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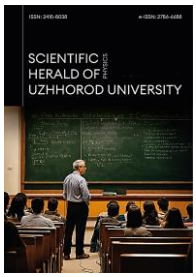

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A model of the process for forming the readiness of future mathematics teachers to teach schoolchildren in the context of the PISA-2021 concept

Kuanysh Nurpeyssov
Zhetysu University
040009, 187A Zhansugurov Str., Taldykorgan, Republic of Kazakhstan

Duisebek Nurgabyl*
Zhetysu University
040009, 187A Zhansugurov Str., Taldykorgan, Republic of Kazakhstan

Abstract

Relevance. The relevance of the research topic lies in the fact that educational tasks in geometry contribute to the formation and development of mental abilities, spatial imagination, which are necessary in logistics, architecture and construction, mechanical engineering, cartography and other fields of applied science.

Purpose. The purpose of the study is to study the stage of training of future mathematics teachers in the direction of implementing the PISA-2021 concept.

Methodology. Among the theoretical research methods, analysis and synthesis, the method of comparison and generalization were used. At the stage of the empirical part, an experimental pedagogical study was conducted on the basis of three universities of Kazakhstan.

Results. The article examines the issue of designing the learning process in the context of forming the readiness of future mathematics teachers to carry out pedagogical activities. A system of content components of the future teacher's general readiness to teach schoolchildren was determined. The signs and stages of formation of the readiness of future mathematics teachers to teach schoolchildren in the context of the PISA-2021 concept have been identified. A model of the process of forming the professional readiness of future mathematics teachers to teach schoolchildren in the context of the formation and development of their mathematical thinking, spatial ideas, and divergent thinking has been built skills of the 21st century.

Conclusions. The study confirms the effectiveness of a new model for preparing future math teachers, showing high student proficiency in mathematical and pedagogical skills, while noting potential for broader application and challenges in implementation due to current school curriculum limitations.

Keywords: readiness components; stages of the learning process; thinking abilities; geometric problems; section of polyhedra.

Introduction

The global development of the world economy over a long period of time, aimed only at achieving the maximum profit and minimizing any costs, has led to dangerous systemic natural disasters, environmental disasters, global climate change, social inequalities and spiritual degradation of the planet's population. The search for a solution to these global problems has led to a revision of the systemic view of the world around us and the realization of the need for sustainable development.

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*Corresponding author

In this regard, 17 sustainable development goals were formulated at the next UN summit in 2015. Sustainable development is a systemic, harmonious, comprehensive development of the quality of life of the population of Earth. One of these goals, the fundamental goal is to provide a person with a quality education that provides for the comprehensive development of the individual.

In 2018, the Organization for Economic Co-operation and Development (OECD) proposed the concept of "The Future of Education and Skills: Education 2030" [1]. In this concept, special attention is paid to the content of the school curriculum, were skills that will be in demand in the future have been highlighted. As part of this concept, the OECD is implementing the PISA-2021 research program. The PISA-2021 study emphasizes the importance of forming and developing the thinking skills of the 21st century in schoolchildren [2].

In this regard, the reform of secondary education is being carried out in the world educational systems, as well as in the education system of the Republic of Kazakhstan. The main goal of these reforms is to update the content of secondary education, aimed at the harmonious development of the student as a person, the formation of their functional literacy, mental skills of the 21st century.

Such a school education reform puts forward new requirements for the professional readiness of future teachers, which requires universities to reorient the entire higher education system: updating the content of higher education, shaping students' readiness to teach schoolchildren in the context of the OECD program concept.

Many researchers, in order to increase the level of functional literacy of schoolchildren in the context of PISA research, have increased scientific and practical interest in the problems and methods of teaching future teachers of functional literacy. An analysis of the educational programs of universities in Central Asia and the Republic of Kazakhstan, familiarization with the practical work of teachers of these universities shows that in the process of organizing the training of future teachers of mathematics, there are certain distortions that reduce the effectiveness of training a future teacher of mathematics. These distortions are to some extent manifested in the absence of unified approaches in determining the general readiness of future teachers for professional activities, components of their readiness to teach mathematical literacy to schoolchildren in the context of the PISA-2021 concept.

In addition, practice has shown that the process of training future teachers in universities is mainly limited to the formation of the knowledge that is necessary to study the school course of mathematics, while the learning process is aimed only at developing convergent thinking among students.

However, the analysis of studies by domestic and foreign authors devoted to the organization of the process of training future teachers showed that their readiness for professional activity should be provided not and only by the quality of the acquired knowledge and skills, but also with formed mental abilities, value orientation, and skills for the implementation of pedagogical activities. At the same time, many scientific studies in the field of education are mainly aimed at describing the PISA statistics, at describing the problems of teaching mathematical literacy to schoolchildren.

An analysis of the results of the works of R. Karatepe and C. Akay [3], H. Semilarski et al. [4], B. S. Haug and S. M. Mork [5] revealed that in many schools in some countries of the world, work on the formation and development of 21st century skills among schoolchildren remains almost unexplored. In the studies of P. Erten [6], M. Bakar and N. Ismail [7], it was found that the majority of teachers in the learning process are not able to recognize the developmental opportunities of learning tasks and teach students the skills of the 21st century. The article by R. Lavi et al. [8] explores the problem of choosing a teaching method for schoolchildren from the standpoint of developing their 21st century skills. P. C. García et al. [9] notes that for the formation and development of mathematical competence, schoolchildren lack high-quality educational resources and competent teachers.

Thus, the need to solve these and other problems, their theoretical and practical significance in the training of future mathematics teachers determines the relevance of the research topic.

Materials and Methods

The theoretical methods of scientific knowledge that were used during the research include the method of analysis and synthesis from the methods of detailed study of scientific sources in the direction of training future teachers. The comparison method was used to compare the similar and different features of the implementation of the PISA-2021 concept. The method of generalization was used to determine key positions and approaches in the direction of the described issues.

The analysis of the results of studies on the formation of the readiness of future teachers in the context of the OECD program concept allows to identify additional new signs of the readiness of future teachers of mathematics to teach and educate schoolchildren: the ability to make a decision (a reasonable choice of the desired option from a variety of possible options), apply interdisciplinary knowledge (in particular polytechnic knowledge), mathematical reasoning skills. In order to identify future teachers' ability to make decisions, apply polytechnic knowledge, mathematical reasoning skills, in 2023, an experimental pedagogical study was conducted on the basis of three universities in Kazakhstan (written work, questionnaires, and conversations).

The study involved future teachers (n=113). The analysis of the data made it possible to establish the lack of decision-making skills in 85% of students, the ability to apply polytechnic knowledge (79%), and the skills of mathematical reasoning (72%). In the process of teaching students' geometric problems, focused on the use of polytechnic knowledge, mathematical reasoning skills, it was revealed that most students lack spatial imagination (92%), they have difficulties in establishing relationships between different disciplinary concepts, building graphic models. In this regard, teachers of higher education are faced with the most important questions:

– development of a new content of mathematical disciplines aimed at the formation and development of polytechnic knowledge, spatial imagination, mathematical reasoning, skills of the 21st century;

– development of a methodology for teaching future teachers of mathematics to build graphical models that would contribute to the formation and development of polytechnic knowledge, spatial imagination, and thinking skills of the 21st century.

Scientific monographs, manuals, textbooks, publications and Internet resources were analyzed in the context of scientific research. In the process of evaluating the practical stage of the implementation of the process of forming the readiness of future mathematics teachers to teach schoolchildren in the context of the PISA-2021 concept, the results of an experimental survey of future mathematics teachers conducted by the author of the study were used.

Literature review

The problems of training future teachers in the context of the updated content of education in the Republic of Kazakhstan were described in the work by T. Mukhametkaliev [10]. The general readiness of a future teacher for pedagogical activity in the psychological and pedagogical literature is described as a complex multifaceted process of personality formation, consisting of interrelated components of readiness in the processes of forming the readiness of future teachers for social work, teaching schoolchildren in the classroom and in extracurricular activities allocate competence-based and criterion-level approaches [11-16].

The importance of spatial thinking in the educational achievements of students in the field of STEM, the need to teach students spatial thinking skills at an early age were substantiated, as well as the views and beliefs of mathematics teachers on the development of students ' mathematical abilities, spatial representation in the process of teaching mathematics were highlighted in the research of K. M. Gagnier and K. R. Fisher [17], H. Burte et al. [18].

M. T. Battista [19], K. H. Lee et al. [20], in order to develop curricula for school algebra and geometry, they analyze the mental activity of students in the independent formulation of the definition and properties of polyhedrons. S. A. Sorby and G. C. Panther [21] note that the success of students in completing PISA test tasks directly depends on the formation of spatial thinking in schoolchildren, which is underestimated in the strategy for improving the mathematical literacy of students in international PISA exams, which could ultimately contribute to the quality preparation of schoolchildren for real adult life.

The analysis of the above-mentioned and other works showed that the issues of teaching students the methods of constructing flat-sections of polyhedrons, the formation and development of divergent thinking, spatial representation, and mathematical abilities by solving problems on a constructing flat-section of polyhedrons remains insufficiently explored.

The relevance of these problems in education predetermined the purpose of the study, which is to develop a model for the formation of the readiness of future teachers for educational and upbringing activities by solving geometric construction problems in the context of the OECD program concept.

Results

Signs and components of readiness

The conducted research makes it possible to determine the main signs of the readiness of future mathematics teachers to teach and educate schoolchildren:

– positive emotional motivation for pedagogical activity, self-education and knowledge;

– formed core competencies (possesses modern mathematical knowledge, has the ability to formulate, apply and interpret mathematics to solve problems in a variety of practical contexts, reason logically, provide evidence (mathematical literacy), has the ability to motivate schoolchildren for learning, for self-education, organize effective learning for schoolchildren, is able to analyze, diagnose learning outcomes and personal development of schoolchildren);

– formed stable positive value-personal qualities;

– formed skills of the 21st century.

The analysis of normative documents in the field of education of the Republic of Kazakhstan and the experience of university teachers, mathematics teachers allow to conclude that the formation of the general readiness of a future teacher is characterized by a target component. Thus, taking into account the selected components, as well as the analysis of the well-known scientific principles of personality formation authors can determine the readiness of students to training schoolchildren on the construction of flat-sections of polyhedrons as a single system of interdependent target, epistemological, praxeological, axiological components of readiness.

In this regard, using the example of teaching students to construct plane sections of polyhedral, authors will construct a model of the process of forming the professional readiness of future mathematics teachers for teaching schoolchildren in the context of the OECD program concept. To this end, authors will consider in more detail these components of the readiness of future mathematics teachers to teach schoolchildren:

1. The target component is determined by the social order of society, which includes the goals and objectives of the learning process, reflects the formation of the general readiness of future mathematics teachers to teach schoolchildren. The target component is the backbone component of the specified components of the student's readiness.

2. The epistemological component of the readiness of future teachers to training schoolchildren how to construct cross-sections of polyhedrons includes knowledge of the contents of educational material, the algorithm for solving construction problems, the content of the set and solved pedagogical problems.

3. The praxeological component of the readiness of future mathematics teachers is determined by their professional abilities, skills, the effectiveness of knowledge, educational, scientific and life experience, formed thinking abilities.

4. The axiological component is a socially significant component of readiness and includes the value orientation of the future teacher. Value orientations are the inclusion of a value attitude in the content of a personal quality and their management in one's activity.

So, the axiological component of the readiness of future mathematics teachers is determined by their value orientations and in particular by their interest in the chosen profession of a teacher, satisfaction with the results of pedagogical activity, positive motivation for education and self-improvement.

Stages of learning

Now, let consider the learning process as a field of activity for the formation of students' readiness for pedagogical activity. This approach, as well as the analysis of the above components of readiness, allows to identify the stages of the process of forming the readiness of future mathematics teachers to teach schoolchildren how to construct flat-sections of polyhedrons.

1. Motivational stage. Practice has shown that the majority of secondary school graduates who entered pedagogical universities do not have a conscious need for learning and pedagogical activities. As a result, many of them after graduation, goes to work in a different field, if they choose the profession of a teacher, then they supplement a number of teachers who are forced to engage in pedagogical activity.

It is known that the success of a student in mastering the educational material depends not only on their thinking abilities, but also on the formation of educational motivation. There is a certain system of interconnections between motivation and thinking ability. In this regard, let single out the techniques that form the conscious interest of students in the problems of constructing sections of polyhedrons:

– an accessible presentation of the problem statement with new content;

– showing that the studied educational material is an addition or deepening of already acquired knowledge;

– disclosure of the pedagogical, cognitive and practical orientation and significance of the studied educational material;

– the establishment of interdisciplinary, and within inside disciplinary ties;

– the inclusion of historical and mathematical information in the learning process of educational material;

– establishing links between the studied educational material with new achievements of applied science, etc.

The listed techniques contribute to the creation of new sensations in students; ensure the launch of mental activity-based, cause cognitive interest, surprise. In this case, students are faced with contradictions between the assimilation of new educational material and the acquired knowledge, intellectual baggage and the needs of society. All this arouses a conscious interest of the student in new educational material, in pedagogical activity.

2. The cognitive stage of forming the readiness of the future mathematics teacher for professional activity is a key stage; it contains praxeological, epistemological, axiological components of readiness. Since the effectiveness of training, as well as the volume, quality and effectiveness of the acquired knowledge, the formation of thinking abilities directly depends on their success in professional activity. Teaching students will be effective if it forms the systematic and the durability of knowledge.

3. The activity stage is the stage of the formation of professional qualities in future teachers of mathematics. The essence of the activity-based stage is to train students to carry out pedagogical activities, develop methodological recommendations for the organization of the learning process of schoolchildren. The choice of the activity stage of training is justified by pedagogical praxiology. The study showed that at this stage, the activity approach forms the skills and abilities necessary not only in pedagogical activity, but also in other spheres of human life. The pedagogical activity of the teacher is to manage the learning process, namely:

– preparation for the learning process (motivation for learning, analysis of educational material, choice of presentation method);

– organization of the educational process (presentation and consolidation of new material);

– assessment and analysis of educational achievements of schoolchildren;

– correction and rescheduling of the educational process.

4. The value-personal stage of the formation of the future mathematics teacher's readiness for professional activity is defined as the stage of the formation of a value attitude towards a person, the environment, a student and the manifestation of these relations in their activities and in the actions of the future mathematics teacher. At the value-personal stage, the inclusion of values in the content of personal quality is formed, and their management in their activities. At the same time, the value attitude of future mathematics teachers to educational and upbringing activities is characterized by one of the following manifestations:

– students do not show motivation for professional activity, as well as a humane attitude towards the of schoolchildren personality.

– students show a professional attitude towards of schoolchildren only as a participant in pedagogical activity, they are not sufficiently motivated to carry out educational and upbringing activities;

– students show a humane attitude towards the of schoolchildren not only as a participant in pedagogical activity, but also as a person, they have a high motivation to carry out educational and upbringing activities.

The revealed levels of students' value attitude to pedagogical activity allow to conclude that it is necessary to search for such a teaching methodology that would allow students to form a value attitude towards future professional activities. The historical and educational component is associated with the beginning of the formation of the concepts of "value" and "personal-value attitude" among students. The psychological and pedagogical component is aimed at the formation of students' personal-value attitude in the process of implementing the activity-based teaching method and is connected by the humane attitude of the teacher to the student.

The cognitive component is aimed at the cognition of universal values that establish the development of the humanistic behavior of the student's personality and at revealing the significance of value systems in the future pedagogical activity of the student. The recognition by students of universal human values determines their ideas about professional activity as a socially oriented pedagogical phenomenon

5. Reflexive stage. The choice of the reflexive stage is justified by cognition, understanding of the productivity of pedagogical activity, i.e., pedagogical axiology. Such cognition, of necessity, presupposes the implementation of a reflexive assessment, an analysis of the effectiveness of this activity. The significance of the reflexive stage of the future mathematics teacher's readiness to teach schoolchildren how to construct cross-sections of polyhedrons lies in the objective assessment of the educational and personal achievements of schoolchildren by means of a criterion method for assessing student achievement. According to the content of the participants, reflection can be group, pair, and individual. At the reflexive stage, two key abilities are targeted for development. The first is the capacity to objectively evaluate one's own personal achievements. The second is the skill to fairly assess both the educational and personal progress of students.

Model of the process of formation of professional readiness of future teachers

Thus, in order to form the readiness of future mathematics teachers to teach schoolchildren, authors have identified motivational, cognitive, activity-based, value-personal, reflexive stages. Each of the considered stages has its own specific features, they are all interdependent, interrelated and have a common goal – to ensure the training of a highly professional mathematics teacher. For example, on the one hand, the motivation of students is a key condition for the implementation of productive educational and cognitive activities. On the other hand, properly organized educational and cognitive activity forms a value attitude to educational work and, in general, to pedagogical activity. The systematic nature of the stages of training is due to general didactic principles, as well as the following important principles:

– the principle of continuity, which is ensured by continuity between all stages of training and education;

– the principle of variability, which involves the formation of divergent thinking in students, the development of mental activity and spatial thinking;

– the principle of creativity, which presupposes the formation of future teachers of mathematics creativity in solving educational problems;

– the principle of integrity. The systemic integrity of these stages is ensured by the formation and development of all personal and professional qualities of the future mathematics teacher. In practice, integrity is manifested in the ability to plan and implement the educational and cognitive process as a systematic solution to the posed pedagogical problem;

– the principle of clarity. As you know, pictorial visibility is used as a means of learning new things, and to illustrate the algorithm for solving a problem, and for better memorization of educational material. The role and significance of the principle of visibility is clearly manifested in the formation of a spatial representation when solving problems of constructing sections of polyhedrons;

– the principle of awareness, activity and self-reliance independence. This principle is ensured by conscious, active, independent assimilation, comprehension, consolidation of educational material and application of the acquired knowledge.

As a result, authors can present a model of the process of forming the professional readiness of future teachers of mathematics to teach schoolchildren to build flat sections of polyhedra, the formation and development of their pedagogical qualities, mathematical reasoning, spatial representations, algorithmic, divergent thinking, skills of the 21st century as an integral system (Figure 1).

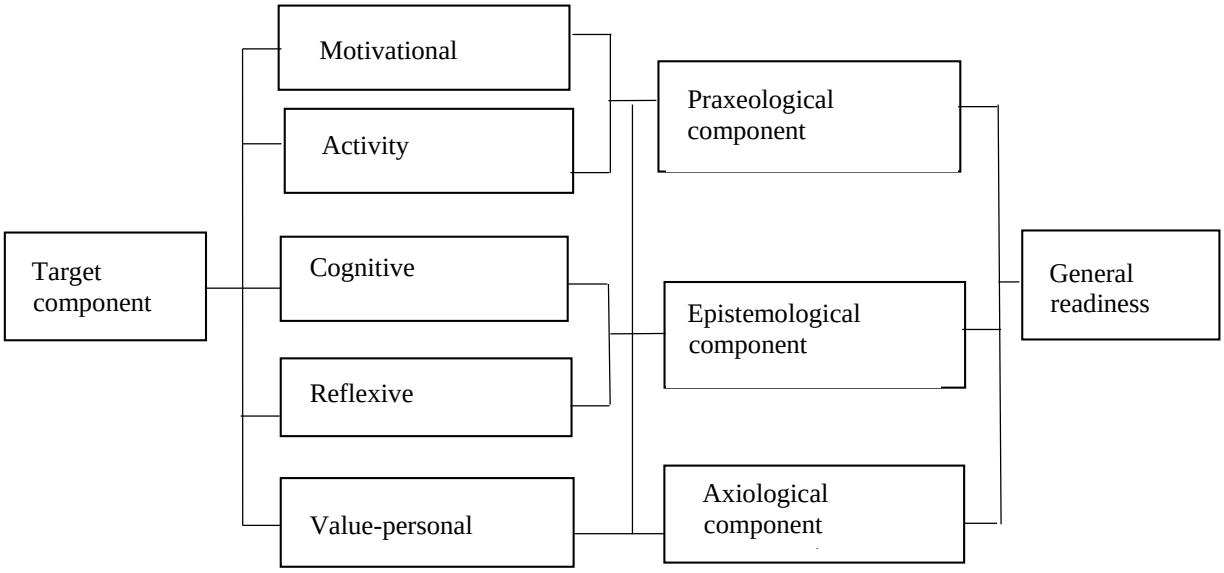

Figure 1. Model of the learning process of the future teacher

The proposed model allows for a comprehensive and systematic approach to developing professional readiness in future mathematics teachers.

Examples illustrating the process of step-by-step formation of the readiness of future teachers

Let consider model problems with ambiguous conditions that illustrate the process of formation and development of the readiness of future mathematics teachers to teach

schoolchildren how to construct plane sections of polyhedral. Let define the forming and developing possibilities of these tasks:

1. At the motivational stage, authors first construct tasks with ambiguous conditions, that form students' motivation to learn teaching materials.

Example 1. Given a cube $ABCDA_1B_1C_1D_1$. It is necessary to draw a plane through the data the points: A) through the vertex A; B) through the vertices B and C; C) through the vertices A, B, C.

Observation and comparison make it possible to identify a general pattern in several particular cases. Namely, students are convinced that through a given point, as well as through two given points, an infinite number of planes can be drawn, and through three given points, one single plane can be drawn.

2. At the motivational stage, authors first construct tasks that form students' motivation to learn teaching materials.

Example 2. Different points M, N, K are given on the edges of the cube $ABCDA_1B_1C_1D_1$. It is required to determine the possibilities of constructing a flat section of a cube with a cutting plane MNK.

With a careful analysis of the conditions of the problem, the students, working in pairs or in some subgroup, are convinced that the points M, N, K on the edges of the cube $ABCDA_1B_1C_1D_1$ can be arranged in various ways a plural of times.

Each pair offers different options for constructing the desired plane. At the same time, students are convinced that if all three data points are located along one edge, then the task of constructing a section will be ambiguously solvable. If two points are located along one edge, and the third one is on another edge, then the problem will be uniquely solvable, and so on.

3. At the cognitive stage of learning, authors first propose tasks that are methodological in nature, requiring knowledge about the pedagogical methods of teaching schoolchildren the elements of constructing sections of polyhedrons. For this purpose, authors will present the developed by tasks on construct, which are the components of the cognitive stage.

Example 3. In a straight parallelepiped $ABCDA_1B_1C_1D_1$, the base is a parallelogram with an acute angle $\angle BAD = 60^0$, and $AB = a, AD = b, AA_1 = c$. On the ribs of this prism, the points P, Q, R should be placed so that as a result of section this cube by the PQR plane, a triangular straight prism with a volume of $\frac{\sqrt{3}abc}{12}$ is obtained. Ask questions and solve the problem.

We draw the attention of students to the fact that visibility is used both as a means of learning new things and to illustrate the spatial representation and conditions of a given problem. The following questions can be posed to this problem:

1. As a result, what section of a given parallelepiped can be used to obtain a triangular straight prism?

2. Based on the area of the base and the volume of the parallelepiped under consideration, how can the P, Q, R points be positioned so that the cross-section results in a triangular straight prism with a volume of $\frac{\sqrt{3}abc}{4}$?

Analyzing are data of problem and the questions posed, students come to the conclusion that the PQR plane will be depicted as a diagonal plane, and the P, Q, R points will be located, respectively, on the vertices of the B, B_1, D_1 (Figure 2). Thus, authors obtain a triangular straight prism $ABDA_1B_1D_1$. Further, calculating the area of the base of the found prism, authors find that $S_{ABD} = \frac{\sqrt{3}}{4}ab$. Then the volume of the sought triangular straight prism will be $V = \frac{\sqrt{3}abc}{4}$.

Example 4. Given a rectangular parallelepiped $ABCDA_1B_1C_1D_1$, where $AB = a, AD = b, AA_1 = c$. Points should be placed on the rib of this parallelepiped so that, as a result of section this parallelepiped by the PQR plane, a triangular straight prism with a volume equal to $\frac{abc}{36}$ is obtained. Ask questions and solve the problem.

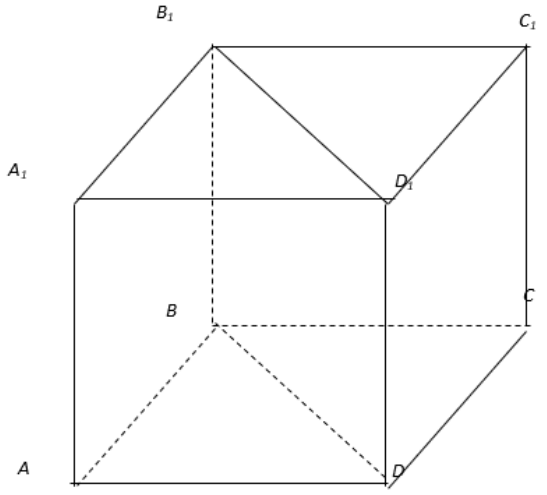

Figure 2. PQR plane

Comparing the conditions of problems 3 and 4, authors come to the conclusion that in both problems a straight prism is considered, it is required to construct a section so that as a result of sectioning this prism by a plane PQR, authors got a triangular straight prism with a given volume.

To this problem, the following question can be posed: How should the points P, Q, R be arranged so that as a result of the section, a triangular straight prism with volume $\frac{abc}{36}$ is obtained?

Comparison sets the stage for analogy. Students, bearing in mind the questions posed, as well as analyzing the conditions of this problem, note the following: if the P, Q, R points are respectively located at the vertices of the B, B_1, D_1 of this prism, and therefore the PQR plane is a diagonal plane, then the volume of the sought triangular prism will be $V = \frac{abc}{2}$. Hence, students conclude that the area of the base of the desired triangular prism should be less than the area of the triangle ΔABD.

Further, analyzing the algorithm for solving problem 3, by analogy, students come to the conclusion that the PQR plane will be parallel to the rib AA_1. Choosing various options, they find that $\mathrm{PA_1} = \frac{\mathrm{A_1B_1}}{3} = \frac{\mathrm{a}}{3}$, $\mathrm{QA_1} = \frac{\mathrm{A_1D_1}}{6} = \frac{\mathrm{b}}{6}$. In this case $\mathrm{S_{PQA_1}} = \frac{\mathrm{ab}}{36}$, and the plane PQR will be parallel to

the rib AA_1 (Figure 3). Then the volume of the desired straight triangular prism will be $V = \frac{abc}{36}$.

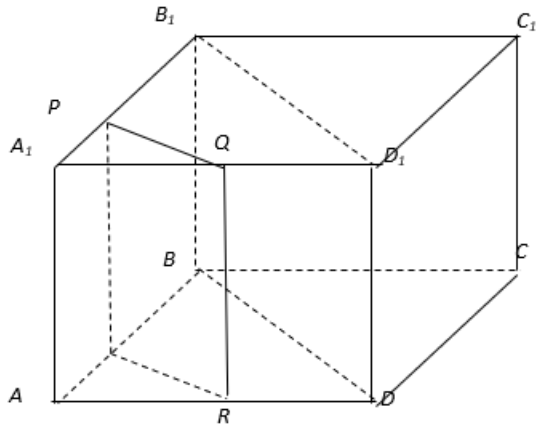

Figure 3. PQR plane parallel to the rib

After that, the following question can be posed to this problem: Do you think this problem is solvable in the only way? Generalizing the result, students easily conclude that the problem has many solutions. Thus, the process of constructing the required plane section of a polyhedron, discussing the solution of these problems form and develop students' mathematical reasoning, critical, divergent, algorithmic thinking, communication, reflection, research skills (skills of the 21st century), contribute to the development of polytechnic knowledge, spatial representation.

After that, students can be offered tasks that can be solved observing all of stages of solving problems on the construction flat-sections. As already noted, solving problems on the construction usually includes next stages: analysis, construction, proof, research. Each of these stages shape and develop critical thinking and 21st century skills.

3. At the activity stage of training, it is necessary to organize the educational activities of future teachers, through which they have form and develop professional skills and abilities:

For the formation and development of these professional qualities of the future mathematics teacher, authors use the activity-based approach. This approach is based on a problem-based teaching method. The essence of the problem-based teaching method is that students are assigned tasks that require a creative approach to solving the problem. So, for example, to solving next problem requires creativity.

Example 5. Is it possible to construct a flat section of the pyramid $ABCS$ by the plane π, given by the points M, N, lying in the inner part of the faces ACS, ABS respectively, and by the point $K \in AB$?

To solve this problem, you can offer work in pairs. As you know, students consciously assimilate that teaching material, which, when studied and consolidated, are discussed, spoken and explained to others. Students, working in pairs, choose an algorithm and methods for solving the problem.

4. At the value-personal stage of training, authors suggest using famous technologies for the formation of universal human values: an interactive conversation between the professor and future teachers about the main aspects of pedagogical activity; the dual method of forming the values of the teaching profession.

5. At the reflexive stage of training, based on the essence of reflection, authors propose the following algorithm for organizing reflection:

– stopping the process of cognitive activity;

– recreating the algorithm of already committed actions in orally or in writing form;

– analysis of the algorithm of already committed actions, identification and assessment of its productivity end usefulness, determination of the conformity of actions to the set educational goal;

– determination of the results of reflection.

Before solving a particular educational problem, it is useful to carry out reflection motivational state on the learning. The following is an educational task for independent work.

Example 6. Construct a section of the pyramid $ABCS$ by the plane π, specified by the inner point $N \in BS$ and points M, K located in the inner part of the SDC, ADS faces, respectively.

Reflection gives:

– to evaluate the effectiveness of using the mixed method for constructing sections of polyhedrons (using the method of central projection, properties of lines and planes);

– the possibility of comprehending the importance of each stage of constructing sections of polyhedrons;

– the possibility of establishing the level of assimilation of the content of the algorithm for solving the problem (for example, I did not know this, but now I already know, and I learned of this more deeply, etc.);

– to restore the known definitions, statements, properties in memory.

Thus, reflection takes an important place in the implementation of the educational process.

Discussion

The results of the study demonstrate that there are many approaches to creating successful teacher education not only in PISA leader countries. This mainly stems from cultural as well as structural differences between countries. It can also be argued that PISA-oriented competencies are taught by future teachers in a broader list of offerings. In various countries, efforts are being made to prepare and train future teachers to impart both scientific and professional knowledge to students.

In modern conditions, digitization occupies a key place, which makes it necessary to study information and media literacy in pedagogical education. During the period of the pandemic, due to the spread of COVID-19, the relevance of Internet information resources, digital media, etc. in the context of education has increased. In this direction, the introduction of school internships became important, the integration of mentoring at the stage of transition and the formation of a structured educational program in the conditions of continuous work became an actual topic for detailed scientific research and also the possibility of adaptation in the specified area.

The analysis of scientific research on the subject of functional literacy of students contributes to the development of pedagogical professional competence.

Improvement of the teacher's competencies becomes possible when a single system of methodical base for pedagogical activities is formed. Competences of teachers in the conditions of new requirements for the level of quality of school education should also provide conditions for the development of functional literacy of all participants in the educational process and, above all, students. Monitoring works in the direction of formation of functional literacy continue to be implemented. It was in 2021 that for the first time in the PISA studies, according to the leading components, an assessment of creative thinking was introduced. Then this field became one of the additional elements in the monitoring of functional literacy.

Summarizing the outlined characteristics, the authors M. Doil and V. Pietzner [22] in their scientific study devoted to a systematic review of the structure of the education of natural science teachers and the construction of pedagogical education in PISA-leading countries came to the conclusion that in the content of the training of future teachers for the professional sphere, an important place occupy such qualities of a teacher as personal, professional and cognitive. Also, the formation of the assessment of these qualities contributes to ensuring a certain level of acquired skills, thinking and activity abilities, motivational approach of future teachers in the context of PISA, which helps in achieving high success in the professional field. According to the results of the research, it can be said that the opinions coincide, because it was found that the success in the students' performance of the multifaceted PISA tasks directly depends on the quality of the students' mathematical thinking, their interdisciplinary knowledge, technical skills, the formation of their general perception and spatial thinking. It is also worth noting that the professional competence of the future teacher is developed and improved by epistemological, axiological and praxeological factors of readiness.

It is also worth agreeing with the opinion of scientists N. E. Susilowati et al. [23], who in their work, the essence of which was to study the creative thinking of PISA-2021 students, that value relations are a very important feature of personality, because reveals its relation to high human values, namely to man, society, life, knowledge, skills, activity, nature, etc. This is so, because in the educational space and in the process of educating students, value attitudes act as a key guide in the organizational activities of students who are faced with a choice, as well as an assessment of the listed personal values.

The authors C. Viac and P. Fraser [24] studied the well-being of teachers and write that active, problem-based, interactive, algorithmic approaches to student learning have a great influence on the motivation of teachers. It is with the help of such approaches that the teaching staff encourages students to carefully study the given material. It is necessary to agree with the stated opinion, since the implementation of motivation in a certain teaching method is carried out through a number of methods, for example, regarding the choice of the type of activity, drawing up algorithms, solving problems and analyzing their formulation, clarifying difficult questions and formulations, organizing conversations for the purpose of discussing and solving problem situations with using the acquired knowledge in practice and performing certain activities in training conditions. There is also an incentive here for the possibilities of using techniques that consist in the use of visual images.

According to the study by K. H. Weng and G. T. Eng [25], the essence of which was to analyze the development and renewal of innovations in mathematics and science education outside of PISA, the concept of mathematical competence is considered as the ability of a person to apply mathematical knowledge in real conditions, to understand in detail the structure and method of mathematical modeling, create mathematical models, investigate them, interpret the obtained result, etc. In this context, the conclusions of the authors coincide with the statements of the results, since the purpose of the PISA program for the assessment of mathematical literacy is to create indicators that demonstrate the level of effectiveness of the country in preparing pupils and students to use mathematics in various directions, for example, in personal, professional or social activities. This is why PISA has developed a mathematical literacy program and a framework for multifaceted competency testing.

Comparing the results of the author M. U. Balagtas [26] in the study of mathematics and science education in the context of PISA with the data obtained in the conducted study, it is possible to highlight the aspect of creative competence, which involves creative innovative activity, the formation of new proposals and value meaning. Creative competence is determined by the level of quality of the expected result in learning, internal motivation for cognitive activity and specific educational goals. Creativity in professional training involves the formation of new professional results by the student.

Scientists L. T. Wu et al. [27] in a scientific paper devoted to the study of technology integration in mathematics lessons, concluded that the tools that shape the process of reflection are the means of mathematics. In the direction of mathematical activity, the law of dialectics is widely revealed, therefore, mathematics can be considered from the perspective of the theory of knowledge.

The use of contextual tasks that meet the requirements of PISA international standards in the educational process are not only a method of forming students' mathematical literacy, but also a means of improving teachers' competencies. Completing tasks related to functional literacy forms the skills of assimilating mathematical knowledge, mathematical modeling, etc. Solving such tasks contributes to the student's success in adult life. The concept of scientific, information and media literacy courses require detailed scientific research.

Conclusions

To prove the effectiveness of the developed model of the process of forming the readiness of future mathematics teachers to teach schoolchildren, a diagnostic event was carried out. In order to identify the level of students' readiness to teach schoolchildren, written work was carried out. The analysis of the written work performed by the students revealed that 84.6% of the students mathematically correctly constructed a flat section of a straight prism and a regular pyramid. At the same time, 71.3% of students showed thinking abilities at a high level,

the remaining 28.7% showed thinking abilities at an average level.

Analysis of the coefficients of the readiness formation of future mathematics teachers showed that 72% of students have sufficient abilities to reflect on the activities of schoolchildren, 81% of students have the ability to apply pedagogical approaches to teaching schoolchildren in methods of constructing sections of polyhedrons, to solve problems on the construct flat-section of polyhedrons, to organize own pedagogical activities, and also the educational activities of schoolchildren. The analysis of the results of the questionnaires showed that 71% of students have formed a motivation to carry out educational and cognitive activities at a professional level, and 67% of students have formed value attitudes towards the individual, the environment and society at a professional level.

The results obtained prove the effectiveness of the developed model of the process of forming the readiness of future mathematics teachers to teach schoolchildren, the formation and development of their pedagogical qualities, skills of the 21st century, mathematical reasoning, spatial representations and divergent thinking.

Considering the learning process as a field of activity for the formation of components of the readiness of a future teacher of mathematics, authors have identified the motivational, cognitive, activity, value-personal, reflexive stages of the process of forming the readiness of future teachers to teach schoolchildren. On the example of constructing a plane section of polyhedrons, construction a model of the process of formation and development of professional readiness of future teachers in teaching schoolchildren, developing their mathematical reasoning, spatial representations, divergent and algorithmic thinking, skills of the 21st century as an integral system is constructed.

The results obtained can be used in the process of formation of readiness for all future teachers to teach schoolchildren, regardless of the content of the educational program and predetermine the direction for further research in the theory of designing the content of academic disciplines, are of great practical importance in the process of forming the professional qualities of future teachers.

Note that the complexity of the widespread use of the methodology for teaching future mathematics teachers to construct of cross-sections of polyhedrons is the absence system of problems in the school geometry course for constructing a sections polyhedron, the cumbersomeness of their constructions, a relatively large expenditure of time, necessary for teaching students and schoolchildren how to solve such problems.

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Conflict of Interest

None.

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Модель процесу формування готовності майбутніх учителів математики до навчання школярів у контексті концепції PISA-2021

Куаниш Нурпейсов
Жетисуський університет
040009, вулиця Жансугурова, 187А, м. Талдикорган, Республіка Казахстан

Дуйсебек Нургабил
Жетисуський університет
040009, вулиця Жансугурова, 187А, м. Талдикорган, Республіка Казахстан

Анотація

Актуальність. Актуальність теми дослідження полягає в тому, що навчальні задачі з геометрії сприяють формуванню та розвитку розумових здібностей, просторової уяви, які необхідні в логістиці, архітектурі та будівництві, машинобудуванні, картографії та інших галузях прикладної науки.

Мета. Метою дослідження є вивчення стану підготовки майбутніх учителів математики в напрямі реалізації концепції PISA-2021.

Методологія. Серед теоретичних методів дослідження використовувалися аналіз і синтез, метод порівняння та узагальнення. На етапі емпіричної частини було проведено експериментальне педагогічне дослідження на базі трьох університетів Казахстану.

Результати. У статті розглядається питання проектування навчального процесу в контексті формування готовності майбутніх учителів математики до здійснення педагогічної діяльності. Визначено систему змістових компонентів загальної готовності майбутнього вчителя до навчання школярів. Виявлено ознаки та етапи формування готовності майбутніх учителів математики до навчання школярів у контексті концепції PISA-2021. Побудовано модель процесу формування професійної готовності майбутніх учителів математики до навчання школярів у контексті становлення та розвитку їх математичного мислення, просторових уявлень та дивергентного мислення навичок 21 століття.

Висновки. Дослідження підтверджує ефективність нової моделі підготовки майбутніх учителів математики, демонструючи високий рівень володіння студентами математичними та педагогічними навичками, водночас відзначаючи потенціал для ширшого застосування та виклики у впровадженні через обмеження чинної шкільної навчальної програми.

Ключові слова: компоненти готовності; етапи навчального процесу; мисленнєві здібності; геометричні задачі; переріз многогранників.