Cloud-oriented Training Technologies as a Means of Forming the XXI Century Skills of Future Mathematics Teachers

Mariia Astafieva[1[0000-0002-2198-4614]], Dmytro Bodnenko[1[0000-0001-9303-6587]] and Vladimir Proshkin[1[0000-0002-9785-0612]]

[1] Borys Grinchenko Kyiv University, Kyiv, Ukraine
m.astafieva@kubg.edu.ua, d.bodnenko@kubg.edu.ua, v.proshkin@kubg.edu.ua

Abstract. The possibilities of cloud-oriented learning technologies based on computer-based mathematical systems (SCM) to form the skills of the XXI century of future mathematics teachers, in particular, critical thinking, have been substantiated. It has been established that computer support for this process is effectively provided by SCM GeoGebra and cloud-based learning technologies. It has been established forms and methods of education in which SCM GeoGebra and cloud-oriented learning technologies are used. It has been experimentally proved the expediency of using cloud-oriented technologies on the basis of SCM for forming the critical thinking for future mathematics teachers. The estimation of efficiency is carried out by methods of the theory of fuzzy sets.

Keywords: cloud-oriented learning technologies, systems of computer mathematics, cloud services, skills of the XXI century, ICT, future teachers of mathematics.

1 Introduction

One of the tasks of educational reforms is the formation of the skills of the XXI century of a modern person. Researchers consider the skills of the XXI century (educational and innovative, informational, media and computer, life and professional) in the context of educational life skills, and their formation is considered to be the most important goal of modern high school and secondary school. One of the key skills of the XXI century is critical thinking. It is an important and universal instrument in the professional activity of the teacher of mathematics, because mathematics is the basis of STEM-education that is actively being introduced into the practice of the modern Ukrainian school for the purpose of developing pupils with critical thinking and ability to research.

Today we are dealing with the so-called "digital generations" that were born and growing in a high-tech information society, and has many significant differences from their peers. Therefore, there is a need to seek new pedagogical methods to increase the efficiency of the educational process, adequate to modern challenges and needs. The purposeful use of SCM and cloud-oriented technologies is one of these ways.

2 Literature Review

Well-known foreign and Ukrainian scholars studied the problem of forming the skills of the XXI century (J. Dewey, R. Paul, D. Halpern, B. Trilling, Ch. Feidl, D. Kun, O. Pometun, I. Zymnia, etc.). However, presented scientific researches used mainly the material of social and humanitarian disciplines. At the same time, in the previous scientific works of M. Astafieva and V. Proshkin [1-3] it is proved that mathematics can serve as an effective tool in shaping the critical thinking of future teachers; some examples of the use of information and communication technologies for the increase of the efficiency of this process are given.

Theoretical and methodical principles of the use of computer-oriented methodical systems of mathematics training are covered in the works of scientists such as M. Zhaldak, S. Semerikov, Yu. Tryus, O. Spivakovskyi, Yu. Ramskyi, and others. Thus, the methodical features of the introduction of critical thinking technologies on the basis of the use of computer algebra and dynamic geometry packages were highlighted by T. Oliinyk [4]. S. Lytvynova carried out the testing of cloud services for the formation of skills of the XXI century students [5]. N. Morze disclosed the means of ICT for developing the skills of the XXI century [6], and etc. Despite the diverse scientific researches this problem remains relevant and insufficiently investigated in the context of the use of cloud-oriented technologies (on the basis of SCM) in the study of mathematical disciplines in higher education establishments.

The purpose of the article is to substantiate the possibilities of cloud-oriented technologies (on the basis of SCM) for forming the skills of the XXI century of future mathematics teachers.

3 Research Methods

The achievement of the research goal was facilitated by the use of such methods: scientific literature analysis; synthesis, generalization, systematization for the theoretical substantiation of the pedagogical technology of the formation of critical thinking; diagnostic (conversation, content analysis, testing) for tracking the dynamics of the level of the formation of critical thinking of students; a pedagogical experiment in order to prove the effectiveness of the application of cloud-oriented training technologies for the skills of the XXI century; mathematical methods (on the basis of the theory of fuzzy sets) for evaluation of the results of experimental work. Experimental base: Borys Grinchenko Kyiv University and A.S. Makarenko Sumy State Pedagogical University.

4 Research Results

4.1 Formation of Critical Thinking of Future Mathematics Teachers and Its Support by Cloud-Oriented Technologies of Training

The results of external independent evaluation of Ukrainian school graduates in recent years and the questionnaire for junior courses students of the specialties "mathematics",

"informatics" of some universities, as well as mathematics teachers indicate that the skills of critical thinking of pupils, students and teachers are not formed or formed weakly [1-3]. Thus, today there is an urgent need, a public request for pedagogical technology aimed at developing the critical thinking of students – future mathematics teachers.

From the point of view of tools and instruments for this purpose a mathematical disciplines are advantageous. They teach to think logically (with the adherence to the laws of mathematical logic) and responsible (understanding the limitations of own knowledge and the possibility of mistake; the willingness to impartially consider a point of view different from one's own, the internal need to be probative and truthful in their own judgments, readiness to overcome obstacles for the sake of cognition truths). And through visualization using ICT mathematics aspires to sensory perception, the formation of persistent associations in the consciousness of the individual through visual images that promotes the development of spatial imagination and geometric intuition. Solving tasks stimulates creative search, develops research skills, teaches to organize and mobilize the knowledge, make you operate in conditions of uncertainty, and promote communication. We have developed the pedagogical technology of forming the skills of the XXI century, in particular, critical thinking and ICT literacy, of students when solving geometric tasks for the construction and experimentally proved its effectiveness [1; 2].

Relying on the positive experience of introducing this technology into school practice [1] and taking into account the effective use of cloud-oriented technologies in organizing student research [7], we have developed a pedagogical technology for the formation of critical thinking of future mathematics teachers by means of mathematics, which consists of the target, the content-procedural and control, and evaluation components. The essential element of technology at all stages of its implementation is the purposeful use of cloud-based learning technologies. Without going into the detailed description of all the components of the proposed pedagogical technology, we must mention only the key elements of content-activity (content, forms, methods, and means of learning) and evaluative-reflexive stages of technology implementation, role and place of SCM and cloud services.

The content-activity stage involves the design of a holistic pedagogical process which ensures the formation of critical thinking of future mathematics teachers. In fact, we are talking about what exactly needs to be changed in the content of the training, which forms and methods of training to choose in order to increase the level of formation of the investigated competence. *Contents of training.* As noted above and as practice confirms, mathematical disciplines have wide possibilities for forming critical thinking through the organic combination of formal logic (abstraction) and constructivism (visibility, imagery). Unfortunately, in recent years, the prevalence of formal-analytical approaches which does not contribute to the formation of students' imagination and figurative thinking, complicates the perception and understanding of concepts and facts, exhausting it itself essence. Our approach assumes resistance to natural sensory perception as the first and necessary link of knowledge, its absolute basis, which helps to form students with a correct idea of the essential characteristics of the subject of the study. Only on this basis the thinking and speech of the individual develops; there is a successful transition from partial to general, from concrete to abstract.

Forms of training. When selecting any of them, there are conditions for the subject, active communication and interaction of the teacher-student, student-student (during the classroom lecture or practical classes and, especially, outside of them, both on-the-spot and virtual through cloud services storage and sharing of data, drawings, joint documents. *Learning methods based on research* are focused on problem learning, heuristics. The task of research-based learning is to provide conditions in which the student communicating directly with the object or comparing certain facts with an appropriate degree of independence states a new, unknown to him previously fact or comes to a new conclusion for him. Among the means of training is expected to use various cloud services, such as those aimed at working together with text, tabular, multimedia data, and the use of computer mathematics and WEB-SCM systems. Note that students can choose arbitrary SCM in the implementation of the project task (new applications are constantly appearing on the network, which eventually become cross-platform), but with a compulsory wish to interpret the advantages and disadvantages of the chosen SCM.

The cloud-oriented learning technologies are used to: organization of communication in the process of solving mathematical tasks, discussion of ideas, opposition, discussion, collective search for solutions, joint projects, etc., *examples of cloud services – forums, chats, groups, bitrix24;* implementation of research training, in particular, conducting experiments for the promotion and testing of hypotheses, working on common documents in the clouds, e*xamples of services – documents, cloud storage, presentations, SCM GeoGebra;* creation of presentation and multimedia materials, *examples of cloud services – presentations, Moovly, Pixel Expres, Picassa, Wewideo, etc.;* monitoring of the educational process using questionnaires, diagnostics, surveys, in other words, the interactive relationship with the students, *examples of cloud services – forms, Learning Apps, Kahoot, etc.;* evaluation of tasks solutions online (using cloud services, access to an online resource is provided which contains criteria for evaluating the problem and individual sheet of each group), *an example of cloud services – tables.*

Thus, learning becomes a kind of intellectual partnership between a computer and a student, which enhances students' knowledge, develops their research competencies, develops critical thinking. The determination of the effectiveness of the technology of forming critical thinking takes place at the **evaluative-reflexive stage**.

4.2 Implementation of the Developed Pedagogical Technology in the Practice of Bachelor's Degree in Mathematics Training

Our technology of forming the skills of the XXI century and critical thinking in particular with the use of cloud-oriented learning technologies and SCM GeoGebra was tested experimentally. The experiment was conducted during September-December 2018. The experimental group included 44 people: students of the first - third year of the specialty "Mathematics". The control group consisted of 62 persons: students of the second and third year. Participants of both scientific groups, in particular, implemented a collective project: developed 29 dynamic models (with elements of animation) to various topics of geometry and mathematical analysis in SCM GeoGebra. For example, dynamic model for the Pascal theorem (Fig. 1a, b).

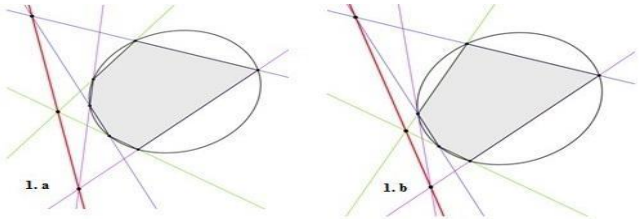

Fig. 1. a, b Two positions of the dynamic model for the Pascal theorem

After four months of work, we conducted diagnostic testing in the control and experimental groups. The test [8] contained 20 tasks. Testing did not check the level of academic achievement, but aimed at assessing how much a person would be able to use elementary knowledge and skills for possible life difficulties and challenges, that is, what is actually the most important sign of critical thinking. A comparative analysis of the results is presented by a histogram (Fig. 2) in which we see that all the questions of the test students of the experimental group responded better.

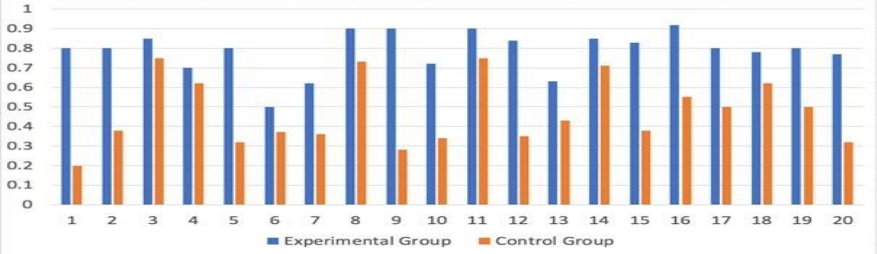

Fig. 2. A comparative analysis of the results is presented by a histogram

The multicriterial assessment of the critical thinking level was carried out by the methods of the theory of fuzzy sets [9] and is represented by the terms of the linguistic variable "Critical Thinking" (Fig. 3).

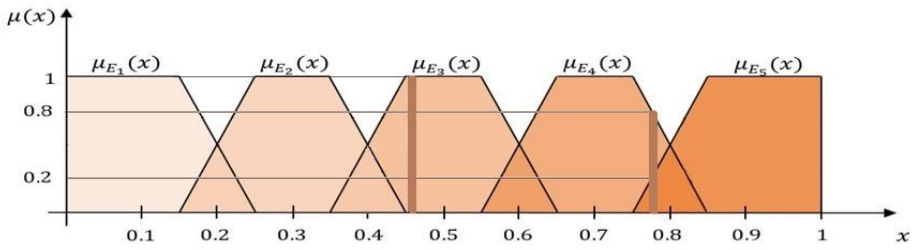

Fig. 3. Terms of the linguistic variable "Critical Thinking"

We have identified five levels (so-called terms) of critical thinking: E_1 – initial, E_2 – low, E_3 – average, E_4 – sufficient, E_5 – high. The terms are given in the form of trapezoidal membership functions of the quadruple of numbers. Given the verbal-

numerical Harrington scale we will take for our task. The calculation of the coefficients of the formation of critical thinking has shown that for the control group it is 0.46 and is average (belongs to term E_3), for the experimental group it is 0.77, which is 67% higher and corresponds to more than sufficient level (belongs to terms E_4 and E_5), Consequently, the level of critical thinking of students of the experimental group can be characterized, for example, as "more than sufficient".

5 Conclusions

The expediency and the possibilities of cloud-oriented learning technologies (based on SCM) are grounded for forming the skills of the XXI century for future mathematics teachers. It has been established that computer support of the developed pedagogical technology is effectively provided by cloud-oriented learning technologies and SCM GeoGebra, which has all the above-mentioned capabilities. The analysis of the results of the introduction of the developed technology on the basis of the theory of fuzzy sets confirmed the feasibility of using cloud-oriented technologies (on the basis of SCM) for developing the skills of the XXI century for future mathematics teachers. Studying the possibilities and effectiveness of computer support for the key skills of the XXI century building through the development of open online courses at LMS MOODLE using other cloud-oriented tools and technologies will be the subject of further research.

References

1. Astafieva, M., Proshkin, V., Radchenko, S. (2017). Pedagogical technology of forming students the skills of the XXI century in the process of solving geometrical tasks for construction. *Pedagogical education: theory and practice.* 28. pp. 34-43. (in Ukrainian).
2. Astafieva, M., Proshkin, V., Radchenko, S. (2017). Geometrical tasks for construction as an effective tool for XXI centuryskills development. *Educological discourse*. 3-4. pp. 122-136. (in Ukrainian).
3. Astafieva, M., Proshkin, V., Radchenko, S. (2018). Formation of critical thinking of future mathematics teachers by means of geometry. *Educological discourse.* 1-2. pp. 100-115. (in Ukrainian).
4. Oliinyk, T. Using ICT to develop critical thinking. *Computer-based learning systems*. 8. Available at: http://www.ii.npu.edu.ua/zbirnyk-kosn/74-zbirnyk-8?start=0. (in Ukrainian).
5. Lytvynova, S. (2013). Cloud technologies: Peculiarities of the activity of teachers in virtual subject communities *Theory and method of e-learning*. Iss. IV. pp. 165–170.
6. Morze, N., Kocharian, A. (2015). Морзе Н.В. Information and communication competence of scientific and pedagogical workers of the university. Historical development of the formation of a conceptual apparatus. *Pedagogical education: theory and practice.* 24. Available at: http://nbuv.gov.ua/UJRN/Potip_2015_24_5. (in Ukrainian).
7. Bodnenko, D. M.(2015). Cloud oriented technologies as a factor of research-based training. *Information Technologies and Learning Tools.* Vol. 48, Iss. 4. pp. 122-139. (in Ukrainian).
8. Diagnostic test "Critical Thinking". Available at: http://e-learning.kubg.edu.ua/dn/mod/quiz/view.php?id=29794. (in Ukrainian).
9. Vasylevych, L., Bodnenko, D., Vasylevych, O. (2017).Methods of estimating competence as a system of fuzzy statements. *ICT in Education, Research and Industrial Applications: Integration, Harmonization and Knowledge Transfer*, pp. 9-17.