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PSYCHODIDACTIC APPROACH TO THE CREATION OF TEXTBOOK TEXTS FOR THE PROMOTION OF INTELLECTUAL DEVELOPMENT OF STUDENTS (ON THE EXAMPLE OF SCHOOL MATHEMATICS)*

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Abstract. *Introduction.* The most important factor for students' intellectual development is the teaching content. A textbook text is a didactic unit of teaching content. Therefore, the question arises about the requirements for modern textbook texts in the framework of the psycho-didactic approach.

Materials and Methods. The study was conducted based on an analysis of the psychological features of the intellectual development of students within the psycho-didactic approach, which is based on the psychological and pedagogical rationale of the multifunctionality of modern mathematics teaching materials.

Results and Discussion. The concept of development-focused educational text, which should be constructed as a multidimensional semantic space (hypertext), is introduced. Classification of development-focused educational texts is presented (using school mathematics as an example) based on the ontological theory of intelligence, targeting the enrichment of the main components of students' mental experience – cognitive, conceptual, metacognitive, and intensional experience. Typology of pedagogical developmental texts of different types in teaching mathematics in middle school is given.

Conclusion. The use of developmental textbook texts contributes to understanding mathematical material and developing students' intellectual resources.

Keywords: *educational content, textbook text, psycho-didactic approach, intellectual development, comprehension, mental experience, typology of development-focused educational texts*

Introduction

The content of school subjects is an essential factor in the intellectual development of students. It requires the study of the psycho-didactic approach, according to which forms and methods of learning are developed based on a combination of subject-didactic, methodological, and psychological knowledge (Davydov, 1966; Zankov, 1990; Panov, 2004; Gelfman, 2004; Gelfman, Kholodnaya, 2018; Psychodidactics of modern textbook..., 2019; Kidron, 2010; Malara, Navarre, et al., 2003; Brousseau, 1997; Simon, Tzur, 2004; Hershkowitz, Schwarz, Dreyfus, 2001; Bikaner-Ahsbahs, 2004; Kholodnaya, Gelfman, 2016).

There are different views on the role of textbook texts in modern school education (using school mathematics as an example). According to one point of view, a textbook text is a

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presentation of mathematical knowledge adapted to the abilities of students of different ages (and then such a text is simply a statement of reference material or a mathematical learning task). The other position states that there is no need for specially designed textbook texts since the preparation of instructional materials and their presentation in class is the sole responsibility of the teacher, who organizes learning activities for students and is responsible for the quality of their acquisition of mathematical knowledge.

A textbook is a tool that organizes modern learning content. However, several studies have pointed out that traditional mathematics textbooks are closed in that they restrict the readership to very narrow activities (Love, Pimm, 1996). It is also emphasized that many students cannot effectively use their textbooks as learning tools (Weinberg, Wiesner, 2011).

In our opinion, according to the requirements of the psychoeducational approach, firstly, a textbook text should not contain prefabricated knowledge (as a reference or problem book, it should be a set of textbook texts in the form of a textbook for students), because mathematical knowledge will have a developmental effect only if it is designed in accordance with the mental (especially intellectual) development of students. Secondly, work with texts (analysis, highlighting of main ideas, interpretation, and creation of original texts) is an important factor in intellectual development, and ignoring it deprives students of the possibility of individual, silent intellectual work. It is important to emphasize that aligning mathematics instruction with the structure of children's thinking will reduce the sense of anxiety that children often experience in mathematics classrooms (Picker, Berry, 2001). Effectively analyzing the language of mathematics as it is used in mathematics textbooks will help make students aware of the importance of learning (O'Keeffe, O'Donoghue, 2015).

This article aims to introduce the concept of a "development-focused educational text" describe its characteristics and introduce the types of development-focused educational text based on the psycho-didactic approach (using school mathematics as an example).

Materials and Methods

The student's interaction with the various subject areas in the learning process is mediated by a *textbook text*. The text is the natural source that provides the learner with the necessary intellectual resources (new knowledge, new ways of thinking, new perspectives on this or that problem) for his or her life. In school education, the text is considered a prerequisite for productive learning, especially within the framework of "reading theory," according to which a student-reader actively constructs meanings (concepts) while working with texts (Weinberg, Wiesner, 2011).

A new generation of textbooks has evolving texts that can transform a textbook into an intellectual guide. An evolving textbook text is a kind of hypertext because several specific features characterize it.

1. Variety and nonlinearity – textbook texts contain texts of different genres and types (informative, problem-solving, paradoxical, action-oriented, gamified); they are divided into fragments of different complexity; they initiate different types of learning activities (students may engage in task-based, research-based, project-based, or creative activities); they provide different ways of implementing educational information (verbal, visual, hands-on, emotional).

2. Ambiguity and inconsistency – there are elements of uncertainty in textbook texts (tasks with incomplete or excessive data, alternative approaches to solving the same problem, and different analyses of the problem situation).

3. Focus on students' experiences – textbook texts are communicative and contain numerous direct and indirect questions and appeals to students. In addition, the narrative basis of the text plays a unique role as a prerequisite for providing emotional support to students and incorporating

their everyday experiences. Finally, the inclusion of personal experiences is ensured by the possibility of choosing the learning pace and method according to the student's level of preparation, cognitive preferences, and abilities.

4. Independence in conceptualization – in textbook texts, knowledge is not conveyed in a prefabricated form: First, the text creates motivation to learn a new concept. Then students are guided to consider essential and non-essential features of the concept, independently formulate definitions, use visual models of the given concept, and apply the new concept in different situations. Textbook texts are designed to teach the ability to self-monitor learning activities (including self-assessment of actions in search of errors, and independent planning of steps in studying the material). Of particular importance are texts that initiate the process of independent writing of original texts on specific topics of the school mathematics course. Thus, when working with this type of text, the mechanisms of self-regulation of students' intellectual activity are trained.

Emphasizing the role of textbook texts in the school mathematics classroom challenges the widely held stereotype that "teaching mathematics means teaching students to solve problems. The more problems they solve and the more complex those problems are, the more effective the learning outcomes will be." We believe that teaching mathematics means teaching students to work with the meanings of mathematical concepts and activities by focusing on the conceptual and procedural apparatus of mathematical thinking and learning mathematics as a particular way of looking at the world. The higher the level of theoretical understanding of a particular subject area, the more successful a person is in solving tasks relevant to that subject area.

In this work, the following theoretical research methods were used: systematic analysis of the problem (identification and formulation of the main contradiction, search for ways to solve it, systematization of existing research, and summary of arguments in the formulation of a new problem); and modeling, in particular, development of a logical-semiotic model (psycho-didactic classification of textbook texts of developmental psychology).

Results and Discussion

The creation of development-focused educational texts according to the requirements of the psychoeducational approach, is one of the main directions of the emergence of modern Developmental Learning. The novelty of our approach lies in the fact that developmental learning texts, on the one hand, represent a projection of the structure of scientific-mathematical knowledge and, on the other hand, enable the formation of psychological mechanisms of productive intellectual activity.

Accordingly, the following question arises: what can serve as a psychological basis for the design of developmental mathematical texts so that the textbook texts promote the formation of students' intellectual abilities?

The psychological mechanisms of the intellectual development of a personality are related to the processes of enrichment of "individual mental experience" described in the ontological theory of intelligence by M.A. Kholodnaya. According to the structural model of intelligence proposed within the framework of this theory, four levels (forms) of experience can be distinguished in the composition of mental experience, each of which has its own purpose (Kholodnaya, 2019):

● *Cognitive experience* – responsible for the reception, storage, ordering, and transformation of information.

● *Conceptual experience* – provides for generalization, abstraction, modeling based on a selection of essential features and patterns, interpretation, and construction of new mental content.

● *Metacognitive experience* – provides for self-regulation of one's intellectual activity and choice of strategy for self-learning.

● *Intentional (emotional and evaluative) experience* – characterizes individual preferences and inclinations in the selection of learning materials and problem-solving methods related to the unique personal experiences of a particular person.

The psycho-didactic typology of development-focused educational texts suggests the construction of different types of textbook texts that ensure the enrichment of the main components of cognitive, conceptual, metacognitive, and intensional (emotional and evaluative) experiences of students in the process of learning mathematics in grades 5-9 (see details: Gelfman, Kholodnaya, 2018). Each type of mathematical developmental text addresses and contributes to the formation of a particular component in the structure of the four forms of mental experience.

The following is a (using mathematics texts as an example) (Table 1).

Table 1

Psychodidactic typology of development-focused educational texts

Forms of mental experience	Components in the structure of mental experience	Features of learning and cognitive activity	Types of learning tests
Cognitive experience	Ways of information encoding	Verbal-symbolic way of information encoding	· Mastering mathematical symbols · Finding a formula · Getting definitions
		A visual way of information encoding	· Normative image formation · Image motivation · Image development · Image classification · Converting from a verbal-symbolic method of information encoding to a visual one · Initiation of individual imagery experience
		Subject-practical way of information encoding	· Laboratory work · Situation in practice
		Sensory-emotional way of information encoding	· Emotional impression · Metaphor · Game
	Declarative cognitive structures	Cognitive structures of mathematical concepts	· Introduction of a focus sample · Frame · Compendium
	Procedural cognitive structures	Cognitive structures of ways of mathematical activities	· Algorithm (procedure) · Operation
Conceptual experience	Semantic structures	The semantics of the mathematical language	· Term meaning · Systematization of term meanings · Translation from the language of mathematics into the native language
	Categorical structures	Identification of categorical features and formation of relations between categories	· Identification of concepts' attributes · Evaluation and selection of concepts' features · Establishing connections between concepts · Motivation of a new concept · Categorization of concepts' content · Concept enrichment · Application of a concept in various situations · Packing up a content of a concept
	Generative structures	Constructing concepts and creating texts	· Searching for and generalization of patterns · Modeling · Micro composition · Independent creation of originals texts · Invitation to the project

End of Table 1

Forms of mental experience	Components in the structure of mental experience	Features of learning and cognitive activity	Types of learning tests
Metacognitive experience	Involuntary and voluntary mental control	Planning	· Program · Choosing a goal · Making a plan
		Predicting	· Formulation of a hypothesis · Prediction under uncertainty · Predicting the end result of students' actions
		Self-regulation	· Ways to self-control · Selecting a method of self-control · Finding and analyzing errors
	Metacognitive awareness	Self-reflection on personal intellectual activities	· Reflection of the solution methods · Self-assessment of students' knowledge and skills · Learning self-diagnosis · Psychological feedback
	Open cognitive stance	Willingness to work with conflicting information	· Problematizing · Alternative · Clash of opinions · Impossible situation
Intentional (emotional and evaluative) experience	Preferences Beliefs Mindset	Choice of a way of learning	· Choice of activity method activity · Choice of cognitive position · Individual cognitive style
		Actualization of intuitive experience	· Guessing · Creative work
		Valuable attitude toward the learning material	· Mathematics in the surrounding world · Key lines in mathematical development · History of mathematics

As part of the educational project "Mathematics. Psychology. Intellect" (MPI), teaching materials with developmental learning texts of different types were developed and implemented (Enriching Learning Model in MPI Project, 2002; Gelfman, Kholodnaya, 2018; Gelfman, Dozmorova, Demidova, 2014; Gelfman, Podstrigich, 2006; Kseneva, 2006; Lopatkina, 2009; Prosvirova, 2006; Pustynnikova, Lisura, Sazanova, 2004; Smolyakova, 2006).

Let us characterize some types of developmental textbook texts and give examples of such texts.

"Text is an individual cognitive style." Texts of this type provide students with opportunities to manifest their cognitive style, master many other cognitive styles, and thus expand their cognitive abilities.

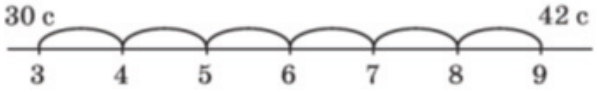
Textbook texts of this type usually contain characters that are carriers of a particular cognitive style, especially the style of information encoding (verbal-symbolic, visual, factual, sensory-emotional).

Here is an example of a textbook that promotes mastery of the ability to choose how to encode information.

1) Task. An athlete runs each successive lap 2 seconds longer than the previous lap. He ran the ninth lap in 42 seconds. What time did the athlete finish the tenth lap? The third lap?

2) Sasha read the task and said that the athlete ran the tenth lap in 44 seconds. How did he know that?

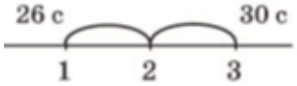
3) Volodya took notes to answer the question of how much time the athlete needed for the third lap:



$42 – 2 \cdot 6 = 30$ (s) – the third lap.

Explain these notes.

4) Sergey continued Volodya's reasoning and made the following entry:



Explain what this means.

5) Vasya said that the sequence of time values in which the athlete runs the first, second, etc. Lap is an arithmetic progression. How does he know that?

6) Natasha said that all the questions in the task could be answered with the formula for the nth member of an arithmetic progression. Check.

It should be noted that the use of the subject-practical way of information encoding, especially laboratory work, interests students, motivates them to learn new things, and creates a positive emotional attitude towards the learning material. As an example of the text, "text lab" is used a task in which students are asked to embroider a parabola. This subject matter experience becomes the basis for self-control by plotting a quadratic function.

Here is an example of a text that aims to enrich the conceptual experience, particularly to train the ability to highlight the essential features of the concept of "decimal fraction" and actively apply thinking operations such as analysis, comparison, and generalization.

Consider the table with the numbers

Thousands	Hundreds	Tens	Ones	Comma	Tenths	One-hundredths	Thousands	Tens of thousands
	4	0	0					
		4	0					
			4					
			0	.	4			

What pattern did you detect in the lines of the table? What purpose does the point serve in the table?

There is a number in the table that is not a natural number. For example, the number 0.4 is a decimal fraction that is "*Point four*." Explain how this number got into the number table.

How would you fill in the blank rows in the table?

Which numbers in this table are *natural* numbers? Which numbers are *decimals*? In what situations have you encountered decimal numbers? Make sentences about natural numbers and decimals using the highlighted words and expressions.

One of the characteristics of the formation of metacognitive experience is the ability to respond to one's intellectual activity and to take responsibility for its results. In this case, students' metacognitive awareness is important, which includes awareness of the nature of their own learning activity, self-assessment of their knowledge and skills, self-diagnosis of learning, and knowledge of the characteristics of their cognitive activity.

Of particular importance are textbook texts of the category "text – reflection on ways of solving." Working with such texts, students develop procedural knowledge about mathematical

activities and understand the internal "structure" of various mathematical actions. Such texts are structured as follows: they present several different ways of solving a mathematical problem and then discuss the special features (advantages) of a particular way; they provide an opportunity to evaluate the solution of "another student" from the point of view of whether a better way can be chosen.

Here is an excerpt from the text "Choosing a Way to Solve Quadratic Equations."

a) The equations are given:

1) $\frac{1}{3}x^2 - \frac{2}{3}x - 1 = 0$; 2) $x^2 - 5\frac{1}{5}x + 1 = 0$;

3) $7x^2 = 5$; 4) $0{,}06x^2 + 0{,}012x = 0$;

5) $0{,}7x^2 - 3 = 0$; 6) $x^2 - 4x - 5 = 0$;

7) $x^2 - 4\frac{4}{5}x - 1 = 0$; 8) $2x^2 = -6x$;

9) $x^2 - 2x + 1 = 64$; 10) $x^2 + 2x - 80 = 0$;

11) $x^2 - 10{,}5x + 5 = 0$; 12) $x^2 - x + \frac{1}{4} = 0$;

13) $x^2 - 40x + 111 = 0$; 14) $x^2 + 6x + 4 = 0$;

15) $x^2 + 2mx + q = 0$; 16) $ax^2 + 2bx + c = 0$;

17) $3x^2 - 10x + 3 = 0$; 18) $9x^2 - 20x = 24x$.

Which equations will you solve first? What are some ways to solve these equations? Solve them.

What methods will you use to solve the other equations?

Group the equations by the way you solve them. Can all of these equations be grouped together? Split into two groups? Split into three groups? Give these groups names.

b) Mark the possible solutions for these equations in the table with "+."

For each equation, mark the solution path that you think makes the most sense with "*."

Are all the solution paths for quadratic equations that you know included in the table? If not, complete them. Are there any methods in the table that you have not used to solve these quadratic equations?

Do you think these remaining methods are effective? If so, select the quadratic equations that could be solved using these methods.

Equations	Solutions						
	Using the root formula	Use of Vieta's formulas	Factoring a trinomial using decomposition	Reduced quadratic equation	Applying the Root Formula of a Quadratic Equation with an Even Second Factor	Representing a quadratic trinomial as a square binomial (if possible)	extracting a square root in partial quadratic equations
1) $\frac{1}{3}x^2 - \frac{2}{3}x - 1 = 0$ …							

Create a guide for choosing a rational method for solving a quadratic equation. You can use verbal instructions, diagrams, drawings, or examples for such a guide.

One of the main goals of modern teaching is to develop the ability to create various models. Text – modeling creates the conditions for developing the ability to conceptualize (to construct theoretical representations based on the abstraction of relationships that occur in a particular subject content).

The text type "text – choice of cognitive position" is necessary to activate students' learning and cognitive activity to preserve their identities. In addition, textbook texts of this type create conditions for actualizing personal life experiences and expressing a personal opinion on various aspects of educational activity. This goal is served, for example, by the epilog with which the sections in the textbook "The World of Quadratic Equations" are concluded. Here is an example of such a text.

"AFTERWARD In "Arithmetica Universalis," Isaac Newton wrote that setting up an equation for a problem is like translating from one language to another. Setting up such an equation is translating from an ordinary language into a mathematical one. Thus, the difficulties involved in setting up an equation are those of translation.

For example, to translate a sentence from English into Russian, we must first understand the sentence correctly and, secondly, be familiar with the means of expression of the corresponding terms in Russian.

Apart from that, sometimes we can break a sentence into its components and translate it word by word.

However, translation is not always so simple. Often it would be best if one did some preliminary work, paying attention, not to the meaning of individual words but the meaning of the sentence as a whole. In this case, one would need to restructure the sentence before translating it and put the idea expressed in it into different words.

Here is an example of two English sentences translated differently:

"Birds of a feather flock together." The literal translation is "Птицы с одинаковыми перьями собираются вместе – birds of the same feathers flock together." And the translation found by the author in Russian proverbs is: "Рыбак рыбака видит издалека – The fisherman sees the fisherman from afar."

Here is another example: "Do not count your chickens before they are hatched," the Russian equivalent is "Цыплят по осени считают – Chickens are counted in autumn."

What similarities and differences do you see between these translations?

Find common expressions, proverbs, and idioms from different countries and nations that have the same meaning."

We believe that developing and using developmentally appropriate textbook texts of different types will, first, expand the content area of mathematics instruction and, second, allow teachers to create more effective individualized learning pathways for students with different levels of education and thinking.

Conclusion

In our view, the psycho-didactic typology of development-focused educational texts is a valuable tool that can enhance the understanding of mathematics teaching material and promote the growth of students' intellectual resources by enriching the most important components of their mental experience. Moreover, our proposed approach to shaping the content of mathematics instruction in schools raises the urgent question of whether a modern mathematics textbook should be a reference (problem) book or an intellectual self-help book.

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