



EDUCATIONAL AND METHODOLOGICAL ELECTRONIC TEXTBOOK “METHODS OF TEACHING MATHEMATICAL WORD PROBLEM SOLVING TO PUPILS OF GRADES 1-4”

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Abstract: *The article focuses on the structure and peculiarities of the content filling of the educational and methodological electronic textbook “Methods of teaching mathematical word problem solving to pupils of grades 1-4”. The authors describe the methods of its usage in the process of students’ self-guided work on the course “Methods of teaching mathematics in primary school”. The paper presents the results of the experimental work on introducing this educational and methodological electronic textbook to the process of methodological training of future primary school teachers at the state institution - the K. Ushynsky South Ukrainian National Pedagogical University.*

Keywords: educational and methodological electronic textbook, training of future primary school teachers, course “*Methods of teaching mathematics*”, teaching mathematical word problem solving.

INTRODUCTION

Training teachers of the New Ukrainian School is a topical issue in Ukraine’s higher pedagogical education. The new State Standard of Primary School (2018), the new standard curricula (2018, 2019) require that the teacher apply modern teaching methods and technologies. Obviously, under such conditions it is the pedagogical university where future teachers should acquire the knowledge, abilities and skills that form the basis of the teacher’s methodological competence, in particular in teaching mathematics in grades 1-4.

The goal of methodological training at the pedagogical university is to develop the methodological competence in future teachers. In our study, we interpret primary school teachers' methodological competence as a system-based personal formation, reflected in the ability to organize and conduct the process of teaching mathematics to pupils of grades 1-4 at the level of modern requirements, the ability to solve methodological issues successfully, based on theoretical and practical readiness to teach the subject. (Skvortsova, 2013, 2017).

Primary school teacher's methodological competence in teaching mathematics in primary school is formed as a result of mastering the course "Methods of teaching mathematics". Therefore, it is important to look for ways to improve the effectiveness of teaching this course to future primary school teachers.

1. TRAINING FUTURE PRIMARY SCHOOL TEACHERS IN TEACHING MATHEMATICAL WORD PROBLEM SOLVING

The course "Methods of teaching mathematics" includes lectures, practical / laboratory classes and students' independent (self-guided) work. At the K. Ushynsky South Ukrainian National Pedagogical University (Odesa, Ukraine), his course is structured in 12 content modules, with five modules devoted to methods of teaching mathematical word problem solving to young learners, the content of which is presented through several topics:

Module I "Methods of teaching problem solving in grades 1-2":

Topic 1. General questions of the methodology of teaching problem solving in primary school. Topic 2. Methods of forming the skills of solving simple problems in grade 1. Topic 3. Methods of forming the skills of solving simple problems in grade 2. Topic 4. Methods of introducing the concept of "compound problems". Methods of forming the skills of solving compound problems in grade 2.

Module II "Fractions in the Course of Elementary Mathematics": Topic 1. Methods of forming comprehension of parts of magnitude (fractions). Methods of forming skills of solving problems that contain fractions. Topic 2. Methods of forming comprehension of fractions. Methods of solving problems that contain fractions.

Module III "Teaching methods of problem solving in grades 3-4": Topic 1. Methods of forming skills in solving simple problems in grades 3-4. Topic 2. Methods of forming skills in solving compound problems in grade 3.

Module IV. Typical problems containing constant values are: Topic 1. Methods of forming skills in solving problems for finding the fourth proportional. Topic 2. Methods of forming skills in solving problems on double reduction to one. Topic 3. Methods of forming skills in solving problems on proportional division. Methods of forming skills in solving problems on finding the unknown by two differences.

Module V “Typical problems on processes”: Topic 1. Methods of forming skills in solving problems on joint work. Topic 2. Methods of forming skills in solving problems on simultaneous motion in different directions.

The need for such a broad and in-depth consideration of didactics of teaching primary school children is conditioned by the fact that mathematical word problems are the subject of mathematics teaching from the 1st to 4th grades and they form a separate content line of the typical educational programme (2018, 2019) “Mathematical Problems and Research”. Our practice shows that for primary school children, solving problems is perhaps the most difficult activity, since solving problems is a heuristic activity that is not algorithmic. Therefore, there is a need for high-quality training of future primary school teachers for teaching pupils solving mathematical word problems, and this, in turn, justifies the search for the means that will satisfy this need.

In the first stage of our research, within the framework of formative experiment, we studied the state of higher pedagogical education in 7 universities of Ukraine which provide training for future primary school teachers. According to normative programmes of the course “Methods of teaching mathematics” approved at these universities, we analysed the number of content modules and hours that were allocated in different universities of Ukraine to train future teachers for further teaching pupils solving problems. We have selected the following programmes for the analysis: K. Ushynsky South Ukrainian National Pedagogical University, Kherson State University, Borys Grinchenko Kyiv University, Ivan Franko National University of Lviv, Mykolaiv V.O. Sukhomlynskyi National University, Lesya Ukrainka Eastern European National University, Vasyl Stefanyk Precarpathian National University, Taras Shevchenko National University “Chernihiv Collegium”. The results of the analysis are presented in the table (see Table 1).

Table 1.

The number of hours allocated to the study of the methodological system of teaching mathematical problem solving in pedagogical universities of Ukraine

Name of the higher education institution	Number of modules	Lectures (hours)	Practical (seminars) classes (hours)	Individual work (hours)	Total (hours)
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K. Ushynsky South Ukrainian National Pedagogical University	5	26	28	62	112
Kherson State University	3	26	22	42	90
Borys Grinchenko Kyiv University	1	6	6	14	26
Ivan Franko National University of Lviv	1	8	18	24	50
Mykolaiv V.O. Sukhomlynskyi National University	2	10	10	40	60
Lesya Ukrainka Eastern European National University	1	6	8	12	26
Vasyl Stefanyk Precarpathian National University	2	8	12	24	44
National University of "Chernihiv Collegium" Taras Shevchenko	1	8	6	7	21

Source: Own work

As seen from the table, the largest number of content modules and hours allocated to the study of this programme issue is observed at the state institution “K. Ushynsky South Ukrainian National Pedagogical University”. To study all these issues, the developer of the programme (S. Skvortsova) allocated 112 hours of the total number of hours (240 hours). A similar situation is observed at Kherson State University – for studying the methods of teaching mathematical word problem solving 3 modules (90 hours) are allocated.

The analysis of educational programmes also made it possible to see the number of hours allocated for students’ independent (self-guided) work while mastering the methods of teaching problem solving. And in this regard we should mention again the state institution – K. Ushynsky South Ukrainian National Pedagogical University (62 hours from 112 hours) and Kherson State University (42 hours from 90 hours). Thus, it can be argued that these universities have created more favourable conditions for training future primary school teachers in teaching mathematical word problem solving to primary school children. On the other hand, the curricula of most universities in Ukraine allow only 1 or 2 modules and the number of hours varies from 26 to 60 for mastering the methods of teaching problem solving to primary school children.

As a result of the data analysis presented in Table 1, it can be argued that in the pedagogical universities in Ukraine, in most cases very little attention is given to training students in teaching problem solving. Based on the fact that the new version of the State Standard (2018) virtually all the general learning outcomes of the mathematical education field (namely, students examine situations and identify problems that can be solved using mathematical methods; model processes and situations, develop strategies (plans) of actions for solving various

problems; critically evaluate data, process and result of solving educational and practical problems; apply experience of mathematical activity in cognizing the outside world) are determined by the components of primary school children’s skills of solving plot-based problems, we think it is expedient to allocate more academic time for content modules on methods of teaching solving problems, to update the content of teaching students this issue in accordance with the new normative documents of general primary education. In view of this, the problem of our scientific research is relevant for the practice of training future primary school teachers at Ukrainian higher education institutions.

It is obvious that the shortcomings in the organization of the methodological training of primary school teachers in teaching mathematical word problem solving do not contribute to the acquisition of methodological competence by future teachers. However, when looking for ways to improve the methodological training of prospective primary school teachers we should not limit it only to optimizing the content of the normative programmes of the course “Methods of teaching mathematics” in the sense of increasing the number of hours to study the methods of teaching solving problems. It is important to look for learning aids that create the basis for improving students’ preparation for teaching primary school children solving mathematical word problems. Among these aids, scholars have recognized the educational tools which are based on Information Technology (IT).

2. USING INFORMATION TECHNOLOGIES IN TRAINING FUTURE PRIMARY SCHOOL TEACHERS

IT are widely used in modern life, without IT it is impossible to imagine the educational process at the university today, in particular training future primary school teachers. S. Skvortsova and T. Britskan studied the problem of future primary school teachers’ readiness for using IT in educational process (Skvortsova, 2019). Scholars studied the problem of training primary school teachers in the use of information technologies (IT) in the process of teaching mathematics, in particular, in the aspect of using a variety of online services for teachers. The author described the peculiarities of the development of modern primary school children’s cognitive processes, and, based on this, substantiated the necessity of using IT in mathematics classes. Moreover, the scholar analysed the results of diagnosing the state of teacher’s readiness for implementing IT and revealed the necessity of systematic training of teachers for the use of IT.

Therefore, IT is a way to improve the efficiency of training future primary school teachers for teaching mathematical word problem solving; it is possible to use IT not only in the classroom but also in students’ extracurricular activities.

The problem of using IT in training future primary school teachers was in focus of work of a number of Ukrainian scholars, namely T. Britskan, M. Haran, V. Imber, V. Kotkova, N. Morse, L. Petukhova, O. Sagan, S. Skvortsova,

O. Spivakovskiy, O. Sukhovirskiy, V. Chichuk et al. Thus, L. Petukhova analysed current approaches to the use of IT in the educational process of universities and proved the effectiveness of the use of the distance learning system “Web-multimedia encyclopaedia ‘History of Pedagogy’” in the process of training future primary school teachers (Petukhova, 2007). L. Petukhova, O. Spivakovskiy, V. Kotkova worked out and introduced the course “Information and Communication Technologies in Primary School” into the curriculum of Kherson State University (Spivakovsky, 2011).

O. Sagan, M. Haran and O. Liba emphasize the need to review educational programmes for primary school teachers in the context of forming their methodological and informational competence. The solution of the problem is seen by the authors in transforming the methodological system of informational education through the organization of blended learning, introduction of relevant electronic tools, etc. (Sagan, 2018).

Scientific studies concerning the use of IT when mastering the course “Methods of teaching mathematics” for future primary school teachers by S. Skvortsova and M. Haran, allowed the authors to summarize the requirements for multimedia presentation of a lecture on this course, including requirements to the content of multimedia presentation; to the visual and audio support; to the text; to design; to navigation quality. Compliance with these requirements allowed scholars to create high-quality multimedia presentations of lectures on teaching mathematics that can increase the efficiency of the educational process. This objective was achieved by the authors by enhancing the informative nature of the lecture; stimulating students’ motivation to learn; facilitating the perception of educational information through its visualization; stimulating students’ attention by means of using animation and colour effects; providing perception, understanding and memorization of information through the simultaneous presentation of information in various modularities (visual and auditory), etc. (Skvortsova, 2018).

The problem of selecting IT tools that could be used in the educational process of universities is widely researched by Ukrainian scholars in collaboration with colleagues from Poland, Slovakia, and Australia (E. Smyrnova-Trybulska, E. Ogrodzka-Mazur, A. Szafrńska-Gajdzica, M. Drlík, M. Cápaj, J. Tomanová, P. Švec, N. Morze, R. Makhachashvili, M. Romanyukha, M. Nakazny, L. Sorokina, Tomayess Issa, Theodora Issa). The scholars presented a rating list based on the quality and quantity of the selected IT tools, and offered recommendations for creating a good presentation and didactic video, as well as citing common mistakes made by designers and users (Smyrnova-Trybulska, 2016).

These recommendations can be applied to the use of IT tools in the development of multimedia instruments in any course. Definitely, certain courses have their own specific requirements to consider when elaborating IT-based learning tools.

In the context of the problem of training future primary school teachers for teaching mathematics, S. Skvortsova and M. Haran developed and tested an innovative multimedia methodological complex of the course “Methods of teaching mathematics”. It assumes presence of a constructor of lecture presentations; bank of multimedia materials for practical / laboratory classes (videos of mathematics classes, electronic versions of currently used mathematics textbooks for grades 1-4, normative documents of primary education, educational aids for teachers, etc.); multimedia material bank for students’ independent work (video recordings of classes, electronic versions of currently used mathematics textbooks for grades 1-4, normative documents of primary education, teaching manuals, electronic textbooks and manuals for students, video presentations of lectures, video recordings of comments on certain questions of programmes, references to Internet resources, etc.); test bank (Skvortsova, 2017).

Thus, S. Skvortsova and M. Haran proved the effectiveness of using multimedia tools to increase the efficiency of training future primary school teachers for teaching mathematics.

Among the bank of multimedia materials, the authors distinguish electronic textbooks and students’ course books, but these are only electronic versions of paper counterparts. In our opinion, it is an electronic educational and methodological manual, in which systematic and visualized educational content offering the student an opportunity to study at the appropriate level of difficulty and providing various options for support, educational and final testing, etc., will allow to facilitate students’ independent work. Therefore, the purpose of our study is to develop a content-based and structured electronic educational manual “Methods of teaching pupils of grades 1-4 solving mathematical word problems” for future primary school teachers, and methods of its use by students in the process of independent work.

3. EDUCATIONAL ELECTRONIC TEXTBOOK AS A MEANS OF ORGANIZING STUDENTS’ INDEPENDENT WORK

Electronic Tutorial (Textbook) is an electronic educational publication with a systematic presentation of educational material that is relevant to the educational programme, contains digital objects of various formats and provides interaction (<https://mon.gov.ua/ua/news/mon-dlya-gromadskogo-obgovorennya-proekt-nakazu-pro-zatverdzhennya-polozhennya-pro-elektronnij-pidruchnik>).

An electronic textbook is not just a pdf file of a regular paper textbook. It is created on the basis of certain software which makes it possible to expand the capabilities of a regular textbook by using all kinds of hyperlinks to multimedia files (audio, video, embedded encyclopaedias, 3D illustrations), cross-links between different sections of the textbook, animation effects (Skvortsova, 2018).

An electronic textbook per se is seen by Iryna Androshchuk and Ihor Androshchuk as pedagogical software that has a convenient hypertext structure and provides educational information, guides the study of a course based on the individual abilities and preferences of students (Androshchuk 2017).

The essential features of an electronic textbook are its interactivity – the possibility of instant feedback, step-by-step control of the action performance, control of the correctness of the action result, an opportunity to receive the necessary dose of assistance (Skvortsova, 2018).

Iryna Androshchuk and Ihor Androshchuk emphasize the interactive nature of an electronic textbook, an opportunity to provide feedback, the availability of navigation and the search engine. Moreover, the level of interactivity can vary from simple movement through links to students' direct involvement in modelling certain processes. Scholars created an electronic textbook "Methods of labour training" for training teachers of labour (Androshchuk, 2017).

The implementation of the interactivity principle in an electronic textbook enables students to become active participants in the educational process, to be engaged in educational and cognitive activities aimed at independent mastering and improving knowledge on a particular topic, educational discipline, to widen their horizons (V. Gushchenko and O. Patsulko 278). Thus, scholars highlight the main advantage of an electronic textbook over the printed one – the possibility of interactive communication between the user and the components of the textbook.

Interactivity is closely related to the opportunity of taking into account the individual characteristics of each student: depending on individual capabilities and needs, students can work at different levels of difficulty – some will stop at basic tasks, while others can do academic research and solve problems of increased complexity, work at levels of analysis, synthesis and evaluation. Thus, an electronic textbook provides means for implementing a differentiated approach, moreover, in two versions – both in terms of the level of difficulty of the tasks and the dose of assistance. With regard to differentiation by the dose of assistance given to a student, this can be either usual clues or highlighting the fragment in which the error was made, redirecting to the theoretical material necessary for the solution, or a link to the ready-made solution with a proposal to perform a similar task (Skvortsova, 2018).

Iryna Androshchuk and Ihor Androshchuk also emphasize the possibility of placing educational material in the electronic textbook according to the levels of complexity. Thus, students themselves choose the volume and complexity of the educational material, the duration of its learning. This is achieved through the creation of a hypertext structure of the manual, the presence of hyperlinks that support the provision of differentiating educational material (Androshchuk, 2017).

Another important benefit of an electronic textbook is provision of students' feedback. It is through the interactive nature of student interaction, the computer-assisted environment and the availability of an automatic knowledge diagnostic system that students' feedback is provided. Therefore V. Gushchenko, O. Potsulko offer at the end of their textbook sections to give control questions, exercises, tests, and at the end of the course – final test, which gives an opportunity to obtain information about the level of mastering the educational material (Gushchenko, 2018).

Thus, electronic textbook is aimed at providing an opportunity to take tests (training and control) at intermediate stages and upon completion of the study of the topic; an opportunity to analyze the test results and analyze the material in which the error was made (Skvortsova, 2018).

This will increase the effectiveness of independent study, self-control, improve students' cognitive activity and motivation, and give teachers an opportunity to analyze and correct the educational process.

The issue of electronic textbook design is raised by Kimberly Anne Sheen and Yan Luximon. The researchers point out that when designing them, authors do not always take into account how students perceive the interface components. For this reason, researchers shift their focus when designing an electronic textbook to the needs of students. They identify the components of a future electronic textbook that are built on students' perception of coursework and determine the connection with gender differences, experience, and academic background. The researchers conducted a university-wide online questionnaire and received more than 700 responses. The results showed that text, markers, tools, bookmarks, multimedia, translation tools, dictionaries and encyclopaedias should be included in future electronic textbooks and should be tailored to the curriculum (Sheen, 2017).

Studying the didactic aspect of creating electronic textbooks for training future teachers, E. Ivanova and I. Osmolovskaya focused on options for filling the educational environment (a textbook-navigator, a textbook, a set of materials for independent work, etc.), structuring information (as a scenario of the educational process, the designer of the educational process, the integrator of the specified educational process, etc.). The researchers made a list of materials that can be used as a basis for assigning tasks for students to work independently: 1) videos of classes or their fragments with real teachers and students; 2) a set of articles, texts, normative documents, as well as links that will provide deepening and expansion of students' subject knowledge; 3) Internet website addresses where students can obtain the necessary accurate information about the subject in a form that most closely matches their psychophysiological characteristics (Ivanova, 2016).

Thus, taking into account, on the one hand, the efficiency of using IT for organizing students' independent work, and on the other hand, the fact

that at least half of the total educational load must be allocated to students' independent study, the relevance of creating an effective educational and methodological support for future teachers' independent work based on IT including the creation of electronic textbooks is quite evident.

4. EDUCATIONAL AND METHODOLOGICAL ELECTRONIC TEXTBOOK “METHODS OF TEACHING MATHEMATICAL WORD PROBLEM SOLVING TO PUPILS OF GRADES 1-4”: STRUCTURE AND CONTENT

Based on the considered requirements for electronic textbooks, we have developed an educational electronic textbook “Methods of teaching mathematical word problem solving to pupils of grades 1-4” for students, future teachers in the specialty 013 “Primary education”.

On the starting page of the “Electronic Textbook” the title “Methods of teaching mathematical word problem solving to pupils of grades 1-4” is given and two sections are offered: “About the programme” and “Study” (Figure 1).



Figure 1. Homepage of the electronic textbook

Source: Own work



Figure 2. Section “About the programme”

Source: Own work

By clicking on the section “About the programme” we find ourselves on the page which provides information about the developers of the electronic textbook, as well as we have an opportunity to download software on our computer, which will help to work with it at a top level of quality (Figure 2).

Clicking on the button “Study”, we find ourselves on the page which contains content modules on teaching methods of solving mathematical word problems in the primary school mathematics course (Figure 3).



Figure 3. Section “Study”

Source: Own work



Figure 4. Sections of the content module 1

Source: Own work

Clicking on a specific content module (Figure 4) the student gets access to the topics that make up this module and to the final testing.

For example, the content module 1 “Methods of teaching problem solving in grades 1-2” consists of the following topics:

Topic 1. “General Questions of Methods of Teaching Problem Solving in Grades 1-2”.

Topic 2. “Methods of Forming Skills of Solving Simple Problems in Grade 1”.

Topic 3. “Methods of Forming Skills of Solving Simple Problems in Grade 2”.

Topic 4. “Methods of Familiarizing with the Concept of “Compound Problem”. Methods of Forming Skills of Solving Compound Problems in Grade 2”.

Final testing.

Each topic is explained through the following sections: lecture, practical work (if planned by the programme), tasks for students’ independent work (SIW), list of references and training test (Figure 5).

For example, topic 2, “Methods of Forming Skills of Solving Simple Problems in Grade 1”, contains the following sections: “Lecture # 2,” “Practical Work,” “SIW Tasks”, “References” and “Training Test”.

By clicking on the section “Lecture”, students open a list of questions that are discussed at the lecture (Figure 6). So they have an opportunity to pay more attention to the issues that interest them more.

For example, Lecture #2, “Methods of Forming Skills of Solving Simple Problems in Grade 1”.

Plan of the Lecture

- 1. The content of teaching the topic according to the new curriculum.*

2. *Visual aids and didactic material.*
3. *The order of studying the topic. Analysis of current textbooks.*
4. *Methods of teaching specific issues of the topic.*

✓ *The content and methods of the preparatory stage before introducing the concept of the problem.*

✓ *Methods of introducing the concept of the problem to the first grade schoolchildren.*

✓ *The technique of forming the concept of the problem and the process of solving it.*

✓ *Types of simple problems for grade 1 and methods of working on them.*

✓ *Learning to write a short record of the problem.*

✓ *Notion of the inverse problem.*



Figure 5. Sections to Topic 2, Content Module 1

Source: Own work



Figure 6. Plan of lecture #2, Topic 2, Content Module 1

Source: Own work

Moreover, each of the questions offered, through a hyperlink, “unfolds” as a lecture summary containing basic information, examples and additional information “hidden” in the links. In this way, students have an opportunity to choose independently the volume and level of mastering the material that satisfies their cognitive needs (Figure 7).

For example, fragments of the lecture # 2, “Methods of Forming Skills of Solving Simple Problems in Grade 1”:

Content and methods of the preparatory stage before introducing the concept of the problem.

In the first stage of mastering the specific content of arithmetic actions, pupils do practical exercises to combine or remove geometric shapes, and then introduce a schematic interpretation of these arithmetic actions using geometric shapes.

- Операція об'єднання двох множин, що не перетинаються розкриває конкретний зміст дії додавання.
- Операція виділення підмножини з множини розкриває конкретний зміст дії віднімання.

7. Запиши вирази за малюнками. Знайди їх значення.

Figure 7. Links – example of the tasks from the textbook

Source: Own work

3. Про що або про кого йдеться в задачі? Розглянь короткий запис. Розкажи, що записано на схемі.

1) У бабусі 4 качки і 3 гуски. Скільки всього птахів?

2) У двох коробках лежать опівці. У першій — 10 опівців, а в другій — 5 опівців. На скільки менше опівців в другій коробці, ніж в першій?

! Об'єкти, про які йдеться в задачі, — це ключові слова.

(1) Перекажи усю задачу. Розкажи умову задачі. Яке запитання задачі? Поясни, що позначають числові дані задачі. Що позначає число 4? число 3? Що позначає шукане число?

Про що йдеться в задачі? У задачі йдеться про качок та гусок. Качки і гуски — це ключові слова задачі. Розглянь текст задачі: вони висіли білякиним кольором. Ці слова записані у короткому записі задачі одне під одним — у стовпчик.

Чи відомо нам, скільки качок у бабусі? Відомо, 4. Розглянь, де в тексті качки висіли білякиним кольором гуски висіли білякиним кольором 1 качка та 3 гуски

Figure 8. Links – example of the way of working on the task from the textbook

Source: Own work

Teaching writing a short record of the problem

In the next stage, it is advisable to acquaint pupils with a brief record of the problem. This work should be gradual.

First, pupils should analyse the short notes already prepared for the problem, then supplement the short record with numerical data, and, finally, make a short record of the problem themselves (Figure 8).

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Figure 9. Section “References”

Source: Own work

Методика формування загального вміння розв'язувати задачі

Формування поняття „задача” та вміння розв'язувати прості задачі

Формування загального вміння розв'язувати прості задачі відбувається за етапами, які є загальноприйнятими в методичній науці:

I етап – підготовча робота до введення поняття „задача” (1-й клас);

II етап – ознайомлення з поняттям „задача”, його структурними елементами та етапами її розв'язування (1-й клас);

III етап – формування загального вміння розв'язувати будь-які прості задачі (1-4 класи).

За методичними системами М.В. Богдановича та Л.П. Кочиніної на етапі підготовчої роботи в учнів формується конкретний зміст дії додавання і віднімання, йде робота з розвитку мови дітей, коментування малюнків тощо. Це пояснюється тим, що поняття „задача” вводиться на задачах на знаходження суми й остачі

Figure 10. Fragment of the scanned page from the textbook by L. Koval and S. Skvortsova “Methods of teaching mathematics: theory and practice”

Source: Own work

If after a detailed reading of the lecture content students have any questions, they may turn to the section “References” (Figure 9). Clicking on the References displays a list of manuals and normative documents (if necessary) containing the scanned pages from the primary sources according to the topic of the lecture.

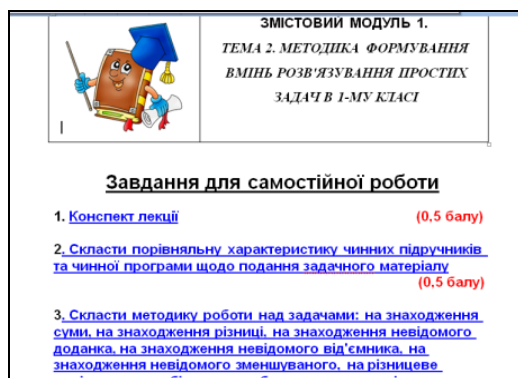
For example, Lecture #2 “Methods of Forming Skills of Solving Simple Problems in Grade 1” (Figure 10).

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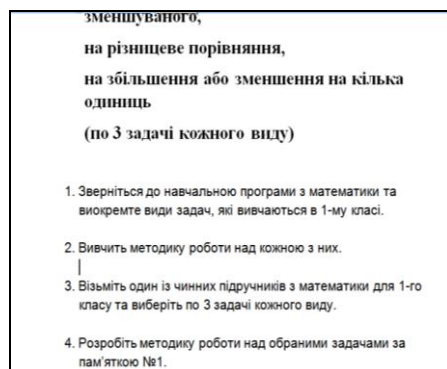
ЗМІСТОВИЙ МОДУЛЬ 1.
ТЕМА 2. МЕТОДИКА ФОРМУВАННЯ
ВМИНЬ РОЗВ'ЯЗУВАННЯ ПРОСТИХ
ЗАДАЧ В 1-МУ КЛАСІ

Завдання для самостійної роботи

1. Конспект лекції (0,5 балу)
2. Скласти порівняльну характеристику чинних підручників та чинної програми щодо подання задачного матеріалу (0,5 балу)
3. Скласти методичку роботи над задачами: на знаходження суми, на знаходження різниці, на знаходження невідомого доданка, на знаходження невідомого від'ємника, на знаходження невідомого зменшуваного, на різницеve порівняння на збільшення або зменшення на кілька одиниць

Figure 11. Section “Tasks for independent work”

Source: Own work



зменшуваного,
на різницеve порівняння,
на збільшення або зменшення на кілька
одиниць
(по 3 задачі кожного виду)

1. Зверніться до навчальної програми з математики та виокремте види задач, які вивчаються в 1-му класі.
2. Вивчіть методичку роботи над кожною з них.
3. Візьміть один із чинних підручників з математики для 1-го класу та виберіть по 3 задачі кожного виду.
4. Розробіть методичку роботи над обраними задачами за пам'яткою №1.

Figure 12. Methodological recommendations for students' independent work

Source: Own work

After working on the content of the lecture and literature on the topic, students should move on to the tasks for independent work (Figure 11).

For example, Lecture #2 “Methods of Forming Skills of Solving Simple Problems in Grade 1”.

Tasks for independent work

1. Write a lecture summary (0.5 points).
2. Make a comparative description of the current textbooks and the current programme concerning submitting reference material (0.5 points).
3. Work out the methods of work on problems: on finding the sum, on finding the difference, on finding the unknown addend, on finding the unknown minuend, on finding the unknown subtrahend, on comparing the differences, on increasing or decreasing by several units (3 problems of each type) (2 points).
4. Study fragments of the class notes on the given material and prepare one of the notes at your choice (0,5 points).

- Preparation for studying the problems.
 - Methodological guidelines for the class.
- Addition and subtraction of 4.
 - Methodological guidelines for the class.
- Problems on missing numerical data. Problems with extra numerical data.
 - Methodological guidelines for the class.
- Short problem record.
 - Methodological guidelines for the class.
- A short record containing three keywords.
 - Methodological guidelines for the class.
- Inverse problem.
 - Methodological guidelines for the class.
- Problems on finding the unknown minuend or subtrahend.
 - Methodological guidelines for the class.

Each task for independent work is provided with methodological recommendations and distribution of points, which students can get under the condition of correct completion of the task (Figure 12).

For example, Lecture #2, “Methods of Forming Skills of Solving Simple Problems in Grade 1”.

Tasks for independent work

3. Work out the methods of work on problems: on finding the sum, on finding the difference, on finding the unknown addend, on finding the unknown minuend, on finding the unknown subtrahend, on comparing the differences, on increasing or decreasing by several units (3 problems of each type) (2 points).

Methodological recommendations for performing the task:

1. Refer to the educational programme in mathematics and distinguish the types of problems that are taught in grade 1.
2. Study the methods of work on each of them.
3. Take one of the currently used 1st grade textbooks in mathematics and select 3 tasks for each type.
4. Develop methods of working on the selected problems on the memory note number 1.

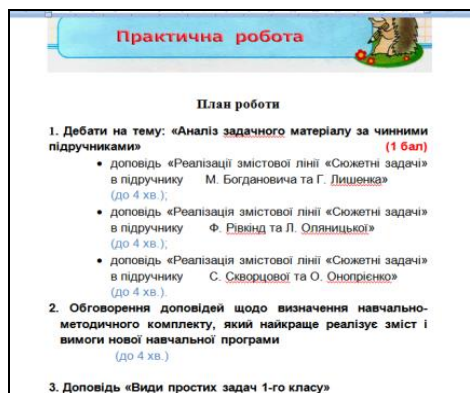


Figure 13. Section “Practical work”

Source: Own work

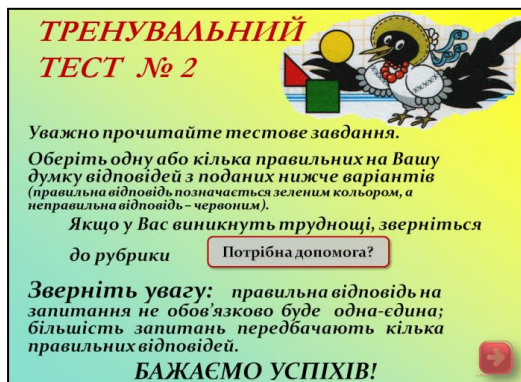


Figure 14. Section “Training Test”

Source: Own work

For the purpose of effective preparation for practical classes, students may refer to the section “Practical work” and familiarize themselves with the plan of the practical class, prepare reports or fragments of lessons, etc. (Figure 13). Similarly, for each assignment, the number of points that a student can get and the time allocated for the demonstration of solving the assignment are already determined.

For example, topic 2, “Methods of Forming Skills of Solving Simple Problems in Grade 1”.

Plan of practical class

1. Debates on the topic: “Analysis of problems according to currently used textbooks” (1 point). Report up to 4 minutes
2. Discussion of reports concerning the definition of an educational set that best realizes the content and requirements of the new educational programme (up to 4 minutes).
3. The report “Types of simple problems of grade 1 (1 min.) (0,5 points).
4. Solving situational tasks (1 point). Demonstrate a fragment of the lesson on working with the problems on:
 - finding the sum (6 min.);

- *finding the difference* (6 min.);
- *finding the unknown addend* (6 min.);
- *finding the unknown minuend* (6 min.);
- *finding the unknown subtrahend* (6 min.);
- *comparing the differences* (6 min.);
- *increasing or decreasing numbers by several units* (6 min.).

5. *Test on the topic “Methods of Forming Skills of Solving Simple Problems in Grade 1” (15–20 min.).*

The training test can be considered a logical continuation of independent work, its purpose is to show the student’s readiness for practical classes and determine the level of mastering the topic (Figure 14).

For example, topic 2, “Methods of Forming Skills of Solving Simple Problems in Grade 1”. First, students are provided with a brief instruction on how to correctly complete the test tasks.

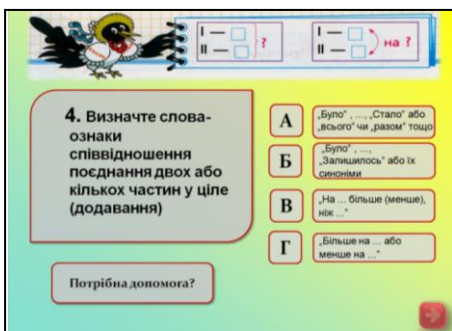


Figure 15. Task of the training test #2 to topic 2 “Methods of Forming Skills of Solving Simple Problems in Grade 1”

Source: Own work

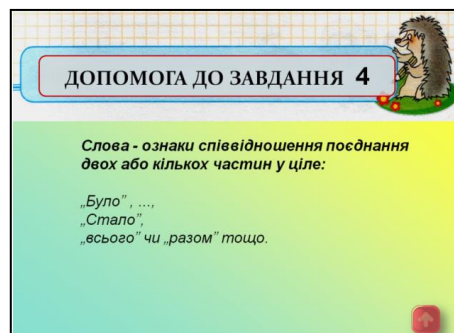


Figure 16. Support for task 4 of the training test 2

Source: Own work

Then, test tasks are introduced to students (Figure 15).

For example, training test # 2 to topic # 2, “Methods of Forming Skills of Solving Simple Problems in Grade 1”.

Determine the words-signs for the ratio of combining of two or more parts in the whole (addition):

- A) *“It was” , ... , “It became” or “in total” or “together” , etc.*
- B) *“It was” , ... , “It remained” or their synonyms.*
- C) *“By ... more (less) than ...” .*

D) “More by ... or less by ...”.

Do you need any help?

Students are given an opportunity to answer the questions of the test, but if they have any difficulties, they can ask for help in the link, which provides either a lecture fragment or tips, or even the correct answer with appropriate comment (Figure 16).

For example, topic 2, “Methods of Forming Skills of Solving Simple Problems in Grade 1”.

Training test #2

Support for the previous task. Words-signs of the ratio of combining two or more parts in a whole “It was”, ..., “It became” or “in total” or “together”, etc.

Файл Тест Настройка Справка

Виберить опорну схему до задачі.
До кіоску привезли 4 ящики помідорів, по 9 кг у кожному ящику, а огірків - на 7 кг менше, ніж помідорів. Скільки кілограмів огірків привезли до кіоску?

Виберить один із 4 варіантів відповідей:

О1 $9 \cdot 4 + 7$ кг

О2 $9 \cdot 4 - 7$ кг

О3 $9 \cdot 4 + 7$ кг

О4 $9 \cdot 4 - 7$ кг

Дальше (продовжити)

Тест завер: 4/20 00:22:38 00:02:58 00:07:52 Ціна 3 балів Рів

Figure 17. Section “Final testing”

Source: Own work

After mastering all the structural elements of the content module, we invite students to go through final testing, which is a synthesis of tasks from training tests to each topic that are combined by random sampling. The purpose of testing is to determine the indicators of the formation of cognitive component of future primary school teacher’s methodological competence in teaching primary school children mathematical word problems solving.

5. USAGE OF EDUCATIONAL AND METHODOLOGICAL ELECTRONIC TEXTBOOK “METHODS OF TEACHING MATHEMATICAL WORD PROBLEM SOLVING TO PUPILS OF GRADES 1-4” IN THE PROCESS OF STUDENTS’ INDEPENDENT WORK

The effectiveness of using the educational and methodological electronic textbook “Methods of teaching mathematical word problem solving to pupils of grades 1-4” in the process of students’ independent work in the course “Methods of teaching mathematics” was tested during the pedagogical experiment in 2016-2018.

In order to select experimental and control groups before the beginning of the experiment in the 2016-2017 academic year, we conducted the testing of students of the 3rd year, specialty 013 “Primary Education” of the Faculty of Primary Education of the K. Ushynsky South Ukrainian National Pedagogical University (82 students) and the Pedagogical Faculty of Kherson State University (97 students). Since the course “Methods of teaching mathematics” is based on the knowledge, skills and abilities acquired by students in the course of studying pedagogical disciplines, in particular “Didactics of primary education”, the purpose of testing was to diagnose the level of didactic, psychological and mathematical preparation.

The students – prospective primary school teachers – were offered an initial test that contained 20 closed-ended questions and provided one of four possible answer options. Each correct answer was assessed as one point. The first part of the test was aimed at testing students’ didactic and psychological knowledge. The questions presented in this part of the test involved testing general knowledge and were related to the normative provision of primary education, forms, methods, teaching aids, as well as the psychological patterns of teaching, age and psychological characteristics of primary school children (10 questions in total). The second part of the test was to test students’ knowledge in mathematics. This section included questions about logic, the theory of the multitude, combinatorics, solving equations and inequalities, basics of geometry, as well as the ability to solve basic mathematical problems (10 questions in total).

As a result of processing students’ answers to the test questions, the ratio of the total number of points received by the students during the course of the test tasks performance to the maximum number of points for the test (the coefficient of test performance) was calculated. Summarized results of the initial test, reflecting the level of students’ didactic, psychological and mathematical preparation are presented in Table 2.

Table 2

Average indicators of the level of students' didactic, psychological and mathematical preparation before studying the methods of teaching mathematical problem solving

Name of the higher education institution	Average points	Coefficient of test performance
K. Ushynsky South Ukrainian National Pedagogical University	13,2	0,66
Kherson State University	13,1	0,65

Source: own work

As an experimental group, we chose students of the 3rd year of specialty 013 "Primary Education" of the Faculty of Primary Education of the K. Ushynsky South Ukrainian National Pedagogical University (82 respondents), and as a control group – students of the 3rd year of specialty 013 "Primary education" of the pedagogical faculty of Kherson State University (97 respondents). The students of the experimental group used the educational and methodological electronic textbook "Methods of teaching mathematical word problem solving to pupils of grades 1-4" in the process of independent work, and for the students of the control group the organization of independent work did not imply the use of this textbook.

The educational and methodological electronic textbook "Methods of teaching mathematical word problem solving to pupils of grades 1-4" is intended for open access and use in the classroom to provide independent work of students – future primary school teachers during mastering the course "Methods of teaching mathematics", as well as for independent work at home and for practitioners while teaching primary school children solving mathematical word problems.

Therefore, first of all, in the first lesson, students were explained the main purpose of using this guide, its opportunity to contain modern ways of presenting information, interactive means of knowledge control, including those for self-examination.

The electronic textbook itself is located on a separate magnetic medium – a DVD. It has the following parameters: memory capacity is 1.12 GB. System Requirements: Autoplay Menu Designer 3.6, Microsoft Office PowerPoint 2007, Adobe Flash Player.

A copy of the textbook is placed in the electronic archive of the library of the K. Ushynsky South Ukrainian National Pedagogical University (<http://dspace.pdpu.edu.ua/>).

Each student had an opportunity to use it on-line or download the educational electronic textbook on their computer or on a disk or a flash drive.

Working with the electronic educational manual, the students of the experimental group had an opportunity to get acquainted with the list of content modules on the methods of teaching problem solving; each of them contains several topics, and the students could choose the topic that they wanted to work on.

By going to the relevant topic, namely the lesson plan, the students had an opportunity to study each question in detail by posted hyperlinks from detailed consideration of individual aspects to the description of the methods of work on individual tasks of the textbook. This way, in the volume and content of educational information there is a differentiation according to the level of students' cognitive needs and capabilities.

After mastering the content of the topic, the students took a training test, while performing it, they could use clues, or even look at the correct answer. After mastering all the topics at the end of the module, they took the final test, which is a composition of the training tests' tasks which are composed by random sampling.

After studying the first topic “General questions of the methodology of teaching problem solving” and having passed training tests, the purpose of the survey was to determine the benefits of this textbook to students over the traditional (paper) textbooks in the process of performing tasks independently.

The results of the survey are as follows. 92% of respondents mentioned the opportunity to master the educational material outside the classroom. Even if the students were absent at a lecture or practical class, the electronic textbook could provide them with the information to catch up on missing material, complete self-study assignments, and successfully complete a training test. The positive side is that 78% of the respondents mentioning the usefulness of the electronic educational and methodological textbook do not diminish the role of classroom, communication with teachers and counselling for their own learning.

Another indicator, which was found in 64% of respondents, as a continuation of the first one, is the development of the skills of independent work. That is, the students noted that they were given instructions and methodological recommendations in amount sufficient to master the material on their own. They could not say that about the printed textbook.

The presence of hyperlinks, the ability to quickly move from one part of the textbook to another at any convenient time, was underlined by 89% of respondents. And almost the same number of respondents (84%) confirmed that this method of presenting the educational material contributed to the fast memorization of information.

Working with the electronic educational textbook, the students claimed that it is as adapted to their needs as possible, enables each student, regardless of their level of preparation, to individualize their study, exercise self-control, i.e. to acquire

knowledge and skills on the topic at an individual pace, using the required dose while assessing their real capabilities.

Also, one of the advantages of the electronic textbook over the traditional one was seen by the students of the experimental group in its structure which helps students monitor their achievements, it was confirmed by 75% of the respondents.

The purpose of studying the discipline “Methods of teaching mathematics” is the formation of future primary school teachers’ methodological competence, so the final section was aimed at studying the impact of the developed educational and methodological electronic textbook on the level of formation of this personal quality in students.

To determine the level of formation of future teachers’ methodological competence in teaching mathematical word problem solving to young learners, we used the methodology of S. Skvortsova and Ya. Haievets, presented in the monograph (Skvortsova S., 2013). Primary school teachers’ methodological competence in teaching mathematics is understood as a composition of components: normative, variational, special and methodological, technological, design and modelling, control and assessing. Each component contains motivational and value-based, cognitive, activity, reflexive and creative components. Therefore, for diagnosing the level of teacher’s methodological competence in teaching problem solving the following criteria were selected – motivational, content, operational and activity-based (Skvortsova, 2013).

Thus, the effectiveness of using the educational and methodological electronic textbook “Methods of teaching mathematical word problem solving to pupils of grades 1-4” was tested in accordance with the indicators: desire (motivational criterion), knowledge (content criterion) and ability (operational and activity-based criterion) by individual components of primary school teachers’ methodological competence. Differences in indicators’ manifestation (by persistence of desire, completeness and generality of methodological knowledge etc.) are the basis for characterizing the levels of formation of primary school teacher’s methodological competence in teaching problem solving (low, high, sufficient).

The low level proves that students’ activity does not meet the requirements of the teacher’s methodological activity in teaching problem solving to students; the average level of methodological competence allows the teacher to only partially perform professional functions of teaching problem solving according to his available methodological activities; a sufficient level indicates the ability of primary school teachers to teach problem solving and achieve the intended educational goals and students’ development; a high level implies teacher’s creative approach to teaching mathematical word problem solving to students, the ability to create innovative methodological approaches, authorial methods.

After completing the study of modules devoted to the methodology of teaching problems solving, a survey was conducted. The purpose of the questionnaire was

to identify the level of formation of methodological competence by the motivational criterion.

The conducted diagnostics testified to the dominance in the control (64%) and experimental (78%) groups of the desire for perfect professional activity in teaching primary school children solving mathematical word problems.

The majority of students demonstrated a well-formed desire to effectively teach mathematical word problem solving to primary school children, working with any educational and methodological set in mathematics recommended by the Ministry of Education and Science of Ukraine (48% in EC and 44% in CG), desire to apply acquired knowledge and skills during real-time mathematics classes according to any educational methodological set (44% in EG and 37% in CG), desire to realize the goals and objectives of the content line “Mathematical word problems” (45% in EG and 28% in CG). There was also fixed a desire to introduce modern teaching technologies to teaching mathematical word problem solving to primary school children (21% in EG and 19% in CG) and to strive for the realization of criteria for assessing pupils’ academic performance in solving mathematical word problems (21% in EG and 20% in CG).

In order to determine the level of formation of methodological competence by the content, operational and activity-based criterion students went through testing. The final test consisted of two parts: the first part was aimed at the diagnosis of the levels of content criterion formation, and the second part – at the operational criterion of partially-methodological, design and modelling components of methodological competence in teaching pupils solving mathematical word problems.

The summarized results obtained by the levels of methodological competence are clearly presented by means of a diagram (Figure 18).

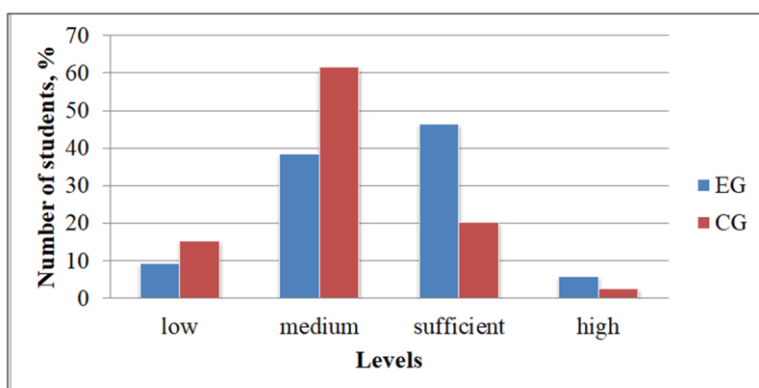


Figure 18. The distribution of students of the experimental and control groups by the level of methodological competence formation

Source: Own work

As evidenced by the results of the pre-final stage of the experiment, 5.8% of the students of the experimental group showed a high level of methodological competence formation, while in the control group the results were 2.7%. 46.4% of EG students and 20.2% of GG students showed a sufficient level. A medium level was diagnosed in 38.5% of EG students and 61.7% of CG students. 9.3% of EG students and 15.4% of CG students remained at a low level.

The analysis of the study results showed significant positive changes in the experimental group. This leads to the conclusion that the use of the developed educational and methodological electronic textbook “Methods of teaching mathematical word problem solving to pupils of grades 1-4” in the process of mastering the course “Methods of teaching mathematics”, which became the basis of experimental learning, offers much better results than traditional training.

CONCLUSION

The efficiency of students’ mastering of the course “Methods of teaching mathematical word problem solving to pupils of grades 1-4”, in particular modules devoted to the methodology of teaching mathematical word problem solving, is provided by the creation and introduction of the educational and methodological electronic textbook “Methods of teaching mathematical word problem solving to pupils of grade 1-4” into the educational process.

In the course of independent work, students using this tutorial were able to view a list of content modules on the teaching methodology of solving problems and topics included in each module. By clicking on a specific topic, students move on to the lesson plan, with each issue of the plan also opened through a hyperlink. The content of a specific item in the plan also contains a hyperlink that allows the student in accordance with his or her own cognitive needs to explore the content of the problem more deeply. In addition to the lesson plan, each topic has references to the list of references, and students have an opportunity to study each source by clicking on the hyperlink. By clicking on an assignment for independent work on a particular topic, students are able not only to review the assignment, but also, if necessary, to get recommendations for its completion. If students need more detailed help, they may receive some clues or, even, samples of the completed assignment with a proposal to do the same. Also, on the starting page of the topic, students can review the plan of practical training, go to the training and final tests.

The textbook contains a sufficient number of electronic materials to provide students’ independent work: electronic versions of currently valid mathematics textbooks for grades 1-4, regulatory documents, scanned teaching aids for teachers and students, references to online resources, etc.

As a result of the conducted pedagogical experiment, during which the educational and methodological electronic textbook “Methods of teaching mathematical word problem solving to pupils of grades 1-4” was introduced into the process of mastering the discipline “Methods of teaching mathematics”, changes in the level of formation of future teachers’ methodological competence in teaching mathematics were found in the experimental group. It was also found that the students of the experimental group, compared with the control group, have more opportunities to use IT in teaching mathematics to young learners and are more eager to do it. Based on the analysis of the experimental data obtained, we arrive at a conclusion about the effectiveness of the developed electronic textbook for training future primary school teachers in teaching mathematical problem solving to pupils.

The study does not exhaust all aspects of the problem of using IT in training future primary teachers in teaching mathematics in primary school. The prospects for further research may be related to the extension and development of the electronic educational manual to all content modules of the course “Methods of teaching mathematics”.

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