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RESEARCH ARTICLE OPEN ACCESS

Application of The Case-Study Method in Higher Education in Teaching Engineering Graphics Subjects, Solutions in Scientific Research, And Measures for Improvement Based on Innovative Technologies

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ABSTRACT

The article analyzes the application of the case method in education to engineering, technical and exact sciences, the results of scientific-pedagogical research on the topic, and foreign and local experience in teaching engineering graphics subjects. In particular, the practice of creating cases of engineering-technical content in educational institutions training personnel in technical areas, and the specific aspects of their introduction into education, have been studied. As a final conclusion, ways of improvement based on the integration of innovative technologies are shown.

Keywords: Engineering graphics, artificial intelligence, independent learning, case-based education, spatial imagination, CAD education, adaptive learning.

INTRODUCTION

The method of teaching practical situations (life situations), case-study, became active in the teaching of natural-scientific and technical subjects by the 2000s. In world education, as well as in Russia and the CIS territories, its application is observed in teaching special subjects in the fields of technology, tourism studies, medicine, etc. A.M. Derkach [1] and Zhulkova [2] studied it in teaching chemistry, N.V. Zubova [3] studied complex cases in physics, and G.M. Gadzhikurbanova [4] and O.S. Markovich [5] studied the case-study method in exact and natural sciences in informatics through subject-oriented cases.

We encountered the application of the case-study method to teaching graphic subjects in the works of N.D. Belousova, devoted to educational cases on the topics “Complex section,” “Non-detachable joints,” and “Gear meshes and joints” [6-7]. V.A. Cherepennikova developed “Rule for drawing оформление” [8], L.M. Vasilyeva and I.N. Ponikarova developed “Threaded joints” [9], N.S. Bushmakina developed “Complex situational tasks” (construction direction) [10, 11], E.V. Drydina and A.A. Gavrilov developed “A set of educational-methodical materials for architecture students” [12], O.F. Piralova and F.F. Vedyakin developed “Research cases” [13], L.N. Sagach developed “Sketch and working drawing of assembly unit parts” [14], S.M. Chernikova developed “Practical cases on the subject” [15], S.G. Matyukhina developed “Familiarization with ALT windows” [16], and M.V. Bychkov developed case assignments in the teaching of “Agroengineering” [17].

According to the principle of the theoretical-praxeological approach, the author proposed the composition of the case (mini-case, briefing) [1, 2].

By case, the authors understand a complex pedagogical

instrument that combines simple phenomena, and by case-technology they understand the profession-oriented educational technology of a specific open or hidden problematic situation. A technological map and a methodology for checking the effectiveness of applying the developed complex case-technology to practical physics were attached by [3].

On the basis of real or invented (artificial) situations, it is possible to introduce short-term or rapid training, aimed at a specific goal, into all types of assessment and control [4].

In forming general and professional competencies, the case-study method was applied, and the methods of "problem-based learning" and "Koosa cubes" were also used [6, 7].

It is possible to use the case before covering a new topic, in independent mastering of topics, and also in organizing practical classes individually or in small groups. The requirements for a case are: 1) situation — an event taken from life; 2) context (content) of the situation — chronological, historical, place-location, specific features of the event and participants; 3) commentary on the situation; 4) questions and tasks; 5) appendices [8].

Tasks with a separate case for each student (individual, adaptive, in italics from the author) lead to increasing motivation in the educational process, activating the process of cognition, and stabilizing the skill of analyzing situations [9].

According to the research of investigators, under conditions of competence-based approaches, the main criterion of the quality of engineering-graphic training is fundamentality, professional orientation, problem-targetedness, and the sign of advancement. Based on this structure, in order for the student's engineering-graphic competence to be reflected in qualifications and professional-personal characteristics, the student must master the knowledge, skills, and abilities that ensure successful activity in modeling engineering objects and presenting their drawing (project). To implement this, the structure of complex situational tasks has been proposed in Figure 1 and Figure 2 [10, 11].

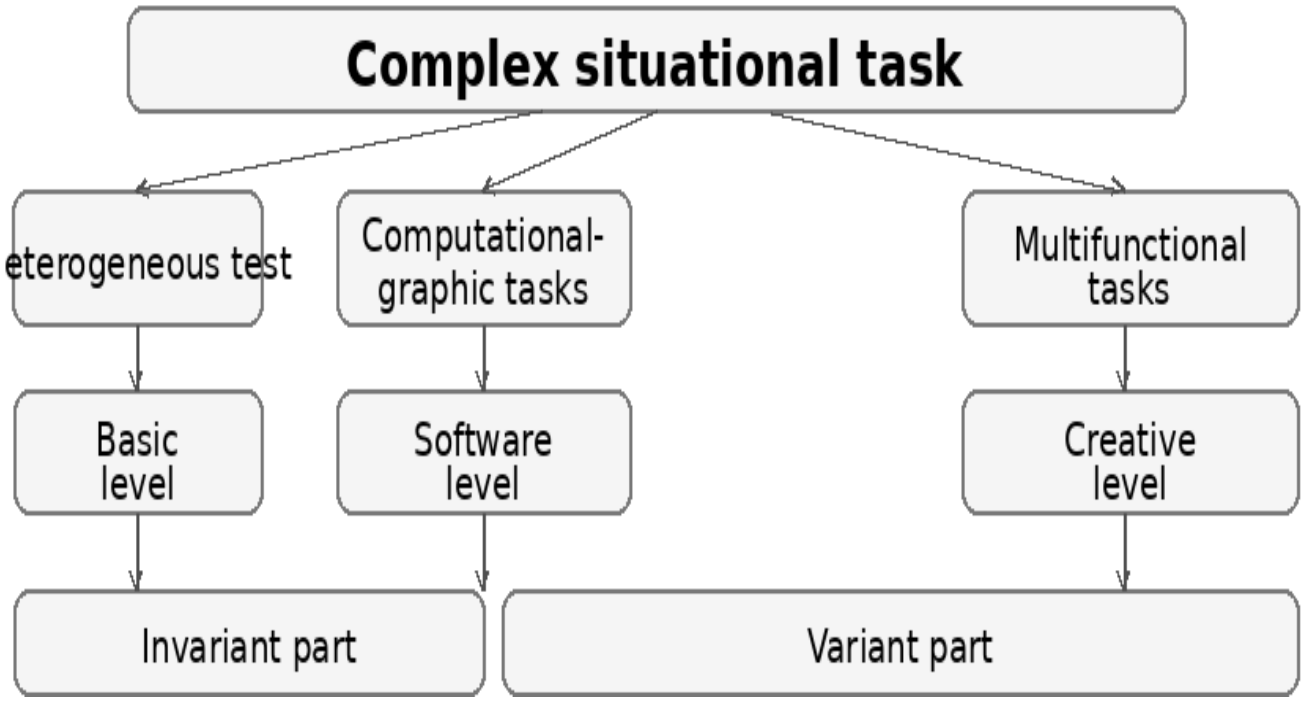

Figure 1. Structure of Complex Situational Tasks [10, 11].

COMPLEX SITUATIONAL TASK

Variant 1

In the village of Yashur-Bodja, a new two-story kindergarten for 190 places is being built. The project of the building was developed according to OTI B2 1840-1220 GOST 30647-99. The external doors DN21-9 GOST 24698-81. The building is made of masonry of steel water-gas pipes Dn = 25 mm. Above the entrance doors there are transoms with glazing. The thickness of the external wall is of ordinary clay brick masonry 770 mm.

1.1. THE DRAWING SHOWS:

1. kindergarten plan;
2. section;
3. facade;
4. plan at elevation 0.000;
5. plan at elevation 3.000.

Tasks 1.1-1.10 — basic level;

2.1-2.2 — software level;

3.1-3.2 — creative.

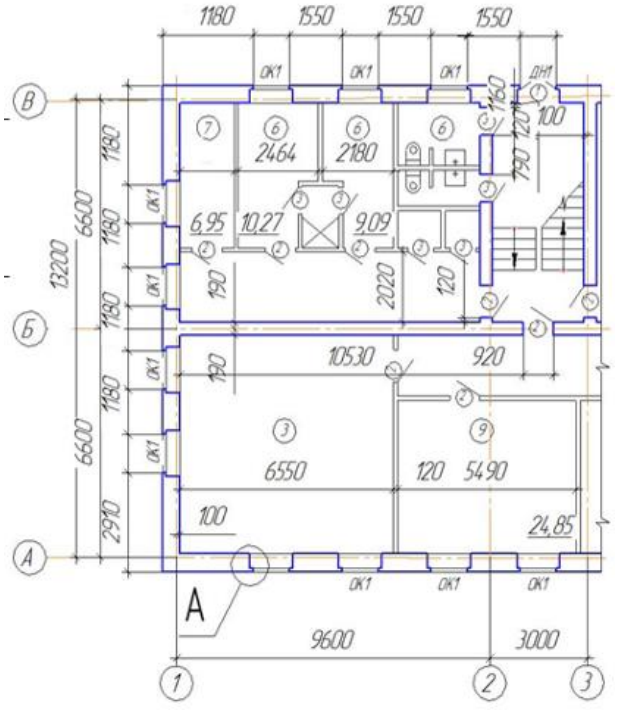

Figure 2. One Part of the Complex Situational Task [10, 11].

The author proposed developing real existing architectural objects as case assignments, in which several educational tasks are carried out: searching for general information and technical characteristics, explaining the architectural-engineering solution of the object, and creating presentations, reports, layouts, and models for demonstration. The method made it possible to adapt the content of the "Theoretical Mechanics" course to the "Architecture" direction [12].

The authors classify the graphic subject by the example of a bridge connecting fundamental and practical sciences. They proposed to future engineers case assignments such as individual, one-person (passive), collective (discussion), and research types, which induce the highest independent activity in students. As a means of filling the basic gaps from school, they proposed 1) independently identifying and eliminating errors, 2) developer (customer) cases [13].

The main condition in applying the case is the presence of a problematic situation and a contradiction that gives rise to practical situations. The contradictions used to generate practical situations and tasks related to the subject of engineering graphics are:

- in facts known and new for students;
- in the knowledge mastered by students and the knowledge necessary to solve the task;
- when knowledge is multiform;
- when changing the method of applying knowledge;
- in the impossibility of implementing the theoretical probable path by the selected method;
- in the student's knowledge and the information necessary to solve the problem situation;
- in using mastered knowledge in new conditions;
- in exercises worked out mentally and experimentally — detailing an assembly drawing (analysis), assembly drawing and general view (synthesis), composing units and their component parts (comparison), drawing details or assembly unit drawings according to a certain feature (classification), independently performing a drawing according to the classification and operating principle of a technical device (comparison by analogy) [14].

The author emphasizes that, in connection with this method, the role of the pedagogue-teacher also changes. He or she must become not an ordinary lecturer, but an organizing retranslator. The qualitative aspect of education becomes актуализирован, and traditional teaching methods are integrated with modern educational technologies. The case can be used not only in the educational process, but also in the examination. In creating a case, the following stages were proposed: defining the educational goal, finding an organization and establishing relations with it, collecting primary and secondary information and developing the case content, case approbation, agreeing the case with the organization, publishing or registering it [17].

The case method makes it possible to be used in cooperation with interactive methods such as "Brainstorming," "game method," and "problem method" [18].

In foreign experience, Zhang Wenying and Yuan Yuefeng [19], while focusing attention in the case on the fundamental knowledge, concepts, and methods of descriptive geometry and engineering graphics, state that the engineering drawing course integrates computer graphics, geometric modeling, scientific research, and general graphic design methods into real engineering practice. This course gives engineering-technical personnel the opportunity to thoroughly master the engineering language, learn to solve engineering problems, and master modern digital design technologies [19].

P.K. Raju and S.S. Sankar conducted research in engineering education on determining what skills case-study and multimedia cases develop in students, and on the problem of which teaching methods develop the necessary competencies in engineering students. Advice from the authors' personal experience includes: introducing multimedia to reveal the connection between theory and practice, demonstrating the connection of engineering education with real-life events using digital technologies, developing a set of tools for evaluating the effectiveness of case-study, etc. [20].

The mentor-pedagogues of our republic T.R. Rikhsiboev [21], A.O. Ashirboev and K.G. Malikov [22] formed a bank of cases for engineer-pedagogues in the training and advanced training of pedagogical personnel.

Based on scientific analyses, we propose a model of integration with innovative technologies in teaching graphic subjects on the basis of the case method in current higher education conditions (Figure 3):

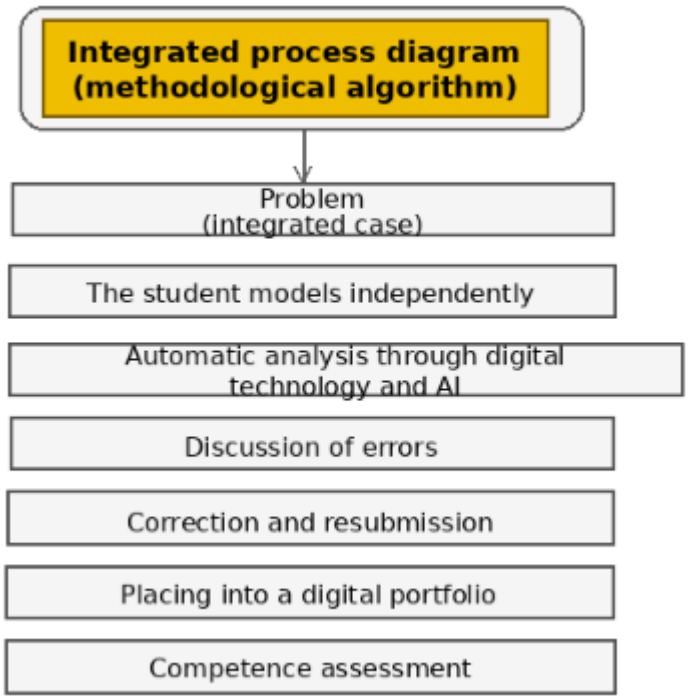

Figure 3. Integration of innovative educational technologies into the pedagogical process.

By comparatively analyzing the studies, proposals, and considerations of the specialists reviewed, we arrive at the following scientific assumptions and conclusions:

- Each teacher-pedagogue should master priority models in the world educational space such as case-study and problem-based learning https://www.thecasecentre.org/caseTeaching/guidance/onlineCaseTeaching#;

- To identify the factors for creating strong (correct) cases that organize successful teaching in engineering graphics (improving existing cases);

- To coordinate the types of graphic cases according to classification (genre-typology) (educational, controlling, organizing independent learning, etc.);

- Tasks, problems, assignments, and tests of graphic content according to case technology (strategy) should be based on life situations;

- To create innovative methodological-technological developments for transmitting the content of educational material (multimedia content, virtual educational platform, portfolio for an independent learning trajectory).

In this, pedagogues-teachers are required to have pedagogical experience and skill, creative ingenuity in technical situations of their profession, and the art of turning interesting information from found sources into life situations for educational cases.

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