Journal of Education and Human Development
June 2024, Vol. 13, No. 1, pp. 10-21
ISSN: 2334-296X (Print), 2334-2978 (Online)

Published by The Brooklyn Research and Publishing Institute.
DOI: 10.15640/jehd.v13n1a2
URL: https://doi.org/10.15640/jehd.v13n1a2

Active Teaching through Mathematical Problems in Primary School

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Abstract

Active teaching is a key component in the education system at all stages of education. In practice, introduction of active teaching in mathematics teaching in primary school poses significant challenges for teachers. To solve this problem, we have developed a methodological approach described in this article. In particular, we suggest an active teaching model whose realization is linked to the inclusion of problems with developmental and interdisciplinary content in the teaching process in mathematics classes. The solutions of these problems are associated with particular themes in mathematics classes. We discuss the methodology for constructing the systems of problems with developmental and interdisciplinary content in accordance with particular themes in mathematics classes in primary school, which is based on the scheme that we developed. We have also analyzed the indicators of including such problems in mathematics classes in primary school and the results of the educational experiment demonstrating that the author's methodological approaches provide a high quality of mathematical education for primary school pupils, make the teaching process interesting and attractive, and ensure their involvement in the process of active teaching and learning through the systems of specially selected problems.

Keywords: mathematical problem; active teaching; primary school; statistical evaluation; educational experiment

1. Introduction

1.1 Background

In the first grade, pupils are involved in the process of active learning(Stella V, 2001) and it is therefore important thatthe teaching process is interesting for pupilsin order for them to form and develop logical thinking (Batchelor S, Torbeyns J, Verschaffel L**,** 2019). Using mathematical problems with developmental function makes learning as enjoyable for them as playing (Godfrey J, Stone J,2013) and ensures that pupils have school readiness. At the same time, however, the question is how to achieve all this? How to make a mathematics class interesting and attractive for pupils?(Ginsburg H, Lee JS, Boyd JS, 2008).In the lower grades, mathematics is associated with solving problems, which means we should look for the key in the problems. What is our situation today?(Elmore RF, Peterson PL, McCarthy SJ, 1996).It may be said without exaggeration that situation is unsatisfactory, even regrettable. School mathematics textbooks cannot ensure pupils' interest because of similarity of the problems and the ways to solve them, which makes the teaching process in the lower grades boring and annoying.

1.2 Research goals

- To develop theoretical foundations, methodological approaches and criteria for teaching how to solve systems of mathematical problems with developmental and interdisciplinary content for primary school pupils;
- To develop solving techniques and teaching methodology for the systems of mathematical problems with developmental and interdisciplinary content for primary school pupils;
- To work out the systems of mathematical problems with developmental (Wickstrom H, Pyle A, DeLuca C, 2019) and interdisciplinary content for primary school pupils;
- To develop the methodological approaches, which will help primary school pupilsin developing their practical skills and active learning by solving systems of mathematical problems with developmental and interdisciplinary content;
- To incorporate the process of teaching into a single system through using the systems of mathematical problems with developmental and interdisciplinary content for primary school pupils;

- To raise general level of education;
- To improve the quality of mathematics education for primary school pupils; (Frye D, Baroody AJ, Burchinal M, Carver SM, Jordan NC, McDowell J, 2013)
- To encourage readiness of primary school pupils for active learningthrough mathematical problems with the content of developmental and interdisciplinary links (Elbahri M, SolimanA, Yliniemi K, Abdelaziz R, Homaeigohar S, Zarie ES, 2018);
- To work out new methodological approaches and recommendations through the implementation of mathematical problems with developmental and interdisciplinary content for primary school pupils.

2. Methodology

We used various research methods, in particular historical, comparative, descriptive, evaluationresearch and so on.We used historical research when it was necessary to establish the effectiveness of teaching the issues discussed in the past and to draw conclusions. For example, when studying the psychological and pedagogical foundations of mathematical problems with developmental and interdisciplinary content for primary school pupils, we considered the approaches implemented in the past. The same approach was used when analyzing the school mathematics textbooksand so on.

We also applied a comparative method when using historical research to compare different research materials and to identify the benefits of the implemented method of research.

In some cases, we needed to observe directly the process of teaching to generate the required information, in order to investigatedifferent situations and special cases. In this case, we used descriptive research.

2.1 Novelty of research

- We have studied psychological, pedagogical and methodological patterns of implementation of the systems of mathematical problems with developmental and interdisciplinary content for primary school pupils, indicators of the including the systems of these problems, and expected educational outcomes;

We have studied methodology for working out the systems of mathematical problems with developmental and interdisciplinary contentfor primary school pupils and have developed specific methodology to solve them that provides the basis for offeringnew methodological recommendations for teachers, pupils, experts, and education stakeholders.

2.2 Target of research

- Mathematical problems considered in the process of teaching for primary school pupils;
- The process of teaching the systems of mathematical problems with developmental and interdisciplinary content intended for active teaching in primary school.

2.2 Research strategy

The study included the qualitative and quantitative components, and was carried out in four phases:

2.3 Qualitative component

The quantitative component was preceded by the qualitative study aiming to identify indicators for assessing the quality of learning in primary schoolsfor the quantitative component. Within the qualitative component, the focus groups(respondents) were questioned, including education experts, school principals, resource centers, parents and teachers. The qualitative component was implemented within the first six months from the beginning of the study.

2.4 Quantitative component

The purpose of the quantitative component was to collect information from the target groups - teachers, school principals, education experts, resource centers, and parents, according to indicators identified within the qualitative component.
We deemed it optimal to use a random walk method.

2.5 Selection method

We used the stratified random selection to select schools, for which we used a geographic region and type of settlement as stratification variables:

1.Schools in the mountainous regions;
2. Village schools;

3. Urban schools.

Respondents in each region/settlement were selected using the random walk principle

The evaluation research was used mainly when we conducted statistical analysis of studies performed as a result of traditional teaching outcomes and approaches that we developed. We assessed the result of the evaluation research using statistical criterion χ^2 that confirmed the advantage of the methodological approach used.

Studies carried out using statistical methods have proven a progress in the academic performance of pupils, a shift to active teaching and improvement of the quality of general education through the use of the systems of mathematical problems with developmental and interdisciplinary content.

We applied system analysisresearch, which we performed in phases:

- The data for analysis was broken down into several parts;
- We assessed each part;
- We received the final result.

The presented methodology ensures high scientific quality of the research, as well as the reliability and validity of the results obtained.

3 Stages of research

3.1 Research was carried out in four stages:

I-stage- A survey of the existing situation with mathematics teaching and learning in public and private primary schools;identifying thechallenges and strengths; assessment, designing anaction plan. In parallel, we started to composemathematical problems with developmental and interdisciplinary content;

II-stage- Implementation of the action plan, working on theoretical and practical issues relevant to active teaching(Hayward PA,2019). Holding the trainings forprimary school teachers and specialiststo introduce thedeveloped materials. Composingmathematical problems with developmental and interdisciplinary the content;

III-stage- Including the developed materials in the process of teaching. Methodological supervision and control over the teaching process. Adjustmentsto the plan,where necessary; workingon the corrected issues. Holding trainings on the materials developed.Composingmathematical problems with developmental and interdisciplinary the content;

IV stage - Assessing the results obtained using statistical criteria.

Based on our research, we have established that majority of primary school pupils do not like to solve mathematical problems, because they are boredbysolving typical problems(Beilock SL,Maloney EA, 2015). And we can say that by solving such problems, it is impossible to achieve high levels of logical thinking among pupils, and they cannot raise pupils' intelligence. Therefore, we started to think about developing different approaches for primary school pupils to mathematical problems that would make the learning process fun and give it a developmental function as well (MarottaSM, Hargis J, 2011). To find out the thing the primary school pupils love and interested most, we conducted a survey. More than 900 pupils were involved in this survey. The results of a survey showed that most of all, pupils love watching cartoons and their characters (34%), fairy tales and their characters (23%), children's computer games (21%), works of fiction and movies about pirates, desert islands, and treasure hunters (16%), and other children games (6%). After analyzing these data, we decided to compose mathematical problems for primary school pupils based on the following principle:to compose the problem statement so that we introduce in it their favoritefairy tale and cartoon characters, pirates, treasure hunters, and so on, in accordance with age development of pupils, while in terms of the content, the problems have a developmental content that is, to compose problems whose solution requires searching, or in other words, non-standard mathmeticallympiad problem. The practice shows that pupils like to take part in the process of solving such problems (the statistical analysis of the educational experiment is shown below), while also showing the low interest in solving problems from typical school textbooks. Why do pupils have particularly positive attitude towards such problems? What is the main reason for this? The answer to this question is simple. The problem statementis attractive for pupils and they enjoy reading it without coercion. After reading the problem statement, the teacher, by putting the questions for one or two minutes, revives the pupils' favorite magic world and characters that inspire pupils' readiness to solve the problem. And the problem, with its structure, has the developmental content, its solution requires searching, intellectual discipline, which develops logical skills in pupils and creates a prerequisite for solving problems with the same content in the future as well, that is, the scheme that we developed helps primary school pupils to solve developmental problems without any coercion, which develops

their logical thinking and promotes in-depth and profound learning of mathematics, raising their intelligence. We have considered the developmental problems that are solved by applying the Dirichlet principle, analogy, generalization, invariants and semi-invariants, the use of incomplete and complete inductions, analytical and synthetic methods, deduction, the use of generalization techniques, graphs, ordered couples, analogy, test and sampling method, combinatorial and probabilistic problems containing the elements of the theory of sets and so on. Of particular interest to primary school pupils were logical problems and fluid transfer problems. To question – in what grade should we start solving developmental mathematical problems, we answer that the inclusion of developmental mathematical problems in the teaching process in mathematics class should start from the first grade and continuein all grades. During one lesson, we have to solve one or two problems of suchcontent and no more than one problem should be given to pupils as homework, which is similar to problem that was discussed in classes, but its complexity is relatively low. We would also like to note that only the teacher decides on the topic, the extent, content and complexity of problems to be included in the process of teaching, since it depends on the psycho-physiological abilities of pupils (Berk LE, Winsler A, 1995), the level of their mathematical knowledge, their age development and so on.

- We worked out the system of mathematical problems with developmental and interdisciplinary content for primary school pupils according to the scheme that we developed:
  Transfer of knowldge from discipline A of primary classes (not from mathematics) → mathematical problem with the content of discipline A, the statement of which is associated with knowedge transferred to pupil → solving the mathematical problem set → after writing down the answer to the solved problem, pupils are given questions, which strengthen their knowledge in discipline A.

- For primary school pupils, we developed the forward and backward interdisciplinary linkages between mathematics and nature study, mathematics and fine and applied arts. The forward interdisciplinary linkage implies explaining any particular event or fact in other discipline using mathematical methods. The backward linkage implies proving particular mathematical provision, or solving mathematical problem using methods and approaches from other discipline. To compose mathematical problems with backward interdisciplinary linkages for primary grades, we used the scheme that we developed:
  Mathematical problem with the content of discipline A (not mathematics) for primary grades → solving the mathematica problem → a numerical value of answer to solved problem enhances or/and strengthens the knowledge acquired by pupil in discipline A.

- Based on the questionnaire surveys of teachers, we identified the key topics, during examination of which, the inclusion of the systems of problems containing interdisciplinary links would be most effective. These topics are: the systems of mathematical problems ofenvironmental content, the systems of mathematical problems with the content of ethnographic tour, the systems of the astronomy and space-related mathematical problems, the systems of the economics and finance-related mathematical problems, the systems of mathematical problems related to healthy life-style with the content of interdisciplinary links and so on. Given the psycho-physiological state of primary school pupils, we decided that when implementing interdisciplinary contentaround any topic, it is necessary to follow the scientific principle, which implies that the theoretical knowledge that was delivered to pupils or any particular data contained in mathematical problem mustreflect factual and scientifically justified information, since pupils easily memorize numerical values, and if later the information that they obtained from other sources does not match the data already known to them, this may disappoint them. To that end, we deem it necessary that the teacher, who decided to include the systems of mathematical problems with interdisciplinary links in the teaching process for primary school pupils, has to create first the information base around the topic which will reflect real numerical data on the basis of which the teacher will compose mathematical problem with interdisciplinary content.Wewill consider briefly how we worked out the systems of mathematical problems with interdisciplinary content around the above stated topics.

- The process of teaching in primary school is active and effective when the teacher is able to involve all pupils in the the process. When is this achieved? While the topic of the lesson is interesting to pupils in terms of content, when they already have some knowledge about the topic of the lesson that they are trying to demonstrate in front of the class"Classroom innovation can involve finding unique ways to present material to students. Engaging students with the material will support their understanding of the broader implications of what they learn and how it relates to their lives" (Ronald VM, 2018). Such topics may vary in the senior classes, while in primary school the teacher does not have much choice, since range ofknowledge of primary school pupils is not wide and deep. The issues that teacher can include in the process of teaching in primary school are the environmental education issues, which are naturallyof high relevance and can be used

thematically to establish interdisciplinary links. We believe that more attention needs to be paid to the nature and environmental education of pupilsat school from the very beginning of their education, since environmental issues are of global importance and all humanity is involved in solving them.

Explanation and study of teaching materials with environmental content takes place mainly during classes of nature study, fine and applied arts, mathematics and native language,where, in a form accessible for pupils, the links between animate and animate nature, as well as between various components of animate nature (plants, animals, etc.) and human beings are considered. In the later period, pupils get acquainted with the world around them and identify connections that are relevant from environmental viewpoint, which helps them in establishing logical links.

While teaching in primary schools, it is advisable to use environmental field trips whose purpose and function is practical contact with environmental issues covered in the content of the course of nature study and other disciplines, which is reflected in the observation of plants and animals, as well as some production processes described in the teaching materials, visiting historical sites discussed in classroom materials, verification of data given ina statement of mathematical problem with the environmental content referring to the height and age of trees and plants, and so on. These environmental education field trips arouse pupils' interest, the pupils go outdoors, to the enterprise or factory, get acquainted with some of the manufacturing processes, take measurements, weigh objects, which helps them to develop practical skills. Sometimes, especially in lower grades, it is also advisable to organize simulated educational field trips. During environmental education field trips, pupils have the opportunity to measure and verify on their own some data that they will use later in solving mathematical problems with environmental content.

It is methodologically justified for primary school mathematics classes to include mathematical problems of developmental and interdisciplinary nature with environmental content, in particular, when covering mathematical problems of the relevant type. The process of teaching implemented in this way does not take up more class time, but it has a high developmental effect of pupils because by incorporating problems with such content, the process of teaching is integrated into a single system which promotes active teaching of pupils, the creation of a new knowledge and modern teaching methodology, which becomes the basis of developing relevant recommendations (Ginsburg H, Klein A, Starkey P, 1998). It is also effective to include mathematical problems of developmental and interdisciplinary nature with environmental content during extracurricular, facultative and mathematics club activities.

Mathematical problems of developmental and interdisciplinary nature with environmental content are virtually absent from the primaryschool mathematics textbooks, and therefore, teachers have to compose them, for which, as we said above, the teachers first need to develop a database containing the available information on environmental issues related to the flora, fauna and so on. For example, data related to tree species life, tree height, environmental significance of forest, the environmental role of birds and insects in nature, the length of rivers, the spaces between different human settlements, the distance from Earth to moon, from Earth to the sun, country's national parks, nature reserves, etc. It is advisable to write down the collected data in a table format, which will then help pupils to compose differentmathematical problemswith environmental content by themselves.

- It is knownthat innovative approaches in primary school are based on interdisciplinary links, which can be even more effective if we use a new form of interdisciplinary links in primary school, such as an ethnographic tour. When conducting an ethnographic tour, pupils and teachers have the opportunity to independently collect data that they will use as a database. Based on them, the teacher composes mathematical problems with interdisciplinary links relevant to the topic of ethnographic tour and includes them in theteaching practice in primary school. The situations described in such mathematical problems are known to pupils, they have already seen and experienced them, which makes it easier for pupils to perceive the problem situation, to understand its content, which arouses their natural interest in solving this problem. After completing the ethnographic tour, pupil should be able to develop the right attitude towards the selected ethnographic issue, ensure its observation and gather the necessary material surrounding the ethnographic issue, integrate the existing interdisciplinary knowledge and use knowledge acquired in practice forseparate disciplines.
- Before working out the systems of mathematical problems with interdisciplinary links related to astronomy and and space, we collected the required data on the Earth, a satellite of the Earth – the moon, and lunar phases. Then we introduced pupils to the information about the first living creatures sent into space, provided them with information about the first spacemen, the first women in space, the records set in space, artificial satellites, and much more. Based on these data, we then worked out the system of mathematical problems

with interdisciplinarycontent, developed exercises requiring to fill in the gaps in the text, and then we launched a mathematical quiz on space exploration.

- We paid special attention to the promotion of a healthy lifestyle for improving the health of primary school pupils, becausemany primary school pupils are not well aware of the basic detailsof a healthy lifestyle. A healthy way of living is a prerequisite for human health, longevity, and discharging social responsibilities. It contains numerous components, but we separated the basic parts from them:

- Acquiring health skills, health skills development starting in early childhood;
- Ensuring the safety of the outside world, studying its impact on human health;
- Discarding unhealthy habits(tobacco, alcohol and drug consumption);
- Eating in moderation, according to individual and physiological characteristics. Awareness of the quality of used products;
- Movement –a physically active life, including daily special physical exercises, taking into account age and physiological characteristics;
- Hygiene - personal and social hygiene, knowledge of basic first aid skills;
- Fitness.

We collected the required data on these basicaspects, designed a system of mathematical problemswith interdisciplinary links, and then we included them in the process of teaching. In particular, we developed the systems of mathematical problems with interdisciplinary content relatedto human/pupil's body and mathematics, healthy nutrition and mathematics, healthy lifestyle and mathematics, bad habits and mathematics. We specifically addressed the road traffic regulations and mathematics. We believethat primary school teachers must regularly remind pupils of the elementary rules of roadsafety, when to cross the street according to traffic lights, not to play and not to cross the roadway, the need for a specialseat for babies in a car, and so on.

- The socio-economic transformations taking place in the world brought about changes in people's standard of living, which has put on the agenda adaptation of individuals to the demands of the modern market economy. The solution of these challenges is closely linked with pupils'level of education in economics, which in my vision, must be one of the focus areasat all levels of education. It is methodologically acceptable and appropriate that discussion of mathematical problemswith economic content should start in primary school, to which end, it is necessary to develop the methodological aspects of teaching mathematical problemswitheconomic content in the early grades, which involves training all pupils at elementary level in economics. When teaching mathematical problems ofeconomic content,the teacher has a concrete task to transferthe basic economic knowledge to pupils which may relate to individual economic behavior, family economy or industrial-economic processes, the forms of ownership, various types of work organization, the basics of social and economic security of young people and so on. It should be noted that the basic economic knowledge alone is not the basis for the formation of economic education of an individual. The active position of each primary school pupil in the process of economic education helps selct the way ofeachpupil's personal development, which defines the range of their self-realization, thus guaranteeing the acquisition of further economic knowledge and skills in a modern market economy. In the process of economic education, the economic knowledge is transformed into the findings that are realized in behaviors and actionswhich are driven by their economic needs and personal interests, which in turn depend on the economic culture of the society.

Teaching economics to primary school pupils is a social mandate of the society. Their economic education should be implemented indifferent directions as follows: introduction to economic education of primary school pupils in the main disciplines; Integrated course for economic education of primary school pupils;the inclusion of a special economic education course in the teaching process of primary school pupils, etc. Unfortunately, in most primary schools, almost nothing is done in terms of economic education, and in schools where economic issues are introduced to pupils only on the initiative of primary school teachers,this process is disorderly and spontaneous. This is due to the lack of methodological literature for primary school pupils related to teaching economic issues. According to the interviewed teachers, experts and economists, the main reason for the low level of economic knowledge and economic education is non-systemic teaching. One reason of this is thatprimary school teachers have not received scientific and methodological trainingin economics. The second reason is that teachers use traditional approaches, methods and techniques when teaching the economic issues that do not take into account specific features of teaching economic issues. The third reason is that there is no common approved

vision of what economic issues should be studied by primary school pupils. The fourth reason is that, despite the numerous scientific and methodological works in economics, the psycho-pedagogical foundations of the economic issues for primary school pupilsbased on their age and psycho-physiological capabilitieshave not yet been developed. To date, no coherent methodological system has been created that provides pupils withthe required material of economic nature, the teaching of which will be provided by a didactic movement from simple to the complex, and will be consistent with the pupil's age and psycho-physiological abilities and responds to modern requirements of teaching economics. The approach to teaching economics to primary school pupils is as follows:

- Since economics in primary school is not taught as an independent discipline, economic issues should be taught within the main subjects (mathematics and native language) by including economic issues using the interdisciplinary links;
- The teaching process should be conducted without any coercion; the emphasis should be placed on teaching practical everyday matters, for which simple household economic problems should be used;
- Economic problems should be included in primary school mathematic class, when a teacher explains, proves or repeats a particular arithmetic operation, or uses a particular approach, while the the problem of an economic content is solved using the same operation or a specific approach;
- Teaching economic issues in this form in primary school requires neither adding a separate discipline nor additional teaching time;
- The implementation of interdisciplinary contentfor primary school pupils will contribute to the country's social andeconomic development, while the issues of the formation of economic cultures of primary school pupils become part of a key strategic problem in the educational system.

We have developed methodological approaches to solving mathematical problems with economic content that are compatible with the third grade mathematics course. During class, weoffer pupils to transform mathematical problems into lessons in a way that expresses simple concepts of economics, the relationships and operations between the economic concepts. To that end, we consider the system of problems consisting of blocks. By solving such problems, pupils become familiar with economic concepts, perform particular operations and arithmetic calculations. By solving the economic problems, mathematics class becomes more meaningful and diverse, it activates the students'mental activities, enriches and extends thepupils' knowledge with mathematical and economic terms, facilitates the acquisition of basic knowledge of the economic issues and accustoms pupils to the rules applicable to the correct and economically beneficial behavior under market economy conditions, helps them in the analysis of situations and cases, to find independently the right solutions theoretically and practically implement them. Solving the problems with economic content in primary school mathematic class helps teachers to bridge the gap between the daily needs and the pedagogical process.

- When working out the systems of problems with developmental and interdisciplinary content for primary school pupils, We used the following scheme:

$$\text{Problem} \rightarrow \text{theory} \rightarrow \text{problem.}$$

Through this approach, pupils are able to learn better problem solving, and they consider the theoretical and practical issues of the subject as an integral unit, which is important when studying the disciplines such as mathematics and nature study.

- When teaching solving and composing mathematical problems with developmental and interdisciplinary content for primary school pupils with reference to each other, we used the following schemes:

$$\text{Sameness} \rightarrow \text{equation and Sameness} \rightarrow \text{equation} \rightarrow \text{problem.}$$

3.3 Experimental validation of findings

Solving these and similar problems in primary school serves to form pupils' positive attitude towards mathematics, as well as to increase the quality of teaching as evidenced by four pedagogical experiments that we conducted in schools during four semesters.

The experiment involved 605 pupils from primary schools in different regions (high mountain, rural and urban regions). We divided the primary pupils involved in the experiment into two groups: in one group we grouped together pupils from schools where the systems of mathematical problems with developmental and interdisciplinary content are included in the teaching process, while in the second group, we grouped pupils from schools where the teaching process does not include such systems of mathematical problems.

The experimental study was conducted in two phases on three forms of teaching during four semesters. Prior to the pedagogical experiment, we analyzed written tests and pupils' independent work that included issues considered in the paper. During the preparation stage, we identified thetopics in the syllabus wherewe deemed it possible to include the systems of mathematical problems with developmental and interdisciplinary content, and we developed the teaching methodology, which subsequently, during practical work, underwent insignificant changes. The educational experiment demonstrated the effectiveness of the inclusion of the systems of mathematical problems with developmental and interdisciplinary content in the teaching process. The participants in the experiment wereaged8-10. Of 605 pupils, 319 were girls and 286 were boys.We would like to note that based on the results, involvement of boys and girls in the experiment had no any significant differences, all the results of the experiment were fully consistent with the average results for both boys and girls, so gender differenceissues did not require consideration during the experiment Vukovic RK, Lesaux NK, 2013).

The specific issues considered in the work are virtually absent from primary school mathematics textbooks, and very few problems we may find in the textbooks in an unsystematic waydo not receive due attention from the teachers. Therefore, our primary focus was on teaching to solve mathematical problems with developmental and interdisciplinary content in primary school based on the materials that we gathered.

During the pedagogical experiment, we used mathematics textbooks, problems taken from the supplementary teaching materials, and problems that we had specially composed.

The experimental study was conducted in two stages on three forms of teaching:

First stage– The preparatory experiment was conducted in classes, facultative and mathematics club activities, during which students worked on mathematical problems from school textbooks as well as the ones with developmental and interdisciplinary content that we composed on the basis of data that we gathered.

Second stage – The educational experiment was conducted in classes, facultative and mathemeticsclub activities.

The purpose of the preparatory experiment was to test the pupils' level of mathematical knowledge. We were particularly interested in pupils' skills of solving mathematical problems with developmental and interdisciplinary content composed in accordance with the curriculum, which allowed us to checking to what degree acquired knowledge was realized in practice, how they used it when solving these problems.

During the preparatory experiment, in mathematics classes, facultative and mathematical club activities, we included mathematical problems with developmental and interdisciplinary content composed in accordance with the themes of primary school curriculum, which do not require any additional time for teaching.

Based on the results of the preparatory experiment, we can draw conclusions as follows: in order to identify the benefits of including in the curriculum and targeted teaching of the systems of mathematical problems with developmental and interdisciplinary content in primary school, it was necessary to conduct an educational experiment. We analyzed the available modern methodological literature on interdisciplinary links in mathematics which we adapted to the topics of primary classes. We selected the methodological approaches that are acceptable to us and mathematical problems whose solution gives us a significant time effect and develops pupils' logical thinking. We set out a practical work plan. In addition, we selected and elaborated the issues necessary to develop a theoretical basis which will ensure the methodologically sound inclusion of mathematical problems with developmental and interdisciplinary content in primary school mathematics classes. In other words, we have developed the theoretical foundations for including mathematical problems with developmental and interdisciplinary content in the teaching process in primary school. To this end:

- We determined the relationships between mathematical problems containing developmental and interdisciplinary links composed in accordance with the themes of primary school curriculum, and problems to be considered within a school course in mathematics;
- We developed the methodological underpinnings for including mathematical problems with developmental and interdisciplinary content in the teaching process;
- We identified the goals and objectives of including mathematical problems with developmental and interdisciplinary content in the teaching process.

During the educational experiment, we used the databases that we collected, and on that basis we developed mathematical problems with developmental and interdisciplinary content that we included inthe teaching process. Some of them we discussed during classes, facultative and mathematics club activities, some we setthem for independent work. The main goal of the educationalexperiment was to confirm the effectiveness of the inclusion of mathematical problems with developmental and interdisciplinary content in the teaching process, and

improving mathematics education through the inclusion of interdisciplinary and developmental problems in the teaching process. The educational experiment lasted for five semesters. We did our pre-test at the beginning of the experiment. During this test, pupils had to solve mathematical problems with developmental and interdisciplinary content, quite similar to the onesin the preparatory experiment. This task was fully completed by one third of the pupils. During the semester, some pupils collected the data needed for composing the mathematical problemswith developmental and interdisciplinary content, and the teacher examined with them mathematical problems composed on the basis of the material compiled. The subsequent tests were conducted at the end of each semester. Pupils' outcomes were increasingly higher during each subsequent test. During the fifth test, more than two-thirds of the pupilsfully completed the task, which demonstrates the need for the inclusion of mathematical problems with developmental and interdisciplinary content in the teaching process, and this improves mathematics education.

In addition to the groups participating in the educational experiment, we also observed the control groups selected. The pupils' level of mathematical knowledge in these groups was almost the same. Average ratings were 7.5 and 7.4 respectively. Pupils from the experimental group collected the data needed for composing the mathematical problems with developmental and interdisciplinary content, during the teaching process, they solvedmathematical problems containing developmental and interdisciplinary content, and teaching was conducted in accordance with the described methodology, while in control groupsteaching was conducted in the traditional format.

The effectiveness of the developed methodology was tested at the end of the semester in the form of problems assigned for the final written test. Each test consisted of one question that contained in turn a mathematical problem with developmental and interdisciplinary content, although this problem could also be solved in another way.

Let us take a statistical assessment of the solution of interdisciplinary and developmental mathematical problems for the experimental and control groups during the five semesters of the experiment. The table below shows the results of five tests. The first one aimed to determine the pupils' overall level of mathematical knowledge; the remaining four checkups aimed to test mastering the approaches available.

The experimental and control groups have been assessed on the following two criteria:

1. How many pupils attempted to solve interdisciplinary and developmental mathematics problems?
2. Of them how many pupils were able to get a right solution.

The experimental results are given in Table 1.

Table 1

Groups	Experimental					Control				
Number of pupils	310	310	310	310	310	295	295	295	295	295
Solution I	199	201	202	208	200	162	164	167	173	169
Failed to solve	111	109	108	102	110	133	131	128	122	126
Solution II	157	158	159	161	155	110	112	113	115	120
Failed to solve	42	43	43	47	45	52	52	54	58	49

Since there is no large deviation from the solution of each problem, let's move on to the evaluation average values. We calculated the difference between these two values using the χ^2 criterion [1]. The value T_{kr} of the criterion statistics for the data level and $\alpha = 0,005$ and the degree U of freedom $\nu = 1$ from Table [1] is equal to 7.68, that is, $T_{kr} = 7,68$. A null hypothesis T_0 is that the difference in test scores between the experimental and control group pupils is random. An alternative hypothesis T_1 - is statistical difference, that is, it is not random. The results are shown in Table 2.

Table 2

Groups	Experimental	Control
Number of pupils	310	295
Solution I	202	167
Failed to solve	108	128
Solution II	158	114
Failed to solve	44	53

For statistical calculation of the criterion T_n of the conducted experiment, we used the following formula:

$$T_n = 2 \cdot \frac{N(O_{11}O_{22} - O_{12}O_{21})^2}{n_1 n_2 (O_{11} + O_{21})(O_{12} + O_{22})} \quad [1]$$

The values in this formula are taken from tables 3 and 4, which in turn have been obtained from Table 2.

Table 3

I sign	Experimental	Control
Solved	$O_{11} = 202$	$O_{21} = 167$
Failed to solve	$O_{12} = 108$	$O_{22} = 128$
	$O_{11} + O_{12} = n_1 = 310$	$O_{21} + O_{22} = n_2 = 295$

Where $n_1 + n_2 = N = 605$.

Table 4

I sign	Experimental	Control
Solved	$O'_{11} = 158$	$O'_{21} = 114$
Failed to solve	$O'_{12} = 44$	$O'_{22} = 53$
	$O'_{11} + O'_{12} = n_1' = 202$	$O'_{21} + O'_{22} = n_2' = 167$

Where $n'_1 + n'_2 = N' = 369$.

We got the following values:

For the first criterion - $T_n = 9,2913$ and for the second criterion - $T'_n = 9,3499$. Since both values are greater than T_{kr} , therefore, the decision-making hypothesis T_0 for both criteria is replaced by an alternative hypothesis T_1 , that is, the differences by the first and second criterion between the experimental and control groups is not random. In the first and second signs are not random

Pupils in the experimental and control groups were under identical training conditions, the only difference being one assignment containing problem with the developmental and interdisciplinary content, so the obtained difference can be explained only by the fact that the inclusion of mathematical problems with developmental and interdisciplinary content in primary school in the experimental groups has proved to be effective.

We also found that the mean scores of assessments in native language, nature study and fine and applied arts were significantly higher in the experimental groups participating in the educational experiment. In particular, the mean score in the native language in the control groups was 8.7 at the beginning of the experiment, and 9.3 at the end of the experiment, in nature study, the relevant data were 8.1 and 8.7, and in fine and applied arts- 8.8 and 9.5, while in the control groups, the mean assessment scores were not changed significantly. In addition, throughout the course of the educational experiment, we studiedchanges in the written and spoken production of pupils in the experimental and control groups. Studies have shown that the written and spoken production of pupils in the experimental and control groups have become relatively more logical, they formulate and communicate their ideas clearly by highlighting the key components of their idea. During the same period, there were no significant changes in the written and spoken production of pupilsin the control group. Based on the above data, we can conclude that by including the methodology that we developed in the teaching process, the academic level of

primary school pupils in mathematics and in their native language, natural sciences, and fine and applied arts increased significantly, as well as the level of general education of pupils improved markedly, the teaching process has become more attractive to primary school pupils, and solving mathematicalproblems in their teaching activities has become a pleasurable process (Davide N, Jeanne M, Jacky S, 2011).

3.4 Research findings

- Psychological, pedagogical and methodological bases of mathematical problems with developmental and interdisciplinary content for primary school pupils were developed and scientific and methodological analysis of school mathematical textbooks for I-II grades was conducted;
- The major disadvantage of traditional teaching stems from the lack of methods and techniques for solving mathematical problems which makes the problemsmonotonous and exercises boring. Psychological and pedagogical approaches justify the need for including special techniques of solving mathematical problems with developmental and interdisciplinary content in primary school, which is the way for active teaching forprimary school pupils;
- We developed a methodology forteaching how to solve and compose problems in conjunction, which allows a teacher to compose mathematical problems from the the pupils' field of interest that will have relevance to the thematic content attractive to them. The statement of this problemarousespupils' interest and the process of teaching becomes attractive;
- Methods for solving specially selected mathematical problems and a special methodology for their teaching in the lower grades were developed. In particular, exercises with interdisciplinary links between mathematics and nature study and methodology for teaching how to solve them. The emphasis is placed on the modern methodological approaches.
- The systems of mathematical problems with developmental and interdisciplinary content for primary school pupils.

We worked out methodological guidelines for mathematics teachers.

4. Conclusions and recommendations

The educational experiment allows us to make the following conclusions:

1. The methodological approach that we developed involving mathematical problems with developmental and interdisciplinary content in the in primary school practice has proved to be effective and its use in the teaching process is appropriate, it does not require additional time for teaching, has a developmental effect on pupils, serves to assimilate in depth the knowledge of primary school disciplines;

2. Mathematical problems with developmental and interdisciplinarycontent should be included in the teaching process in primary school in connection with specific key topics of two or more school subjects, but one class should address one or two such problems at most, one problem similarbut less complexthan theproblem examined in classshould be set as homework.

3. The use of mathematical problems with developmental and interdisciplinary content in primary school contributes to deepening pupils' mathematical knowledge, and motivates pupils to deeply and thoroughly study not only mathematics but also other subjects(Harding JF,2015).

The developed methodological approaches contribute to making teaching in primary school more effective, they will increase the pupils' interest in learning, will raise their intellectual level, and will provide the basis for in-depth and thorough school education. All this was confirmed by the educational experiment.

References

Batchelor S, Torbeyns J, Verschaffel L (2019). Affect and Mathematics in Young Children: An Introduction.Educational Studies in Mathematics, 100(3):201-209.

Beilock SL, Maloney EA (2015). Math anxiety: A factor in math achievement not to be ignored. Policy Insights from the Behavioral and Brain Sciences, 2(1):4–12.

Berk LE, Winsler A (1995). Scaffolding children's learning: Vygotsky and early childhood education. Washington, DC: National Association for the Education of Young Children.

Elbahri M, Soliman A, Yliniemi K, Abdelaziz R, Homaeigohar S, Zarie ES (2018).Innovative Education and Active Teaching with the Leidenfrost Nano chemistry. Journal of Chemical Education, 95(11).

Elmore RF, Peterson PL, McCarthy SJ(1996). Restructuring in the classroom: teaching, learning and school organization.

Frye D, Baroody AJ, Burchinal M, Carver SM, Jordan NC, McDowell J (2013). Teaching math to young children: A practice guide (NCEE 2014-4005). National Center for Education Evaluation and Regional Assistance.

Ginsburg H, Klein A, Starkey P (1998). The development of children's mathematical thinking: Connecting research with practice. Child psychology in practice, 5:401-476.

Ginsburg H, Lee JS, Boyd JS (2008). Mathematics education for young children: What it is and how to promote it. Society for Research in Child Development, Social Policy Report, 22(1).

Godfrey J, Stone J(2013).Mastering Fact Fluency: Are They Game?Teaching Children Mathematics, 20(2):96-101.

Harding JF (2015). Increases in Maternal Education and Low-Income Children's Cognitive and Behavioral Outcomes. Developmental Psychology, 51(5):583-599.

Hayward PA (2019). Active Teaching to Manage Course Difficulty and Learning Motivation. Journal of Further and Higher Education, 43(2).

Marotta SM, Hargis J (2011). Low-Threshold Active Teaching Methods for Mathematic Instruction, 21(4):377-392.

Ronald VM (2018) Innovation for Motivation: First-person presentations, Childhood Education, 94(5):14-22.

Stella V(2001).How children learn.Learning requires the active, constructive involvement of the learner.International Academy of Education (IAE) Educational Practices series-7.

DavideN, Jeanne M, Jacky S(2011). Understanding the Role of Objects in Cross-Disciplinary Collaboration.

Vukovic RK, Lesaux NK (2013).The Language of Mathematics: Investigating the Ways Language Counts for Children's Mathematical Development. Journal of Experimental Child Psychology, 115(2):227-244.

Wickstrom H, Pyle A, DeLuca C (2019). Does Theory Translate into Practice? An Observational Study of Current Mathematics Pedagogies in Play-Based Kindergarten. Early Childhood Education Journal,47(3).