Neural network model of mathematical knowledge and development of information and educational environment for mathematical training of engineers

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Abstract. The paper proposes a new model of mathematical knowledge representation based on the hierarchical neural network structure of the links between various elements of knowledge. The concept of the level of knowledge and the minimum element of knowledge— «the quantum of knowledge» are introduced. On the base of the developed model, the structuring of mathematical knowledge corresponding to the basic mathematical training of engineers was carried out. The information and educational environment Nomotex was developed for mathematical training of engineers based on the proposed model of knowledge representation and a unique collection of 3D animation of all basic mathematical knowledge, as well as examples of the use of knowledge in engineering. The information and educational environment allows implementing individual educational trajectories in which the educational process is automatically formed from the neural network structure of knowledge according to the specified output competences of the engineer. A specialized software for visualizing educational trajectories was developed. Informational and educational environment allows to realize the multilevel and continuity of mathematical preparation, taking into account the nature of the activity of engineers in their mathematical preparation, taking into account the specifics of engineering training in mathematical courses. The information and educational environment allows implementing distance education, creating online courses, video lectures and automated testing. The introduction of the information and educational environment provides an increase in the attractiveness of the learning process through the extensive use of 3D visualization and animation, as well as computer game elements in the process of mathematical learning. Information and educational environment NOMOTEX, provides the possibility of implementing a systematic approach in the study of mathematical knowledge. The results of the experimental implementation of the information and educational environment in the educational process of engineers at the Bauman MSTU are presented.

1. Introduction
The creation of information-educational environments is one of the most promising modern trends in education as [1]. Considerable attention is currently being given to the creation of virtual workshops for computer simulation and their application in the educational process as [2]. Important issues are also the problem of individualization of the educational process as [3] and a technique of formation of mathematical competencies of modern engineers [4-12].
This article presents some results of the development of a new specialized Information and educational environment NOMOTEX, designed for the formation of educational programs for training engineers in mathematical knowledge, and the implementation of new technology of mathematical training of engineers.

The NOMOTEX and new technology of mathematical training of engineers are developed in Bauman Moscow State Technical University (BMSTU) Scientific-educational center (RTC) "SIMPLEX".

2. The basic principles of the new technology of mathematical training of engineers
The new mathematical technology of education of engineers is based on the following basic principles:
- carrying out the process of teaching mathematical knowledge in a specialized information and educational environment;
- application of new hierarchical neural network structuring of mathematical knowledge;
- visualization of mathematical concepts using modern computer technologies;
- integration of the network of mathematical knowledge in a knowledge network in different areas of engineering Sciences;
- applied orientation of mathematical knowledge;
- use of hypertext thesaurus of mathematical knowledge;
- the ability to conduct interactive independent work, contributing to the consolidation of the acquired skills of the use of mathematical knowledge;
- the possibility of using the technology in the remote access mode, within the framework of e-learning programs, within the framework of open education programs.

3. Neural network of knowledge
The knowledge neural network presents as a set of vertical (hierarchical) and horizontal links connecting nodes (sections) of knowledge. Hierarchical relationships in various fields of science and technology are proposed to be divided into 8 main hierarchical structural levels (figure1):
1. Knowledge (consists of fields of science)
2. Fields of science (established 26 major fields, including physics and mathematics science - PhMS)
3. Science (PhMS - includes mathematics, physics and mechanics)
4. The science sections (mathematics divided into fundamental mathematics and applied mathematics)
5. Disciplines
6. Chapters
7. Paragraphs
8. Knowledge quanta

The existing classification of Sciences, adopted in the Higher Attestation Commission (HAC) and referred to as "Passports of scientific specialties" is taken as the basis of the structuring of levels 1, 2 and 3 (Directions of science) [5]. The advantages of this classification among many other similar variants [6] are compactness (the minimum number of introduced areas of science - 26) and clarity of the division of Sciences by subject (minimizing the cases of classifying smaller sections of science simultaneously in several different larger sections). The names of structural levels 1, 2 and 3 are almost generally accepted.

Disciplines are the most well-established sections of the areas of science, which are taught in most classical and leading technical universities. Chapters are logical independent sections of the discipline, which are formed on the basis of the existing experience of educational activity. Paragraphs - are sections of the Chapter, representing a minimum volume of logically homogeneous body of knowledge. The knowledge quantum is an elementary unit of knowledge that cannot be divided into parts without losing its meaning. The analogy with the physical quantum as an indivisible part of the physical quantity is quite appropriate.
The concept of knowledge quantum, as well as the neural network of knowledge itself, is proposed by authors.

7 types of mathematical knowledge quanta are introduced:
- A-axiom,
- D-definition,
- Ds-definition set,
- S-statement (proved),
- T-theorem (proved),
- C-consequence (proved),
- P-explanation,

All knowledge quanta are connected with each other by horizontal links.

Figure 1. Neural network structure of representation of mathematical and engineering knowledge in NOMOTEX (global planar representation of a neural network of knowledge).

4. Information and educational environment NOMOTEX

To implement the new mathematical technology of training in RTC "Simplex" established a specialized Informational and educational environment NOMOTEX implementing Internet technology in the educational process, using the django framework, languages pyton and java scrypt. The NOMOTEX allows you to perform two main functions: 1) to automate the methodological work on the formation of individualized educational programs that can be prepared for a specific target group of students within a specific engineering field of training, 2) to implement directly the educational process of teaching students mathematical courses, formed taking into account their specific future engineering specialization.

5. Features of the new technology of teaching mathematics with the help of the NOMOTEX.

A new technology for teaching engineers in mathematics with the help of the NOMOTEX can be implemented, both in classroom form using interactive panels and other similar means, and with the help of remote open education resources. Only the ability to connect to the Internet is mandatory for the application of the technology, since NOMOTEX is created and operates on the basis of Web technologies.

The NOMOTEX allows you to conduct lecture classes and independent work in an interactive mode.

The learning process is carried out on educational trajectories, which is a sequence of knowledge quanta, passed in a certain sequence during the study of a particular mathematical course or educational program in general. To visualize educational trajectories in the NOMOTEX created an original software tool.
6. Conclusions
A new technology for mathematical training of engineers was developed, based on the use of the specialized information and educational environment NOMOTEX.

The new technology of mathematical preparation is aimed at:
- improving the quality of training competitive engineering personnel for knowledge-intensive industries, capable of solving problems of developing and introducing the latest models of machinery and technology;
- the creation of an atmosphere of a positive attitude of students towards mathematical sciences, and as a result, the increase of the level of mathematical knowledge necessary for the development of the creative abilities of engineers of the future, which in turn should create favorable prerequisites for replenishing the ranks of engineers with talented young people.

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