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DEVELOPMENT OF RESEARCH COMPETENCE OF UNIVERSITY STUDENTS DURING LEARNING MATHEMATICS

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Abstract

The development and implementation of high-tech technologies largely depends on the reproduction of scientific staff potential. In this regard, universities already at the level of bachelor degree program should pay particular attention to the training of students for future research activities. Commonly, graduate bachelors who have entered a Master program are not sufficiently proficient in scientific methods to continue their studies. This fact indicates that in a bachelor program there is a shortage of educational resources for the development of research competence. For the purpose of its development, the authors propose to give more opportunities to scientifically oriented students to show their abilities in academic disciplines. The subject area of mathematics provides great opportunities for the development of mathematical modeling as a method of scientific research, and therefore, the development of research competence of students. In order to use effectively these features, it is advisable to analyze the educational material from the point of view of the idea of individualized learning. In this case, the evaluation criteria may be the possibility of the adaption of educational material for a student and the expansion of the applied spectrum of mathematical information. As a tool for the development of the research competence of students, the authors propose a construction task. Solving this problem a student learns to use mathematical modeling as a method of scientific research.

Keywords: Research competence, individualization of training, construction task.

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1. Introduction

Academic scientists in many countries (Cuevas, Guillen, & Rocha, 2011; Dominguez & Judikis, 2016) actively discuss the issue of the development of research competence of university students. This competence is expressed in the ability to apply the methods of scientific research in professional activities (Koldina, 2015). While studying at a university, students are aware of the need to master competencies in various types of professional activities and, of course, there are always students who are ready to start a scientific career. The recognition of individual capabilities and needs of trainees is the basis of student-centered education system, which is recognized as effective (Wright, 2011). In this context, educational innovations in the individualization of education should identify the students who are most capable of research activities. Readiness for this type of activity is individual, as it is a personal characteristic and depends, in particular, on the experience of the application of research methods.

2. Problem Statement

A graduate bachelor may proceed to research activities in an organization engaged in scientific, technical and / or innovative activities. It is important to note that nowadays innovation cycle is compressed (it is expressed in the reduction of time between the acquisition of new knowledge and the creation of technology). In addition, disciplinary lines in research and development are blurred. Therefore, this feature of the modern world should be reflected in the training of students. For a successful future career in scientific field, a student should be able to master deeply the research methods already at the level of undergraduate program (Zeidmane & Čerņajeva, 2011). In addition, a graduate can continue his studies at a Master program, performing research work in the format of a Master thesis.

However, as the experience of academic staff working with undergraduates shows, for the majority of students this work turns out to be very difficult due to the lack of readiness for research work, which is their leading activity (Komarova, 2008; Konstantinova, 2013; Pegashkin, Gavrilova, & Kornisik, 2009).

Thus, the problem of the formation of research competence of bachelor degree students is relevant in any scenario of educational trajectory. Obviously, in addition to high motivation graduate bachelors entering a Master program should have sufficient experience in the application of scientific research methods. Such training will become a “bridge” to a Master program, i.e. will contribute to the realization of the idea of continuity in a two-level education system (Guseva, 2012).

In teaching mathematics, the traditional educational model is predominant. It is aimed more at studying theoretical material than at its practical application in professional activities, and insufficiently considering the potential of scientifically oriented students.

3. Research Questions

Teaching mathematics opens wide possibilities for the formation of the research competence of students. The subject of the article is the development of this competence through the inclusion of a special class of construction task in the educational process. The process of the solution of these problems reflects the logic of the phases of scientific research.

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4. Purpose of the Study

The purpose of the article is to substantiate the requirements for the content of educational material, as projections of the idea of the individualization of education, as well as the description of the main means of the formation of research competence - a set of educational design tasks aimed at the use of mathematical modeling as a method of scientific research.

5. Research Methods

The theoretical research method is used in this article. Based on a systematic approach, the development of the research competence of students is considered as a subsystem in the system of teaching mathematics at a university. On the basis of a student-centered approach, a student is considered as a subject of educational mathematical activity, as a result of which he acquires research competence.

Based on the task approach, defining the learning task as a unit of learning activities, the authors give the rationale for the development of a set of learning tasks-designers as a means of developing research competence.

6. Findings

It is possible to single out two categories of students, for whom the possession of research competence will be especially important. The first group includes students, initially aimed at continuing education in a Master program (and in Post graduate program); the second group includes students who have not decided yet to study or not in a Master program, but they have the ability to do research. Such students should be given the opportunity to fulfill their cognitive needs related to research activities (Robotova, 2013). There are several reasons explaining the necessity of such an approach.

They are as follows:

- Firstly, students motivated to enroll in a Master program will be able to determine their educational trajectory;
- Secondly, if a graduate student decides to return to a university as a Master program student, he will be the most prepared one for the study at the second level, which means that in the future he will succeed in research activities;
- Thirdly, research activity is one of the types of professional activity of a bachelor, in which a graduate student may find his occupation after graduation.

It is known that mathematical methods are widely used in research and development. In this regard, it is necessary to determine the conditions for the development of research competence in the subject area of mathematics. According to the authors, the possibility of the adaption of educational material for a student and expansion of the applied spectrum of mathematical information can be attributed to such conditions. The authors revealed the essence of these conditions.

The possibility of the adaption of educational material for a student means that this material must be sufficiently "flexible", i.e. accessible to an average student, but at the same time, it has the potential for a deeper immersion for students who showed interest in mathematical modeling. It is known that educational information has a three-dimensional essence: quantitative, substantive, and a dimension, which reflects the

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level of abstraction of educational material (Zenker, Simon, Gros, & Daubenfeld, 2014). In the educational process, the quantitative dimension of information is related to the perception capabilities and carrying capacity of a student; substantial is associated with its basic or former mathematical knowledge; the dimension reflecting the degree of abstraction is related to academic levels of knowledge (it is obvious that the degree of abstraction of information for a graduate student in mathematical areas will be much higher than for a bachelor of non-mathematical areas of training). In other words, the educational material should be built up not only "in broad", but also "in deep", i.e. it should be chosen in such a way that it can include not only relatively typical tasks, but also creative ones, with the possibility to report on them at student scientific conferences.

The expansion of the applied spectrum contributes to the solution of the recognized problem of the formalism of mathematical knowledge, which proves to be useless in the formation of scientific worldview of students (Myshkis, 2009). If the basic mathematical training of undergraduate students includes such sections as linear algebra, differential and integral calculus of functions, differential equations, discrete mathematics, probability theory, mathematical statistics, then the applied spectrum should contain theoretical material and educational tasks. The last ones can use the above-mentioned sections of mathematics as a mathematical apparatus for modeling.

The main tool for the development of research competence is a set of educational tasks, during the solution of which a student uses mathematical modeling as a method of scientific research.

According to the authors, the development of research competence, the process of the solution of an educational task should enable a student to study the phenomenon of it from different points of view, and not just within the framework of the condition and formulated problem. For this, a task needs to be flexible in terms of its structure. The flexibility of structure is determined by the application context that gives such an opportunity (Lungu, 2014). The authors call this type of task "a construction task".

The authors define "a construction task" as a specially developed interdisciplinary educational task with a transformation potential in which variation of the conditions of the problem leads to a qualitatively different result. The process of the solution of an educational construction task involves reflecting the logic of the phases of scientific research: design, technological, and reflexive (Novikov & Novikov, 2010).

The main difference between an educational task and other types of tasks (for example, a professional task) is that its purpose is to change the subject of activity. During the solution of a construction task, a student develops his personal qualities aimed at the formation of readiness to apply mathematical methods in research and development, which means that a task reaches its goal. The most important advantage of such an educational task is that a student is aware of the goal of educational mathematical activity, and this, in turn, increases the motivational component of training.

The authors considered the features of the structure and content of "a construction task" in detail.

Taking as a basis the logical structure of an educational mathematical problem proposed by Friedman (2009), the authors defined the main unit and additional units of a construction task (Table 01). The main unit is the subject area (the set of all objects that are considered in the task).

An additional unit includes:

- The relations and connections of objects (quantitative and qualitative characteristics);

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- The requirement or problem of a task (finding the desired characteristic, desired relation, creation of an object, proof of approval, etc.)

The authors paid particular attention to the possibility of the transformation of a task. The transformation of the main block of a construction task occurs in accordance with the following provisions:

- The subject area of the task does not change. These can be objects of a social communication process, for example, a group of people, match results, etc.;
- The relationships and / or relationships of objects are subject to change. The known relation may become unknown, it may change qualitatively or quantitatively;
- The requirement or problem of a task may change.

Table 01. Structure of a construction task

Main unit	Additional units (variables)	
Subject area	Relations and connection of objects	Requirement or question of a task

Let's review an example of the task designer, revealing methodical features of blocks superstructures. It is necessary to note that the complexity of the main task in this case may change both “in broad” and “in deep”. In the first case, a task retains the previous level of complexity, but allows exploring an object or objects on the other hand, in a different capacity. In the second case, the variation of the original problem acquires the ideological and / or technical complexity. Ideological complexity is in the choice of appropriate solution of a problem and technical is in the implementation of the chosen method of solution.

The authors considered an example of a construction task, revealing the methodological features of additional units.

The main unit of a task:

There is a company management staff. It is known that the opinion of its president is equally influenced by the opinions of his two first vice-presidents and his own. One of the first vice-presidents (vice-president-1) forms his opinion only on the basis of the opinion of the head. Other first vice-president (vice-president-2) gives equal weight to his own opinion and that of the two other vice-presidents. Finally, both second vice presidents are influenced only by their own opinions. Who has real power in this group, i.e. who does really influence the final opinion of a group?

Will the group come to a final general opinion with the following initial opinions (if it does, what is it?):

President = 10,

The first vice-president-1 = 20,

The first vice-president -2 = 20,

The second vice-president -1 =100,

The second vice-president -2 = 100

What happens if the second vice president changes his mind by 200?

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The subject area of this task consists of five objects - group members. These objects have explicitly specified characteristics in the task - initial opinions, as well as some implicitly specified characteristics - influence in the group. The unknown characteristics of the objects in the problem are the desired and intermediate, i.e. finding which in the text of the task is not required, but they are needed to find the desired ones. The desired characteristics are the final opinion of the group and the greatest influence in the group, intermediate, for example, a weighted sum of initial opinions.

Additional units in which the connections and the question of the main unit of the task are changed:

Unit 1 (the previous level of complexity is preserved): *The task of external management: How the influence coefficients can be changed in order to achieve the desired final opinion of the group?*

Explanation. The solution of this problem involves the same mathematical apparatus, performing the same mathematical operations as the main task, so its transformation into an external control task (unit 1) led to a new task; the level of complexity remained the same.

Unit 2 (technical complexity). *Sustainability Challenge: How stable is the final opinion of the group to small changes in impact coefficients?*

Explanation. The technical complexity of this task is reasoned by the fact that its solution requires an additional computer experiment in order to vary the coefficients and track the change in the group final opinion.

Unit 3 (conceptual complexity). *The external task of disagreement of the system: how is it possible to change the coefficients of influence, so that the final opinion is unreachable?*

Explanation. The ideological complexity of this task is in the choice of different approach to its solution. In this case, the intuition and creative search of a student is important.

7. Conclusion

The implementation of the idea of the individualization of education at a higher education institution means, among other things, the identification of students who are predisposed to research activities. The task of the development of research competence should be in teaching of individual scientific disciplines, since mastering each of them ensures the application of appropriate scientific methods. In order to achieve this purpose, the educational programs of disciplines should include elements that enable students to master these methods more deeply and subsequently discover their research potential.

The article formulated and substantiated the criteria for the selection of educational material in teaching mathematics aimed at the development of research competence at university: the possibility of the adaption of educational material for a student and expansion of the applied spectrum of mathematical information.

The essence of the concept “construction task” is disclosed as a specially developed interdisciplinary educational task with a transformation potential in which variation of task conditions leads to a qualitatively different result. The process of the solution of an educational construction task reflects the logic of the phases of scientific research.

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