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Research paper

Application of Information Technologies to Improve the Quality of Mathematical Trainingo Teachers of Natural-Science Disciplines

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Abstract

The actuality of the problem stated in the article is due to the fact that the level of professional competence of future teachers of the natural-science subjects largely depends on the quality of mathematical training, which is largely provided by the use of computer technologies in higher mathematics classes. Information technologies are indispensable for the effective organization of the educational process in the modern conditions of teaching the course of mathematical disciplines. As a result of the study of this problem, the authors used methods that allowed defining the definition of mathematical competences of teachers of natural-science disciplines (theoretical analysis of pedagogical literature) and confirming the effectiveness of using information technologies in higher mathematics classes (pedagogical experiment). The main results of the research consist in the allocation of four levels of mathematical competences (low, medium, high, very high), and in the definition of the system of basic mathematical competencies. The obtained results allow to answer the question how on the basis of computer technologies to develop the mathematical competencies of future teachers of the natural-science disciplines more effectively, and, supplementing the existing theory of higher education, contribute to solving the issues of motivation for teaching higher mathematics.

Keywords information technologies, mathematical competences, mathematical training, teachers of natural-science disciplines..

1. Introduction

The purpose of this work is to carry out the comparative analysis of There are objective contradictions between the needs of modern society in qualified teachers of the natural-science disciplines, using competently mathematical and computer methods and models in their professional activities, and the real level of readiness to use computer technologies; the presence of computer systems that allow to increase the level of professional training of future teachers of the natural-science disciplines, and the insufficient elaboration of the theoretical and practical bases for their use in the educational process. With regard to mathematical preparation, these contradictions are concretized in the contradiction between the need to form the mathematical competences of future teachers of the natural-science disciplines and traditional approaches to the organization of the educational process. Taking into account the identified contradictions, the research problem is: how to develop the mathematical competencies of future teachers of the natural-science disciplines more efficiently on the basis of computer technologies. The purpose of the article revolves around the theoretical underpinning and experimental proof of the effectiveness of the use of computer technologies for the development of mathematical competencies of future teachers of the natural-science disciplines.

The works on general pedagogical problems of improving education can be single out separately [1], [2], [3]. Issues of improving mathematical education from different sides were discussed by many scientists. We can single out works on basic mathematical training of students [4], [5]; structure and content of mathematical training [6], [7].

The choice of information technologies is due to a sufficient theoretical and practical development of the problems of informatization of education, carried out from various positions. In recent years methodological aspects of the application of computer technologies in teaching higher mathematics have been considered in [8], [9], [10], [11], [12], [13].

Mathematical competences of teachers of natural-science disciplines are integral and personal-professional characteristics of graduates of pedagogical universities of natural-science specialties, manifested in theoretical and practical readiness and ability to use the system of acquired mathematical knowledge, skills, and experience at a high pedagogical level due to qualitative learning of the content of mathematical education in their professional activity.

The formation of a broad mathematical erudition based both on knowledge in various mathematical disciplines and on the experience of their interdisciplinary use is ensured by the use of computer technologies by the future teachers of the natural-science disciplines in higher mathematics classes.

The pedagogical practicability of implementation of capabilities of information technology tools in the teaching of mathematics is determined by such factors as immediate feedback between the user and the means of information technology; possibility to change and enrich the content of the material; computer visualization of educational information about objects or patterns of processes, phenomena; automation of the processes of computing, information retrieval activity, operations for the collection, processing, transfer, replication of information; automation of the processing of the results of the training experiment with the possibility of repeated repetition of any fragment or the experiment itself.

One of the directions in the use of computer technology in education is the use of applied software systems for the computerization of complex mathematical calculations, helping in some way to better and faster learn the most difficult sections of a particular discipline.

We suppose that the need for the application of special mathematical systems in the university in the study of mathematical disciplines is determined by the following reasons: a modern teacher should be oriented towards the use of modern software in carrying out various mathematical calculations; the use of these systems will make it possible to complicate the tasks solved in the classroom, which will allow us to better understand the material; application of these systems makes it possible to increase the proportion of independent work in the learning process; these systems will allow to solve research problems in the learning process in a greater degree.

We believe that the use of mathematic computer system Mathematica motivates students to study this discipline, ensures the effectiveness of the entire learning process.

2. Methods

We suggest using the method of gradual verification of calculations using the Mathematica system. Here is an example of a task with a solution.

The task. Compute the indefinite integral:

$$\int \frac{(x-1)}{x^2(x-2)(x+1)^2}dx$$

Solution.

The notation:

A - calculation in the traditional way (manually);

B - check the performed action with the Mathematica system.

I. A) Fix the given proper fraction $\frac{(x-1)}{x^2(x-2)(x+1)^2}$.

We decompose the subintegral function into the following partial fractions

$$\frac{(x-1)}{x^2(x-2)(x+1)^2} = \frac{A}{x^2} + \frac{B}{x} + \frac{C}{x-2} + \frac{D}{(x+1)^2} + \frac{F}{x+1}.$$

We reduce the last equality to the common denominator and discard it:

$$x-1 = A(x-2)(x+1)^2 + Bx(x-2)(x+1)^2 + Cx^2(x+1)^2 + Dx^2(x-2) + \\ + Fx^2(x+1)(x-2).$$

Hence, multiplying brackets and combining similar terms, we will have:

$$x-1 = (B+C+F)x^4 + (A+2C+D-F)x^3 + (-3B+C-2D-2F)x^2 = \\ + (-3A-2B)x - 2A.$$

B) In[1]:= Collect[A (x-2) ((x+1)^2)+B (x (x-2) ((x+1)^2))+C (x^2) ((x+1)^2)+D (x^2) (x-2)+F (x^2) (x+1) (x-2),x]

Out[1]=-2 A+(-3 A-2 B) x+(-3 B+C-2 D-2 F) x2+(A+2 C+D-F) x3+(B+C+F) x4

II. A) Equating the coefficients for the same powers of x in both parts of the identical equation, we obtain a system of equations for determining the coefficients A, B, C, D. F:

$$\begin{cases} B+C+F=0, \\ A+2C+D-F=0, \\ -3B+C-2D-2F=0, \\ -3A-2B=1, \\ -2A=-1. \end{cases}$$

Having solved the system manually, by expressing one variable of the equation through other variables of the same equation, and substituting it into the following equation, etc., we obtain

$$A=\frac{1}{2},\ \mathrm{B}=-\frac{5}{4},\ \mathrm{C}=\frac{1}{36},\ \mathrm{D}=\frac{2}{3},\ \mathrm{F}=\frac{11}{9}.$$

B) In[2]:= Solve[{B+C+F= =0,A+2 C+D-F= =0,-3 B+C-2 D-2 F= =-0,-3 A--2 B= =1,-2 A= =-1},{A,B,C,D,F}]

Out[2]={{A 1/2,B -5/4,C 1/36,D 2/3,F 11/9}}

III. A) Thus we obtain the decomposition of a rational fraction by the simplest:

$$\frac{(x-1)}{x^2(x-2)(x+1)^2} = \frac{1}{2x^2} - \frac{5}{4x} + \frac{1}{36(x-2)} + \frac{2}{3(x+1)^2} + \frac{11}{9(x+1)}.$$

B) In[3]:= Apart[(x-1)/(x^2 (x-2) (x+1)^2)]

Out[3]=1/(36 (-2+x))+1/(2 x2)-5/(4 x)+2/(3 (1+x)2)+11/(9 (1+x))

IV. A) Integrating, we obtain:

$$\int \frac{(x-1)}{x^2(x-2)(x+1)^2}dx = \frac{1}{2}\int\frac{dx}{x^2} - \frac{5}{4}\int\frac{dx}{x} + \frac{1}{36}\int\frac{dx}{x-2} + \frac{2}{3}\int\frac{dx}{(x+1)^2} + \frac{11}{9}\int\frac{dx}{x+1} = \\ = \frac{1}{2}\int x^{-2}dx - \frac{5}{4}\int\frac{dx}{x} + \frac{1}{36}\int\frac{d(x-2)}{x-2} + \frac{2}{3}\int (x+1)^{-2}d(x+1) + \frac{11}{9}\int\frac{d(x+1)}{x+1} = \\ = -\frac{1}{2x} - \frac{5}{4}\ln|x| + \frac{1}{36}\ln|x-2| - \frac{2}{3(x+1)} + \frac{11}{9}\ln|x+1| + C.$$

The original integral was represented as the sum of five integrals, the first and fourth of which represent the standard integral $\int x^n dx = \frac{x^{n+1}}{n+1} + C$, and all the others are: $\int \frac{dx}{x} = \ln|x| + C$.

B) In[4]:= Integrate[1/x^2,x]

Out[4]=-1/x

In[5]:= Integrate[1/x,x]

Out[5]=Log[x]

In[6]:= Integrate[1/(x-2),x]

Out[6]=Log[-2+x]

In[7]:= Integrate[1/(x+1)^2,x]

Out[7]=-1/(1+x)

In[8]:= Integrate[1/(x+1),x]

Out[8]=Log[1+x]

V. B) In[7]:= Integrate[(x-1)/(x^2 (x-2) (x+1)^2),x]

Out[7]=1/36 (-18/x-24/(1+x)+Log[-2+x]-45 Log[x]+44 Log[1+x])

The wide use of the Mathematica system was the impetus to the fact that we applied it in teaching students some of the topics of mathematical disciplines for gradual verification of the performed mathematical operations. As experimental during three years we selected two groups of first-year and second-year students. We developed a comprehensive methodology, which included a traditional study of the topic, i.e. performing tasks manually, and using the computer system Mathematica. Some methodical recommendations on the study of certain topics (classroom and independent) were made for students. There were two classes for each topic.

3. Results

The classes had the following structure:

1) a brief introduction to the topic and the necessary functions of the Mathematica system;

2) individual assignments performed by students in two ways: manually and step-by-step execution using the Mathematica system.

Based on the results of the test, we obtained Table 1.

Table 1:. The results of tests at the I and II academic years

		Manual solution of the problem				Solving problems using Mathematica			
		achievement		quality		achievement		quality	
		I term	II term	I term	II term	I term	II term	I term	II term
I academic year	I AY	83%	78%	56%	55%				
	II AY	83%	83%	67%	60%	83%	92%	58%	83%
	III AY	75%	85%	60%	60%	75%	90%	55%	70%
II academic year	I AY	88%	77%	62%	50%				
	II AY	93%	80%	71%	50%	71%	90%	57%	65%
	III AY	80%	80%	50%	50%	90%	100%	70%	70%

This allowed us to draw the following conclusions:
1. At first juniors have difficulties in a computer code because of absence of programming skills. Therefore, the quality indicators for solving problems manually exceed the same parameters when solving problems in the Mathematica system. Going forwards the quality and achievement indicators for solving problems in the Mathematica system for both courses already exceed the same indicators when solving problems manually. 2. However freshmen are faster trained to apply the Mathematica system for mathematical calculations than second-year students already accustomed to the traditional study of higher mathematics. Therefore the quality and achievement indicators for both methods of solving problems for juniors are practically the same. As for the second year students, the quality and achievement indicators for solving problems manually are already slightly higher than the same indicators when solving problems in the Mathematica system.
Going forwards in the first year, the indicators of quality and achievement in solving the tests by juniors using both methods already exceed the same indicators of second-year students. Therefore it is necessary to begin teaching higher mathematics with the verification of the actions taken with the help of the Mathematica system from the first year.
By combining students who studied mathematical analysis in a traditional way in a control group, and students who studied mathematical analysis using the Mathematica system and Internet technologies in an experimental group, we performed a comparative analysis of the results of the examination period on this subject in both groups (Table 2). As can be seen in Table 2 the first term achievements of the students of the experimental group determine further successes. At the end of the next term students' residual knowledge is checked in the practical class; or the task of the professionally important topics of the previous term is included in the test paper.
Four levels of the development of mathematical competences are defined (where Pst is the student's term grade, Kst is the mathematical competence coefficient): 1) 0.5 Kst <0.7 (low level), 2) 0.7 Kst <0.8 (middle level), 3) 0.8 Kst <1 (high level), 4) Kst = 1 (very high level). All the data obtained indicate that the experimental group has reached a sufficient level of preparedness.

4. Discussion

The following deficiencies of the method of gradual verification of calculations using the Mathematica system were revealed:

1) large study time expenditures in the first classes;

2) reduction of the total number of examples;

3) often external incongruity of correct answers.
The following advantages of the method of gradual verification of calculations using the Mathematica system were proved:

1) timely finding of errors in calculations;

2) students acquire practical skills in conducting mathematical reasoning and analyzing the results;

3) development of such thinking components as flexibility, degree of structure, etc .;

4) the possibility of an in-depth analysis of the variants of tasks in the process of classes, increasing the informativeness of practical studies;

5) the rapid learning of the computer, the activation of independent work.

The results of the experiment confirmed the effectiveness of the Mathematica system application in the higher mathematics classes and allowed to use it in pedagogical universities.
As our experience has shown, when studying the course of higher mathematics with the use of special computer mathematical systems to solve a certain type of mathematical problems (for example, the Mathematica system for gradual verification of the performed mathematical operations), the future teachers of the natural-science disciplines develop the following additional competencies during the first years of studying:
- elementary computer skills;
- the ability to acquire new knowledge (not only mathematical), using modern educational and information technologies;
- research ability, ability to learn;
- to know one of the foreign languages (have the ability to translate mathematical terms, recommendations from the English language);
- the ability to apply basic knowledge in the field of informatics and modern information technologies in practice;
- to have an idea of the latest achievements of science;
- ability to work independently and in a team;
- ability to apply analytical and numerical methods of solving problems with the use of ready-made software;
- to have perseverance in achieving goals;
- the ability to use specialized knowledge in the field of informatics for learning the core information disciplines;
- be able to solve mathematical tasks and problems from various areas of mathematics, which require some originality of thinking, etc.

At the same time, it should be noted that the competences of this type, which will be formed by students at senior courses only, are formed already from the first year of study at the university.

This indicates that the application of the Mathematica system is appropriate when studying individual subjects of mathematical disciplines by university students.

With all the diversity of teaching technologies, the implementation of the leading pedagogical functions remains with the teacher. When choosing particular software for use in his work, the teacher inevitably faces the need to prefer one or the other of them. He should not forget that a modern specialist should be a creative person, be able to take correct, often non-standard decisions in complex situations, be ready for continuous self-education, and have a system-oriented style of thinking.

It is the professional competence of such a specialist that is the ultimate goal of education and the main characteristic of its quality. The basis for solving these problems is the qualitative mathematical education of graduates of universities, achieved in the process of applying competently selected packages of applied mathematical programs in the process of preparation for higher mathematics.

Table 2:. Comparative analysis of the results of the examination period on mathematical analysis for the control and experimental groups

Marks \ term	5, 4		3		
	I	II	I	II	I
experimental group	69%	72%	25%	25%	6%
control group	52%	52%	39%	37%	9%

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References

[1] Kozhanova T.M., Karev B.A., Khabibullina G.Z., Ibragimov I.D., Khisamiyeva L.G., Zaytseva N.V., Kulkova M.A. The didactic construct of design technologies in the educational process of modern university / Mediterranean journal of social sciences. - 2015. - vol.6. - № 2 S3. – PP. 225-232. – http://www.mcser.org/journal/index.php/mjss/issue/view/108

[2] Betz, N. Contributions of self-efficacy theory to carer counseling: a personal perspective / N. Betz // The Career Development Quarterly. – 2004. – Vol. 52. – PP. 340 – 353.

[3] Gulnaz Mavletzyanovna GALEEVA, Olga Aleksandrovna AKTASHEVA Forecasting the Dynamics of Foreign Direct Investment in the Russian Economy, Astra Salvensis, Supplement No. 2/2017, p. 137

[4] Kamil Maratovich ARSLANOV, Artur Ilfarovich KHABIROV About the Weak Party of the Loan Contract, Astra Salvensis, Supplement No. 2/2017, p. 323.

[5] Malygina O.A. The study of mathematical analysis on the basis of the system - activity approach: a textbook. - Moscow: 2008. - 416 p.

[6] Kudrin D.A. The conference is communication and exchange of experience // Innovations in Education. - 2010. - No. 3. - P. 93-98.

[7] Shaldybina O.N. Didactic model of development of mathematical competence of students of Secondary Specialized Educational Institution: the author's abstract. - Kazan, 2010. – 24p.

[8] Hsu, W.K. Determinants of computer self-efficacy – an examination of learning motivations and learning environments / W.K. Hsu, S.S. Huang // Journal of Educational Computing Research. – 2006. – 35(3). – pp. 245 - 265.

[9] 1 Shatilova L.M., Borisova V.V., Kasatkina O.A. (2018). Representation of the linguistic and cultural concept “lie” in the French and Russian language picture of the world, 34(85), Pp. 194-212.

[10] 2 Bakhyt S., Kalimbetov B., Khabibullayev Z. (2018). Possibilities of Mathematical Problems in Logical Thinking, Development of Secondary Education Pupils, 34(85), P.p. 321-338.

[11] Makletsov S.V., Starshinova T.A., Khabibullina G.Z. Fofmation model of information competence of bachelors specializing in mathematics & computer sciences / Journal of organizational culture communications and conflict. – 2016. - v. 20, Sp. issue 2 – PP. 173-179.

[12] Khabibullina G.Z. The main problems of using computer technologies in teaching mathematics in universities / Kazan Pedagogical Journal. - No. 1 (102). - 2014. - P.75-80.

[13] Khabibullina G.Z., Khayrullina L.E., Fadeeva E.Yu. Application of the Mathematica system in the process of studying the main sections of mathematical disciplines / Kazan Pedagogical Journal. - 2015. - No. 2 (109). - P.73-77.