic rules of creation of hand made sketches
   - creating surfaces based on designing plane figures, surface topology is determined by a hand made sketch
   - ways of transforming a frame of reference (local frame of reference)
   - creation of solid model of an object by axonometric sketch
   - issues of solid modelling in measured aspect, determining solid location in space and its size
   - issues concerning designing and angles measurements, length and distance
   - creation of complex virtual engineering models based on prime solids and such transformations: planar intersections, logical (sum, product, result), copying of space elements etc.
   - geometrical classes of engineering problems (both global and local) and mathematical subjects which describe them (descriptive geometry, analytical geometry, differential geometry and others)
3) stages of professional improvement cover the following
   - creation of working drawings of details, assumption or an object
   - creation of libraries aiding designing process
   - documentation management
4) improvement of designing skills (postgraduate studies, specialist and improvement courses)

FINAL REMARK

Finally let us recollect the words of Gaspard Monge, a prominent French mathematician and engineer and thus one of the fathers of polytechnic education (one of the founders of *Ecole normale* and *Ecole polytechnique, Paris* 1794), who determined aims of *descriptive geometry:*

This science has two main aims. Firstly – to present on a drawing, which has only two dimensions, 3D objects which can be exactly given. From this point of view it is necessary for an engineer who creates any design as well as for everybody who should supervise its realization and finally ministers who should carry their tasks themselves.

The second aim of descriptive geometry is to take from a detailed description of bodies everything that inevitably results from their form and mutual location. In this sense it is a measure for searching for the truth. Monge gives numerous examples to pass from the known to the unknown, and since geometry has to do with subjects which can be understood best it is necessary to introduce it to the curriculum of national education. It is useful not only for developing intellectual abilities of a nation and in this way it favours development of human nature but also it is indispensable for workers whose task is to give certain shapes to bodies.

At the same time Professor G. Monge remembers about the fact that :'Delight which accompanies science can win

repugnance to intellectual effort, which is so characteristic of a mankind and make them find satisfaction in exercising their mind – which for majority of people seems boring and sad task.'

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