Potential of the higher mathematics course in digital education

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Abstract. Rapid changes taking place at present in the society determine the vector of education development, form requirements to an educated person. The connectivism theory, disclosing the features of education environment under conditions of education digitization, allows to outline the learning strategy in individual subjects. The connectivism education is a complex process including plunging into information environment, maximum use of accumulated knowledge, skills to determine timeliness of the acquired knowledge and its relevance under modern conditions, various trends of communication among participants in learning, ability to detect links among various areas of knowledge, theories, concepts. Objective of the research is to substantiate opportunities of application of connectivism education environment during studying mathematics in higher school, to disclose potential of the higher mathematics course and to confirm experimentally the efficiency of the proposed learning strategy. Methods used in the research were as follows: analysis, statistic methods, generalization, systematization, the method of rising from the abstract to the concrete upon consideration of functionality of digital products, system approach, experimental verification of research results. Results and novelty of the research implied the following: substantiation and development of principles of connectivism learning theory, development of the strategy for construction and implementation of educational programs of higher mathematics course, experimental verification of the dependence between the level of mastering the higher mathematics course and the level of use of digital technologies. The use of the connectivism learning theory allowed to outline the approaches to expansion of content of the higher mathematics course. The main features of the presented course are plunging of students into information environment by means of assignments aimed at maximum use of programs for symbolic mathematics. Studying of certain sections of the higher mathematics course, in particular, analytic geometry and linear algebra, is exemplified based on the developed learning strategy.

Keywords: connectivism, programs for symbolic mathematics, Pearson's correlation coefficient.

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1 Introduction

Nowadays the connectivism theory is intensively discussed in scientific publications, its essence is learning in digital era [1]. There are both supporters and opponents of this theory. The processes occurring in the society at present, in education in particular, promote development of this theory, its improvement and accumulation of various experience [2]. The connectivism learning is a complicated process including plunging into information environment, maximum use of accumulated knowledge, ability to determine the timeliness of acquired knowledge and its importance under present conditions, various trends of communication among participants in education, ability to detect interrelations among various regions of knowledge, theories, concepts [3]. Higher school is not an exception and education in higher school should be constructed on the basis of the connectivism theory, that is, adhering to predefined principles.

The hypothesis of research is comprised of the assumption that implementation of higher mathematics course will improve the quality of education under digitization conditions if the education in higher school is based on the principles of connectivism learning and potentials of mathematics as such are taken into account.

The research objective is to substantiate opportunity to use the connectivism learning environment upon studying mathematics in higher school, to disclose the potential of higher mathematics course and to confirm experimentally the efficiency of the proposed educational strategy.

The research tasks are as follows:

- to analyze scientific publications, to reveal and to substantiate the main principles of construction of the connectivism learning theory in terms of the existing didactics;
- to disclose the potential of higher mathematics course, to formulate strategy of construction and implementation of modern educational programs for higher mathematics course;
- to perform education of students in the frames of higher mathematics course using the principles of connectivism learning theory;
- to analyze the results of studying mathematics in higher school, to reveal the dependence between the level of mastering higher mathematics and the level of the use of digital technologies during learning.

2 Methods

The following theoretic methods of research were used:

- analysis of scientific publications devoted to philosophical, social, and psychologic and pedagogic issues related with construction of the connectivism learning theory, development of educational programs for higher mathematics course under conditions of digitization;
- generalization and systematization of data acquired during analysis, revealing general trends of development of higher mathematics course under conditions of digitization;
- rising from the abstract to the concrete upon consideration of functionality of digital products and their actual application for development of educational programs for higher mathematics course;
- –the system method allowed to reveal system-forming element of the strategy of development and implementation of educational programs for higher mathematics course.

The statistics methods and tools included the method of correlation analysis, in particular the Pearson’s correlation coefficient and SPSS packet.

3 Results

T.A. Astashova [4] and A.S. Voronkin [5] disclose the principles of the connectivism learning formulated in reference sources, such as Wikipedia. While considering the principles of the connectivism learning in terms of existing didactics, we have highlighted the following regularities:

- the principle of education digitization requires for connection of network of special nodes and data sources, program products, communication resources;
- the principle of consciousness and activity of education; the essence of this principle is to recognize patterns and to reveal meanings between the knowledge areas and concepts;
- the principle of interrelation between theory and practice consists in knowledge of various approaches to solutions to a set of practical problems and opportunity to select the optimum one, corresponding to modern requirements;
- the principle of continuity of education and cognition, i.e., education is comprised of making decisions. The correct selection today can become false one tomorrow due to modified conditions, under which the solution was made;
- the principle of education efficiency is interrelated with ability to expand and to update the acquired knowledge.

The strategy of development of the main educational programs for higher mathematics course covers three system-forming components: content, methods, and tools.

The content of higher mathematics course in addition to fundamentals includes the software products (programs for symbolic mathematics), which allow to carry out mathematical studies requiring for computations and analysis, to develop and to analyze the solution algorithms for various problems, to develop mathematical models and to perform computer experiment, to analyze and to process data, to visualize some notions, to apply graphics, to develop graphic and computing applications. For instance, while studying the rotation surfaces in analytical geometry, a teacher not only discloses fundamentals but also forms a package of assignments aimed at the use of system programs. The aim of these assignments is to obtain rotation surfaces using computer graphics. Another example from linear algebra is solution of equations. Students are proposed to analyze software allowing to solve equations of various levels of difficulty, to reveal vulnerabilities of such software, to create special network accessible not only for students of the given course or university but also for any users interested in this research.

Active and interactive methods are preferred among the education methods, such as research methods, systematization, generalization of experience, method of tasks, etc. A teacher partially acts as facilitator.

The main learning tools are digital products in all forms: MOOCs, webinars, educational platforms, dedicated programs, online simulators and others.

Implementation of higher mathematics course is possible for such forms of education as resident, nonresident, distance, and mixed learning.

The experiments were performed with 112 students specializing in Construction, Don State Technical University.

In order to confirm the efficiency of the performed work, we subdivided the considered students (experimental flow) into blocks according to the following principle: different level of the use of digital technologies and different level of mastering higher mathematics course. Applying short correlation analysis, we studied whether the level of mastering higher mathematics course depended on the level of the use of digital technologies.

Accordingly, among the considered students those were selected, who used the digital technologies at different levels:

- completely used: 5 scores;

- sufficiently used: 4 scores;
- insufficiently used: 3 scores;
- did not use: 2 scores;
- did not know, did not use: 1 score.

The level of mastering higher mathematics course was evaluated as follows:

- "5" – high level;
- "4" – above medium level;
- "3" – medium level;
- "2" − below medium level;
- "1" − low level.

The correlation coefficient was calculated as follows:

$$R_{xy} = \frac{n\sum_{i=1}^{n} X_i Y_i - \sum_{i=1}^{n} X_i \sum_{i=1}^{n} Y_i}{\sqrt{(n\sum_{i=1}^{n} X_i^2 - (\sum_{i=1}^{n} X_i)^2)(n\sum_{i=1}^{n} Y_i^2 - (\sum_{i=1}^{n} Y_i)^2)}}$$

where X was the level of the use of digital technologies; Y was the level of mastering higher mathematics course.

$$\sum_{I=1}^{112} X_I = 376 \quad \sum_{I=1}^{112} X_I^2 = 1448 \quad \sum_{I=1}^{112} Y_I = 442 \quad \sum_{I=1}^{112} Y_I^2 = 1856 \quad \sum_{I=1}^{112} X_I Y_I = 1604$$

$$R_{XY} = \frac{112 \times 1604 - 376 \times 442}{\sqrt{(112 \times 1448 - (376)^2)(112 \times 1856 - (442)^2)}} = 0{,}834239$$

Therefore, the coefficient of correlation between the level of the use of digital technologies during learning and the level of mastering higher mathematics in the frames of the experiments was equal to Rxy=0,83.

The following conclusions were obtained on the basis of the acquired results: the level of mastering higher mathematics course depended by 83% on the level of the use of digital technologies.

4 Discussion

The issue of construction of education process in higher school under conditions of digitization has at present several solutions, among which we have outlined two main variants:

- the use of ready virtual learning environment;
- the use of separate educational digital products.

The firs trend is supported by Ye.N. Dronova [6], G.V. Kravchenko [7], V.N. Minina [8], M.V. Osipov [9] and others. This trend is characterized both by advantages and disadvantages. The advantages are comprised of well-developed user-friendly interface, which is universal for studying any subject, allowing to arrange education of student group or course in distant or mixed formats. The disadvantages include impossibility to prepare final statement of marks for a semester and attendance record of students. These operations

should be performed manually either on paper or electronically. Herewith, even if this virtual learning environment is common for the university, that is, students and teachers pass simple registration, then it is still impossible to obtain final rating and attendance record of students, since the platform does not provide such function. Moreover, in such case the virtual environment is a tool to organize training of various formats. As we have already mentioned, the use of virtual environment should be substantiated in legal framework of the university. A student should have opportunity to select the form of learning in the same way as in nonresident and resident forms.

The second trend is supported by Z.G. Goncharova [10], G.P. Dudchik [11], S.L. Loginova [12], A. Saykili [13], F.P. Tulinayo [14], P. Ssentume [14], and others, they prefer to use separate digital products. We consider this approach as point-like, implementation of this trend does not promote formation of elementary digital competence of students.

E.M. Gusakova and T.A. Gusakova [15] describe in details active and interactive learning methods in digital environment. This category of methods is not an innovation; it has been used in the training process for quite some time. At present, modification of only learning methods does not lead to high-quality results, does not promote solution to the issue of education digitization.

5 Conclusion

The main research conclusions are as follows.

Thus, we have outlined the principles of construction of the connectivism learning theory in accordance with the classic approach of modern didactics.

In the frames of the research, we adhere to holistic approach to the issue of education digitization, which is comprised in consideration of the connectivism learning in higher school while studying higher mathematics course. The holistic approach to the problem allows to consider system-forming elements in interrelations governed by certain principles of construction of education.

Efficiency of the strategy of construction and implementation of learning program in the frames of higher mathematics course is substantiated and experimentally confirmed. The main distinction of this strategy is supplementing of the content of higher mathematics course with programs for symbolic mathematics, development of materials allowing to implement the learning process in various formats using researching methods of education and communication opportunities of digital products.

The experimental section of the research was performed with students of technical university. Th experiment was launched for the students of pedagogical training, Southern Federal University, characterized by its peculiar features; the results will be processed at the end of 2020-2021 academic year.

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