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Functions of Graphics as a Methodological Basis of Graphics Science

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Abstract. It is considered the methodological problem of the development of the scientific specialty 05.01.01 – Applied geometry and engineering graphics, namely, a search for the scientific content of the "graphics" components. This suggested to consider the concept of functionality or features of graphics. Thus, the key notion of content, and therefore the term definition graphical components of the scientific specialty 05.01.01 proposed the concept of "graphic technology". According to the author, such renaming significantly strengthens and enhances the prospects of scientific research in the field of graphics. From another point of view, such actions in the future could increase the viability of graphics in the system of higher education.

Key Words: functions of graphics, graphics technology, applied geometry

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1. Introduction

The prospects of any science, thus the viability of an appropriate pedagogical (educational) component is determined by the quality and integrity of this science methodology.

The current problem of the graphics existence *as a modern educational discipline* is largely determined by the problem of the existence of modern graphics *as a scientific direction* and the actual content, relevance of its methodology. In Ukraine, the Geometric and Graphic Sciences, at the administrative-scientific level, are legally formed as a synthesized *scientific specialty* (05.01.01 – Applied Geometry and Engineering Graphics). In fact, this is a science combining methods and tools (Applied Geometry) and image technologies (Engineering Graphics). It should be noted that the methodological platform of Applied Geometry has been more or less clearly formed over the past 15 years [6]. At the same time Engineering Graphics remained an outdated pedagogical scheme, which in fact does not contain promising knowledge-intensive areas of research.

The article is an attempt to search and systematize the scientific content that can be put into the concept of "graphics". To do this, we need to use the system approach, build the

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appropriate typology, and on this basis, to propose methods for constructing the methodological principles of graphics as a science. From our point of view, the defining element of this process is the use of the concept of "Graphic Technologies".

An important legal step is made. The Ministry of Science and Education of Ukraine proposed to formally transform the specialty 05.01.01 and define it as "Applied Geometry and Graphic Technologies". So, the problem of formally updating the definition of the specialty 05.01.01 is in fact not formal. In the conditions of the transformation of the system of scientific personnel attestation in Ukraine and the general shift of emphasis in the development of graphics to instrumental-computer approaches and the actual elimination of other areas, there is a problem of system definition of graphics as *a modern science*.

2. Principles of solving

The state of experience in the development of scientific research and specialists training in the direction of "Graphic Sciences" suggests that a new paradigm is required for a strategic existence and, in general, for the survival of graphics *as a science*, as well as an updated organizational and scientific platform.

The format of this paradigm is the emphasis on the technological capabilities of all areas of the graphics.

The basis of its construction and implementation is a systematic, organic use of existing operating tools, maximum use of creative graphing functions, grounded binding to the instrumental basis of graphical modeling which Applied Geometry is.

Technically, the transformation of "Applied Geometry, Engineering Graphics" to "Applied Geometry and Graphic Technologies" requires the following steps:

a) a detailed analysis of the concept of "graphics" and its contents as an object of research, first of all, with the identification of its knowledge-intensive components;

b) a clear system definition of the functionality (functions) of the graphs and schemes of the possible combination of these functions;

c) through functions — substantiation of the paradigm of "graphic technologies" and determination of the priority vectors of development of this direction as an organic component and technological platform of the specialty 05.01.01.

3. Background of the problem

The specialty 05.01.01 is synthetic both on the basis of the tool and in the sphere of applications. (The term "synthetic" is used here in the meaning of synthesizing some scientific direction using elements of the various sciences.)

It is the symbiosis of tools (applied geometry) and technologies (engineering graphics) that forms the structure of this specialty and the research directions determined by engineering graphics.

The methodological basis of the descriptive (later *applied*) geometry was largely formed as a result of the assimilation of a new at that time engineering branch of the theoretical foundations of synthetic geometry. Subsequently, the transformation of descriptive geometry (which avant-garde scientific potential was practically exhausted) into applied geometry was due to the permanent renewal of the tool arsenal, new interpretation schemes and the emergence of new technology platforms. In addition, over the past half-century, applied geometry

has substantially expanded the scope of its tools, actively involved and "geometrized" external instrumental means. At the same time, engineering graphics in the scientific sense remained in a limited implementation sector.

Consequently, in 05.01.01 we have a symbiotic *two-element* specialty, the interaction of components which should lead to a significant synergistic effect. In fact, the latter is actually absent because of the inequalities of the current state of development of the composition of the given scientific system and the methodological uncertainty of the concept of "graphics" as a science (with subsequent definition of derivative concepts, the structuring of content, the formulation of current and future problems, etc.).

Goal.

Thus, the essence of the problem we outlined is the definition of the concept, structure and subject-scientific content of the research of the "Graphic Technologies" direction as an organic component of the scientific specialty 05.01.01.

4. Definitions and typology

Graphics is an extremely wide range of concepts, in connection with which there are various attempts to organize and classifications.

Firstly, it is obvious that in any kind of graphics there are own or involved and adapted technologies — *technologies of graphics*, for which graphics is **the object** of the study.

Definition 1. *Engineering graphics* is a set of means, methods and forms of graphical representation of information on engineering objects (in engineering, technology, construction, architecture, etc.). Obviously, the technologies of using the instrumental capabilities of geometric modeling have long gone beyond the category of "engineering graphics".

Definition 2. *Graphics* is a complex area that includes a formalized and / or creative process of obtaining images of a certain dimension and function, as well as a plurality of results from this process (visual image, semantic sign, schema, etc.).

Definition 3. The subject of *graphic technology* is any organized, structured and algorithmic description and / or research of a certain formalized object with *graphical instrumental tools*.

From the typological point of view the definition of the concept of "graphics" contains several categories for classification. Let us consider the well-known approaches and complement the relevant lists with new positions from our point of view.

From *the structural-functional* point of view is considered:

- graphics as a technological means of transmitting information (images);
- graphics as a technological sequence of image acquisition (process, set of processes, technology);
- graphics as the basis of schematization, the basis for the formation of rules and norms (scheme, structure);
- graphics as a form of artistic creation (graphic arts);
- graphics as a science (methodological, instrumental and technological basis of systemic and scientific application of graphic means).

From *a technological* point of view are known:

- technology of artistic graphics;
- technologies of traditional technical (engineering) graphics;
- computer graphics technology;
- technologies of graphic synthesis (graphics as synthesizing platform, providing a qualitatively new result in a particular subject area).

There are also *special* and *universal* technologies of graphics (invariant to the typological variety of graphics and its purpose). The classification of *subject areas of graphics* is also known. In accordance with it there are:

- artistic graphics, architectural graphics, semantic-symbolic graphics, engineering graphics (which can be defined as *branch graphics*);
- computer graphics (invariant technologies, created on a graphical basis);
- graphic calculations or computational graphics (synonym of graphic or graph-analytical modeling);
- scientific-illustrative graphics.

5. Functions of graphics

Analyzing the above classification of graphics and technologies of graphics, we note some of its fragmentation. At the same time, it can be used to develop a methodological platform for graphic technology. In our opinion, the basic element for its creation is the notion of *functionality* or *functions* of graphics. Note that the following features are localized conventionally; in reality, there are many examples of their mixing, simultaneous, sequential or parallel application.

First of all, we select three hierarchically constructed groups of graph functions (in order of complication):
a) figurative functions, b) active functions and c) creative functions.

- Figurative functions (where graphics are a service or determinant of *a static* element of a particular system, or even its ultimate goal):
  – informative;
  – artistic-figurative;
  – illustrative;
  – symbolical.
- Active functions (graphics are an active service tool for the implementation of certain conversion or interaction processes):
  – communicative;
  – formalizing;
  – interpretive;
  – cognitive.
- Creative functions (graphics are a conceptual element of the system):
  – modeling;
  – technological;
  – synthesis.

Consider the list below in detail, focusing on the content of each function and its knowledge-based scientific resource.

The **informative** function of graphics is to use it as the most psychologically comfortable and visual way of presenting information. Despite the diversity of forms, the general key issues are: the study of information presentation capacity, graphical representations optimization (taking into account the professional preferences, norms, traditions, special needs, the environment of use, etc.).

The **artistic-figurative** function of graphics is determined by all the known classical and newest technologically determined directions and forms of graphic arts. Through the development of IT tools and geometric computer modeling, synthetic forms such as fractal painting or visual performances, for example, are obtained.

The **illustrative** graphic function is the implementation of a graphical accompaniment of a certain information stream presented in any other non-graphic form. Here the concept of "graphic illustration" should be considered as widely as possible: both by the structure of the illustration, the forms and methods of its binding to the basic information, and by the types of information flow, which is illustrated. Special attention is given to the **scientific and illustrative** function which should *optimally* accompany the scientific information usually presented in the semantic-symbolic form, in the form of definitions, algorithms etc. There are cases where such illustrations acquire artistic figurative [3, 4].

The **symbolic** graphic function displays the spectrum of its possibilities in semiotics. From a linguistic point of view, graphics are the basis of education and the form of representation of characters, letters, graphs, symbols of any language. The expressiveness and conciseness of graphic ways of symbolized objects and concepts representing is important in developing the design of icons, advertising tools, guides, etc.. The synthesis of artistic and figurative and symbolic graphic functions is implemented in the art of calligraphy and the development of author's artistic fonts forms (e.g., [2]).

The **communicative** function of graphics is to use it as an information translator. The practical implementation of the function is quite varied: as an artistic-figurative form of reproduction of the sequence of events (comics), as a means of compact information transfer of a certain destination (actualization of the symbolic function of the graph), as an image form of translation from one language to another (the concept of language will be understood in "expanded" sense).

The **formalizing** graphic function is a subset of *graphic modeling* tasks in the development of methods for the hardening of real object images. Traditionally, the function is implemented in the technology of sketching. The research purpose of the function is to develop methods, ways and forms of graphical formalization, particularly in the synthetic use of conventional and computer-technological means [1]. It is also of interest to determine the critical degrees of roughness with the control of image recognition and the completeness of the transmission of information.

The **interpretative** function of graphics is the implementation of graphical variability. Graphics and graphical interpretations differ in a wide variety of multivariate as a powerful tool for the most visual representation of information. Searching for the most acceptable and comfortable forms of graphical interpretation is an important problem, taking into account functional, professional, age and psycho-physiological features. The role of graphic representations in the interpretive schematics of geometric modeling is also a poorly understood problem [7].

The **cognitive** graphic function is a key element of providing or supporting the cognitive, in particular, the educational process. The efficiency of these processes is a direct function of the effectiveness of their graphical components. In turn, the effectiveness of using graphic tools is determined by their relevance and accuracy in relation to solved problems. For example the development of spatial imagery and geometric memory through graphic tests and games, active forms of graphics in modern information technology techniques for learning foreign languages, graphical support for the functioning of simulation systems, etc.

The **modeling** graphic function is implemented as a component of geometric modeling which is a subsystem of graphical and graph-analytical modeling. It is known that constructivity and visibility are the "methodological differences" of Applied Geometry, where visibility is directly provided by graphic means. Thus, the graphic must become an element of the instrumental application of geometry, forming a self-contained set of instrumental means, methods of graphic modeling. The development of graphically-oriented decision-making systems also deserves attention in addition to the further development of constructive-synthetic graphic methods, nomogram-coordinate models [8]), multidimensional graphic models, etc.

The **technological** function of graphics is the ability to form technological platforms (design, calculation, research) on a graphical basis. Obviously, any other graphic functions can be implemented separately or in a complex. It is also important that the graphics are the defining form of description and presentation of processes, algorithms, techniques, technological schemes. Some well-known examples of the creation of branch technology platforms, as well as invariant graphic technological schemes (network design on the graphs, Sankey charts, etc.) are known. Research in the field of optimization of graphical interfaces and other components of communication systems is also worthy of attention.

The **synthesis** function of graphics is one of the most important functional forms that implements intersector, in particular, inter-scientific interaction. The synthesizing function has at least three forms of implementation. First: the graphics acts as a reinforcing instrumental platform for a certain field of knowledge (*one-sided synthesis*). Despite the fact that any modern scientific industry explicitly or implicitly uses graphic forms and tools, it is important to understand that system graphics platforms are used quite infrequently. One-sided synthesis makes it possible to form new, graphically interpreted areas of research by involving graphic functions and forms that are not specific to it. The second form of synthesis — *multisided synthesis* — it is integration of two or more independent directions by means of graphics, including by creating unifying graphical technological platforms. (Some associations are well-known: mathematics + art, geometry + information technology, etc.). Obviously, a systematic methodological research is needed to find promising areas for graphical synthesis. The third form of implementation is *the internal synthesis of graphic functions*, the complex implementation of its operational potential through the appropriate combination of functions "for the task". Such synthesis will allow to systematize and optimize the schemes of using graphic means.

By combining this analysis of graph functions, we formulate several integral directions of research in the direction of "Graphic Technologies".

1. Investigation of the problem of universality (invariance) of graphic means and technologies, in particular, on new perspective directions and tasks.

2. Research of synthesis of graphic technological possibilities (methodology of combining traditional and newest graphic means in designing, art, interface technologies, etc.).

3. System study of possibilities, prospects and consequences of integrated application of graphics of different dimensions in various graphic technological systems.
4. Research of graphic possibilities of development of interface technologies (optimization of visual representations, training systems etc.).
5. Creation and development of the graphic technology structures optimization for various application areas as a special focus of research.
6. System development of graphic means and technologies of cognitive direction.

6. Conclusion

The development of the methodological paradigm of applied geometry requires its balancing with appropriate studies of graphic technology. The above-described functional approach to constructing the methodology of modern graphics is the first step towards the creation of theoretical foundations of graphic technologies, which, in our opinion, stimulates the systemic and synergetic development of the specialty 05.01.01.

The main source of scientific creativity in the development of graphic technologies is, in our opinion, "the glass bead game" — the free use and combination of the entire arsenal of creative tools generated by the multifaceted graphic functions [5].

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