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Development of the Personalized Model of Teaching Mathematics by Means of Interactive Short Stories to Improve the Quality of Educational Results of Schoolchildren

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Abstract

The problem which is solved by this research is due to the need to resolve the contradiction between the requirements of the modern economy for the quality of mathematics training of future specialists and an insufficiently developed methodological base for training graduates that meets these requirements.

The aim of the study is to theoretically substantiate and experimentally test the effectiveness of the personalized model of teaching mathematics by means of interactive shorty stories to improve the quality of educational results of schoolchildren.

The research methodology is the analysis and generalization of literature on the problems of improving the quality of mathematics education, the use of digital technologies to personalize learning. The following empirical methods were used: observation, analysis of the results of work in the AXMA Story Maker application (choice of answer, number of attempts to find a solution, read publications, etc.). In the experiment the Fisher criterion was used to process the results.

Research results. The work clarifies the essence of the concepts “personalized learning model”, “visual short story” and highlights the didactic functions of interactive short stories in relation to mathematics education. The authors described directions of activities at mathematic, in which the personalized educational model is a condition for the successful implementation of

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personal trajectories.

The conclusion summarizes the features that should be taken into account when designing the personalized learning model: correlating the didactic purpose and the result of work in the nonlinear environment, choosing a plot for a short story, personalized trajectory of cognition, etc.

Keywords: mathematics education, digital technologies, interactive environment, visual short story, personalization of learning, AXMA Story Maker.

1. Introduction

1.1. The relevance of the problem

The relevance of the presented study is due to the following factors:

1. The educational policy of the modern digital school is aimed at improving the quality of education. In particular, the provisions of the federal law "On Education in the Russian Federation" establish that distant technologies and e-learning can be used in the implementation of educational programs, including mathematics (Karakozov, Ryzhova, 2019). In the context of introduction of the state standard of basic general education, which takes into account the principles of the system-activity approach, the use of interactive technologies acquires particular relevance (Aleksandrov et al., 2017).

2. Mathematics education is an integral part of general education. Mathematics, which is reasonably proved by A. S. Kotyurgina et al. (Kotyurgina et al., 2020), is one of the basic subjects at school, it supports the study of other disciplines (physics and mathematics, humanitarian, etc.). In modern conditions a certain amount of fundamental mathematics knowledge, knowledge of mathematics methods are becoming compulsory elements of the culture of the nation. In addition, learning mathematics performs developmental functions: intellectual skills, which are necessary for any person, regardless of what field of the activity the person will be engaged in the future, are formed.

3. In the theory and methodology of teaching mathematics, according to E.A. Perminov, D.D. Gadzhiev, M.M. Abdurazakov (Perminov et al., 2019), much attention is paid to the search and implementation of new methods and means for high-quality training of graduates of secondary schools to consciously use mathematics knowledge and skills necessary for their future professional activities, and the formation of holistic ideas about this science as part of the common human culture.

4. Modern education analysts at the Higher School of Economics under the leadership of L. L. Lyubimov are developing the author's Concept for the Modernization of Education and believe that the new society needs people who can independently make decisions, ... predict their possible consequences" (Lyubimov, 2020). The inclusion of interactive digital means in the educational, cognitive, mathematics activities of students should contribute not only to increasing academic performance in mathematics, but also to contribute to the holistic development of the personality, the realization of creative abilities and cognitive interests of each student (Galimova et al., 2019).

In other words, innovative pedagogical technologies and modern digital resources should be the basis of the information educational environment that takes into account individual personality traits. N.I. Isupova, T.N. Suvorova argue that in the modern personified educational space, digital resources should complement and expand the range of educational and cognitive influences, enrich cognitive practice, and promote the mastery of the culture of thinking (Isupova, Suvorova, 2018).

Such thinking, according to M. Novitasari et al., is most in demand in the modern society (science, industry and economics), since the corresponding intellectual activity supports decision-making in an uncertain future (Novitasari et al., 2020). The visual component of interactive media affects visual and emotional memory (Olefirenko et al., 2019).

Thus, there is a practical need for the use of interactive digital tools to improve the quality of teaching mathematics in the personified educational space.

1.2. Research purposes and objectives

The purpose of the study is determined from the need to study the features of the development of a personalized model of teaching mathematics by means of interactive short stories to improve the quality of mathematics education.

The following were identified as the main objectives:

– to clarify the essence of the concepts: "personalization of learning", "personalized learning model", "visual interactive short story" in the context of the requirements of the digital school;

– to describe the didactic potential of AXMA Story Maker as a visual interactive short story development tool;

– to design a personalized environment for teaching mathematics based on interactive short stories, focused on improving the quality of educational results of schoolchildren;

– to describe the directions of the cognitive activity of schoolchildren in the AXMA Story Maker environment;

– to present the system of the teacher's work on the structure of the visual interactive short story, its text (task) component;

– to experimentally test the effectiveness of the developed teaching methodology by means of interactive short stories to improve the quality of mathematics education of specialists of the future.

2. Relevance

2.1. Literature review

The analysis of Russian and foreign scientific works on the research problem is carried out in three directions:

1) search for new methods and means in teaching mathematics to improve the quality of mathematics education;

2) identifying the didactic potential of digital technologies to support the personalization of teaching mathematics;

3) generalization of the experience of using modern interactive methods and tools when teaching mathematics.

2.1.1. Analysis of Russian scientific and pedagogical literature

The inclusion of interactive short stories and educational quests in the cognitive activity of students are current directions for the development of the didactic system (Karavaev, Soboleva, 2017). E.A. Perminov, D.D. Gadzhiev, M.M. Abdurazakov also conclude that in the general system of knowledge there is an increase in the importance of mathematics, the penetration of mathematics models and methods into various spheres of human life (Perminov et al., 2019). In these conditions in the theory and methodology of teaching mathematics it is necessary to pay more attention to preparing graduates of a general education school for the use of mathematics knowledge and skills which are necessary for their future professional activities and the formation of ideas about this science as part of a common human culture.

N.A. Urvanova notes that high-quality teaching mathematics in the digital school presupposes the active inclusion of interactive digital means in educational and cognitive activities of students (Urvanova, 2018). Their choice and application should contribute to increasing academic performance in mathematics, the realization of the creative abilities and cognitive interests of each student.

It is the mentor of the digital school who can and should choose personalized learning technologies that maximally work to form the type of thinking and way of action that is in demand in the digital society. Other authors complement these ideas and argue that distant technologies, e-learning, interactive tools and activity methods should be used when teaching mathematics (Galimova et al., 2019). N.A. Urvanova also formulates the condition that innovative pedagogical technologies and modern digital resources should be the basis of the educational environment, adjusted to individual personality traits (Urvanova, 2018). Moreover, N.A. Urvanova notes that in such a specially designed educational model the student receives maximum conditions for the development of "the ability to learn". Researches on the study of the issues of personalization of learning and the use of digital technologies to design a personalized learning model were also analyzed.

For example, N.V. Chernyaeva reasonably argues that an important direction in the educational policy is the transition from "mass" education to the personalized one (Chernyaeva, 2020). According to the author, the main aim of personalized learning is to provide conditions for self-realization of students. N.V. Savina notes that in the personalized educational model the student receives maximum conditions for the development of "the ability to learn" (Savina, 2020). Appropriate conditions must be supported by the personal educational route, a trajectory of cognition, curriculum, and information environment.

The most comprehensive methodological approach to developing the personalized model of teaching mathematics based on digital technologies is presented in the study of E.G. Sabirova, T.V. Fedorova, N.N. Sandalova (Sabirova et al., 2019). The authors conclude that the number of digital educational resources for personalization of learning is constantly increasing. However, in order to purposefully and methodologically effectively include the appropriate services in the educational process the mentor needs to know principles and conditions of personalization of education. In addition, it is the teacher who should understand the range of educational tasks that can be solved with the help of electronic resources; determine methodological functions, types of educational activities that digital technologies support and initiate. The purpose of their research is to identify the effectiveness of the interactive educational platform Uchi.ru for personalized teaching of mathematics in primary school.

So, there is an objective need to analyze and generalize the experience of using modern interactive methods and tools when teaching mathematics.

O.I. Vaganova et al. examine the general methodological aspects of organizing the learning process using modern interactive didactic tools. In the research the concept of “interactivity” refers to the interaction between objects (Vaganova et al., 2020). The authors formulate the following requirements for interactive teaching aids: support of motivation (the appearance of an incentive for students to study the subject); management and regulation (directing the attention of students to the study of objects, phenomena). Z.I. Isaeva notes the following didactic properties of interactive teaching tools: multimedia, instrumentality, adaptability, information content, motivation (Isaeva, 2019). E.V. Soboleva, M.S. Perevozchikova prove that designing interactive quest rooms as organizational forms of cognition and educational technology is not one of the options for gamification of the digital educational space, but also contributes to the formation of intellectual competence of the individual (Soboleva, Perevozchikova, 2019).

E.N. Nikolaeva, I.P. Egorova prove that with the help of interactive methods it is possible to increase academic performance in the subject, the involvement of students activities, thereby contributing to the personalization of learning (Nikolaeva, Egorova, 2020). Including interactive techniques has a beneficial effect on creative, critical and creative thinking.

E.A. Levchenko, A.V. Mantorova describe the concept of a visual interactive short story "Getting Through" as a variant of the development of creative thinking, imagination and formation of foundations of the scientific worldview. However, such interactive tools have been developed only for classes in history, literature, and English (Levchenko, Mantorova, 2020).

Thus, Russian modern researchers convincingly prove that the inclusion of interactive services for visual short stories and quests in educational and cognitive activities not only meet the goals and challenges of the education system, but also allows to prepare demanded and competitive professionals of the future for the country's economy.

2.1.2. Analysis of foreign studies

Analytical work in this part of the study was also carried out in three directions.

As part of the first direction, it should be noted that foreign scientists are unanimous in the opinion that it is educational achievements in mathematics that are the basis of quality education in general (Gault, 2019; del Río, Sanz, Búcari, 2019). In particular, J. Park et al. reasonably argue that mathematics knowledge acquired in primary school determines the success of further education, readiness of adolescents to think independently, and to the reasoned activity (Park et al., 2016). Researchers identify five conditions for personalized learning: formation of subject-oriented skills; development of thinking (critical, analytical); support of students by the teacher; use of various didactic methods, forms and means of teaching (for example, electronic educational resources, simulators, educational and interactive quests); use of information technologies when teaching.

According to S.K. Bawa, R. Kaushal, J.K. Dhillon, development of personalized learning is one of the priorities of modern mathematics education. The authors conclude that the use of information technologies can improve the quality of teaching mathematics (Bawa et al., 2020). A. L. Alfaro-Arce, M. Alpízar-Vargas study the didactic potential of multimedia programs (combining text, sound and music, graphics, animation and still images) in teaching elementary mathematics (Alfaro-Arce, Alpízar-Vargas, 2019). Based on statistical data they substantiate the effectiveness of such multimedia applications for the development of mathematics skills.

D. Hillmayr et al. also conclude that the use of digital technologies can improve the quality of teaching mathematics (Hillmayr et al., 2020). At the same time, scientists carry out the experiment which confirms that the use of intelligent learning systems, modeling and work with dynamic mathematical tools is much more effective than the usual multimedia course support.

K. Bovermann and T. J. Bastiaens conclude that the use of interactive tools and applications in the mathematics classroom provides variability in the presentation of tasks, uniqueness of exercises, quick assessment, and necessary trajectory correction, changes in the difficulty of the level, competitiveness and the game approach to learning. To create such applications tools that are part of the integrated Microsoft Office suite and other applications that do not require programming skills are used (Bovermann, Bastiaens, 2020).

In turn, an increase in literacy, formation of the critical worldview is the basis for the preparation of future generations (Radović et al., 2019). According to the provisions of J.F. Harding et al. personalization is the creation of the learning environment which matches unique abilities and needs of the student in order to achieve the potential of students (qualities, talents) (Harding et al., 2019). Personalization is a process during which the subject acquires individual properties and qualities that allow him/her to fulfill a certain social role, to build relationships with other people (Catarino et al., 2019).

The concept of "personalized learning" is used to refer to a process that consists of a set of educational programs, methods and teaching techniques, which is aimed at identifying and taking into account educational needs, interests and individual characteristics of the student (Radović et al., 2019).

According to E.M. Ghazali, D.S. Mutum, M.Y. Woon, education in school should take into account cognitive interests and professional aspirations of the student (Ghazali et al., 2019). In the work of O.C. Yung, S.N. Junaini, A.A. Kamal, L.F. Md Ibharim, based on the analysis and generalization of the didactic capabilities of QR codes for teaching, priorities for the development of web technologies, interactive short story services, the authors reasonably highlight a promising direction in the new educational realities – the use of game mechanics to support the cognitive activity of students in the mathematics course. The use of means of interactive short stories and quests in the mathematics activity, the construction of a mathematical model in a playful form helps to activate knowledge, increase the interest and curiosity of the teenager of generation Z (Yung et al., 2020). The authors note that with the help of such visual objects it is possible to increase mathematics academic progress, involvement of students activities, thereby contributing to the personalization of learning.

Using interactive techniques stimulates creative, critical and creative thinking (Mora-Luis et al., 2020). Improving the quality of mathematics education in the context of personalization presupposes the innovative approach to teaching, the use of non-standard tools and technologies (Catarino et al., 2019). Moreover, if applied correctly, this approach can qualitatively increase the effectiveness mastering the educational material and activate the cognitive activity of schoolchildren, and promote professional self-determination (Helmlinger et al., 2020).

However, as the analysis of the literature has shown the practical implementation of interactive visual short stories and quests in teaching mathematics, the use of software applications that take into account the principles of didactics and contribute to improving the quality of mathematics education cause certain difficulties (More, 2018). It should be noted that there is a need to allocate additional time and labor resources, work with the educational mathematical content of the application, knowledge of the basics of didactics and their use in practice, the choice of software, etc. (Bocconi et al., 2018).

Thus, new challenges of the time determine modernization of mathematics school education: a transition to personalized learning takes place (Bawa et al., 2020), interactive methods and means are actively used to present facts, tasks and exercises, to support modeling (Harding et al., 2019).

At the same time, in other school subjects (literature, history, English), interactive technologies also support formation of the scientific picture of the world, development of mental processes, and creativity. In particular, game applications and visual interactive short stories are being developed. Therefore, to improve the quality of teaching mathematics it seems appropriate to use such interactive short stories as the basis of the personalized educational environment.

3. Materials and methods

3.1. Theoretical and empirical methods

The following methods were used in the study: theoretical analysis and generalization of scientific literature on the problems of improving the quality of mathematics education; using digital technologies to personalize learning; didactic potential of visual interactive literature as a kind of computer games.

The main methodological principle of the study is determined by the key condition for personalized learning and presupposes the freedom to choose the educational path. This principle of choice is realized in the space of the interactive short story. The interactive short story is both a learning tool and a play space. Interaction with the user in the visual interactive environment is implemented mainly with the help of textual information. The text can be accompanied by video, images, sounds.

The use of interactive short stories in teaching mathematics is supported by the following system of didactic principles: accessibility, consistency, connection between theory and practice, conscious activity, individual approach, cooperation. On the other hand, teaching mathematics (the study of rigorous scientific facts, mathematical calculations, etc.) is supported by the artistry of the text, ideas in the imagination of the user-player, plot, and interaction of characters.

To obtain up-to-date information on qualitative changes in the educational achievements of students in mathematics the following empirical methods were used: observation, analysis of work results in the AXMA Story Maker application (choice of answer, number of attempts to find the right solution, study of theoretical material in publications, use of audio background, etc.).

The use of tools for designing visual interactive short stories was carried out as part of the course “Entertaining mathematics”. This course is included in extracurricular activities of personality development in secondary school № 11 in Kirov.

Control tests, as a research method, given an opportunity to assess the level of mathematical training of the subjects research with the help of specially selected exercises. An input control was organized to form the experimental and control group, the control included five tasks (do logical inferences, calculate a value from a ready-made mathematical expression, work with a problem formulation, draw up a mathematical formula, use information technologies to automate mathematical calculations). 121 students of grade 7 were involved in work with interactive short stories. The average age of the respondents was 13 (51 % girls and 49 % boys).

Despite the fact that for the implementation of interactive short stories there are many software tools (Twine, Quest, Apero, Kvester, AXMA Story Maker, etc.), the research uses the AXMA Story Maker application as a software tool. Its main advantages include the fact that using the application does not require programming skills, simplicity and convenience of the user interface, availability of ready-made templates for publications, support for various languages (Russian, English), the application provides a wide range of functionalities for designing visual travel games, interactive short stories.

Statistical processing of the research results was performed using the Fisher test.

3.2. The base of research

The use of design tools for visual interactive short stories was carried out as part of course “Entertaining mathematics”. This course is included in extracurricular activities of personality development in secondary school № 11 in Kirov. 121 students of grade 7 were involved in work with interactive short stories. The average age of the respondents was 13 (51 % girls and 49 % boys).

The sample was not random. An input control was organized to form the experimental and control group, the control included five tasks. The tasks were designed according to the principles of didactics. The content of the tasks meets the requirements of the standards of International and Russian education. To ensure conditions for group homogeneity, the same teacher conducted classes on the basics of mathematics for all students.

This teacher also formulated systems of educational tasks, directed information interaction in the process of solving problems by schoolchildren in the AXMA Story Maker environment. Work with interactive applications was performed in the same classrooms, on the same hardware and software. The materials for the test were developed by the authors in accordance with the current standard of basic general education.

3.3. Stages of research

The research was carried out in three stages.

At the preparatory stage of the experiment software that support the implementation of interactive visual short stories was studied and analyzed: Twine, Quest, Apero, Kvester, AXMA Story Maker, etc. After comparing the software for the implementation of interactive short stories according to the selected criteria, the application AXMA Story Maker was reasonably chosen. Next, the didactic potential of its tools for personalizing mathematics learning was explored. To assess the input conditions materials from a specially organized control event (5 tasks) were used.

For the correct solution of control tasks the student could receive the maximum of 12 points. The work was considered completed (mark "credit") if the student scored more than 7 points.

Thus, it was possible to collect data on 121 schoolchildren of whom the experimental (60 students) and control (61 students) groups were formed. The sample was not random. The average age of the respondents was 13. In the experimental group there were 51 % of girls and 49 % of boys.

The second stage of the study was to correlate the topics of the course "Entertaining mathematics" (elements of logic, formulas, equations, inequalities, motion problems, percentage problems, etc.) with the capabilities of the software for creating interactive short stories. In particular, the system of classes was determined.

Proposed titles were formulated, plots for interactive short stories, focused on the rational use of AXMA Story Maker tools for personalizing teaching mathematics, were designed: "Eastern Horoscope", "Systems of Notation", "Seven Wonders of the World", "Professions of the Future", etc.

The third stage of the research is experimental teaching, the inclusion of a mathematics elective for purposeful work with the means of interactive short stories in the curriculum.

4. Results

4.1. Clarification of the essence of basic concepts

Personalized education in the presented study is considered as an educational approach using individual educational trajectories. It is the approach, according to the results of which the level of individual motivation increases, cognitive interests are satisfied, and the professional self-determination of each student is supported.

The author's understanding of the meaning of "personalized learning" assumes that the student gets the opportunity to choose: the content (from the proposed); the speed, and in some cases the place of training, and the format of the assignments; the method of designing and implementing the educational process; the self-realization mechanism; the form of organization of the learning process.

An interactive short story is a story, the artistic image and content of which are realized with the help of a computer program. The Interactive short story is both a learning tool and an interactive game genre. It tells a story that appears on the screen in the form of text, video, sometimes with background music.

Visual interactive short story is an interactive learning tool. It is a story. The artistic image and content of the short story may vary depending on the student's actions. The use of software services for the implementation of interactive short stories creates additional conditions in order to form in students the style of thinking that is in demand in society. This style of thinking involves the search for various ways to achieve the goal and understanding the laws of chance. The effectiveness of the organization of the corresponding mathematical activity is determined by the capabilities and skills of the mentor in the digital school.

The use of the developed learning model in the experimental group was aimed at forming a set of educational results in mathematics:

– subject (arithmetic and logical operations, rounding and use of alphabetic symbols, construction of graphs of functions and tables, use of scientific mathematical terminology, etc.);

– metasubject (universal principles and patterns, tools for modeling phenomena and processes; understanding the areas of application of mathematical knowledge and skills in the digital society; simple and complex conditions; working with a problem formulation; search, presentation and storage of information; inductive and deductive ways of reasoning; algorithmic nature of activities in the interactive environment, etc.);

– personal (formation of the sense of responsibility to other users for reliability of information; development of critical thinking and creative abilities of students when analyzing and making generalizations of information in the course of solving problems; support for independent choice in the interactive environment; use of digital resources for the implementation of educational and cognitive goals and self-development, etc.).

So, to achieve the aim of the research, the personalized model of teaching mathematics was developed, the components of which are: the interactive short story (plot for presenting a sequence of mathematical facts), the software tool (AXMA Story Maker application); game elements (levels, process visualization tools, characters), didactic principles of teaching mathematics (individualization, accessibility, consistency, etc.).

The personalized model of teaching mathematics by means of interactive short story is divided into the following levels:

Level 1. "Personalization for learners". By means of interactive short stories in the experimental group the teacher creates conditions and opportunities for acquiring new mathematical knowledge and skills. In the designed conditions and in the process of interactive interaction with the software environment students make their own choice, observe the reaction of the environment, receive either confirmation of their hypothesis or return to the previous fragment of the short story.

Level 2. "Personalization by efforts of the student". In the interactive visual environment when studying mathematical patterns, ideas and approaches , a member of the experimental group receives new tools, algorithms, methods in order to personalize own subsequent learning.

It should be noted that in the developed personalized model of teaching mathematics, the rate of presentation of a new fragment of the short story is also designed taking into account the individual characteristics and capabilities of the experimental group participants.

Another important circumstance is that for the experimental group work with fragments of the visual short story in the interactive environment presupposes obtaining fundamental theoretical knowledge while playing. By including game elements, not only the presentation of the educational material is changed, but when solving mathematical problems positive emotional background is maintained and stress factors are minimized.

The author's conclusions of the presented work confirm the previously obtained information by E.V. Soboleva et al. on the effectiveness of the use of interactive technologies when teaching mathematics (Soboleva et al., 2018).

The advantages of the AXMA Story Maker software include the following:

– free version allows to create game applications, tests, interactive short stories, quests;

– structure of links between paragraphs is displayed on the main screen. The user can adjust the workspace to suit own characteristics of information perception;

– official website has a guide for authors, a blog and other teaching materials to help the developer;

– finished resource can be saved and used as an html file;

– no specialized programming skills are required;

– possibility to work without Internet access.

The AXMA Story Maker application integrates the capabilities of the JavaScript language. Figure 1 shows the workspace and tools for making a publication. When adding text, one can work with color, font and format; there are tags for designing paragraphs and links; there is a possibility to add buttons and audio files; there are functions for copying, scaling, etc. Thus, when developing and filling a short story, the mentor of the digital school is required to have basic skills and information literacy.

Thus, the use of AXMA Story Maker made it possible to use text information, graphics, and sound when designing interactive visual short stories.

All of the above, firstly, corresponds to the age and psychological characteristics of the thinking of modern adolescents; secondly, it organically complements the rigor of mathematical theories.

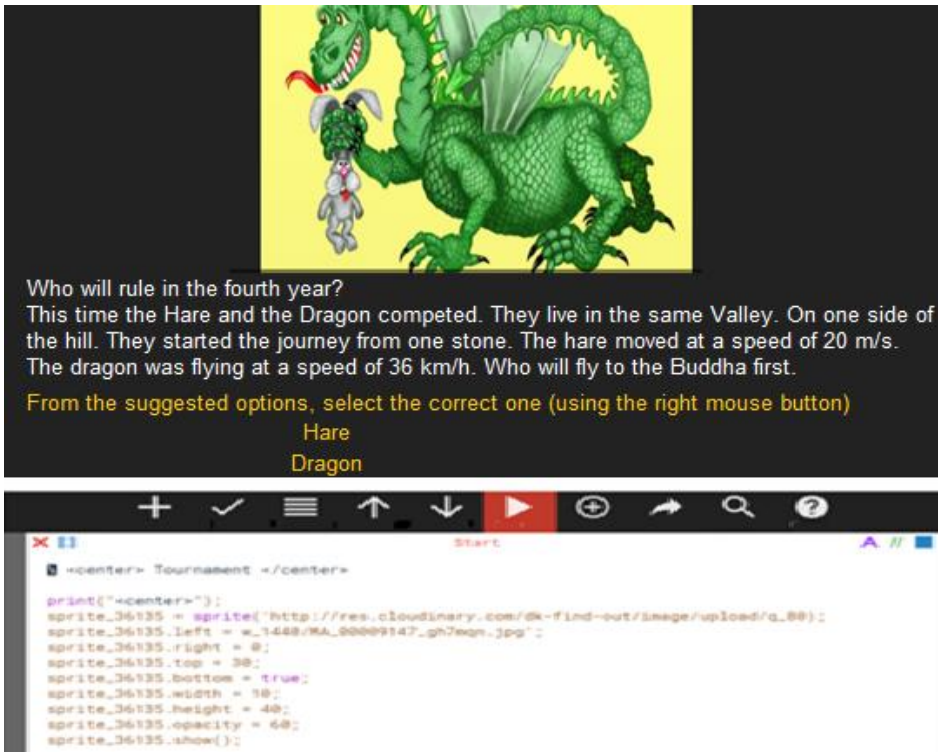

Fig. 1. Work with the content of the publication

4.2. Educational and cognitive activity of students in the visual interactive short story environment

Visual short stories include two main elements: visual (static pictures) and literary (the text of the story itself).

With the help of interactive short stories the personalized learning model was designed and implemented, it is focused on a qualitative change in the level of academic achievements of schoolchildren. The entire story is divided into publications – images of the working field, which combine various forms of information presentation (text, graphics, sound). Each publication is a separate element of the learning model. Movement through the plot of the story, movement of the character through publications is determined by the choice of the student. The content of the publications is mathematical theory, practice-oriented tasks and exercises.

The meaningful elements in the developed educational model in mathematics for students of the experimental group are: the concept of the formula, the arithmetic expression, the equation/inequality, the roots of the equation, etc. It should be noted that the study of each topic in the experimental group is designed for several classes (mastering new material, developing mathematical skills when working with publications of the visual novel, doing control tasks in the interactive environment).

In the experimental group the primary focus was precisely on the acquisition of new theoretical knowledge, its meaningful application when solving mathematical problems. To involve students in complex intellectual activities (due to the need to memorize, formulate, generalize, check, etc.), rigorous mathematical calculations, the means of interactive stories were used. Introduction to the independence, cognitive activity, argumentation and responsibility for decision-making took place through the nonlinear space of the game world. The means of interactive short stories were used to involve students in complex intellectual activities (due to the need to memorize, formulate, generalize, check, etc.) and rigorous mathematical calculations.

As an example let us consider one of the interactive visual short stories in AXMA Story Maker, which supports mathematics learning in the personalized model for the experimental group.

Once the Lord of the country X decided to choose his successor among all the wise men, scientists of the kingdom of Oz. He invited them to his place under the pretext of participating in the tournament “What? Where? When?” It was winter time and there were severe frosts. To get to

the site of the tournament travelers had to go through a forest, a valley, a ravine, unfriendly giants, a lake, a swamp, and abandoned villages. Let us describe some of the features of the presentation of mathematical material in publications of the interactive short story.

All guests independently chose their paths and means of transportation. So, one of the publications of the short story contained the following task as an alternative: from two cities, the distance between which is 140 km, two wise men began to move towards each other. At first, the expert Cube came out on foot and an hour later his friend Compass left by carriage. The speed of Cube is 5 km/h and it is 2 times less than the speed of Compass who goes by carriage.

The essence of math activity: make an equation and determine the time before friends' meeting. Working with the interactive environment assumes that from the proposed options the student must choose the answer that he/she considers correct. Then the student clicks on this answer with the left mouse button and goes to the next publication.

[[*10 hours| Cube and Compass]]

[[15 hours | error Cube's way]]

[[1 hours | error Compass's way]]

The choice of "Error Cube's way" assumed the execution of an additional task for drawing up an equation, expression of one variable through another, etc.

For example, it involved the following task: "To find which way the expert traveled one should find the product of speed and time spent during travel. It is known that the carriage moved at a speed of 10 km/h and the whole journey took 5 hours. Accordingly, Cube overcame "...." km "? From the proposed options, one needs to choose the correct answer and click on this answer with the left mouse button:

[[*50 km| Cube and Compass]]

[[50 km/h| error Cube's way]]

[[2 km| error Compass's way

At the same time, the choice "Cube and Compass" corresponded to the continuation of the short story. For example, go to the next publication: "On the way Cube met his old friend Compass, who was crossing the valley alone. Cube invited him to his carriage, since it would be more fun for the two of them to get there. Compass agreed, and they went to the Lord of the country X together".

Thus, the students in the experimental group received in each subsequent publication either a refinement of the mathematical theory or new mathematical tasks. Next publication is a free choice of each student.

During the implementation factors corresponding to the specifics of mathematics education, didactic principles, mechanics of interactive short stories and quests were taken into account:

– information presented in each of the paragraphs is concise and structured;

– base on interdisciplinary and intradisciplinary relationships;

– tasks and questions for the short story are designed in accordance with the current educational standards and curricula;

– text component is checked for the presence/absence of errors;

– only generally accepted mathematical terms and notations are used.

The students in the control group worked at the elective using the educational-methodological complex of Yu. N. Makarychev et al. This teaching material is focused on updating knowledge, as well as preparing for the study of courses in geometry, physics, chemistry and geography in subsequent classes. The complex is included in the federal list of textbooks. The educational-methodological complex uses a differentiated decoration for various sections: theoretical information, tasks for working in pairs and for revising, entertaining facts on the history of the development of mathematics, etc.

Also, at the elective the participants of the control group used workbooks and training programs, they participated in mathematical dictations. The classes in the control group were organized according to the principle "from theory to practice".

When developing the interactive short story with mathematical content, additional opportunities were also created for the development of teamwork skills, cross-industry communication, and the propaedeutics of working with technical documentation was carried out.

There is on fact that is of particular importance for solving future professional tasks when implementing innovations, the fact is that the concretization of the content of each educational game space with mathematical content does not occur at the initiative of the mentor, which is

typical to the traditional system of teaching mathematics. The direction for mathematical research is determined by the students themselves.

4.3. Experimental evaluation

4.3.1. The ascertaining stage of the experiment

At the first stage of the experiment, materials of specially organized testing were used to assess the input conditions, the test took into account the priorities of the digital society, the competence of the atlas of new professions. All questions and tasks were developed by the authors in accordance with the requirements of state federal educational standards. Students were asked to solve 5 tasks.

The solution to the first problem is associated with the development of logical thinking. For example, students are given cards with a sequence of numbers in a specific order. They need to continue the pattern and determine the number that should be on the blank card.

The solution to the second problem involves calculating the value of a mathematical expression. For example, it is to determine the value of the expression F = m*a if the mass and acceleration are known.

For the correct solution of each of these problems, the student received 1 point.

When solving the third task, the student had to choose from the proposed formulations of problems the one which conditions correspond to a certain mathematical equation. For example, 33 / (x + 6.5) + 4 / (x - 6.5) = 1. For the correct solution of the problem of this level, the student received 2 points. Examples of tasks:

1. The yacht "Pobeda" sailed 4 km upstream of the river, and then another 33 km downstream. Captain Wrangel calculated that they spent one hour on the whole journey. Find the speed of the yacht if the river speed is 6.5 km/h.

2. From the diaries of a young traveler “Today we examined the atolls of the islands. At the same time, our expedition covered 4 km on foot, 33 km we sailed on the ship “Victoria” along the equator forward and 6.5 km when returning back”. Help determine the speed of travelers.

To solve the fourth problem, the student had to compose an equation on his/her own. For example, a cruise ship covered 108 km downstream and 84 km upstream, spending 8 hours for the entire journey. It is known that the speed of the river is 3 km/h. Find own speed of the cruise ship. Having designated the own speed of the cruise ship as x km/h, write an equation that corresponds to the condition of the problem.

For the correct solution of the problem of this level, the student received 3 points.

The fifth task involved the use of software and information technology. For the correct solution 5 points were given.

For example, Hermione decided to organize a picnic for her friends. To do this, she compiled a "memo", where she wrote down all the purchases necessary for a good rest (food, dishes, their quantity, etc.). Hermione, like a real researcher, approached the task in a complex way: the girl studied all the prices in magic stores and shops. For structuring she compiled a spreadsheet with a price range for each item. Determine in which shop Hermione's costs will be minimal.

For example, Hermione decided to organize a picnic for her friends. To do this, she compiled a "memo", where she wrote down all the purchases necessary for a good rest (food, dishes, their quantity, etc.). Hermione, like a real researcher, approached the task in a complex way: the girl studied all the prices in magic stores and shops. For structuring she compiled a spreadsheet with a price range for each item. Determine in which shop Hermione's spend will be minimal.

So, for the correct solution of the control tasks, the student could receive the maximum of 12 points. The work was considered completed (mark “credit”) if the student scored more than 7 points.

Thus, it was possible to collect data on 121 schoolchildren, of whom the experimental (60 students) and control (61 students) groups were formed. The sample was not random. The average age of the respondents was 13. In the experimental group there were 51 % of girls and 49 % of boys.

4.3.2. Forming stage of the experiment

At the forming stage of the experiment the teacher analyzed the requirements of the digital economy to the quality and level of mathematical training of graduates. The provisions of the

current state federal educational standards determine that as part of mathematics education the student must acquire a certain amount of fundamental mathematical knowledge, master the mathematical methods of cognition and the general culture of the nation. In addition, teaching mathematics should perform developmental functions: to form intellectual skills necessary for any person regardless of what field of activity he/she will be engaged in in the future.

Classes for students in the control group were conducted according to the traditional method of teaching mathematics, without special organization of activities in the environment of interactive short stories and quests. They were active and independent in research, which was organized in the form of practical work on solving mathematical story problems, performing exercises on specific topics. Schoolchildren from the experimental group were taught according to the described way.

The second stage of the study was devoted to correlating the topics of the course "Entertaining mathematics" (elements of logic, formulas, equations, inequalities, motion problems, percentage problems, etc.) with the capabilities of the software tool for creating interactive short stories. In particular, the sequence of classes was determined.

1. Acquaintance with AXMA Story Maker, basic commands and user interface icons.
2. Work with forms and text wondows, moving through the branches and levels of the interactive short story. At this stage, the students wrote scripts to implement the short stories algorithm (in Figure 1), determined the sizes and positions of the visual objects necessary for the work.
3. Execution of a demo version of the interactive short story to study or consolidate theoretical material.
4. Passing the test version of the interactive short story.

Approximate titles were formulated, plots for interactive short stories, focused on the rational use of AXMA Story Maker tools for personalizing teaching mathematics, were designed: “Eastern Horoscope”, “Systems of Notation”, “Seven Wonders of the World”, “Professions of the Future”, etc.

4.3.3. Control stage of the experiment

At the fixing stage of the experiment, control testing was also carried out. The types of tasks and principles of assessment corresponded to the tasks and the procedure of the entry test. Information about the measurement results before and after the experiment is presented in Table 1.

Table 1. The results of the test

	Before the experiment		After the experiment	
	Experimental group (60 students)	Control group (61 students)	Experimental group (60 students)	Control group (61 students)
Percentage of students who received the mark “no credit”	56,7 % (34)	55,7 % (34)	15 % (15)	50,8 % (31)
Percentage of students who received the mark “credit”	43,3 % (26)	44,3 % (27)	75 % (45)	49,2 % (30)

The reliability of the obtained results was checked using the Fisher's angular transformation (Fisher's criterion) using the online calculator (https://www.psychol-ok.ru/statistics/fisher/). The critical value of Fisher's criterion for the significance level of 0.05 (φ_{crit}) is 1.64.

The hypotheses were accepted:

Ho – the level of educational results in mathematics in the experimental group is statistically equal to the level of the control group;

H1 – the level of educational results in mathematics in the experimental group is higher than the level of the control group.

The empirical value of Fisher's criterion before the start of the experiment is 0.115 (φ_{emp} = 0.115 <φ_{crit} = 1.64). Therefore, before the start of the experiment, the hypothesis H0 is accepted. The value of the Fisher criterion after the experiment is 2.964 (φ_{crit} = 1.64 <φ_{emp} = 2.964), therefore the hypothesis H0 is rejected and H1 is accepted.

Thus, the shift towards improving the quality of educational results in mathematics of students of the experimental group can be considered not accidental.

5. Limitations

The sample of students was not probabilistic, therefore, experimental data cannot be generalized for the entire students population. For diagnostics, the results of the input control testing were taken into account. Throughout the experiment, creative activity in the interactive environment was carried out by the same teacher, on the same software equipment in special classrooms.

6. Discussion

Doing the quantitative analysis of the obtained results, we conclude that 75 % of the students in the experimental group successfully coped with the control tasks. According to the results of input measurements, this value was equal to 43.3 %. The number of students who did not complete the task decreased from 56.7 % to 15 %. The dynamics of the results in the control group is not so significant. 49.2 % of schoolchildren received the mark "credit". Initially, this figure was 44.3 %. The number of students who could not complete the final test was 50.8 % (compared to 55.7 % after the entry test).

In general, the pedagogical experiment allows to conclude that teaching mathematics according to the designed personalized model based on visual short stories contributes to improving the quality of education. The level of academic results in mathematics in the experimental group became significantly higher due to the fact that the information environment for studying the topics of the course "Entertaining mathematics", supported by interactive means, made it possible to create and provide conditions for: taking into account the individual, age and psychological and physical characteristics of students; studying universal methods, approaches that are the basis of research, educational and cognitive and further professional activities of schoolchildren; developing the skills of independence in decision-making, responsibility for one's choice and its consequences; self-education; creating situations of success; organization of creative activity.

The quality of teaching mathematics also increased due to the fact that both auditory and visual channels of information perception were involved. In the proposed recommendations, we consider it necessary to note the sanitary and hygienic aspect of the use of interactive stories and quests in teaching. So the duration of using the resource in a basic school lesson should not exceed 30 minutes.

When studying the topics of the course "Entertaining Mathematics" in the AXMA Story Maker environment, students learn mathematical facts, theories, methods more consciously, they actively apply them to solve practice-oriented problems; a stable favorable emotional background is created; thought processes (memory, imagination, attention) develop more intensively. The choice of this particular software product made it possible to design the personalized environment that supports the study of basic mathematical concepts, forms demanded mathematical skills, demonstrates the capabilities of new interactive tools and game applications, and provides an experience of independent choice in decision-making.

The results of the study are consistent with the conclusions of J. Jorge, R. Paredes about the didactic potential of interactive tools with functionality for designing a nonlinear trajectory of cognition (Jorge, Paredes, 2018). Moreover, they fully correspond to the data of S. Radović, M. Marić, D. Passey, that visual technology activates cognition, stimulates intellectual work (Radović et al., 2019).

The implementation of the formulated recommendations will allow the teacher of the digital school to create additional conditions for personalization of teaching mathematics. Using AXMA Story Maker to develop the interactive short stories with math content aligns with digital

priorities and convincingly demonstrates the didactic potential of technology to improve the quality of maths education.

7. Conclusion

The study presents a solution to the problem caused by the need to resolve the contradiction between the requirements of the modern economy for the quality of mathematics training of future specialists and an insufficiently developed methodological base for training graduates that meets these requirements. It was assumed and experimentally proved that acquiring high-quality mathematics education by graduates of the modern school is facilitated by work in the specially designed personalized learning environment based on interactive technologies.

The following features of the development of the personalized learning model by means of interactive short stories were noted, they maximally contribute to improving the quality of educational results in mathematics:

1. Correlation of the educational goal (in this case) and the results of educational and search activities in the environment of the interactive short story. First of all, before using a game application that supports interactivity of interaction and the nonlinear personal trajectory of cognition, it is necessary to determine the goals and intended results (personal, subject, metasubject): learners must remember mathematical facts, get logical conclusions, choose a reasoned answer, build their personal educational route from “ignorance to knowledge”. The goal will determine not only the content of the visual short story, but also the number of required publications, plot, and levels of material presentation.

2. Understanding and taking into account the individual, age and psychological and physical characteristics of students.

3. Determination of the place and significance of the interactive short sory for the main course in mathematics: where and when the resource will be used, the duration of the work.

4. Designing the plot of the interactive short story. The plot for the space of the game (as in the described option) can go beyond the limits of the studied discipline. The plot of the short story can be based on a literary work, film events, historical or geographical discovery.

5. The choice of the text component, i.e. features of drawing up the system of tasks and questions. We advise to adhere to the following recommendations: order tasks and questions by level of difficulty; the first problem (the starting point of the short story) is the simplest, containing only known mathematical facts and firmly mastered formulas; the wording should be understandable for students, consistent with their cognitive interests and level of academic achievement.

6. Development of the personalized educational trajectory. When solving each of the problems, the student must be offered a choice of one of several answer options. To do this, the teacher needs to think over the following in the interactive short story:

– what will happen if the student answers the question correctly, and to which publication he/she will move;

– what will happen if the student makes a mistake, and what mathematical theory (volume, degree of detail) will allow him/her to understand and correct it.

The personalized model of teaching mathematics, developed by means of interactive short stories, contributes not only to improving the quality of the obtained subject and educational knowledge, but also contributes to the development of thinking. In the course of educational and cognitive activities in AXMA Story Maker, in the process of making a decision and making an independent choice, soft skills that are in demand by the digital society are formed: planning, search, critical assessment and processing information, the ability to work in an uncertain future, responsibility.

Thus, the use of interactive short stories as the basis for the personalized model of teaching mathematics contributes to an increase in the level of academic achievements of schoolchildren. Research materials can be used to develop ideas for personalizing learning in the digital school.

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