VISUAL MODELS AS A MEANS OF TEACHING IN PRIMARY MATH'S EDUCATION: PROBLEMS OF TEACHER TRAINING

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Abstract

The modern teaching of mathematics relies heavily on the modeling method. At the same time, visual models are the most preferred means of teaching mathematics in primary school. Numerous scientific studies suggest methods for improving the practice of teaching mathematics using visual models. However, much less attention has been paid to the problem of preparing a primary school teacher for the use of visual models in mathematics lessons. The purpose of the study is to identify and describe the features of teachers' use of visual models in mathematics lessons, to identify the problems of preparing students for the use of visual teaching models and to propose one of the approaches to its improvement. To achieve the result, various methods were used: theoretical analysis of modern sources on the use of visual models in teaching mathematics; an observation method for identifying the features of the use of visual models by teachers in mathematics lessons, a case method for determining the attitude of future primary school teachers to the use of visual models. As a result of the research, the problems of preparing students for the use of

visual models in primary teaching of mathematics are highlighted. One of the main problems of this training is the discrepancy between the verbal-logical thinking of an adult and the visual-figurative thinking of a child. Therefore, when developing the ability to teach using visual models, it is important to start not with mastering the technical aspects of building models, but with understanding and accepting the value of educational modeling by students.

Keywords: modelling method of teaching, primary mathematics education, teachers` training, visual models

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Introduction and theoretical framework

The problem of developing the educational abilities of schoolchildren has always been one of the most urgent. The more fully the potential capabilities of the student are realized, the more success the person can achieve in life. One of the effective technologies for enhancing learning is the method of visualizing educational information. In recent decades, global changes have taken place in the field of transmission of visual information: the volume of transmitted information has increased; new types of visual information have emerged, as well as methods of its transmission. Technological progress and the formation of a new visual culture make special demands on the activities of teachers. Visualization helps students organize and analyze information correctly, develops critical thinking, helps students integrate new knowledge, and allows them to link the information received into a holistic picture about a particular phenomenon or object. Diagrams, charts, pictures, memory cards, key notes, presentations, videos, mind maps, mental maps facilitate the assimilation of large amounts of information; it is easy to memorize and trace the relationship between blocks of information.

It should be noted that the leading type of information perception is visual, which presupposes both the development of traditionally visual and innovative means and techniques that make it possible to activate the work of vision in the learning process. It is known that a person receives up to 90 % of information through the visual channel of perception (Vasilevska, Rivza, 2016). In this regard, the role of visual models for the presentation of educational information increases, allowing one to overcome the difficulties associated with learning based on abstract logical thinking.

Visualization in education is a means of connecting abstract and concrete ideas; it allows the teacher to clarify the essence of educational tasks for students and represents the transfer of the studied theory using visual means (Shatri & Buza, 2017). At the same time, visualization is considered both as a teaching tool and as an independent object of research; the formation of visual literacy is recognized as one of the important goals of learning already in primary school (Alper, et al., 2017; Lee, et al., 2017).

The visualization of the studied concepts is considered in modern pedagogical discourse as a key factor in students' understanding of mathematical ideas (Yilmaz & Argun, 2018; Kuleshova, et al., 2019). The visualization of mathematical ideas in primary education is especially relevant due to the specifics of the thinking of younger students. According to Piaget's theory of the development of intelligence, the thinking of a child at the age of 7–12 is at the stage of development of specific operations. A feature of this stage is that thinking gradually becomes more logical, but still continues to be specific, dependent on the perception of the external properties of real objects. Modern research confirms the conclusions of J. Piaget about the specifics of thinking and speech of children of this age (Kurt, 2020).

However, not all visualization contributes to the understanding of students of mathematical theory, and in some cases, the use of specific educational material prevents the development of full-fledged mathematical representtations (McLellan, 1997). Therefore, in studies of the problem of visualization in mathematics education, the need for visual representations of the essential aspects of the studied concepts is emphasized. These essential aspects are often not visible to the child in the direct perception of real and mathematical objects. Such visual representations are *visual models*, and unlike "non-model" illustrations, they show students not external, but internal properties of objects (Urban, et al., 2017).

The effectiveness of using visual models in primary teaching of mathematics is substantiated in scientific research and confirmed in the practice of teachers (Lehrer & Schauble, 2017). Visual modeling provides a solid and conscious mastery of computational techniques (Bartolini Bussi & Mariotti, 2008), and helps primary school students find solutions to math and practical problems (Haylock & Cockburn, 2017).

Modern research of the problem of visual educational modeling is carried out in several directions. First, in the scientific publications the effectiveness of using interactive computer visualization in Primary Mathematics Education is justified. Visual computer models allow you to show the dynamics of real

or mathematical object changes. Modern high-tech computer tools are no longer playing the only role of a means of mathematical knowledge mastering, but becoming a platform for educational research and experimentation (Sergeev & Urban, 2012). Combined with the ability to instantly assess students` achievements and individualize their educational trajectories, they are becoming a part of *artificial intelligence* (AI) trends in education. Despite the experts` ambiguous attitude to the technologization of education, it should be accepted that AI-trends affect education at all the levels including Primary Education (Chassignol, et al., 2018). Second, in the scientific research the effectiveness of traditional didactic means that help to create visual models from real materials or depict them on the blackboard (shit of paper) are studied. Generalization and systematization of using traditional visual means in Mathematics teaching formed the basis of the world-famous "Bar Model Visualization Technique" in schools in Singapore (Osman, et al., 2018). Regular use of visual models, or bar modelling, is an important factor of Singapore students` leadership in PISA and TIMSS international assessments of educational achievement (PISA, 2018) (TIMSS, 2019).

Despite the proven effectiveness of using visual models in the practice of primary school teachers, a number of difficulties arise in their application. The aim of this research: to identify and describe the features of the use of visual models by primary school teachers in mathematics lessons, to identify the problems of preparing students for the use of visual teaching models and to propose one of the approaches to its improvement.

Methods

In the research, the following methods are used: *theoretical analysis* of modern sources on the use of visual models in Mathematics teaching and summary of its results; *the method of observation* to identify the features of visual models used in Mathematics lessons by primary teachers; *the case-study method* to determine the attitude of future primary teachers to the use of visual models; *the ranking method* to identify the priority problems of students` training to use visual modeling. The research has been based on the Faculty of Primary Education, the Belarusian State Pedagogical University named after Maxim Tank, in 2021.

Results and discussion

To study the practice of visual models used by primary school teachers the method of observation has been applied. The authors and students of the Faculty of Primary Education have observed 138 Math`s lessons and compiled detailed protocols of observing the progress of these lessons:

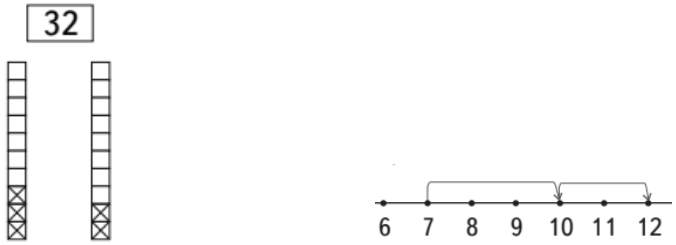
- lesson stages of Explanation (Presentation) and Consolidation (Practice);
- teacher and students` activities;
- types and situations of visual models usage by a teacher;
- students` activity while creating a visual model on their own or under the teacher`s guidance.

Visual models for text problems can be created with real objects (Figure 1, a,) or geometric shapes that replace real objects (Figure 1, b, c).

a b c

Figure 1. **Examples of visual models for problem solving in primary school**

Visual models can be also used for studying numbers (Figure 2, a) and computational techniques (Figure 2, b).



a b

Figure 2. **Examples of visual models for numbers and calculating in primary school**

The analysis of the observation protocols are in Table 1.

Table 1

The frequency of using visual models in Maths lessons

	Teachers	Students	Total Lessons
Explanation	66 (48 %)	15 (11 %)	138 (100 %)
Consolidation	40 (29 %)	32 (23 %)	138 (100 %)

The results obtained show that teachers used visual models in less than half of the cases when explaining new material (48 % of all fragments). Given the visual nature of children's thinking, this is clearly not enough for the formation of mathematical concepts. At the stage of consolidating the studied material, the proportion of situations where visual models were used turned out to be quite insignificant (29 % of all fragments). Taking into account the fact that at this stage of the lesson children often solve difficult problems for them, this result can be assessed as unsatisfactory.

However, the authors consider the situation with the independent construction of visual models by students to be especially critical. Only in 15 % of situations, schoolchildren built visual models together with the teacher at the stage of explaining the material – this means that they were mostly rather passive participants in the training. The situation with the construction of visual models for schoolchildren at the stage of material consolidation looks not much better (23 % of all fragments).

At the next stage of the study, the graduates of the Faculty of Elementary Education of the Belarusian State Pedagogical University were tested in order to identify possible reasons for the use of such rare visual models. First, the students were offered a diagnostic test, during which they had to create visual models for 10 word problems from mathematics textbooks for younger students. The results were evaluated on a 10-point scale according to the number of correctly created visual models. 126 students (74 %) out of 170 scored from six to ten points. The results confirm that most of the faculty graduates are able to create visual models at an acceptable level.

Further, the authors were interested in the opinion of students about the advisability of using visual models in mathematics lessons and the presence of motivation for their application in practice. For the research, the *case method* was applied, since the authors expected to receive with its help more detailed and accurate information about the motivation of respondents than when using the questionnaire method. The students were offered a mini-case, which described a specific educational situation. According to the plot of this situation, the teacher suggested that the children solve the

text problem on their own, but the children could not complete this task. Students were asked to help the teacher – formulate recommendations on how he should explain the way to solve the problem. The study involved 170 students who performed diagnostic control test.

During the results processing the given recommendations were divided into 2 groups. One group includes the recommendations on using verbal methods (discussion, teacher`s explanation); the other one includes the recommenddations on using visual models (Table 2).

The results indicate that the majority of students (62 %) prefer to use verbal methods of explaining the way to solve the problem, and only 38 % recommend using visual models (illustrations, diagrams) to ensure that students understand the problem. The obtained data do not correspond to the results of the diagnostic control work, where the students demonstrated a good level of proficiency in the ability to build visual models.

Table 2

The results of the students' recommendations on the didactic case

	Number of specific recommendations	Total Recommendations
Discussion, teacher`s explanation	106 (62 %)	170 (100 %)
Visual models creating	64 (38 %)	170 (100 %)

Comparing the results of the diagnostic test of students and their answers to the case, the authors concluded that the reason for the rare use of visual models by teachers is related more to their values and beliefs than to the "technical" skills of visual modeling. Despite the proper methodical training for Mathematics teaching at the Faculty of Primary Education, students *choose teaching methods that are more relevant to adults` thinking (students` thinking), but not to children`s thinking.*

To overcome this problem, the process of methodological training of future primary school teachers should be adjusted. From the point of view of the authors of the article, it is important to enrich it with tasks that contribute to the formation of a belief in the need for visual modeling, an understanding of its value in the initial teaching of mathematics. One of the ways to improve the methodological training of students can be a workshop on the analysis of specific situations. To implement this idea, the authors plan to develop a series of case studies, the work on which will require students to make a decision on the choice of teaching tools, rather than demonstrating

methodological skills. Working with values and beliefs is a more complex pedagogical task than skill formation, but it is the value-based part of the methodological competence in visual modeling that can become a decisive factor influencing the use of work methods in primary education in mathematics that correspond to the nature of children's thinking.

Conclusions

Visual didactic modelling is an effective means of mathematical concepts development for primary school students, because it is relevant to children's` thinking of this age group. However, to apply it in school practice, it is important to train teachers who have visual modelling competence. In this problem research, the following results are obtained:

1) primary school teachers use visual models sporadically and unsystematically both at the stage of explanation (presentation) and the stage of consolidation (practice);
2) due to the lack of examples using visual models offered by a teacher, primary school students create a visual model in the lesson only in single cases;
3) the graduates of the Faculty of Primary Education showed a good level of visual models creating skills;
4) despite quite acceptable visual models creating skills, graduates of the Faculty of Primary Education continue to prefer verbal methods of explanation that are more relevant to adults` thinking and to ignore visual modelling that is relevant to specificity of children`s thinking;
5) to improve primary school teachers` methodical training, it`s suggested to implement a workshop with the case-study method using which will require students to decide regularly what didactic means relevant to children need to be chosen and not just ensure practice in visual model creation;
6) understanding and accepting the value of visual modelling by students is a base for methodical competence of visual modelling and can contribute to Primary Mathematics Education improvement.

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