Natural science education: a multiaspect system of models of mathematics

Krasnoyarsk, ASEDU-2020
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1. What is mathematics today?
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   1) compensation for the defects of the human body;

   This is the absence of powerful claws, weakness of the dental apparatus, insufficient muscle strength, etc.
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1) compensation for the defects of the human body;
2) increase in energy supply;

2.1) The domestication of animals, their use of their power for transport, plowing and other activities.
2.2) Application of natural energy sources: water wheel, windmills, sail.
2.3) The emergence of mechanical energy sources: steam engines, internal combustion engines, nuclear energy, etc.
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3) automation of physical activity;

The emergence of industry, mechanical feedback systems, etc.
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   4) automation of algorithmic thinking activity;

   The appearance of devices to facilitate counting, the first mechanical programmable machines (Babbage machine, Hollerith tabulator).
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   3) automation of physical activity;
   4) automation of algorithmic thinking activity;
   5) automation of complex mental activity.
   Modern information systems, including artificial intelligence systems. Newline
   The computer beat not only the world chess champion, but also the world champion in Go!
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Therefore, we proposed to formalize mathematics in the form of a system of models, each of which reflects only one aspect of it, to form a voluminous, complex, multifaceted understanding of mathematics.
1.1. Mathematics as a field of activity

System of mathematical theories and methods
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Intramathematical activity
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Technique of intramathematical activity
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Math applications

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“Pure” math

System of mathematical theories and methods

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Mathematics application method
1.1. Mathematics as a field of activity

- "Pure" math
- System of mathematical theories and methods
- "Applied" math

- Intramathematical activity
- Math applications

- Technique of intramathematical activity
- Mathematics application method
1.2. Apparatus model of mathematics
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Input information →
1.2. Apparatus model of mathematics

Input information

Conceptual apparatus

Converts information to the form standard for a given field of activity
1.2. Apparatus model of mathematics

- **Conceptual apparatus**: Converts information to the form standard for a given field of activity.
- **Analytical apparatus**: Processes information that has a form that is standard for a given field of activity.

Input information flows from left to right, through the conceptual apparatus, and then through the analytical apparatus.
1.2. Apparatus model of mathematics

- **Conceptual apparatus**: Converts information to the form standard for a given field of activity.

- **Analytical apparatus**: Processes information that has a form that is standard for a given field of activity.

- **Adequacy control apparatus**: Controls the level of adequacy of models.
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Input information

- Conceptual apparatus
  Converts information to the form standard for a given field of activity

- Analytical apparatus
  Processes information that has a form that is standard for a given field of activity

Adequacy control apparatus
  Controls the level of adequacy of models

Methodological apparatus
  Provides the development of the scientific apparatus
1.3. Model of mathematics as a system of processes

Mathematical activity can be viewed as a system of processes.
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Diagram:

- Initial mathematical phenomena
- Process
1.3. Model of mathematics as a system of processes

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For educational activity, the most important thing is the changes in the subject of activity that occur as a result of managing the processes of changing mathematical phenomena: their formalization, transformations, translation into another mathematical language, search for a solution to the problem and, in particular, proof of mathematical statements.
1.4. Mathematics as a system of phenomena

*Algebraic approach to mathematical phenomena*

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The approximation mechanism is intended for (approximate) representation of the required model as a result of applying typical transformations and typical combinations of basic models.
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| Basic phenomena | Transformations and combinations of phenomena | Approximation mechanism |

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Historical models of mathematics are used not only in specialized research on the history of mathematics, but also in mathematical research itself (usually as one of the justifications for relevance), as well as in training courses to increase student motivation and establish interdisciplinary connections.
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Usually, two types of historical models are considered:
1) personification, which deals with subjects of mathematical activity, their achievements, relationships between them (for example, teacher-student);
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1) personification;
2) phenomenological, the elements of which are mathematical phenomena, and the authors of these phenomena are considered their main attributes, the conditions for their discovery and application.
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1) personification;
2) phenomenological.

Usually, in teaching practice, historical models of mathematics are considered in combination with other models.
2. Applications of models of mathematics

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In particular, the properties of primes, methods of obtaining (the sieve of Eratosthenes) are considered.
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In the school course of mathematics, a special class of problems is distinguished, the solution of which is based on the properties of divisibility of numbers.
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Moreover, Yu.B. Melnikov, S.A. Shitikov and S.G. Sintsova showed that for a student who does not plan to become a professional mathematician, when certain natural assumptions (taken as postulates) are fulfilled, only two variants of the attitude to the mathematical phenomenon: as an object of activity (for example, it must be remembered, studied, generalized, etc.) or as an instrument of activity (including the method of its application, the possibilities and limitations of use, etc.).
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Let’s consider some applications of mathematics models.
2.1. Models of mathematics as a tool for estimating the adequacy of mathematical courses

Using different models of mathematics allows you to understand how balanced different aspects of mathematics are.
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The model of mathematics as a field of activity and the hardware model of mathematics make it possible to assess how well the management of educational activities is organized in the course.
2.2. Using models of mathematics to form the content of mathematical courses

Analyzing our textbooks from the standpoint of the hardware model of mathematics, we came to the conclusion that it is necessary to significantly increase the amount of material related to the conceptual and methodological apparatus.
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For example, the formal definition of the matrix multiplication operation is now preceded by a discussion of how it would be appropriate to introduce this operation.
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For example, the formal definition of the matrix multiplication operation is now preceded by a discussion of how it would be appropriate to introduce this operation. The result is obtained in terms of an algorithm, the steps of which are described not in the form of a mathematical formula, but as manipulations directly with objects.
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Thus, the problems with obtaining the formulation that arise among students are of a methodological nature.
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The conceptual apparatus is not reduced to a system of definitions!
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Analysis of the content of the training course from the standpoint of other models leads to no less interesting changes in the training course.
2.3. Application of mathematics models to increase motivation to learn

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Using models of mathematics can increase motivation to learn and use mathematics.
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For example, translation from the language of geometric drawings into any language of mathematical text and vice versa.
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\[ \text{Find the angle at the vertex of an isosceles triangle with side 5 and base 6.} \]
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\[ AC = BC = 5, \quad AB = 6 \]
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For example, even outside mathematics, the ability to formalize information is relevant, to translate information from one language to another, with a fundamentally different grammar and other expressive capabilities, control the adequacy of statements by comparing fundamentally different models of the same object reflecting the same aspect of the prototype.

Find the angle at the vertex of an isosceles triangle with side 5 and base 6.

\[
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AC &= BC = 5, \\
AB &= 6 \\
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\end{align*}
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Teaching mathematics allows you to form the ability to build and substantiate hypotheses, use typical strategies of activity (for example, reasoning "by contradiction"), etc.
The electronic manual — is a manual that cannot be printed!

Tutorial "Elementary Mathematics" (rus)
http://lib.usue.ru/resource/free/14/MelnikovAlgebra5/index.html

Tutorial "Mathematical analysis"

Tutorial "Higher mathematics. Linear Algebra and Geometry"

Thanks for your attention!

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Yury Borisovich Melnikov