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Implementation of mathematical training in the context of digitalisation of education

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Abstract. Within the framework of systemic digitalisation of education, the task of assessing the effectiveness of new pedagogical tools has become critically relevant. This article was devoted to the experimental verification of the impact of electronic educational resources (EERs) on the quality of mathematics training among primary school students. The main purpose of the study was to determine the effectiveness of a methodology for teaching mathematics that integrates digital technologies. The research was conducted in the format of a pedagogical experiment during the 2022-2024 academic years at Secondary School No. 8 in Bishkek. In the course of the experimental work, specially developed lesson models incorporating multimedia presentations and specialised EERs such as IBILIM, LearningApps and Komodo were introduced into the learning process. The BaalooApp application was used to monitor skill development and conduct formative assessment. The effectiveness of the experiment was evaluated by analysing and comparing diagnostic and final assessment data. The analysis confirmed an improvement in mathematics training outcomes in the experimental groups. Compared with the baseline and control indicators, the quality of students' knowledge who used EERs increased by 20%. This demonstrates that the integration of digital resources and interactive teaching methods can significantly enhance the acquisition of mathematical knowledge and skills. The findings of the study revealed high effectiveness of the developed methodology employing electronic educational resources. It was established that systematic and methodologically grounded use of EERs not only increases students' motivation but also ensures a qualitative leap in the development of mathematical and information competences, which holds significant practical value for the further modernisation of the educational process

Keywords: mathematics; digital technologies; electronic educational resources; teaching approaches; learning process

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INTRODUCTION

In connection with the rapid penetration of digital technologies into all spheres of life and the changes taking place in the world, the Kyrgyz Republic has taken steps to adapt the education system to the needs of the digital economy, namely, work has begun on updating curricula at all levels of secondary education, secondary specialised education and higher professional education. The digitisation of education is taking place, affecting not only administrative issues but also the application of digital technologies in the educational process. At the secondary school and university levels, the Smart School programme is being implemented, which is a comprehensive programme for the introduction of digital technologies into the educational process, consisting of four main components: the development of teachers' information literacy and students' digital skills, the development of digital educational content, and the development of ICT infrastructure in schools and universities.

E. Egorova (2020) noted that the process of digitisation of education includes such promising innovative technologies as artificial intelligence (AI), virtual reality and blockchain, which enable students to develop a wide range of social skills necessary in a digital society. As pointed out by N. Kaidieva *et al.* (2023), the formation and improvement of the information competencies of teachers, pupils and students will create conditions for the widespread introduction of digital educational resources into the teaching of various subjects. The capabilities of modern information and communication technologies in the educational process allow teachers, students and pupils to use digital educational resources. For example: educational presentations, tests, electronic teaching aids, interactive exercises on various subjects, training programmes, digital games, etc. These digital resources can be used by both pupils and students under the guidance of a teacher, allowing them to develop and improve their practical skills. Information and digital literacy is becoming a key component of professional success for teachers, as it promotes the integration of innovative approaches to teaching and allows teachers to adapt their methods to the needs of modern students who are growing up in a digital environment (Kiryanova, 2024). With the help of digital technology resources, teachers can solve the following tasks: increase the intensity of the lesson, increase the motivation of pupils and students, monitor their progress in learning and adjust the learning process.

Developing the creative abilities and creative thinking of pupils and students is one of the main tasks of education, and digital technologies are one of the solutions to this problem (Aliev *et al.*, 2025). It is impossible to imagine the modern world without digital technologies; they have penetrated all spheres of human activity and have a significant impact on educational processes. Digital technologies expand access to education, making it more accessible to people from different social strata and with different backgrounds (inclusive education). The use of digital technologies enriches the learning process by providing new teaching methods, interactive learning materials and tools for individualising learning (Mambetakunov, 2021).

The formats of virtual and augmented reality open up promising opportunities for teaching various disciplines, including mathematics. According to research by A. Christopoulos *et al.* (2024), the use of digital game-based learning (GBL) for studying mathematics and other STEM subjects can indeed be beneficial and increases student engagement and motivation. Innovative technologies provide the opportunity to develop interactive three-dimensional modelling of necessary mathematical objects, which at this stage significantly improves students' perception of abstract concepts (Minkova, 2025). V. Dalinger (2022) noted that computer technologies make it possible to visualise mathematical objects, so students can write programmes that demonstrate a particular fact or object. Many students know how to use programmes that allow them to use a set of tools for constructing and studying drawings. These programmes make it possible to "discover" and verify geometric facts, the author points out.

Currently, e-learning functions not simply as a supplement to traditional education, but as an equal component that works in conjunction with traditional methods. The most important features of e-learning include increased student activity and motivation, independent and conscious study of materials, and interactive communication. E-learning allows the educational process to be divided into clear stages, which enables teachers and students to constantly monitor the progress of knowledge acquisition. The use of feedback allows teachers to quickly adjust teaching methods, taking into account the individual characteristics, personal potential and pace of learning of each student. For high-quality mathematics education, it is necessary to innovate the existing process of mathematics training by optimising teaching technology with the help of digital tools. The aim of this study was to conduct a pedagogical experiment to test and comprehensively evaluate the effectiveness of the developed methodology for teaching mathematics in primary school using integrated electronic educational resources (EER) to improve the quality of mathematical knowledge acquisition and the formation of meta-subject competencies, including independent work and self-control skills.

LITERATURE REVIEW

One of the important global issues is quality education, as it contributes to the development of personal potential and key competencies of pupils and students. Mathematics is one of the core subjects in the development of key and subject-specific competencies. Mathematical education plays an important role in preparing pupils and students for life, as it develops the competences necessary for solving practical problems: from the moment a child is born, mathematics accompanies them throughout their life. It helps pupils and students develop logic, analytical skills and critical thinking, which they will apply in solving practical problems in real-life situations (Gravemeijer *et al.*, 2017). In the context of digitalisation and globalisation of education, high-quality mathematical training for pupils and students is essential, and the use of electronic educational resources can be the solution to this problem.

Digital technologies in education require teachers to learn new skills and use electronic educational resources effectively (Tsymbal, 2020). For efficiency and to fully unlock the potential of digital educational resources, teachers' professional development must be continuous and systematic (Korol, 2014). Digital platforms allow for the creation of personalised learning programmes that take into account the needs of each pupil and student. They facilitate greater collaboration between students and teachers, even in distance learning. However, digitalisation also creates challenges, such as the need to train teaching staff in the use of new technologies and to ensure the security of student data in the digital environment. There are various approaches to the use of digital technologies in the learning process (Zou *et al.*, 2025). The main ones include: interactive teaching materials-electronic textbooks and applications that provide interactive materials to help pupils and students understand mathematical terms and definitions through visualisation, animation and interactive tasks; software: educational programmes, programmes for teaching mathematical problem solving, graphic calculators, mathematical packages and geometric applications that allow pupils and students to explore mathematical concepts through analysis, visualisation (graphs and diagrams) and practical problem solving; online platforms and educational websites on mathematics, which provide students with the opportunity to study mathematics at a convenient time and at their own pace, as well as allowing them to receive feedback and support from teachers through online communication; the use of computer software and other interactive devices that allow teachers to deliver mathematics presentations in an interactive and more engaging format.

New approaches to digital mathematics education are needed to promote a better understanding of mathematical concepts and stimulate pupils' and students' interest in learning. However, it is important to remember that the successful use of digital electronic technologies in mathematics education requires competent, information-literate teachers who are able to effectively integrate these technologies into the learning process (Gamit, 2023). In the process of developing digital technologies, it has become clear that most e-learning resources should consist of EERs divided into two main didactic tasks: material that teachers can give to pupils and students to help them develop the necessary knowledge, skills and abilities to apply them to solving problems; monitoring of the pedagogical actions learned, achieved mainly through diagnostics. Teachers are not limited in their choice of digital educational resources, but they need to take into account the structure and type of e-learning tools.

According to the definition by A. Sergeev *et al.* (2012), e-learning is learning based on developed scenarios using multimedia and communication technologies. The teacher creates a scenario, the content of which consists of materials that define the learning objective and all components of learning, including assessment methods. With the introduction of e-learning and the development of digital technologies, the concept of electronic educational resources (EER) has become established for public consumption. EER represent educational materials and tools developed and implemented on the basis of digital (computer) technologies. This term encompasses the entire range of digital content used in the educational process. The main types of EER included electronic publications, electronic textbooks, educational software, interactive simulators, and various digital resources for testing and monitoring knowledge. In some areas of knowledge, EER (educational and methodological complex) placed as a set of software, hardware, and educational and methodological tools that provide a full range of educational services aimed at independent learning (theoretical, organisational, advisory, methodological, practical, experimental, etc.).

The main pedagogical tools used in EER are interactivity, multimedia, modelling, communication, and productivity (Abdulrahaman *et al.*, 2020; Muir *et al.*, 2022). Interactivity is interaction that represents a person's intelligent life with their natural and social environment. Multimedia includes a whole range of methods for reproducing visual and sound effects that are logically interconnected and united by a specific didactic idea. Modelling is used to simulate changes in the processes and objects under consideration and to describe an image of an imaginary reality or situation from practical life. Communicability provides communication capabilities, is a direct source of information, performs management functions, and allows quick access to EER services in real time. Indicators of "the learner as a user" raise the effectiveness of learning to a much higher level by automating everyday activities and significantly reducing the time needed to find the necessary information. Thanks to the above tools, EER organises a new educational technology, based on which all types of education are interconnected into a single structure aimed at the individual creative development of the learner. Thus, the range of EER applications is quite diverse and mainly depends on the goals and objectives that the teacher seeks to achieve in the course of the educational process.

MATERIALS AND METHODS

The presented study was conducted as part of a pedagogical experiment aimed at determining the effectiveness of using electronic educational resources in the process of teaching mathematics to primary school students. The study was conducted between the 2022 and 2024 academic years. The study was conducted in three consecutive stages:

- Constatative stage (2023-2024 academic year): assessment of the initial level of mathematical training of students.
- Formative (experimental) stage: introduction of developed lesson models with the integration of EER and

multimedia presentations into the educational process of the experimental group.

- Control stage: conducting a final assessment and comparative analysis of the results in the experimental and control groups.

The theoretical basis of the study was formed by the works of Kyrgyz and foreign researchers devoted to the problems of digital transformation of education, the use of electronic resources in pedagogy and methods of teaching mathematics. In the process of the work, the following theoretical methods were used: analysis, synthesis, comparison, classification and systematisation of scientific sources on the research problem to form a general concept; modelling of conditions for the implementation of mathematics training using digital technologies; studying the state of teaching and analysing the content of the mathematics course in primary school.

The empirical part of the study was conducted at Secondary School No. 8 in Bishkek, Kyrgyz Republic. The study sample consisted of 79 second-grade students (n = 79). Two groups were formed for the pedagogical experiment: experimental group (EG): 40 students; control group (CG): 39 students. The groups were recognised as equivalent at the initial stage based on the results of the initial assessment. The following empirical methods were used to collect empirical data: pedagogical observation of the learning process; questionnaires and surveys of teachers on the use of digital resources in mathematics teaching; study and summarisation of experience in implementing digital educational platforms (electronic textbooks, interactive simulators); diagnostic (initial) and final assessment of students' knowledge using standardised test tasks. The Student Achievement Levels (SAL) online resource was used to analyse the quality of knowledge, and the BaalooApp application was used to monitor and formatively assess the development of mathematical skills. Assessment using BaalooApp was conducted individually with each student (a 3-5-minute task) or as part of group learning.

Primary data processing included calculating the mean values and standard deviations of knowledge indicators. A comparative analysis of the results of diagnostic and final assessments was conducted. To confirm the statistical significance of the differences between the indicators of the experimental and control groups, the non-parametric Mann-Whitney U-test was used, and to assess the intra-group dynamics, the Wilcoxon test (or Student's t-test for dependent samples, assuming normal distribution) was used. Statistical analysis was performed using SPSS software (version 26.0).

At the forming stage, the experimental group used developed lesson models that integrated interactive teaching methods (the learning process was actively accompanied by video materials and interactive tasks) and electronic educational resources, including: IBILIM (a software and methodological resource for primary school classes); LearningApps (an online service for creating interactive exercises); Komodo (an application for personalised mathematics education for children aged 4-11); and the "Learning to Count" programme. In the control group, teaching was conducted using traditional methods and approaches, without the systematic use of the above-mentioned electronic educational resources, but with the basic curriculum remaining unchanged. The pedagogical experiment was conducted in compliance with all ethical standards (ASA, 2018). Informed consent was obtained from the parents (legal representatives) of the 2nd grade students for their children's participation in the study and the processing of the results obtained. All data are presented in an anonymised form.

RESULTS AND DISCUSSION

Using electronic resources in mathematics lessons

The didactic potential of electronic educational resources lied in their ability to significantly improve the quality of mathematical learning by improving the perception of abstract concepts and intensifying students' internal motivation. The introduction of EER did not require a radical overhaul of the structural format of the work programme or lesson plan. The differences between traditional and digital learning formats are evident only at the level of teaching methodology, which is adapted through the integration of digital technologies. The use of digital technologies in mathematics education significantly expands the teacher's arsenal. Currently, there are many specialised online platforms, interactive programmes, mathematical calculators, and applications for developing exercises that can be effectively used in the learning process. One of them is LearningApps (n.d.) – a free online service that allows you to create interactive exercises to assess the knowledge of pupils and students (Figs. 1, 2). This service contains 20 interactive exercises in a game format. Teachers can independently develop tasks using ready-made templates or create similar exercises from the collection (Aitbay kyzy *et al.*, 2024).

The Komodo app (n.d.) is designed for children aged 4 to 11. It works on all devices, does not require children to spend long periods of time in front of a screen, and the learning is personalised by maths teachers to suit each child's needs (Fig. 3).

The electronic educational resource IBILIM (n.d.) is a software and methodology package developed by a team of specialists, including experienced teachers and experts in the field of information technology. The resource contains specialised teaching materials on seven subjects and is intended for use as an additional educational tool in primary schools. Access to the platform is free and does not require prior registration, which ensures its wide availability to the educational community. The materials are relevant for use by primary school teachers, as well as by pupils for independent study and their parents (Fig. 4).

In the context of mathematics education for primary school pupils, IBILIM (n.d.) has high didactic potential. The information is presented in a visually oriented format, which improves the perception of the material and supports opportunities for independent learning activities by students. Systematic use of this resource in mathematics lessons contributes to the formation of key and subject-specific competencies required by educational standards.

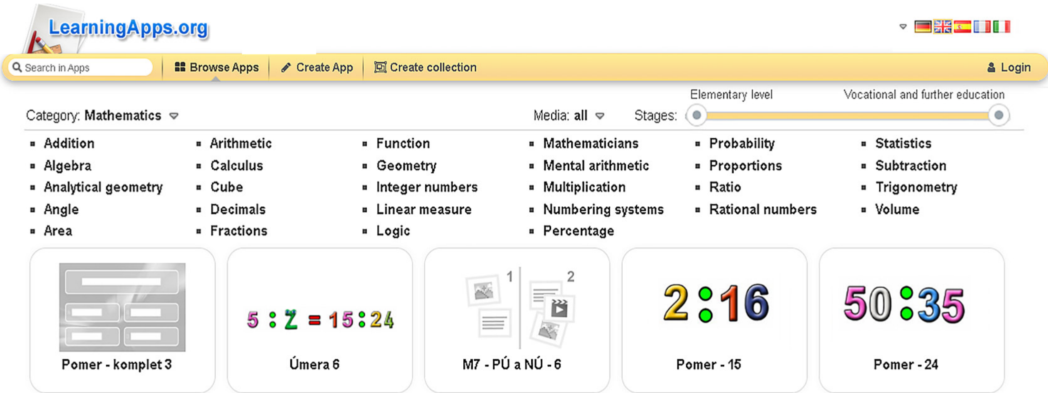

Figure 1. *Online resource LearningApps for creating interactive exercises*

Source: *screenshot from LearningApps (n.d.)*

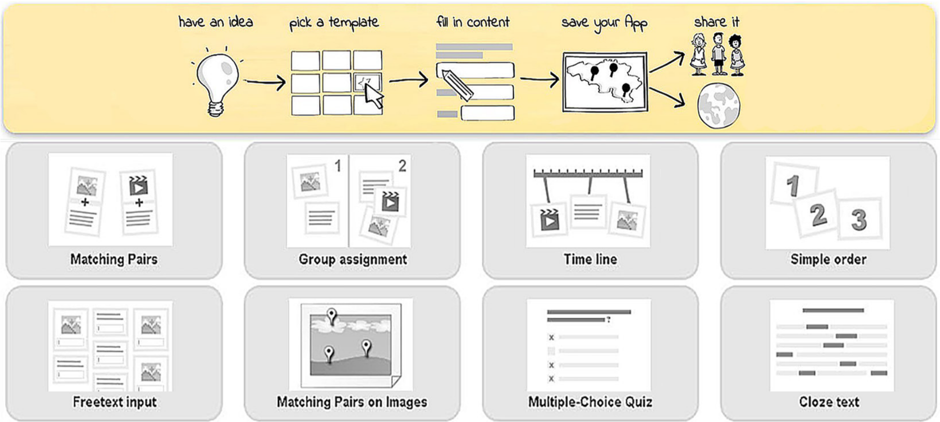

Figure 2. *Task type templates on the LearningApps portal*

Source: *screenshot from LearningApps (n.d.)*

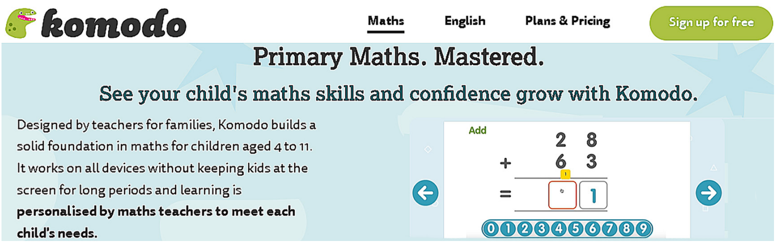

Figure 3. *Komodo Maths programme*

Source: *screenshot from Komodo (n.d.)*

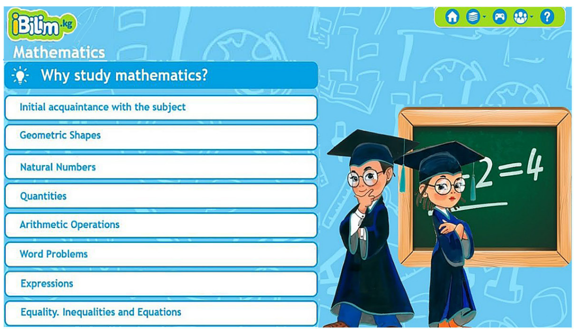

Figure 4. *Electronic resource IBILIM*

Source: *screenshot from IBILIM (n.d.)*

Using the BaalooApp programme in primary school mathematics lessons

The programme BaalooApp was developed by the USAID project "Okuu Keremet!" (n.d.) with the aim of assessing the mathematical abilities and skills of pupils in grades 1-4. With the help of the tools offered in the BaalooApp programme, it is possible to test the level of development of students' mathematical skills on topics covered in the state subject standard for mathematics, identify their strengths in development, and identify problems that students encounter. The use of feedback helps to adjust teaching methods in a timely manner to ensure student success in learning, develop and improve mathematical skills. G. Kazieva *et al.* (2022) in a methodological guide for primary school teachers propose tools for formative assessment of primary school students. Table 1 presents the formative assessment tools offered by BaalooApp.

Table 1. *Tools for formative assessment of students' mathematical skills*

<table>
<tr><th>Quarter</th><th>1st grade</th><th>2nd grade</th><th>3rd grade</th><th>4th grade</th></tr>
<tr><td rowspan="3">I</td><td rowspan="3">Recognition and comparison of numbers up to 10</td><td rowspan="3">Decomposition and composition of numbers up to 100</td><td rowspan="3">Multiplication and division of numbers</td><td>Adding four-digit and three-digit numbers</td></tr>
<tr><td>Subtracting three-digit numbers from four-digit numbers</td></tr>
<tr><td>Multiplying three-digit numbers by single digits</td></tr>
<tr><td rowspan="3">II</td><td rowspan="2">Addition and subtraction of numbers within 10</td><td rowspan="2">Recognition of geometric shapes, identification of differences and similarities between polygons</td><td rowspan="2">Conversion of quantities from one unit of measurement to another</td><td>Division of three-digit numbers by single-digit numbers</td></tr>
<tr><td>Solving problems to find the perimeter and area of geometric shapes</td></tr>
<tr><td>Solution of equations with a "window" (equations) by method of selection</td><td>Adding two-digit numbers</td><td>Decomposition and composition of three-digit numbers</td><td>Understanding place value, reading, writing and ordering numbers within 1,000</td></tr>
<tr><td rowspan="3">III</td><td>Composing and breaking down numbers up to 20</td><td>Subtraction of two-digit numbers</td><td>Constructing a natural sequence of numbers within 1,000</td><td rowspan="3">Conversion of quantities from one unit of measurement to another, arithmetic operations with named quantities</td></tr>
<tr><td>Adding single-digit numbers with carrying over tens</td><td>Solving simple text problems</td><td>Finding the perimeter and area of geometric shapes</td></tr>
<tr><td>Subtraction of a single-digit number from a two-digit number with carry over</td><td>Solving simple addition and subtraction equations</td><td>Solving equations for multiplication and division</td></tr>
<tr><td rowspan="3">IV</td><td rowspan="2">Recognition of geometric shapes and their elements, identification of differences in geometric shapes</td><td rowspan="2">Conversion of one unit of measurement to another</td><td>Adding three-digit numbers with carry over from the tens place</td><td>Solving motion problems</td></tr>
<tr><td>Subtraction of three-digit numbers with carry over</td><td>Solving complex equations (stage 1)</td></tr>
<tr><td>Solving simple text problems</td><td>Understanding the principle of constructing a natural number sequence within 100</td><td>Solving multiplication and division problems</td><td>Solving complex equations (stage 2)</td></tr>
<tr><td>Total</td><td>8 tools</td><td>8 tools</td><td>9 tools</td><td>10 tools</td></tr>
</table>

Source: *compiled by the authors*

Assessment is carried out individually with each student, but group assessment can also be used in group learning. The task takes 3-5 minutes to complete. During one lesson, 5-6 students can be assessed. Students are asked to complete the task presented by the BaalooApp programme. After the student responds, their result is entered into the programme (Fig. 5).

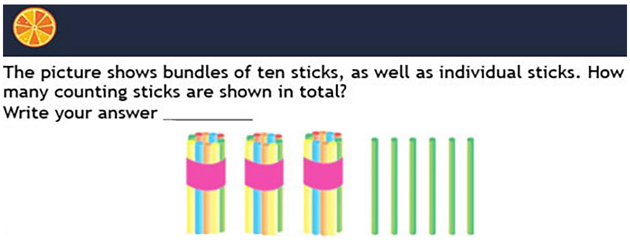

Figure 5. *Tool "Decomposition and composition of two-digit numbers"*
Source*: screenshot from the BaalooApp page*

Software BaalooApp provides the ability to conduct effective formative assessment of students' mathematical skills. The system provides detailed feedback immediately after the test is completed. The key functionality of the application is the comprehensive display of the results of completed tasks, which allows the teacher and student to obtain comprehensive information about the process of acquiring knowledge. Based on this data, the software generates recommendations for individualising the learning process, aimed at correcting identified deficiencies and improving students' mathematical skills. Below are specific recommendations that this programme provides for organising students' learning activities and teachers' methodological work, depending on the percentage obtained.

80-100%. These students did very well on the assignment. Feedback for the student: "You have mastered two-digit numbers, breaking them down into tens and ones, and adding them together. These are important skills for understanding addition and subtraction of two-digit and three-digit numbers, as well as for performing written multiplication and division. Continue to improve these skills." Feedback for the teacher: "You can give these students more challenging tasks to develop their understanding of place value, such as tasks to compose other numbers using the same digits; comparing numbers using place value; and a task to form a three-digit number (its name, notation, and definition of a new place value)."

60-79%. These students were relatively successful in completing the task. Feedback for the student: "You were able to correctly show two-digit numbers break them down into tens and ones. This is an important skill, especially for oral and written addition and reading two-digit numbers, as well as for written multiplication and division. However, you have some difficulty composing two-digit numbers and decomposing them into tens and ones. You should continue to practise this skill." Feedback for the teacher: "Demonstrate the solution of several problems using the example of representing numbers up to 100 as a number of place value addends, composing and decomposing numbers into tens and ones. Then ask the students to take turns explaining how they composed a two-digit number and how they decomposed the number into tens and ones. From time to time, check how the participants are performing the tasks of composing and decomposing numbers up to 100. You can find these examples in the current mathematics textbook for Grade 2, in Modules 1, 6 (Appendix B) and in the "Collection of Tasks".

30-59%. These pupils did poorly on the task. They need help understanding each step of the subtraction process and mastering the use of the algorithm. Feedback for the teacher: "Think about these pupils: why do you think they are having difficulty with these tasks? Do they have a sufficient understanding of what two-digit numbers consist of? Or are they making mistakes in indicating the place value of a digit in a number, which leads to incorrect naming of the value and unit? Discuss the correct and incorrect results with the students to eliminate difficulties and their limitations. Review in detail with students the composition and distribution of two-digit numbers up to 100 in the following steps: (1). Work through ordinal counting, counting by tens, possibly using visual aids (e.g. a number line). (2). Use counting aids to show how two-digit numbers are formed from ones and tens. Pay attention to saying the names of two-digit numbers aloud and writing them down. Give the task of forming any two-digit number, name it and write it down. Then ask to show the number on bundles and sticks (for example, 43 counting sticks). (3). Consider the composition of two-digit numbers up to 100. Pay attention to the place value of digits in examples using graphic models. Give the task of forming a number from ten and any two-digit number and ask the student to say the steps of the task aloud. (4). Give examples of the distribution of numbers into tens and values. Give the task: decompose numbers and get any two-digit number. (5). Work with students on representing two-digit numbers as the sum of place value addends. (6). Give tasks for calculating sums and differences by grouping place value addends and comparing numbers using place value units. Set aside time to observe how each student is working and help them identify incorrect solutions and correct them. You can find these examples in the current mathematics textbook for Grade 1; in Modules 1, 6 (Appendix B); and in the "Collection of Tasks".

0-29%. These pupils did poorly on the task. They need help understanding each step of the subtraction process and mastering the use of the algorithm. Feedback for the teacher: "Think about these pupils: why do you think they are having difficulty with these tasks? Do they have a sufficient understanding of how two-digit numbers are formed? Or are they making mistakes in indicating the place value of a digit in a number, which leads to incorrect naming of the value and unit? Discuss correct and incorrect results with students to eliminate difficulties and their limitations. Review the composition and distribution of two-digit numbers up to 100 in detail with your students using the following steps: (1). Work through ordinal counting, counting by tens, possibly using visual aids (e.g. a number line). (2). Point out the formation of two-digit numbers from degree and degree on the counting aids. Pay attention to saying the names of two-digit numbers and writing them down. Give the task of forming any two-digit number, name it and write it down. Then ask to show the number on bundles and sticks (for example, 43 counting sticks). (3). Consider the composition of two-digit numbers up to 100. Pay attention to the place value of digits in examples using graphic models. Give the task of forming a ten and any two-digit number and ask the student to say the steps of the task aloud. (4). Give examples of the distribution of numbers into tens and values. Give the task of breaking down into tens and obtaining any two-digit number. (5). Work with students on representing two-digit numbers as the sum of place value addends. (6). Give tasks for calculating the sum and difference by grouping place value addends and comparing numbers using place value units. Set aside time to observe how students are working and help them identify and correct incorrect solutions. These examples can be found in the current maths textbook for Year 1; in Modules 1 and 6 (Appendix B); and in the "Collection of Tasks."

Results of a pedagogical experiment on the effectiveness of using digital technologies in the educational process

The results of the pedagogical experiment confirmed the high effectiveness of using digital educational technologies and resources in the process of teaching mathematics to students in the context of the digitalisation of education. This effectiveness was achieved through a combination of interrelated organisational and pedagogical conditions and adequate teaching and methodological support, provided by electronic educational resources, interactive teaching materials and methodological recommendations. One of the key results was a significant increase in the level of academic motivation in the experimental group. The use of interactive platforms, online simulators and digital tasks ensured clarity and a high level of interest in the learning process, which had a positive effect on the involvement of schoolchildren in educational activities. According to the survey, more than 70% of students noted that classes using digital tools contributed to a deeper understanding of mathematical concepts and algorithms. The second significant result was the progressive development of independent work and self-control skills among students in the experimental class. The use of the BaalooApp formative assessment programme and online testing provided a mechanism for immediate feedback, allowing students to quickly correct mistakes and track their individual progress. This mechanism contributed to the effective formation of regulatory universal learning activities. For qualitative characterisation of the level of knowledge in mathematics, a 4-step assessment system was used:

- Level 1 – from 80% to 100%, 4 or 5 out of 5 tasks completed;
- Level 2 – from 60% to 79%, 3 out of 5 tasks completed;
- Level 3 – from 30% to 59%, 2 out of 5 tasks completed;
- Level 4 – from 0% to 29%, 1 task completed out of 5.

A comparative analysis of the control and experimental groups revealed significant differences in the level of mathematical training. As a result of experimental training, the level of mathematical training increased for most students. According to the results of the diagnostic experiment, 15% of students had Level 1, but as a result of experimental training, their number increased to 25%, and Level 4 decreased from 10% to 5%. In the experimental classes, the number of students who coped with tasks of increased complexity increased by 10% compared to the control group. The performance indicators for tasks requiring logical reasoning and the use of digital tools for visualising mathematical models also improved. The effectiveness of teaching mathematics using digital electronic resources is shown in the diagrams (Figs. 6, 7, 8).

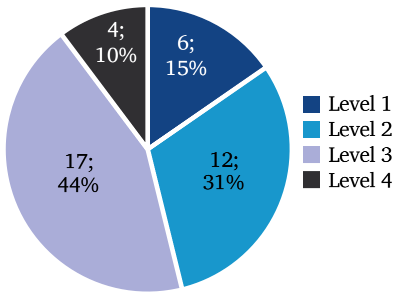

Figure 6. *Learning outcomes of students in the control class*
Source: *compiled by the authors*

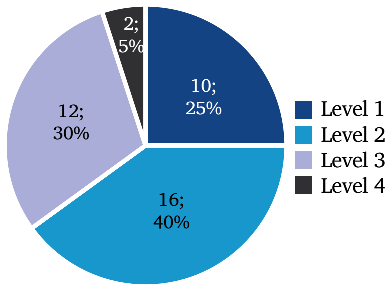

Figure 7. *Learning outcomes of students in the control class*
Source: *compiled by the authors*

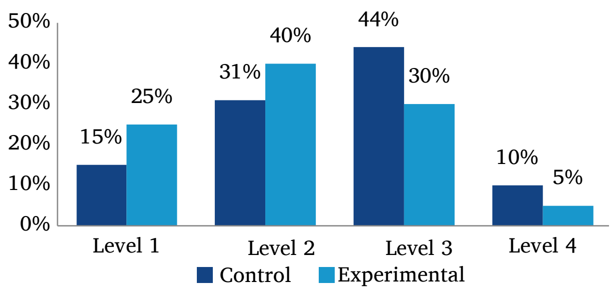

Figure 8. *Comparison of monitoring results for the control and experimental classes*
Source: *compiled by the authors*

Student Achievement Levels (SAL) methodology was used to calculate and systematise student performance indicators. Analysis of the data obtained revealed the following results (Table 2).

***Table 2.** Comparative results of student performance*

Student performance indicators	Control class	Experimental class
Academic performance	89.74%	95%
Quality of knowledge	46.15%	65%
Level of training	52.41%	62.2%
Average score	3.51	3.85

***Source**: compiled by the authors*

The results of the pedagogical experiment demonstrate statistically significant confirmation of the hypothesis about the effectiveness of integrating digital tools into the process of teaching mathematics to primary school pupils. Firstly, it has been confirmed that the introduction of EER has provided a significant increase in learning outcomes, shaped new educational practices, and created conditions for a more flexible and individualised learning trajectory. This is consistent with the findings of N. Saat *et al.* (2024), who in their systematic review also emphasise the positive impact of digital technologies on academic performance in mathematics education. Secondly, discussion of the data obtained shows that the digitisation of the educational process is not limited to improving the quality of subject training, but also stimulates the development of meta-subject competencies: critical thinking, information literacy and digital resource skills. The development of these skills is particularly important, as noted in the work of R. Kirillova & N. Timofeeva (2020), since modern education requires students to develop a broad range of social competencies necessary in a digital society.

Thirdly, the study identified key problems and limitations in the process of introducing digital technologies. Analysis of teaching materials and pedagogical observation in schools showed that digital tools are being used passively, confirming the thesis that there is a lack of systematic attention to the effective use of EER as a means of personal development. The difficulties identified include the need to improve teachers' qualifications, the risks of information overload for students, and technical support issues. The data obtained echoes the research of B. Pepin *et al.* (2023) and A. Khamza *et al.* (2024), which indicates that the successful integration of digital resources requires systematic support for the digital environment, the development of clear criteria for evaluating effectiveness, and methodological support for teachers. It is important to note that, despite the role of EER as a modern teaching tool, they cannot replace teachers in any way. The use of digital resources in the educational process does not limit the role of the teacher but, on the contrary, transforms it. The results obtained showed that prompt feedback and the ability to make timely corrections to the learning process allow the teacher to act not as a passive observer, but as an active moderator who guides learning activities to achieve maximum student success.

CONCLUSIONS

Based on the analysis of theoretical sources and the results of the pedagogical experiment, key conclusions were formulated regarding the effectiveness of integrating electronic educational resources into the process of teaching mathematics to primary school pupils. The study confirmed the hypothesis that the systematic use of digital technologies in the educational process contributes to a significant improvement in the quality of students' mathematical training and their motivation to learn. A comparative analysis of the data from the experimental and control groups showed that students involved in learning using interactive platforms (LearningApps, IBILIM, BaalooApp) achieved higher educational results. This was reflected in an increase in the number of correctly completed tasks of increased complexity, a decrease in the number of typical errors, and an increase in overall academic activity.

It has been established that the use of digital EERs made learning more visual, interactive, and personalised. The use of tools such as BaalooApp, with its instant feedback feature, became a critical element that allowed teachers to quickly adjust their teaching methods and students to develop independent work and self-control skills. Thus, digital educational programmes serve as a powerful tool for differentiating learning and building individual educational trajectories. In addition, the integration of digital EERs significant role in the formation of meta-subject competencies, such as critical thinking, logical analysis and information literacy, which are key in a digital society. Prospects for further research include the development and testing of unified criteria for assessing the effectiveness of the implementation of digital educational resources in schools, as well as studying the long-term impact of the use of digital EERs on spatial thinking and abstraction abilities in students of different age groups.

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Билим берүүдө математикалык окутууну санариптештирүү шарттарына ишке ашыруу

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Аннотация. Билим берүүнү системалуу санариптештирүүнүн шарттарында жаңы педагогикалык куралдардын натыйжалуулугун баалоо маселеси курч мааниге ээ болууда. Бул макала башталгыч класстын окуучуларынын математикалык даярдыгынын сапатына электрондук билим берүү ресурстарынын (ЭБР) таасирин эксперименталдык текшерүүгө арналган. Изилдөөнүн негизги максаты санариптик технологияларды интеграциялаган математика окутуу методикасынын натыйжалуулугун аныктоо болгон. Изилдөө 2022-2024-окуу жылдары Бишкек шаарындагы №8 орто жалпы билим берүү мектебинде педагогикалык эксперимент форматында жүргүзүлгөн. Эксперименталдык иштин жүрүшүндө сабакка мультимедиялык презентацияларды жана “IBILIM”, “LearningApps” жана “Komodo” сыяктуу адистештирилген ЭБРди колдонгон үлгүлүү сабактар киргизилген. Көндүмдөрдүн өнүгүүсүн көзөмөлдөө жана формативдик баалоо жүргүзүү үчүн “BaalooApp” колдонмосу пайдаланылган. Эксперименттин натыйжалуулугу диагностикалык жана жыйынтыктоочу баалоо маалыматтарын талдоо жана салыштыруу жолу менен аныкталган. Алынган маалыматтарды талдоо эксперименталдык топтордо математикалык даярдыктын натыйжалуулугунун жогорулаганын тастыктады. Баштапкы жана көзөмөл тобунун көрсөткүчтөрү менен салыштырганда, ЭБРди колдонгон окуучулардын билим сапатынын өсүшү 20 % га жогорулады. Бул санариптик ресурстарды жана интерактивдүү окутуу ыкмаларын интеграциялоо математикалык билимдер менен көндүмдөрдү өздөштүрүүнү кыйла жакшыртарын далилдейт. Изилдөөнүн жыйынтыктары электрондук билим берүү ресурстарын колдонгон методиканын жогорку натыйжалуулугун көрсөттү. Системалуу жана методикалык жактан негизделген ЭБРди колдонуу окуучулардын мотивациясын гана жогорулатып тим болбостон, математикалык жана маалыматтык компетенцияларды өнүктүрүүдө сапаттуу секирик камсыз кыларын аныкталды. Бул билим берүү процессин мындан ары модернизациялоодо олуттуу практикалык мааниге ээ

Негизги сөздөр: математика; санариптик технологиялар; электрондук билим берүү ресурстары; окутуу ыкмалары; окуу процесси

Реализация математической подготовки в условиях цифровизации образования

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Аннотация. В условиях системной цифровизации образования критически актуализируется задача оценки эффективности новых педагогических инструментов. Настоящая статья посвящена экспериментальной проверке влияния электронных образовательных ресурсов (ЭОР) на качество математической подготовки обучающихся младшей школы. Основная цель исследования состояла в определении результативности методики обучения математике, интегрирующей цифровые технологии. Исследование проводилось в формате педагогического эксперимента в период 2022-2024 учебных годов на базе средней общеобразовательной школы №8 города Бишкек. В ходе экспериментальной работы в учебный процесс были внедрены разработанные модели уроков с использованием мультимедийных презентаций и специализированных ЭОР, таких как «IBILIM», «LearningApps» и «Komodo». Для мониторинга развития навыков и проведения формативного оценивания применялось приложение «BaalooApp». Эффективность эксперимента оценивалась путем анализа и сравнения данных диагностирующего и итогового оценивания. Анализ полученных данных подтвердил повышение результативности математической подготовки в экспериментальных группах. По сравнению с исходными и контрольными показателями, качественный рост показателей знаний учащихся, применявших ЭОР, повысился на 20 %. Это свидетельствует о том, что интеграция цифровых ресурсов и интерактивных методов обучения позволяет значительно улучшить усвоение математических знаний и навыков. Результаты исследования продемонстрировали высокую эффективность разработанной методики с использованием электронных образовательных ресурсов. Установлено, что систематическое и методически обоснованное применение ЭОР не только повышает мотивацию обучающихся, но и обеспечивает качественный скачок в развитии математических и информационных компетенций, что имеет значимую практическую ценность для дальнейшей модернизации образовательного процесса

Ключевые слова: математика; цифровые технологии; электронные образовательные ресурсы; подходы к обучению; учебный процесс