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DEVELOPMENT OF ALGORITHMIC COMPETENCE OF STUDENTS IN MATHEMATICS LESSONS USING INFORMATION AND COMMUNICATION TECHNOLOGIES

Abstract. This article provides a brief overview of scientific works, the authors of which conduct research in the field of education aimed at developing the algorithmic competence of students in teaching mathematics. The main objective of the study is to show the importance of developing students' algorithmic competence with the help of information and communication technologies (ICT). And also, the concept and formation of algorithmic competence in mathematics classes through ICT is considered. A detailed solution of the problem with the development of an algorithm is described. The proposed model for solving problems in mathematics will be useful for the development of mathematical literacy of students and literacy of students in the field of ICT. The elements of the author's methodology of teaching the subject "mathematical literacy" using the algorithmization of the educational process are presented. The proposed teaching method contributes to the development of intuition, logic in students, students are not afraid to make mistakes, expressing their answer, their point of view. The idea is substantiated that the development of algorithmic competence in students in mathematics lessons through ICT remains relevant today, as this is emphasized by international studies under the PISA program (Programme for International Student Assessment), which assesses mathematical literacy and literacy in the field of information and communication technologies. The ability to create, apply and transform signs and symbols, models and schemes to solve educational, cognitive and practical problems, as well as evaluate the results obtained is a necessity for the digitalization of modern life.

Keywords: algorithmic competence, mathematical literacy, ICT literacy, teaching mathematics, information and communication technologies.

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Математика сабақтарында ақпараттық-коммуникациялық технологияларды пайдалану арқылы оқушылардың алгоритмдік құзыреттілігін дамыту

Аңдатпа. Бұл мақалада білім беру саласында студенттердің математиканы оқытудағы алгоритмдік құзыреттілігін дамытуға бағытталған зерттеулер жүргізетін ғылыми еңбектерге қысқаша шолу жасалады. Зерттеудің негізгі мақсаты – ақпараттық-коммуникациялық технологиялардың (АКТ) көмегімен студенттердің алгоритмдік құзыреттілігін дамытудың маңыздылығын көрсету. Сондай-ақ, математика сабақтарында АКТ арқылы алгоритмдік құзыреттілік ұғымы мен оның қалыптасуы жайлы қарастырылады. Алгоритм құру арқылы есептің егжей-тегжейлі шешімі сипатталған. Математикадан есептер шығарудың ұсынылып отырған моделі оқушылардың математикалық сауаттылығын және АКТ саласындағы оқушылардың сауаттылығын дамыту үшін пайдалы болады. Оқу үдерісін алгоритмдеу арқылы «математикалық сауаттылық» пәнін оқытудың авторлық әдістемесінің элементтері берілген. Ұсынылып отырған оқыту әдісі оқушылардың өз жауабын, өз көзқарасын білдіріп, қателесуден қорықпай, интуициясын, логикасын дамытуға ықпал етеді. АКТ арқылы математика сабағында оқушылардың алгоритмдік құзыреттілігін дамыту бүгінгі күні өзекті болып қала береді деген идея негізделеді, өйткені бұл математикалық сауаттылық пен ақпараттық-коммуникациялық технологиялар саласындағы сауаттылықты бағалайтын PISA бағдарламасы (Programme for International Student Assessment) шеңберіндегі халықаралық зерттеулерде ерекше атап өтілген. Оқу, танымдық және практикалық мәселелерді шешу үшін белгілер мен белгілерді, модельдер мен сызбаларды жасау, қолдану және түрлендіру, сондай-ақ алынған нәтижелерді бағалау қазіргі өмірді цифрландырудың қажеттілігі болып табылады.

Кілт сөздер: алгоритмдік құзыреттілік, математикалық сауаттылық, АКТ саласындағы сауаттылық, математиканы оқыту, ақпараттық-коммуникациялық технологиялар.

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Развитие алгоритмической компетенции учащихся на уроках математики с использованием информационно-коммуникационных технологий

Аннотация. В данной статье приводится краткий обзор научных работ, авторы которых проводят исследования в сфере обучения, направленного на развитие алгоритмической компетенции учащихся при обучении математике. Основная задача исследования – показать важность развития у учащихся алгоритмической компетенции с помощью информационно-коммуникационных технологий (ИКТ). А также, рассматривается понятие и формирование алгоритмической компетенции на занятиях математики посредством ИКТ. Описано подробное решение задачи с составлением алгоритма. Предложенная модель решения задач по математике будет полезна для развития математической грамотности учащихся и грамотности учащихся в сфере ИКТ. Представлены элементы авторской методики преподавания предмета «математическая грамотность» с применением алгоритмизации учебного процесса. Предлагаемая методика преподавания способствует развитию интуиции, логики у учащихся, ученики не боятся ошибиться, высказывая свой ответ, свою точку зрения. Обосновывается мысль о том, что развитие алгоритмической компетенции у учащихся на уроках математики посредством ИКТ остается

актуальной на сегодняшний день, так как это подчеркивается международными исследованиями по программе PISA (Programme for International Student Assessment), где оцениваются математическая грамотность и грамотность в сфере информационно-коммуникативных технологий. Умение создавать, применять и преобразовывать знаки и символы, модели и схемы для решения учебных, познавательных и практических задач, а также оценивать полученные результаты – это необходимость цифровизации современной жизни.

Ключевые слова: алгоритмическая компетенция, математическая грамотность, грамотность в сфере ИКТ, обучение математике, информационно-коммуникационные технологии.

Introduction

Modern innovations in education and economy, changes in the labor market necessitate cause the possession of skills that can allow students to analyze and evaluate the situation, information for solving problems, creatively use existing knowledge and experience to gain new knowledge. The skills of mastering information and communication technologies become relevant [1].

In 2017, Kazakhstan became a member of two relevant OECD committees – the Committee on Education Policy and the Committee on Science and Technology Policy, which indicates the international recognition of the achievements of the Kazakh education system.

However, in the domestic system of education and science there are a number of topical issues that need to be addressed. According to the results of the OECD Program for the International Assessment of Adult Competences (16–65 years old) (PIAAC), Kazakhstan ranked below average in numeracy and information and communication technology literacy.

The results of an independent examination in assessing the knowledge of graduates in mathematics, the results of international studies (PISA) highlighted a number of problems. In particular, difficulties were found in solving problems of a practical nature, where mathematical knowledge and skills should manifest themselves in any context. In other words, students experienced difficulties in building mathematical models, drawing up action algorithms, and transferring a known solution method to new conditions.

Nowadays, there remains a need to create pedagogical conditions and technologies that ensure the formation of skills to apply knowledge in non-standard situations. Therefore, active search for new ways and means to form and develop initiative, flexibility of thinking, independence, and the ability to transfer knowledge into the field of practical activity is existing [3].

Research methods

Research methods: general didactic teaching methods (methods for the formation of new knowledge and skills, methods of consolidation, methods of control), analysis, math modeling. The object of the study is the process of teaching mathematics at the senior level of general education. The subject of the research is the method of teaching the algorithmization of students in mathematics lessons using information and communication technologies.

Results and Discussions

The purpose of the study is the methods of forming students' algorithmic competence by the use of information and communication technologies in mathematics lessons.

Algorithmic thinking skills can be considered one of the necessary skills for everyone in modern world. Individuals and society live at a time when they cannot abandon the use of information and communication technologies (ICTs). Thus, they must be ICT literate [3, p.571].

Algorithmic competence is a constituent component of competence in the field of information and communication technologies (ICT competence). The concept of «algorithmic competence»,

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presented in the works of L.N. Udovenko, Yu.V. Korchemkina, V.V. Kalitina, M.V. Kondudar can be summarized as the ability to create an algorithm and implement it as a software product [4, p.19].

Based on the approaches to the concept of «competence», presented in the works of I.A. Zimney, A.V. Khutorsky, B.S. Gershunsky, it is possible to clarify the concept of «algorithmic competence».

Algorithmic competence is a set of knowledge of the main algorithms of the course being studied and the ability to use them in solving problems of a certain range, the ability to combine known algorithms and create new ones, the willingness to apply the algorithmization process in various subject areas [5, p.21]. In the process of teaching mathematics, the formation of algorithmic competence is dynamic in nature, subject to the principles of «continuity, systemacity, succession and staging».

The analysis of the literature showed that the improvement of the process of teaching students through algorithmization was reflected in the studies of I.N. Antipova, V.A. Dalinger, V.M. Monakhova, Yu.A. Makarenkova, M.P. Lapchik and others L.N. Landa first introduced the definition of an algorithmic approach to learning. The problems of forming the foundations of algorithmic culture were the subject of research by foreign teachers (R. Kaiser, A. Speck, G. Krummerheuer, S. Kaune, P. Kadunts), who analyzed the educational potential of various subject areas - mathematics, physics, chemistry, geography, cultural studies, pedagogy and psychology [2, p. 8].

Popova V.V. [5, p. 41] in his study studies the formation of algorithmic competence of students - future ICT specialists.

The article by Çetin Güler [3, p. 580] deals with the skills of algorithmic thinking without computers. Korchemkina Yu.V. [6] in her study analyzes the possibility of using an algorithmic approach in teaching linear algebra to students with advanced study of computer science and its impact on the formation of professional competencies of future bachelors.

We are close to the position of L.N. Udovenko [7], where the methodological possibilities of the competence-based approach of the methodological base in the development of the algorithmic content-methodological line in school mathematics are considered. The author identified four levels of algorithmic competence development. Through comparison, the article provides their distinction, describes the nature of the manifestation of algorithmic competence at each level. The differences between the logical-algorithmic and creative levels from the subject and attributive ones, as well as the ways of forming algorithmic competence are indicated.

The theoretical analysis of the study and educational practice made it possible to highlight the following key points:

- firstly, the development of algorithmic competence in students in mathematics classes through ICT remains relevant today, which is emphasized by international studies under the PISA program (Programme for International Student Assessment), which assesses mathematical literacy and literacy in the field of information and communication technologies;

- secondly, the ability to create, apply and transform signs and symbols, models and schemes to solve educational, cognitive and practical problems, as well as evaluate the results obtained is the need for the digitalization of modern life.

Popova V.V. proposes teaching mathematics in such a way that the result of solving a problem, depending on its nature or practical purpose, the student could receive not only in the form of a number, formula or graph, but also, if possible, in the form of an algorithm or a block diagram of an algorithm. This method of developing algorithmic competence can be adapted for school students [5, p.119].

So, when studying a certain topic, you can tell students from the very beginning that the result of their work (including independent work) should be an algorithm for solving a certain type of problem. It is necessary to draw the attention of students to the fact that they will have to not only solve the proposed problems, but also formalize their reasoning in the form of an algorithm,

consider possible solutions, summarize and analyze the results obtained. In order to master the topic under study, the teacher needs not only to teach the student to solve problems of a particular type, but also to recognize many of these problems in real life and apply the resulting algorithm in practice.

We offer students a task: to write an algorithm and solve a problem. "The section of the tunnel with a perimeter of 18 meters should have the shape of a rectangle, completed with a semicircle. Find the radius of the semicircle at which the cross-sectional area of the tunnel will be the largest.

Consider the compilation of an algorithm and the solution of this problem.

To solve this problem, it is advisable to build a drawing Figure 1 so that students can clearly see and understand what is being said.

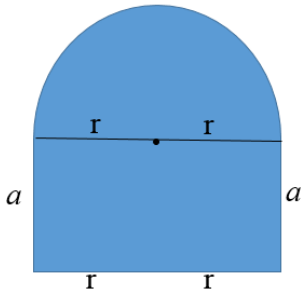

Figure 1 – Schematic representation of the tunnel

1. Consider the figures that make up this figure and write down the perimeter. The first figure is a semicircle, the second figure is a rectangle. $C_{semicircle}=\pi r$; $P_1=2r+2a$, where P_1 is the perimeter of the rectangle, excluding one side, r is the radius of the semicircle, and a is one of the sides of the rectangle. Then, $P_{figures} = \pi r+ 2r+2a$, hence we express a.

We have $a = \frac{P-r(\pi+2)}{2}(*)$.

2. Let's make the dependence of the cross-sectional area of the figure on the radius

$S(r)= \frac{\pi \cdot r^2}{2} + 2ar$.

3. In the equality S(r), we replace $S(r) = \frac{\pi \cdot r^2}{2} + 2ar, a = \frac{P-r(\pi+2)}{2}$, using equality (*).

$S(r)= \frac{\pi \cdot r^2}{2} + 2r\frac{P-r(\pi+2)}{2}$. Simplify and differentiate the resulting equality.

We get $S'(r)= \pi r+P- 2r(\pi+2)$

4. Solve the equation $S'(r)=0$, i.e. $\pi r+P- 2r(\pi+2)=0$, relatively to r.

5. Solving this equation, we have $r=\frac{P}{4+\pi}$

6. Substitute the known value P=18m from the condition of the problem, we get $r=\frac{18}{4+\pi}$, $r\approx 2{,}5$m.

Approximate student response (algorithm):

1. Consider the figures, write down the formula for finding the perimeter.
2. Compose the dependence of the cross-sectional area of the figure on the radius.
3. Differentiate and solve the resulting equation.
4. Substitute the known data of the problem and find the desired value.

In the course of solving this problem, it is possible to discuss such properties of algorithms as mass character, certainty, and effectiveness, emphasize the convenience of using the algorithm, and identify the main difficulties that arose during its compilation. For the formation of algorithmic competence, it is important to observe the principle of staging, that is, in the learning process, based on the level of preparedness of students, rely on their capabilities and take into account the speed of assimilation of the material.

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Work is carried out frontally. Colored zones (green, yellow, red) have been prepared in advance for recording (or attaching) student responses. In the green zone, we will add student options that are proposed to follow when solving the problem. The teacher asks the opinion of each student, the opinion of the majority is taken into account. However, individual responses are not excluded. In the yellow zone we will transfer the answers of students (2–3 answers) which, according to the students, are the closest to the true answer of this task. In the red zone from the yellow, we will transfer the correct answer.

The task condition can be displayed on the screen using a projector. Students learn to work with information presented in various forms (text, tables, diagrams, scheme, pictures, drawings).

With the help of the proposed methodology, the algorithmic competence of students is developing in the study of mathematics, by working out step-by-step actions.

1. The teacher reads the problem, showing the importance of each word, drawing the students' attention to the fact that all the words from the condition carry a certain meaning.

2. Students are invited to read the problem, given time to think about the solution. Students try to select the necessary data if the task contains redundant information.

3. Students solve a problem, simulate a situation, think, sort out possible solutions, use the trial and error method, offering their own solution (algorithm or flowchart), all student answers are recorded (or attached if working with stickers) on a green zone.

4. The teacher, together with the students, analyze all the solutions (algorithm or block diagram) that are in the green zone, selecting 2-3 solutions (algorithm or block diagram) that most satisfy the solution of the problem, and these solutions (algorithm or block -scheme) are transferred to the yellow zone.

5. Analyzing the solutions (algorithm or flowchart) that are in the yellow zone, together with the students of the class, the correct solution (algorithm or flowchart) is determined that satisfies the condition of the problem and write it down in the red zone. As homework, we offer students a solution to problems, taking into account the division of students into groups of humanitarian and natural-mathematical areas. Moreover, the condition of the tasks of an easy degree of difficulty will be written on green sheets, of an average degree of difficulty – on yellow sheets, of a high degree of difficulty – on red sheets. When checking homework, it will be clearly seen how the quality of students' knowledge is growing. That is, the more yellow and red sheets during the test, the higher the quality of knowledge.

After the qualitative development of tasks, a real improvement in the quality of students' knowledge, you can move on to individual tasks.

The tasks are distributed as follows, as shown in Table 1 (Table 1).

Table 1 – Distribution of tasks by difficulty levels, depending on the execution time

Class, direction		**Time to complete one task**
1	**2**	**3**
Humanitarian	Natural-mathematical	
Number of tasks of easy complexity (%)		Up to 2 min
50	20	
Number of tasks of medium complexity (%)		2 min
30	30	
Number of tasks of high complexity (%)		More than 2 min
20	50	

After the qualitative development of tasks, a real improvement in the quality of students' knowledge, you can move on to individual tasks. To determine the degree of difficulty of the task

and the time it takes to solve it, there is a base for preparing for the UNT, where using the program in the filter you can set the required time spent on solving one problem and get a selection of tasks.

The proposed method of teaching mathematical literacy contributes to the development of intuition, logic in students, students are not afraid to make mistakes, expressing their answer, their point of view. Also, the advantage of this type of work is that all students in the class can be involved in active mental work. Periodically, with such work, you can use a survey with a delayed response. With such a survey, after the question, a pause is maintained for 30–40 seconds. This allows you to respond not only to those who think quickly. Delayed reaction helps to attract to work and less energetic students, who take a passive position in the usual survey.

To apply this technique in the work of a teacher, you can use information and communication technologies (ICT):

First, prepare a Microsoft Power Point presentation with the condition of the tasks that will be solved in the lesson.

Secondly, using the capabilities of ICT, divide the slide displayed on the interactive whiteboard into three parts, depicting a green, yellow, red zone for recording the solution (answer) of the problem.

Thirdly, after writing down the options for solving the problem in the green zone, the desired answers can be copied and transferred to the yellow zone. Repeat the same for the red zone.

We will conduct classes according to the proposed method in the form of an experiment with two groups of children. With the first group, consisting of n people, a scheme for solving problems will be analyzed, problems will be solved, including applied ones, without compiling an algorithm and using a computer. In the second group, numbering m people, the same thing will be done (perhaps in a smaller volume), but in addition it will be necessary to create an algorithm for solving problems and propose to solve part of the problems using the Mathcad package. Mathcad is a computer algebra system from the class of computer-aided design systems, focused on the preparation of interactive documents with calculations and visual support, it is easy to use and apply for teamwork. Then a verification work was carried out, composed of three levels of complexity: basic, medium and advanced. When solving problems, students will have the opportunity to use a computer. Students who are able to create algorithms, use them and apply computer programs will certainly show interest in tasks of increased complexity, while achieving certain results [8].

It cannot be argued that it is advisable to accompany the teaching of the entire mathematics course at school with algorithmization and the use of computer programs, but even small inclusions of algorithms in the educational material and providing students with the opportunity to use ICT in the classroom improve the quality of teaching mathematics and increase students' motivation to learn. The use of flowcharts in mathematics classes not only allows you to present the progress of solving the problem in a visual form, but also obliges students to take a more responsible approach to the solution: think through each step, consider possible solutions, optimize the process and critically evaluate the result. The ability to formulate one's reasoning and the course of a decision in the form of an algorithm or a flowchart of an algorithm is a necessary component of the development of algorithmic competence.

Of the two existing methods of teaching algorithms (communication of ready-made algorithms; leading students to discover the necessary algorithms on their own), the latter is a variant of the heuristic method of teaching and is a description of the teacher's teaching activity with the help of instructions, rules, sequences of actions of an algorithmic type, with the help of which the teacher solves certain didactic problems [9].

Conclusions

In conclusion here are the main points: when organizing teaching mathematics in the proposed way, the formation of algorithmic competence accompanies the entire process and does not require a radical revision of the content of the educational material, allowing the teacher to work

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within the framework of the curriculum and in the amount of hours allocated for its assimilation. In the future, the following directions are possible: studying the methodology for developing the algorithmic competence of students through ICT, introducing the developed methodology into the educational process of the subject of mathematics, conducting training seminars and master classes for mathematics teachers in order to improve the quality of teaching in school education [10].

In developing students' mathematical knowledge, the teacher may ask students to explain and discuss various solution methods, verbally link representations and concepts, present mathematical situations in different ways, and invent their own procedures. For computational procedures to be efficient, accurate, and correct, it is important that the teacher pays attention to student understanding and that students have time to practice. To develop flexibility in mathematics, teachers may challenge students with non-standard problems for which they do not immediately recognize the appropriate solution method. Students may also find it helpful to focus on multiple approaches to these non-routine problems. It includes calling on students to explain, justify, and prove solution methods, problem solving, and mathematical results. When dealing with problems in context, the teacher can offer confirmation of the authentic aspects of the problem. Students can also participate in discussions about the authenticity of various aspects of contexts. The contexts used may come from life outside of school and may not initially have an educational purpose in terms of practicing math skills. However, assignments can offer new insights and knowledge about the contexts they are in, whether real world contexts or cross-curricular contexts.

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