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Formation of the Polycultural - Historical Environment of Mathematics Teaching at School

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Abstract

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The relevance of this research is caused by the fact that the transition to new standards of mathematical education raised a new problem – the development of a methodological system of teaching in "the cultural and historic environment". This problem is connected with training of pre-service mathematics teachers that would meet the modern requirements.

The aim of the research is to point out the basic principles and components of cultural and historical methods of teaching mathematics, as well as to develop the technologies that would provide for the corresponding teaching environment.

The leading method of investigation of this problem is the methodology of modeling the process of learning mathematics. It allows considering the problem as a product of a targeted and organized process for the formation of special, cultural and historical, teaching environment.

This article represents developed by the authors a model of methodological system of the teaching mathematics cultural-historical environment forming. Its structural-functional model has a target, methodological, informative, productive, subject-culture bridge, technological components.

The materials of the article are of practical value to actual teachers of mathematics, before which the problem of learning in cultural-historical environment is appeared. It also targets those professionals who train future mathematics teachers in accordance with the new standards.

Keywords: Cultural and historical environment; cultural and historical technique of teaching mathematics; Teacher Professional Standard; cultural-historical pedagogy; cultural-historical psychology; mathematics teacher training.

1. Introduction

The term "cultural and historical environment" is widely used in new mathematics curricula (The Exemplary Curricula, 2011). Teaching mathematics involves developing the views on mathematics as

part of world culture and the one that discovers social, cultural and historic factors of this science formation (The Federal…, 2010). The whole history of mathematics and mathematical education proves their multicultural character.

For instance, according to E.A. Yamburg, the psychological and pedagogic principles of "cultural and historical technique of teaching mathematics" overlap with the principles of cultural and historical pedagogy (Yamburg, 2000). New educational standards were developed on the basis of the principles of the cultural and historical psychology designed by L.S. Vygotsky and his school in 20-30-s of XX century.

Apart from the above it is worth noting the adoption of "The Teacher Professional Standard", which is a guideline for all professional activities of school teachers (The Professional Standard, 2013). Among the labor functions of a school teacher the standard points out the ability "to use psychological approaches such as cultural, historical and developing" (section 3.1.3).

Currently, all researchers recognize the general cultural nature of mathematics. Students' mathematical culture is formed in a special environment that includes worldview and spiritual aspects of education. Under these circumstances special requirements are imposed on the teacher.

2. Materials and Methods

2.1. Methodological system of teaching mathematics in cultural and historical environment

Methodology of mathematics faces up the task of developing theoretical bases and technologies that would help to form cultural and historical environment for teaching mathematics.

For this, it is necessary to define the contents and methods of formation of ideas about mathematics as a part of panhuman culture, universal language of science, allowing describing and studying real processes and phenomena, to assess the value of mathematics in everyday life.

It is necessary to develop methodological system of teaching mathematics in cultural and historical environment in the school, which external environment includes future mathematics teacher training in the process of continuous historical-mathematical education. This subject of research has both scientific and practical interest. As an object of study we understand the steps of formation the cultural and historical environment of learning mathematics, including future teachers of mathematics training. The complexity of the object suggests the need for a system analysis.

The desired system is constructed in accordance with known principles of methodological systems (V.P. Bespalko, A.L. Zhokhov, A.M. Piskala, G.I. Sarantsev, etc.). The components of the methodological system are:

– objectives of learning mathematics in cultural and historical environment;

– the contents of historical-mathematical education of students, future and current teachers;

– regularities, conditions, prerequisites for the functioning of the methodological system;

– the various forms of dialogue of cultures in the collective subject of the educational process (teacher – learner, trainer – student, etc.);

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– the history of mathematics training materials as a collection of various kinds of cultural works – mathematical, historical, methodological, personal;

– methods, forms, means and technologies of the cultural-historical environment of teaching mathematics formation;

– the result of teaching mathematics in cultural and historical environment – the aggregate of individual elements of historic-mathematical culture formed at this time.

The external environment of the system is compiled by common objectives of secondary and higher education, the subject of mathematics and history of mathematics, the labor functions of teachers etc. A holistic model of methodological system of teaching mathematics in cultural and historical environment is represented in Figure 1.

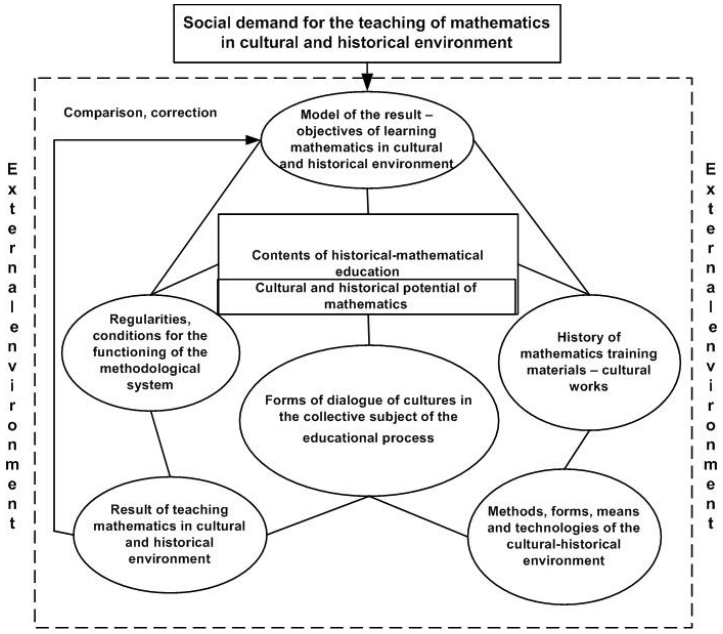

Figure 1. Model of methodological system of teaching mathematics in cultural and historical environment

The basic components of methodological system are highlighted by its leading function in the process of achieving the goal. Appropriateness of the allocation in the structure of methodological system such components and relations between them bases on the universality of the principles of ideologically directed learning mathematics to which this system is embedded.

"The cultural and historical environment of mathematical training" is defined as the environment where students acquire mathematical culture "constants" taking into account their changes and applications in life and science. Methodological system, which is formed in such an environment, we call "cultural-historical technique of mathematics teaching" (Gilmullin, 2016, 2009).

2.2. Cultural - historical background of mathematics teaching at school

School mathematics, considered as a reflection of the corresponding face of culture, provides the students gained in that culture means of orientation in the surrounding world: the ideal objects, the transformation methods and actions with them, ways of fixing their thoughts and actions, some of the

procedures of mathematical creativity, namely: conversion of operations, relations, tasks; procedure modeling; new mathematical objects constructing from known; the search for the aesthetic, etc.

For the purposes of general cultural elaboration of students in the content of mathematical education at school now an additional section "Mathematics in the historical development" is included. The history of the main mathematical opening, mathematical science creators' names have to become the part of mathematical culture of the educated person.

This cultural and historical background is shown also in the educational and methodical sets for the main school made according to standards. For example, it is possible to estimate this cultural and historical environment on the methodical device of textbooks for 5-6 classes (Kuznetsova, etc., 2013; Mordkovich, etc., 2012).

The main assessment procedure of achievement of metasubject results is protection of the final individual project. Historical and mathematical projects contain many objects of their assessment: ability to systematic knowledge development, their independent replenishment, transfer and integration; the ability to address personally and socially relevant problems; the capacity for self-organization and reflection, and others. For this purpose, for mathematical projects may be proposed such topics as "Number systems of different nations", "How to measure the Earth?", "A comparison of the old Russian and Tatar measures", "The contribution of mathematicians from different countries in the solution of equations" and etc.

The assessment of the formation of almost all kinds of universal educational actions (personal, regulatory, cognitive, communicative), as well as specially-subject (mathematical) operations can be on the basis of historical and mathematical material.

2.3. Preparation of the future mathematics teacher to work under the section "Mathematics in the historical development"

In the list of math teacher competencies laid down in the curriculum of mathematics history, along with others, there is a willingness to tolerant perception of social and cultural differences, respectful and careful attitude to the historical heritage and cultural traditions. Let's consider, for instance, the creation of cultural and historical background related to the name of the great Leonard Euler. Euler's name is mentioned in the "Mathematics in the historical development" several times in connection with the study of the different sections of school mathematics. He owns significant results in all areas of mathematics and its applications, which existed in his time.

Scientist made an enormous influence on the development of mathematical education in Russia. Euler is considered the founder of not only the St. Petersburg school of mathematics, but also Russia's first teaching mathematics school. And this cultural and historical background must be displayed throughout the course of the school mathematics.

The following types of historical and methodological activities in the training of future mathematics teachers are applied for this:

–creation of chronological dictionary guide of the main achievements of elementary mathematics;

– identification of the characteristics of mathematical objects: sources; personality, the chronotope;

– adaptation of historical and mathematical material;

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– identification of mathematical facts with the historical epoch;

– solution of historical-mathematical tests;

– study samples of formulation and solution of practical problems in the history of mathematics;

– analysis of the history of nominal theorems, formulas, figures, algorithms, tasks;

– accumulation of historical examples of selfless service to the mathematical science and education;

– preparation of mathematics development synoptic table.

One of the educational space's direction vectors, based on the formation of the aggregate quality mathematical and methodical culture of the future mathematics teachers in teaching the history of mathematics, is dialogueness, regarded by us as a dominant of cultural approach. In the development of specialized cultural approach to the history of mathematics, we rely on a general theory of cultural studies of education, ideologically directed learning math, humanization of mathematics education. These theories developed in the last twenty years due to new concepts and paradigms of secondary and higher education (Zhokhov, 2007; Krylova, 2000).

The modern education philosophy aims at new installations which, unlike installations of technocratic approach, declare a priority of the human person, development of his creative potential, idea of multiculturalism, development of ability to dialogue of cultures.

When designing the above cited cultural understanding on the process of history of mathematics learning, we can stand out the following sections (forms) of the cultures dialogue:

– mathematical culture on its individual meaningful lines in different historical periods of its development;

– mathematics and education, also in different periods and in different geographical locations;

– mathematics and educational texts dialogue, created by the teacher and the pupil, the professor and the student;

– materialized in the spoken dialogue and research (as to the form and style of communication); its actors are teacher – student, student – the author of any material (a historical person, the author of a textbook or some text, and so forth), teacher – student, student – student, trainee and student, etc.

All these kinds of dialogue between cultures have been used by us in teaching the history of mathematics students in pedagogical high school and at school. The purpose of their use is the formation of the future mathematics teachers' professionally oriented qualities.

3. Results

Structural-functional model of methodical system of teaching mathematics in the cultural and historical environment developed by us has a target, methodological, informative, productive, subject-culturebridge, technological components. It should also be taken into account the continuity of the system of mathematical education. Cultural and historical methods of teaching mathematics cover all stages of mathematics education, beginning with primary ones and ending with teacher training and retraining.

Undergraduate teacher training in historical and cultural aspects is included into the curriculum of the subject "History of Mathematics", and the optional course "Historical and mathematical

foundations of teachers' methodological training". They contribute to the formation of historical component of the undergraduate teachers' mathematical and methodical culture, which is attained by the relevant system of teaching history of mathematics. This system promotes developing teacher's labor actions aimed to design cultural and historical training environment.

The formation of cultural and historical environment should begin with primary stages. Federal Standards of Primary General Education and model curricula involve the use of mathematical knowledge for the description and explanation of surrounding objects, phenomena, and the assessment of their quantitative and spatial relations (The Federal …, 2009).

The creation of cultural and historical environment was experimented at "Children's university" in Elabuga Institute of Kazan Federal University. The authors prepared and conducted a number of classroom events, which included the following lectures disputes and discussions: "How did people learn to count?", "Who is Omar Khayyam – a poet or a mathematician?", "Are there any child prodigies in mathematics?", "Mathematical experiments", etc.

Such methods, means and forms of historical and mathematical activity of future teacher will help to detail activities of the mathematics teacher for creation of ideas of social, cultural and historical factors of mathematical science formation. Similar methodical-mathematical experiences are steps on the way of development of a cultural and historical technique of training.

The following step where the cultural and historical technique of training formed is professional development of mathematics teachers. The advanced training courses on a modular and competence-based basis realized in KFU contain several modules, one of which is "Project work". At implementation of the project work according to the chosen section of studying mathematics, or at an elective course, teachers developed also cultural and historical background of studying of a subject.

4. Discussions

I.K. Andronov, I.G. Bashmakova, V.V. Bobynin, N.Ya. Vilenkin, G.I. Glazer, B.V. Gnedenko, Yu.A. Drobyshev, A.L. Zhokhov, F. Klein, A.N. Kolmogorov, D. Polya, T.S. Polyakova, K.A. Rybnikov, G. Froydental, A.I. Shchetnikov, A.P. Yushkevich etc. dealt with a problem of use of potential of mathematics history in training. They considered the following aspects:

– formation of mathematical culture by means of mathematics history;

– usage of elements of history of mathematics in training;

– reform of mathematical education in a historical context;

– principle of historicism and historical and genetic method of training in mathematics, etc.

The aspect of the cultural-historical environment formation of training mathematics studied by us wasn't considered previously.

Yu.A. Drobyshev investigated a problem of multilevel historical and mathematical training of future mathematics teacher (Drobyshev, 2011). Need of extension of the contents of historical and methodical training of mathematics teachers for pedagogical higher education institution in the form of system of knowledge of history of school mathematical education is proved in the doctoral dissertation of T.S. Polyakova (Polyakova, 1998).

A number of master's theses is devoted to various questions of teaching a course of history of mathematics: to its role and value as one of the most important factors of a humanization and humanitarization of mathematical education (N.A. Burova), to selection of maintenance of this course and technique of its realization (A.E. Tomilova), etc.

I.S. Safuanov has developed the theoretical concept of the genetic approach to training in mathematical disciplines in teacher training university consisting in a support on the natural ways and methods of knowledge inherent in the science (Safuanov, 2000).

Special attention to a problem of use of historical and mathematical material in foreign methodical-mathematical researches and practical developments for teachers is paid too (*Hands On History*, 2007).

5. Conclusions

It is established that the developed structural-functional model of methodical system of training in mathematics in the cultural and historical environment can be applied when forming of professionally focused qualities of future teachers in the course of training of mathematics history and other disciplines in pedagogical higher education institution. Forms, methods, means of formation of the cultural and historical environment at various steps of mathematical education are allocated.

Materials of article can be useful on the practical level to the mathematics teachers working according to new educational standards. Also they have a direct bearing on training of future mathematics teachers in higher education institution.

Taking into account the received results of this research it is possible to allocate a number of the scientific problems and the directions demanding further studying: technologization of formation of the cultural and historical environment for the solution of questions of didactics of mathematics, expansion and a specification of practical developments for mathematics teachers.

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