SOUTH-WEST
UNIVERSITY
·NEOFIT RILSKY·
BLAGOEVGRAD, BULGARIA

VOLUME 2
2004

SCIENTIFIC
Research

ELECTRONIC
ISSUE

Basic components of the methodological system for teaching students how to solve creative problems

From "Educational Background and Dialogue in the European Pedagogical Space"(symposium, now being published)

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summary

Considered as part of a whole methodological system, the teaching of students how to carry out creative mathematical activities is of fundamental importance both to the enhancement of the pedagogical efficiency of the educative process and the development of the mathematical skills of primary school pupils. The methodological system for teaching students how to solve creative problems incorporates five basic components which are interrelated and interdependent: aim, content, means, methods, and forms of organization of the educational process. The laying out of this system requires that all its structural components be accurately defined, analyzed and experimentally tested.

Considered as part of a whole methodological system, the teaching of students how to carry out creative mathematical activities is of fundamental importance both to the enhancement of the pedagogical efficiency of the educative process and the development of the mathematical skills of primary school pupils. The methodological system for teaching students how to solve creative problems incorporates five basic components which are interrelated and interdependent: aim, content, means, methods, and forms of organization of the educational process. The laying out of this system requires that all its structural components be accurately defined, analyzed and experimentally tested.

The aim of teaching students how to solve creative problems serves the goal of primary school mathematical education in general. It is in chime with the basic educative objectives that stem from it, especially the one addressing "the development of the mental and creative skills that account for the formation of abilities for generalization through the study of specific situations and the solving of practical and mathematical tasks and problems …" (Todorina, 1994 p. 36). The aim of this kind of education is seen from a learner-centred position and is determined by the fulfillment of the developmental functions of mathematical education in the third grade. The educational content of mathematics in the third-grade has been adapted for creative purposes. It consists of the following elements:

- formation of the notion of three-digit numbers;

- using these to master the four rules of arithmetic;
- familiarization with the interdependence between the components and the results in arithmetical operations;
- familiarization with the two varieties of the distributive property – multiplication and division of a sum and a number;
- familiarization with the surface of a rectangle, with perpendicular and parallel straight lines, types of angles and types of triangles according to their angles;
- drawing a right-angled triangle and a rectangle;
- familiarization with the units of measurement such as gram, ton, square sentimetre, square decimeter, square metre.

With respect to the educational content, the aim is to build:

- skills for the formation of three-digit numbers with a particular number of ordinal units or with a particular ratio between the ordinal units;
- skills for the formation of strings of interrelated numbers;
- skills for differentiation on the basis of a distinctive feature;
- skills for the construction of mathematical expressions on the basis of information set in advance. This may include specific numbers, an arithmetical operation, both numbers and operations, or a particular pattern to be applied.
- skills for composing textual problems with the help of visual aids, on the basis of the external structure (instructions, numerical data, and question) or without knowing the external structure;
- skills for solving arithmetical problems in two ways, in a variety of ways, in the most efficient way.

As regards the educational content in geometry, the aim is to form

- skills for composing geometrical problems which involve drawing geometrical figures or classifying them;
- skills for solving geometrical problems in two ways, in different ways, and in the most efficient way.

In terms of the educational content in algebra, the aim is for students to acquire:

- skills for composing equalities and inequalities;
- skills for detecting the interrelations between the components and the results of arithmetical operations as well as those between the change of the results and the change of the components.

The formation of all these skills is contingent on the mastering of skills for solving algorithmic mathematical problems, which are indispensable as far as creative problems are concerned. The recognition of creative problems as an aim of mathematical education is an essential stage in the development of efficient methods of teaching students how to use their knowledge of mathematics imaginatively.

The educational content has been developed on the basis of the three stages of the formation of skills for solving creative problems – the preparatory stage, the introductory stage, and the reinforcement stage.

At the preparatory stage students are acquainted with the new task through exercises. These are instrumental in the review of knowledge, skills, and habits necessary for solving algorithmic problems such as arithmetical expressions, textual problems, geometrical problems, etc. They also facilitate the review of the interdependence between the components and the results of arithmetical operations

and of the knowledge of equations, equalities, inequalities, geometrical figures. With the help of these exercises students also practice their skills for finding out an unknown component, and for drawing geometrical figures.

At the introductory stage other types of exercises are employed which help clarify the way the new task is to be tackled. They present the method of comparison used to identify similarities between numbers, strings of numbers, textual problems, geometrical figures, etc. At this stage other activities are practiced, including the method of discovering unknown figures in the components and the results of arithmetical operations; the manner in which arithmetical expressions are composed. This is the point where textual problems, geometrical problems for calculation, inequalities, equations, etc are solved, and the method for dividing a geometrical figure into its parts or uniting the parts into a whole is introduced.

The exercises employed at the reinforcement stage contain different versions of setting the new type of creative problem, which underlies the necessity for variety of the solutions. At this point the level of difficulty increases and conditions are provided for student to apply their knowledge and skills creatively.

The means of teaching students how to perform creative mathematical activities constitute an especially designed system of exercises and algorithmic guidelines that aid the formation of skills for solving creative problems. As a whole the system comprises three groups of exercises: preparatory, introductory and reinforcement exercises, corresponding to the three stages of the formation of skills for solving creative problems. In organizing of the exercises within the system, I have taken into consideration the fact that when the creative problem is new to the students, it is treated as an educational objective – the formation of certain skills. Therefore it has to undergo the tree stages discussed above so that students can consciously master the method of its solution. When the creative problem is of a familiar type, it is a means of education and helps students acquire mathematical knowledge and skills. Thus creative problems start out as an objective and end up as a means of mathematical education. This gradual transformation of creative problems into a means of education suggests the formation of full-fledged skills for solving these problems. This is what turns them into an effective means of developing the mathematical abilities of students.

The exercises in the system have been arranged according to their level of difficulty. This type of organization facilitates the application of the ease of understanding principle as it is in accord with the didactic requirement that education should start from the easy to the more difficult, from the familiar to the unfamiliar, from the close to the remote. The choice of exercises in the system is stipulated by the psychological characteristics of the comprehensive abilities of third-grade students as regards their age. These abilities correspond to a certain level of development of the cognitive psychological processes – perception, memory, thinking, imagination. The exercises in the system allow for the perception of the students to be stimulated and directed towards the new cognitive task. In addition, they facilitate the development of such mental processes as analysis, synthesis, generalization, comparison, classification, etc. With their help the processes of memorizing, reproducing, and storing information can develop and improve, and creative imagination can be boosted.

The system makes use of exercises from the third-grade student's book (1) which are often modified or expanded with supplementary information. Additional exercises have also been provided which comply both with the knowledge of third-grade students and the requirements of the curriculum. Heuristic problems and problems with a highes difficulty level have also been included. These are meant for individual work with students who have a proclivity for mathematics.

With respect to the teaching methods, the aim of the system is to show students how to approach the solution of creative problems inventively and imaginatively while they are mastering the educational content on arithmetic, geometry and algebra. The following creative approaches have been designed and approved of in the experimental education:

1. In view of the matter for instruction in arithmetic;
   - composing and writing down three-digit numbers;
   - representing three-digit numbers as a sum of hundreds, tens and ones;
   - comparing and contrasting three-digit numbers;
   - completing and composing strings of numbers defined by a certain rule;
   - composing arithmetical expressions;
   - solving expressions in two ways, in the most efficient way;
   - identifying textual problems in different types of texts;
   - transforming a text into a textual problem;
   - comparing and contrasting textual problems and their solutions;
   - establishing correspondences between a textual problem and the expression that represents its solution, the pattern for its solution, or a relevant drawing;
   - changing the components of a textual problem so that a new one is formulated, another solution can be given or in order to solve the problem in the most efficient way;
   - composing textual problems;
   - formulating textual problems in different ways;
   - solving textual problems in two ways or in the most efficient way;
2. With respect to the instruction matter on algebra:
   - writing down the unknown numbers in arithmetic expressions on the basis of the dependences between the components and the results of the arithmetical operations;
   - writing down unknown numbers in arithmetic expressions in different ways;
   - composing and solving equations using the dependences between the components and the results or on the basis of the knowledge of arithmetical operations with three-digit numbers;
   - composing and solving equalities and inequalities on the basis of the properties of the arithmetical operations;
3. As regards the educational content in geometry:
   - comparing and contrasting geometrical figures;
   - dividing a geometrical figure into parts in various ways;
   - composing geometrical figures by putting their parts together in different ways;

- composing geometrical problems for drawing;
- solving geometrical problems in two ways, in various ways in the most efficient way;
- composing geometrical problems for classifying figures.

The organizational forms of education have been selected in such a way that the highest possible rate of individualization and differentiation is provided in the process of teaching students how to solve creative problems. The successful choice of a form of organization in each particular case is of vital importance for the efficiency of the methodological system.

Following a teaching experiment with third-grade students, the basic structural components of the methodological system for teaching students how to apply their knowledge of mathematics creatively have been adopted in the regular process of mathematical education.