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Developing Cognitive Abilities Through Mathematical Education

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Summary

The most important cognitive abilities include consciousness, observation, the abilities of being active, paying attention, and having direction. Their development can be started in students' first grade and mathematical education can play a major part in it.

The following article suggests means for the development of some of the cognitive abilities. Many mathematical problems and exercises (the major part of which are taken from the first grade maths book by the same author) are discussed.

Students' Cognitive abilities and their influence on the efficiency of education has been a matter of interest of educational psychology for a long time. However the psychologists working in this field of study are not many. In Bulgaria the main part of research has been done by G. Pinyov, D. Yordanov, and At. Nikov. After mentioning the importance of cognitive abilities, he pays special attention to their classification and describes them as follows-observation, ability to pay attention, to be active, to be independent, to be precise and ideologically directed. Nikov goes further than Yordanov and adds to the latter consciousness , direction and others (which he calls 'characteristics'). In his opinion it is a serious flaw of educational psychology that it pays little or no attention to the study of cognitive abilities, and the learner does not only participate in the education process through his cognitive and psychological processes but mainly through his own personal abilities and characteristics.

What has been said above seems to be to a greater extend true for Methodology. The matter of students' cognitive abilities has never been in the center of attention of Methodology (both Bulgarian and Russian). Famous methodologist as Stolyar, Kalyagin, Cherkasov, Metelsky, Skatin Bantova, Pishkalo, Betlyukova, etc have never treated this problem in detail. They usually look at the problem from the point of view of the different methods and exercises use to develop the abilities to observe, be active or independent without noticing the fact that these are cognitive ones. The approach is the same in Bulgarian Methodological literature.

It can be noticed that most authors pay great attention to the problem of developing psychological processes and more precisely to developing thinking processes through mathematics education. Many of them (Stolyar, Metelsky, Istomina and others) discuss the problem in charters of their work , while others (Zankov, Agrinskaya) devote whole their works to it. They mainly deal with thought operations (analysis, synthesis, comparison, generalization, abstraction, etc), their nature,

specific features, the ways and means for their development in mathematical education.

The problem is similar in mathematics curriculum (1^{st} –4^{th} grade). A look at the different curricula for the last 30 years shows that the developing functions of mathematics education are discussed along with its educational functions. Intensive development of mathematical thought in children is achieved through their mathematics education from 1^{st} to 4^{th} grade. In the same way in the curriculum from 1991 these functions are treated in detail and attention is paid to some personal abilities, including the cognitive ones. This is also dealt with in the 1982 curriculum." Educational work in the field of mathematics … plays a leading part in forming the basic notions of nature and social activity (Movement, symmetry, space, quantity and quality) as well as forming the main characteristics and abilities (motivation, creativity, inquisitiveness, independence). It is more widely spoken about the development of the cognitive abilities in newer curricula. It is one of their aims to develop these abilities in students. So it must be said that mathematical education should be organized in away which allows development of these abilities.

The problem of developing cognitive abilities is not discussed well enough in teachers' books. They usually comprise advice on developing thinking processes in students. The main methods pointed out include individual and group work, as well as the creating of obstacles in educational process in order to develop thought operations (comparison, analysis, etc), to create a positive emotional environment during classes and to provoke interest in mathematics. Development of students' intellectual abilities is mentioned along with development different activities in very few teachers' books. It can be concluded from what has been said so far that methodologists should work harder in the field of the above mentioned problems. It is their duty to convince teachers how important cognitive abilities are and to point out the ways and means of their development.

The most important cognitive abilities are as follows: consciousness, independence, observation, paying attention, having direction. All of them can be developed from 1^{st} grade and mathematics should play major part in this process. The specific features of mathematical syllabus favour their formation and development in specially organized and purpose-build educational work.

The aim of this report is to offer means to develop the cognitive abilities. The means that are to be offered concern first grade students. Some of the examples are taken from the 1^{st} grade book in mathematics, in which various exercises are included to form and develop cognitive abilities in students.

One of the most important cognitive abilities is consciousness, that is, understanding the activity aim. To put it otherwise, the student should be aware why he is learning, what he is learning, how he is learning i.e. what is the best and easier way to acquire particular knowledge and skills. In order to achieve this, the educational process has to meet some conditions. One of them is the application of the aim oriented method which means that not only the teacher but also the student should understand what the completion of a given task aims at.

There are different ways in which the method can be used in the educational process in mathematics. Let's, for example, look at the lesson unit which forms the notion of the number and figure 'seven' (Manova, Rangelova, 'First grade Mathematics). To introduce the students to the topic, the teacher points their attention

to the main illustration of the unit and says: ”Let’s look at the illustration and learn how to count to seven.’. After the students look at the illustration and discover what there is in it(the illustration represents an art class) they are asked to find how many items there are in the picture. ‘How many easels are there?’, ‘How many drawings are there?’, ’How many drawings is the girl adding?-One. If we add one more drawing to the other six, there will be seven drawings. Are there other items in the picture that are seven? Count the palettes.’ Afterwards the first grade students attention is drawn to the first task to complete in the lesson. Previously (for example in the lesson units dealing with the numbers up to five) the teacher has shown what the aims of each task are. Later the children are given the possibility to discover what the aims by themselves but still with the help of the teacher. In the discussed lesson the students are asked to fond the aims of the task alone (to learn how to write the figure seven). The class work is carried on in a similar way. ‘Look at task two and tell me what the arrow points at. You have to connect the square with the number seven in it to the picture which consists of five items.- Now what do you have to do in task three?’ At that stage it is still difficult for the children to explain things and use mathematical terms so after they answer the teacher should the correct definition of the answer.

If the aim-oriented method has been used since the beginning of the school year the class work on this lesson can be organized in a different way. For example, the teacher can ask the students to find the aims of all the tasks in the unit by themselves. ‘Look at all the tasks on that page and tell me which one is about writing the figure seven? Find out in which task you have to write down the number of the crayons from the picture. Which task is that? Is there another similar task? What do you have to do in it? Look at the page again. Which task requires you to write down the number of the already studied figures?, etc.

This way of organization of class work provides another condition to develop consciousness-‘creating a situation which requires highly intellectual and creative activity on the side of the learner in order to look for and define new variants and solutions.’(Nikov). To build up this condition, children have to play the role of epxlorers and inventors. They can be encouraged with directions like “look at the illustration. How many different types of materials are there on the table? Find out which of them are not represented in the smaller illustrations?”, or “Find which part of the illustration is missing?”, etc.

Children can be put in a problem situation at the beginning of the lesson when the topic is introduced. In lessons dealing with adding children are asked to find out with the help of an illustration that the parts are given and they have to decide what the whole is. While in lessons dealing with subtraction they have to find that a part is taken away from the whole (quantity). For example, six kites, one of which is in the air, four children, one of which is going home, fourteen scarves, two of which have fallen on the floor.

The building of a positive attitude towards education in students, and more specifically, towards mathematical education and the creating and keeping children’s interest towards learning can be achieved through their participation in different activities. Along with mathematical activities (counting, calculating, drawing, and measuring), students should be given the chance to paint, colour, mould, and express themselves. By alternating activities the teacher allows his students to easily accept and consider what they are being taught as various analyzers take part in the process.

In order to complete the task they have been given, children should compare, analyze, and abstract themselves from what is irrelevant, generalize i.e. perform an intensive analytic and synthetic activity. Some suitable exercises of that kind include: "Draw as many hats as there are in the big illustration.", "Colour in red as many squares as there are coloured in yellow.", "Cut out as many squares/ triangles as the picture shows." Students' interest can be provoked by using untraditional definitions and ways of putting out a mathematical problem. For example:

Fig1

Another personal ability that "should be developed as a constant one in students", is observation. It is said to be "the will and ability of students to notice the minute details and not only the main ones." In Yordanov's terms "observation is a criterion of the level of acceptability of a particular activity and can be released only within the limits of this activity. The importance of observation has also be pointed out by Moro and Habib. " Qualities such as observation, ability to analyze, compare , generalize and abstract should be developed in students if there are expected to learn to make the right types of conclusions. Mathematical education in earlier grades has numerous options in that respect.

Observation has three main characteristics: premeditation, method, activity. So it could be said that if we want to develop that ability in students, we have to be aiming at acceptability of details, their quick and precise reproduction by the means of different psychological processes. In order to achieve that we have to work hard and continuously, starting from first grade. It is advisable that the teachers include tasks for development of the observation systematically. Suitable exercises aiming at that include problems in which students have to look for differences. They are at first done with the teacher's help and then independently. Problems should be graded in difficulty in order to develop the skills to solve mathematical problems. We should begin with problems requiring the finding of two or three differences only. At the level of introduction to that type of tasks, the number of the differences to be looked for should be known to the students. For example:

1. Find the differences between the rows of numbers.

1,3,5,7,9 9,7,5,1,3

2. Find the three differences.

Fig.2

3.Find three differences between the carts.

Fig.3

At that stage work is organized by the teacher. First, the teacher asks the students to find out if the two rows of numbers(task two) have the same number of figures, then students are asked if the figures are the same, what their order is and are the figures in the rows in the same position. Then conclusion is made that in order to find the differences between any two objects, comparison should be made between the same elements, quantity, form ,size, colour, arrangement of elements, order, position, etc.

In the process of assimilation, different tasks in which students have to find the number of differences by themselves can be assigned. For example:

Find the difference between the rows of figures and colour the 0 under the correct answer.

4,14,5,15,6,16 19,9,14,4,15,5

number of differences: 1 ; 2; 3

0 0 0

When developing observation, the so called “families of problems can be used. For example:

Fill in the gaps without doing any calculations.

(fig.4)

Through comparing the numbers included in the task, students find out that they are all the same and the problem can be easily solved by using transposition and connection between the arithmetical operations of adding and subtraction.

Mathematical problems as the following can be used for the same purpose. Example:

- Without calculating put the right sing (>, <, =)
- (fig.5)

- How many squares and triangles are there in the picture?
- (fig.6)

- How many squares and rectangles are there in the picture?
- (fig.7)

- How many squares are there in the picture? Are there any other planes? Write down their number.
- (fig.8)

Another group of problems can be used to develop observation- problems which require finding similar objects. For examples:

Find the same boxes.

(fig.9)

During the second term at school, after the first grade students have gained some knowledge they can be asked to the difference between textual mathematical problems:

1a. John has 5 mini-cars. Peter has two more. How many mini-cars does peter have?

1b. John has 5 mini-cars. Peter has two less. How many cars does Peter have.

2a. Mary cut 14 cm of ribbon and then she cut another 6cm. How many centimeters of ribbon did Mary cut?

2b. Mary cut 14 cm of ribbon and then she cut another 6cm. How many centimeters less did Mary cut the second time?

The tasks that have been discussed, aim for not only developing cognitive abilities of the students but also thought operations(analysis, comparison, abstraction)i.e. they are multi-functional. Therefore they have to be widely applied in mathematics education.

The means that have been mentioned above to develop the cognitive abilities are just a small part of the numerous possibilities that mathematical education has to offer in the first grades at school. Every creative teacher would also use different methods of achieving one of the main goals of educational work in mathematics.