A modified design-analog method of teaching geometry and graphics as a means of integrating of training and design activities of future architects

Liudmila Danchenko1[0000-0001-6541-8406] Nail Tuktamyshov1 [0000-0002-4679-0701]

1Kazan State University of Architecture and Engineering, Kazan, 420043, Russia
E-mail: d9700@yandex.ru

Abstract. The strategy of teaching orthogonal and other projections, as well as the basics of geometry formation of the future architect is based on the practical orientation of the teaching process and is based on a modified design-analog method. Possibilities of the building industry show an urgency of research and realization of methods of shaping geometry in a course of descriptive geometry. The purpose of the study is to develop technology for the formation of design skills of shaping, based on the proposed modified design and analogue method. The object of research is geometrical and graphic training of students pursuing the degree in Architecture or Design of architectural environment. The subject of study is the technology of training of shaping in the course of descriptive geometry and based on a modified design-analog method. The characteristic feature of this method is its connection with the architectural practice of both educational and professional. The methodological basis for its application is the method of creating of the architectural form of an object. The workshop has been tested and allowed to consider a set of actions and operations, their sequence.

Keywords: project method, geometry and graphics, shaping, learning technology, design and analog components.

1 Introduction
The main educational objective of architectural program is to produce graduates who have the ability to create construction projects and combine basic elements of theoretical knowledge and practical skills, which is essential for successful practical work training, self-determination and social adaptation in the professional community. Architecture is a unique art based on the symbiosis of harmony, artistic perception, geometry of formation and exact sciences. This symbiosis implements the relationship between the utilitarian construction industry and the aesthetic vision of the human subject and space environment.

Being a part of a professional community and practicing this profession is predicated upon the specific aspects of this activity, understanding of the profession, way of thinking, motivation, as well as the process of acquiring the necessary knowledge for mastering the "architect's method". As a method of creating a project of an architectural object, the "architect's method" therefore distinguishes the author's ability to determine the overall meaning of its concept, construction, playback capabilities and rules of visualization, which requires skills in image construction, artistic skills, developed visual perception, spatial and project thinking, creative imagination. Many schools of architecture are characterized by the use of classical sources of architectural knowledge, such as the order system, as the basis for the theoretical foundations of design of forms [1-6]. The process of teaching modern creativity is based on historical analysis of the construction of images, drawing, graphic reproduction of an object, and the technique of creating; a specific form allows the use of knowledge of its geometry in modern design [7, 8, 9].

Professional practice of the architect or design activity is aimed at organizing and transforming the human environment, taking into account the requirements of the urban planning situation, regulatory documents and the desire of the customer, and aesthetics of architect’s own vision of the future.
construction. Practicing this profession is aimed to create an architectural design of the structure, coordinate all design stages and sections of documentation for the construction, and is related to the creative process of viewing the geometry of its form and display it in the form of projection drawings [8].

At present, the role of digital technologies in the field of architectural forms imaging is great. This fact is also applicable for teaching graphics on the example of real and illusory architecture, their combination. [9]. Acquaintance with BIM - technologies is of great importance for development of professional skills of future architects [10-12].

Professionalism of an architect is characterized first of all by comprehension of problem-solving methods in design, theoretical knowledge base, developed spatial and design thinking, and also ability to integrate them according to the design task. Thus, professional architectural design activity requires a strong geometrical and graphic training, manifested through the ability to analyze the form, its size, location in space, the determination of the ratio of individual elements, knowledge of the geometric foundations of formation [13, 14, 15]. Such geometrical and graphical training is included in the basic part of architectural education in the subject field of the discipline "Descriptive Geometry" in accordance with its content in the context of architectural practice, that is, the acquisition of necessary specialized knowledge in the field of geometry and graphics during training. Spreading architectural traditions, learning from the master is possible through university workshops: traditional construction, parametric design, and digital construction. [8, 16-18] Organization of geometrical and graphic training in architectural education as a holistic learning activity in the context of the future profession should take into account the changes occurring in its character, be related to the development of spatial, and design thinking of the architect.

2 Methods
The methodological basis of the conducted research is the activity (L.S. Vygotsky, P.Y. Leontief) and archeological (S.A. Druzhilov) approaches, as well as the context and competence approaches, project-based learning methods (J. Dewey).

The methodological basis of the developed modified design-analog method of teaching geometrical disciplines is the "architect's method", i.e. the method of creating three-dimensional structures and determining the method of fixing the obtained result. It is the "architect's method" that combines the traditions of craftsmanship associated with learning from the master, including the academic model of the educational process.

Theoretical basis of the research is modern conceptual provisions on formation of architect's professionalism (A.G. Rappoport, E. Ass), pedagogical research, theory of architectural education (G. Sharun et al.) and concepts of teaching geometry and graphics of the future architect (N.A. Sobolev, H. Steichel). To solve the research task on integration of educational and professional activities through the application of a modified design-analog method of teaching descriptive geometry (geometry of formation) were used:

- Theoretical methods of research (analysis of scientific domestic and international literature on problems of professionally directed education, periodical and documentary materials, generalization, modeling);
- Empirical research methods (observation of the educational process, testing, analysis of design activities, study of architectural practice results).

The use of professional context, namely, the saturation of the educational process with elements of professional activity, which is considered in the works of A.A. Verbitsky as a contextual approach in the educational process at the university, provides the dynamics of transition of the student from academic to project professional activity.

The purpose of the carried out research is technological maintenance of application of a modified design-analog method of training of descriptive geometry, namely its part connected by consideration of the theory of formation and display of object, that is design skills [17, 18].
During research, the problem of working out and approbation of the technology providing success of development of form formation in a context of design activity by means of introduction in educational process of a modified design-analog method and use of its possibilities was solved [19].

At present, the International Union of Architects (IUA) has defined professional standards of architectural practice, which include provisions on the possession of a systematized sum of theoretical and practical knowledge to display the subject and spatial environment accumulated in the learning process and gained practical experience in mastering design methods (sketching, volumetric-planning design), graphic methods and project graphics.

Managers and leading specialists of architectural workshops and design bureaus put forward the requirements for a Bachelor of Architecture, primarily in terms of performing literacy combined with fundamental knowledge:
- knowledge of the geometrical foundations of architectural formation, the concept of the framework, the outline of surfaces, ways of their formation, which are studied when considering the relevant sections of descriptive geometry;
- Ability to make drawings both manually and using graphic computer products;
- Knowledge of techniques of construction of visual images and giving visibility to orthogonal projections of the object, construction of perspective - an important component of the concept visualization [17, 20, 21].

Performance literacy shows the formed level of possession of skills and the skills necessary for performance of the professional actions connected with performance of the technical documentation, including with use of the computer [21, 22].

Complex actions and operations in architectural design require multi-component preparation in the field of geometry and graphics, taking into account the presence of certain abilities and developed spatial and design thinking. For realization of such training, it is necessary to consider features of a design component of professional activity, which is defining. In this regard, the training process should be based on project training methods and "architect's method", as well as on technical methods of visualization. Mentoring the 'architect method' as a method of designing an architectural object is a training activity, one component of which is geometrical training in surface formation and its depiction.

The purpose of training the future architect ready for professional practice can be considered as providing a theoretical basis for the creation of some geometric image in the framework of spatial and design thinking and development of graphic skills of visualization, which is the starting point of architectural design [17, 21].

According to A.A. Verbitsky, the context of professional activity is defined as a system of external and internal conditions of human activity, which affects person’s perception of a particular situation, understanding and transforming its components and in general. The external conditions include the sociocultural sphere of activity the internal conditions include the need for new knowledge that affects the success of practical activity and understanding of its specifics.

In the process of creation of an architectural structure project the information is presented graphically using orthogonal projections and visual images. Being in a learning situation close to the design activity, the student gets the opportunity to apply theoretical knowledge and learning information to solve the problem, as well as to select an appropriate educational program and change the professional direction when needed.

Training philosophy in the discipline "Descriptive Geometry", including the section of surface forming can be defined using the algorithm of project activities and its individual aspects.

The developed modified design-analog method of geometrical-graphic training of architects is a modification of design methods of training and an analogue method of studying of separate disciplines, shows technology of reception of result, through performance of actions peculiar to the declared design activity. In this connection, the modified design-analog method of training is a method of the organization and management of educational process in a context of professional activity in which unity of substantive and procedural aspects is analogue of design practice. That is the acquired
set of theoretical knowledge and practical skills in the field of form formation at a course of descriptive geometry during training represents the result received in the course as analogy of design activity that is peculiar to studying of methods of designing of volume planning decisions. The analogy in this case refers to the similarity of processes of creation and imaging the object in certain properties. Operations directed on formation of performing literacy of the future architect, use of theoretical base and technology of graphic fixation of result correspond to design actions.

The characteristic of training activities in the field of geometry and graphics as an analogy of project activities is as follows:
- Correspondence of professionally oriented tasks in the discipline to the tasks encountered in the design activity of an architect;
- Understanding the context and connection with practical work training which determines the transition of learning information into professional competence;
- Discovering the elements of real design in the training task and the learning process;
- Connectivity and similarity of the problem-solving methods, the unity of visualization requirements;
- Presentation correspondence and result discussion.

Tasks performed by the student make assertions about his personal achievements, enable objective evaluation of the work process, and allow for the results in the intermediate certification.

The evaluation criteria are as follows:
- Graphic performance, accuracy of constructions, presence of projection connection, etc.;
- use of theoretical knowledge, reading of initial data, knowledge of methods of formation of surfaces, their classification, rules of incident.

The students' reflexion is manifested through the process of implementation of the project analogue: the algorithm of implementation, comprehension of the significance of knowledge of the theory of formation, understanding of the stages of the task, subjective satisfaction with the result.

The complex of notions, definitions, actions and operations typical for architectural practice reveals the integration process of the modified design-analog method of training in analogy with the real architectural design, which corresponds to modern architecture and trends of architectural education. The algorithm of the performed actions is positioned as the profile activity on creation of the surface according to the given conditions and its graphic presentation as an object of architecture, which demonstrates the immersion in the professional-like manner [23, 24]

Design and analogue components of the modified design and analogue method of training in comparison with the training and professional activity of the architect, related to the creation and visualization of the architectural concept are presented in Table 1. In this case, the project - analogue is a set of techniques, project actions, carried out by students in a sequence similar and inherent to professional design, as well as operations aimed at solving the problem. The students were given the task to build surface projections according to the given geometrical conditions and to analyze their application in real designing. The result of work should be presented in the form of drawings of two created surfaces and the abstract.

**Table 1. Project and analogue components of training activities and project practice.**

| Project Components | Learning process | Analogue components | Project practice |
|--------------------|------------------|---------------------|-----------------|
| Installation: design task | Geometric conditions for creating a surface (object): $\sum(i, L); \beta(n, m, \pi)$. | Formulation of the idea of the architectural order: technological scheme, number of storeys, proposed layout | |
| Consultation | Determining the image sequence according to the result classification | Work planning and definition of related links | |
| Process implementation | Drawing up a draft | Sketch | |
Analysis and discussion of interim results
Verification, identification of errors and inaccuracies, approval
Submission and approval of the sketch, assignment for further work

Synthesis
Performance of the final projection drawing, examples of applications in architecture and design
Creation of a project proposal, its variants and their comparison

Evaluation and reflexion
Presentation and Study Defense
Presentation and discussion of the project proposal

Thus, the solution of a training project task as an analogy of professional project activity involves the development of professionally directed tasks that imply understanding the context of project practice, task connectivity, and visualization requirements. Organising the task completed through imitation of professional activity into levels or stages can be regarded as essential for a modified design-analog method usage.

The task on the theme "Formation of surfaces" is a project-analogical application of knowledge of form formation at creation of the particular form, the sketch in real architectural activity. The algorithm of design actions is the construction of images of the received surface by rules of forming and graphic presentation in which case students are immersed in the work-related learning environment under "Descriptive geometry" curriculum.

An essential feature of the application of the modified design and analogue method is the study of domestic and foreign architectural experience and the presence of interdisciplinary links with the basic courses of architectural design, which involves the formulation of the task, the construction of projections of the educational architectural form using theoretical knowledge and practical techniques of descriptive geometry. Historically, descriptive geometry, as a science of methods of constructing images, is associated with elements of space: points, lines, planes, the combination of which represent various three-dimensional structures and forms.

The descriptive geometry considers and solves not only problems of construction of images, but also problems of formation that connects discipline with practice of the architect:
- Space model creation, location and display of the spatial form;
- Classification of spatial forms by method of formation, geometrical characteristics of forming, etc.;
- Research and study of the laws of form model reproduction and its elements, position in the spatial structure under given conditions or mental image;
- Study of the basic concepts, definitions and theorems related to form formation (frame, essay, forming, guiding, accessory);
- studying methods of graphical solution of various geometrical problems (metric problems, distance determination, etc.);
- studying the interposition of spatial forms (positional tasks).

The tasks mentioned above constitute the subject of "Descriptive Geometry" course in architectural program, mastering this subject contributes to the improvement of performance qualities and creative intuition of the future architect and architectural practitioner.

The practical form of implementation of the modified design and analogue method is given in Table 2.

### Table 2. Practical form of implementation of the modified design and analogue method.

| Work completion stages | Scope of work | Activities of students | Activities of Teacher |
|------------------------|---------------|------------------------|-----------------------|
| Installation:          | Reading original data and geometrical conditions of the form creation \( \Sigma(i, L); \beta(n,m,\pi) \), | Identifying the algorithm and form creation and imaging method | Demonstration of the significance of the task fulfillment for the project activity |
| Purpose setting - practical significance of theoretical knowledge of form formation, | | | |

...
| methods of transformation, movement, rotation, basic concepts. | Identifying and classifying the surface, as well as the methods of its creation. | A counselor: Sequence of task execution, solution of adjacent tasks, composite solution | Graphical implementation techniques selection | Monitoring, consultation, adjustment, identification of difficulties and assistance in remedying them |
|---|---|---|---|---|
| Thematic analysis of the task, determination of the information source, the sequence of its execution, Theoretical positions of the formation. Rotation, movement. | Realizing: Search and use of the information on a way of formation that is distinctive feature of design activity which result is the drawing of the created form | Surface construction in orthogonal projections | Individual performance of the task | Counseling when required, adjusting and coordinating the research |
| Intermediate analytical: Correcting errors, teacher’s approval, performing the task and drafting the report (theoretical part) | Decision analysis and proof of results. Writing the essay on the formation and application of surfaces in architecture. | Explanation of methods and techniques, correction of detected errors | Recommendations for the final image |
| Generalizing: Drawing and essay writing | Performance of ready drawings according to requirements to an architectural drawing | Commenting the solution, paper defense and answering the questions raised | The role of the customer of the project - viewing, coordination, reception |
| Reflexion, performance evaluation: students' understanding of the significance of the task content for the future profession, objective evaluation of the result and progress, subjective satisfaction with the result and process personally by each student. | Analysis of the finished work, joint discussion and protection of the abstract. | Presentation, participation in discussion, evaluation and self-assessment | Evaluation of student efforts, quality of graphics, additional information, explanation of decision-making. |

### 3 Results and Discussion

Efficiency of application of the modified design-analog method when mastering the form making was experimentally estimated using result analysis of realization, intermediate-analytical, generalizing stages on quantity of the mistakes, correctness and integrity of the created surface, the ability to define applicability of surfaces in real architectural practice (examples of application of surfaces or their fragments) was also taken into consideration.

The experiment was attended by: 74 persons - experimental group, 82 persons - control group. Analysis of the results showed that both groups coped with the obtained task, but 52% of the students of the experimental group chose surfaces with more complex geometrical conditions and location in space. In addition, they showed interest in the surface itself, its frame and application possibilities, which was reflected in the essay. 54% of the students of the control group fully coped with the task within the proposed options, which is also compatible with the design-analog method, as all tasks are
practice-oriented. Other students of both experimental and control groups completed the task, essay, but it was necessary to consult the teacher on giving examples from the existing architecture and there were claims to the graphics.

In the course of the discussion, the pedagogical conditions for using the modified project-based analogue method as a means of integrating educational and practical activities were determined:

– Professionalization of learning geometry of form formation, perception of form and its fixation, including based on continuity of learning;
– Personal-oriented approach to the formation of relevant competencies among students-architects;
– A steady orientation towards mastering the competences related to form formation.

4 Conclusion

In the course of experimental work it was proved that the process of mastering the geometry of formation of the future architect by means of the proposed modified design and analogue method, based on the "architect's method", contributes to the effective and sustainable formation of competencies of formation, understanding of the future profession and self-determination in it.

The use of this method in the process of preparing an architect as a means of integration with architectural practice has shown:

1. The importance of studying the geometry of form formation in professional activity.
2. The importance of integrating theoretical knowledge and practical skills, professional skills.
3. The components of professional training in the field of formation are interconnected, not isolated.
4. The direction of further development of the future architect's creating forms is related to the ability to combine utilitarianism with artistic and aesthetic side.
5. Acquisition by students-architects of search and research skills and critical thinking.
6. Self-determination in the profession, the need for self-expression through creating forms.
7. Realization of personality-centric training in geometry of formation.

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