

## CHAPTER 2

# INNOVATIONS IN THE MANAGEMENT OF EDUCATIONAL INSTITUTIONS

## CONCEPTUAL FOUNDATIONS FOR PREPARING MATHEMATICS AND COMPUTER SCIENCE TEACHERS FOR THE USE OF VIRTUAL CLARITY MEANS

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**Abstract.** In the article, the authors touch on the problem of professional training of teachers of mathematics and computer science in the context of the development of digital technologies and the demand of society for visual support of training. The generalization of scientific and pedagogical research on the training of teachers of mathematics and informatics is presented. The conceptual contradictions of the educational sector, which are proposed to be resolved through the implementation of the author's concept of preparing future teachers of mathematics and computer science for the use of virtual clarity in professional activities, are singled out. Based on the results of the analysis and systematization of scientific sources and own experience of teaching, the requirements for the training of teachers of mathematics and computer science were clarified, taking into account the requests of stakeholders for the effective implementation of professional pedagogical activity. The leading ideas of the concept of professional training of future teachers of mathematics and computer science for the use of virtual clarity in professional activities are revealed. The implementation of the concept is described on the methodological (the provisions of philosophy regarding the development, self-realization, self-improvement of the individual and the unity of the theory and practice of conscious human activity as a subject of cognitive activity, as well as systemic, acmeological, cognitive-visual, synergistic, reflexive-activity, BYOD-approach, made-self-approach), theoretical (based on the formation of teachers' readiness to use virtual clarity as a complex personal education) and practical (characterizes the practical aspects of the implementation of the concept) levels. It is expected that the developed concept will determine the fundamental positions of designing a pedagogical system of professional training of future teachers of mathematics and computer science for the use of virtual clarity tools in professional activities at the level of higher education institutions.

**Keywords:** professional training of the teacher, concept, conceptual foundations, future mathematics and computer science teachers, virtual clarity means, professional activity of the teacher.

**JEL Classification:** I23, I26, I29

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**Introduction.** Professional training of future mathematics and computer science teachers in the context of the development of the educational sphere, its modernization increasingly depends on the formation of professionally significant qualities necessary for the creative performance of future professional duties. At the same time, the educational process is still focused on traditional classical education rather than on the logic of digital innovation in education. First, it provides actions on the introduction of digital technologies, motivating their use to solve the problems of professional training of future teachers and their further professional activities. Therefore, we see the making of the concept of the professional training of teachers of mathematics and computer science, focused on the introduction of digital technologies both in the training itself and the readiness to use digital technologies in professional activities, as relevant.

**Literature review.** Analysis of scientific works related to the training of a teacher of mathematics and computer science revealed the following areas of research:

- *computer science and mathematics* – fundamental ideas and assessments of trends and prospects of modern computer science and mathematics education [10; 21; 40] and the use of IT in vocational education [33; 34];
- *theoretical and methodological* – the theory of teacher training in the conditions of informatization of education [12; 31; 37], theoretical foundations of the formation of professional [27], information [32], methodological [25], visual and informational [19] culture of teachers, conceptual research in the field of theory and methodology of teaching mathematics and computer science [23; 28; 35];
- *psychological and pedagogical* – neurophysiological foundations of the theory of visual perception, theoretical and practical aspects of visual thinking [7; 26; 38], theoretical and methodological foundations of cognitive visualization in teaching mathematics [15; 36].

Along with significant theoretical and methodological developments in the field of training teachers of mathematics and computer science, including technologies for the formation of professional competencies, their methodological training, and preparation for the use of specialized software, we recorded fragmentation of developments on the use of computer visualization tools, in particular, virtual visualization tools in the educational process and appropriate teacher training to use it in professional activities. This is confirmed by several contradictions at the conceptual level of modern education:

- between the active consumption of information content by young people through visual channels of perception and the insufficient use of this activity in the conditions of schools;
- between the potential of higher education institutions for high-quality training of teachers of mathematics and computer science and the insufficient realization of such potential due to moderate updating of the material base and the lack of teachers prepared for the use of virtual visibility;

Potential solutions to these contradictions are:

- development of motivation of future teachers of mathematics and computer science to use the virtual clarity means in professional activities;
- introduction of innovative teaching methods and technologies;
- pedagogical skills of teachers;
- creating an appropriate educational environment using IT technologies;
- organization of educational and industrial practices of students in the workplace of teachers of mathematics and computer science;
- formation of skills of future teachers of mathematics and computer science on the use of virtual clarity in professional activities;
- updating the content of the educational program for the preparation of future teachers of mathematics and computer science;
- control of educational achievements of future teachers of mathematics and computer science;
- development of reflection of students and teachers on readiness for the implementation of modern concepts and innovative teaching technologies.

The search for the most effective of them requires comprehension of the experience gained at different levels of pedagogical education, the development and consideration of methodological approaches to the use of educational technologies in preparing future teachers of mathematics and computer science for the use of virtual clarity, that is, the development of conceptual foundations for preparing future teachers for the use of virtual clarity in professional activities.

**Aims.** The purpose of the article: to develop conceptual foundations for preparing future teachers for the use of virtual clarity in professional activities

**Methods.** To achieve the goal, the analysis of scientific works, comparison of results, and generalization of approaches to the preparation of future teachers of mathematics and computer science were used.

**Results.** The concept is understood as a system of our views on this problem, the author's vision, understanding, and interpretation of the training of future teachers of mathematics and computer science in the system of vocational secondary education.

Theoretical analysis of literature and experience of teaching allowed to list the requirements for teachers of mathematics and computer science, taking into account the requests of stakeholders for the effective implementation of professional pedagogical activity:

- informatics, mathematical, psychological, and pedagogical knowledge;
- mastering modern methods of teaching mathematics and computer science;
- ability to create a digital educational environment with virtual visual aids;
- readiness for professional activities on the use of virtual clarity;
- the ability to observe and then analyze specific learning situations, set tasks for turning these situations into effective ones, and choose possible options that will contribute to achieving this goal;
- the ability to navigate sources of visual content, the means of its creation and distribution, the ability to use author's and borrowed didactic visual materials in the educational process;

- the reflection on the implementation of professional and pedagogical activities.

Based on the current trends in the development of education and its methodology, the principles of competency-based learning, and the process of professional training of future teachers of mathematics and computer science as a social phenomenon aimed at solving certain problems of society, it is advisable to direct to the harmonious development of the individual, capable of creativity and continuous self-improvement. Taking into account these leading ideas and positions of preparing future teachers of mathematics and computer science for the use of virtual clarity tools in professional activities to reveal the content of the concept, we have identified several psychological and pedagogical provisions.

Professional training of future teachers of mathematics and computer science is a process that reflects the scientifically and methodically based measures of higher education institutions aimed at forming the necessary level of professional competence of the graduate during the training. At the present stage of development of higher education, we note the importance of shifting the emphasis from memory development to the development of mental abilities of the personality of the future teacher and his visual thinking.

Therefore, the leading *ideas* of the concept of professional training of future teachers of mathematics and computer science for the use of virtual clarity in professional activities are:

- recognition of the value for the society of professional training of future teachers of mathematics and computer science for the use of virtual clarity in professional activities;
- formation of the readiness of future teachers of mathematics and computer science to use the virtual clarity means in professional activities through the development of the educational industry and digital technologies, as well as taking into account the peculiarities of young people's perception of visual content;
- modernization of the process of professional training of teachers with an emphasis on visual technologies, materials, and means in the information and educational environment of higher education institutions;
- acquisition in the process of professional training of primary experience in the use of virtual visualization tools in the educational process (organization of the digital space for teaching mathematics and computer science; development of accompanying didactic interactive materials in teaching mathematics and computer science; use of Internet technologies and social networks for the organization of informal learning; creation of popular science visual content, etc.);
- taking into account the trends in the transformation of vocational education in the direction of improving the professionalism of future teachers of mathematics and computer science, humanization of higher education, and creating an information and digital environment of an educational institution;
- ensuring personal professional development, self-development, and self-improvement of teachers of mathematics and computer science throughout their lives, forms their positive motivation and ability to achieve a high level of readiness of

future teachers of mathematics and computer science to use virtual clarity in professional activities;

- introduction of new forms of organization of the educational process, in particular, in the application of innovative educational ones, which ensure the effectiveness of educational, methodological, and organizational support.

- creative and creative activity of teachers of higher education institutions, which is aimed at expanding the subject functions of future teachers of mathematics and computer science to form their skills to generate new knowledge and technologies, develop innovative professional and pedagogical products (services, methods, etc.), creatively approach their pedagogical activities.

The concept of the study is revealed at the methodological, theoretical, and practical levels.

*The methodological level* characterizes the concept from the standpoint of philosophy and general methodology. The first uses the provisions of philosophy regarding the development, self-realization, and self-improvement of the individual and the unity of the theory and practice of the conscious activity of a person as a subject of cognitive activity. The second uses the conceptual provisions of pedagogical education, as well as systemic, acmeological, cognitive-visual, synergistic, reflexive-activity, BYOD-approach, and made-self-approach to the professional training of future teachers of mathematics and computer science to the use of virtual clarity in professional activities.

Let us dwell in more detail on these positions.

At the philosophical level, we base the study on a dialectical approach that allows: to study processes and phenomena in their interrelationships, dynamics, and development; to observe the transition of quantitative changes into qualitative ones; to identify internal contradictions, the unity of opposites, based on this, to determine the driving forces of knowledge; be guided by the law of the negation of objections, analyzing in unity the theory and practice of the phenomena studied.

Adhering to the dialectical basis in solving the problem of our research, the laws of dialectics, which are closely interrelated with each other, acquire methodological significance – the law of unity and struggle of opposites, the law of transition of quantitative changes into qualitative ones, the law of negation.

By the law of unity and struggle of opposites, the essence of which is to determine the driving forces of development, we had the opportunity to identify contradictions as an incentive for changes in the professional training of future teachers of mathematics and computer science to use the virtual clarity means in professional activities. This became the basis for the development of an appropriate pedagogical system, the implementation of which is aimed at overcoming these contradictions.

According to the law of transition of quantitative changes into qualitative ones, which reveals the mechanisms for transforming some material formations into others, we had the opportunity to demonstrate the dynamics of the process of forming the professional readiness of future teachers of mathematics and computer science to use virtual clarity in professional activities, determining qualitative and quantitative

changes (criteria and indicators) for assessing the levels of this readiness, as well as to predict its further improvement, taking into account obtained statistical data. By this law, the readiness of future teachers of mathematics and computer science to use the virtual clarity means in professional activity is considered by us as the personal state of the subject, encouraging them to productively use the means of virtual clarity, and the degree of detection of which can be indicated by three levels by the qualitative characteristics of its components: high, medium, low.

Taking into account the provisions of the law of negation, which reflects continuity as a feature of the development process, consisting in preserving and improving in the new object all that is progressive that was achieved at the previous stages of its development, orients us to the importance of familiarizing ourselves with the best foreign and domestic experience of professional training of future teachers of mathematics and computer science for the use of virtual clarity in professional activities and its consideration in the process of creating an appropriate pedagogical system.

With the laws of dialectics, paired categories are closely interrelated, such as necessity and chance, possibility and reality, single and general, part and whole, cause and effect, essence and phenomenon, and content and form. In our study in these categories, it is possible to purposefully investigate objective regular connections and attitudes in the process of forming the professional readiness of future teachers of mathematics and computer science to use virtual clarity in professional activities, to objectively evaluate the results obtained during the study.

So, at a philosophical level, the validity of our research strategy rests on the laws and principles of materialistic dialectics, which are more related to the purpose of the research work, its tasks, and logic.

The interrelation of various approaches of the general scientific and specific scientific methodology of the system of professional training of future teachers of mathematics and computer science to the use of virtual clarity tools in professional activities allows us to present methodological approaches to teacher training:

- system approach [8; 9; 22] means the disclosure of the integrity of the pedagogical system, its assessment, the object of study (professional training of future teachers of mathematics and computer science), the identification of the relationship and functional relationships between its structural components with the definition of the main factors influencing the system and the ability to manage the system for the mandatory implementation of the results obtained in the practice of professional training of future teachers of mathematics and computer science;

- meta subjects' approach [13; 20]) involves the connection with real life and professional situations by using virtual clarity, constant appeal to the personal experience of future teachers of mathematics and computer science, and projection of educational situations for future professional activities;

- reflexive-activity approach [17; 29] involves the formation and improvement of professional knowledge and skills through specific actions in the process of professional training with ensuring the effective implementation of a person-specialist in key areas of his life in the interests of both himself and society;

- the acmeological approach [16; 39] includes the self-realization of future teachers of mathematics and computer science in professional activities through self-reflection, self-education, and self-development;

- synergistic approach [11; 24; 30] provides optimization of the educational process through the implementation of interdisciplinarity and transdisciplinarity, which makes it possible to expand the boundaries of mastering academic disciplines, use cognitive schemes of one industry in another, create a digital environment for communication between participants in the educational process;

- cognitive-visual approach [5;14] is the basis for the formation of future teachers of mathematics and computer science knowledge, skills, and abilities to use the virtual clarity means in future professional activities;

- "Self-made-man"-approach [1;2;3]. involves the identification, consideration, and development of the individual characteristics of future teachers of mathematics and computer science based on self-improvement to develop personality;

- BYOD-approach [4; 6; 18] was used to intensify the educational process using mobile technologies and solve the problem of constant access to educational resources during the preparation of future teachers of mathematics and

Summing up, we note that the combination of these approaches as our methodological concept makes it possible to theoretically consider the ways and methods of solving the problem under study and makes it possible to model the system of professional training of teachers for the use of virtual clarity tools in professional activities.

The professional readiness of future teachers of mathematics and computer science to use the virtual clarity means in professional activities, in our opinion, is a construct of five interdependent components:

- motivational (motivation for the use of virtual clarity in professional activities);
- cognitive (knowledge of the virtual clarity means and their application in professional activities);

- instrumental (ability to work with a means of virtual clarity);

- methodical (possession of methods of using virtual clarity in teaching mathematics);

- reflexive (ability to improve and develop in the field of digital technologies for professional activity and personal development).

Based on it, we characterize the theoretical level of the concept through several theoretical provisions:

- "readiness of future teachers of mathematics and computer science to use the virtual clarity means in professional activities" is a personal education that has a complex structure, and therefore is formed through its components;

- the readiness of future teachers of mathematics and computer science to use the virtual clarity means in their professional activities is one of the results of their professional training, and therefore should be formed under the influence of the pedagogical system, which is connected and implemented within the educational and professional training program for teachers (mathematics and/or computer science), which is offered/developed by the university;

– the process of forming the readiness of future teachers of mathematics and computer science to use the virtual clarity means in professional activities requires the creation of an information and digital educational environment of higher education institutions in which subjects (teachers, students) and objects interact (an educational program, discipline program, digital tools to support the educational process, specialized software in the field (mathematics, computer science), services/programs for creating virtual clarity, didactic materials).

The practical level of the concept is expressed by the practice-oriented aspects of the professional training of future teachers of mathematics and computer science:

– technologization of professional training of future teachers of mathematics and informatics;

– creation of an information and educational environment for professional training of future mathematics and computer science teachers through informatization of the educational process and creation of an information and educational environment in higher pedagogical education institutions;

– practice-oriented professional training of future teachers of mathematics and computer science;

– research work of future teachers of mathematics and computer science;

– pedagogical integration (general scientific interdisciplinary and internal disciplinary areas);

– updating the standards of pedagogical education.

The most effective methods include:

– formation of the experience of subject-subject interaction (conversation, discussion – debate, forum, round table, decision tree);

– stimulation to interact (creating situations of interest, the method of relying on life experience, the method of creating a sense of success);

– solving specific pedagogical and technological situations (design method, method of business games, method of analysis of educational situations, method of group consultations);

– diagnostics of the results of interaction (method of mutual learning, mutual control, and mutual evaluation).

Therefore, the practical level of the concept testifies that it is the formation of the readiness of future mathematics and computer science teachers to use the virtual clarity means in professional activities:

– occurs through the pedagogical system, the implementation of which is based on the information environment of the university;

– requires consideration of the development of information technologies in the field of education and digital technologies in the field of teaching material (mathematics/ computer science);

– requires the formation of knowledge about modern approaches to the visualization of knowledge and the available digital tools for visualizing educational material (mathematics/computer science);

– requires the formation of skills in critical analysis, comparison, and evaluation of means of virtual clarity;



- requires the formation of methodological skills to use the virtual clarity means in professional activities;
- requires *compliance with organizational* (1 – organization of information and digital educational environment of universities; 2 – organization of quasi-professional activities using virtual clearance; 3 – organization of constant communication with stakeholders; 4 – involvement of students in non-formal education (participation in web-quests, in scientific events, mastering courses on open educational resources) and *pedagogical* (1 – strengthening the motivation to use the means of virtual clarity; 2 – the active use of computer visualization tools in the process of studying professionally oriented disciplines; 3 – encouraging non-formal education to credit the results of students' independent work) conditions.

**Conclusions.** The leading ideas and levels of implementation of the concept of preparing future mathematics and computer science teachers for the use of virtual clarity tools in professional activities are listed and characterized by the fundamental positions of designing the pedagogical system of their professional training. In this context, the developed concept is aimed at modernizing the content of education according to the requirements of educational standards, introducing innovative educational technologies in the conditions of creation of information and educational environment of higher pedagogical education institutions, organization of productive mastery by future mathematics and computer science teachers of knowledge about the use of virtual clarity means in professional activities.

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