

METHODOLOGICAL APPROACHES TO DESIGN OF THE ADAPTIVE SYSTEM FOR MATHEMATICAL TRAINING OF STUDENTS

Vera I. Toktarova¹ and Svetlana N. Fedorova²

¹ Assoc. Prof., PhD, Mari State University, Russia, toktarova@yandex.ru

² Prof. Dr., Mari State University, Russia, svetfed65@rambler.ru

Abstract

Functional implementation of mathematical training of students from the perspective of national strategies of higher education development is impossible without taking into account adaptive possibilities of the educational system. The article considers the issues connected with pedagogical design of the adaptive system for mathematical training of students of higher educational institutions. It gives a definition of a methodological approach, proves conceptual levels of methodological analysis: philosophical, general scientific, specific scientific, technological which form a complicated subordinate system. As a methodological framework of the research the authors consider in depth the ideas of system, synergetic, environmental, person-centered, competency building, activity, context, process, axiological, and cultural approaches. They elicited and described main functional and conceptual approaches which made a methodological foundation for the design and development of the adaptive system for mathematical training of HEI students.

Keywords: methodological approaches, mathematical training, adaptive system, pedagogical design, educational process, higher education, student

1. INTRODUCTION

Design and development of the adaptive system of mathematical training of students supposes the orientation on the basic methodological approaches.

A methodological approach is a conceptual position defined by the research and based on the use of the corresponding system of principles, means and methods of project activity. In accordance with the research of Je.G. Judin (1978) a methodology is a characteristic of components of scientific research: object and subject, goals and tasks, a complex of means and methods, as well as a contribution into formation of a sequence of researcher's activities in the process of task solving. The scientist defines the following conceptual levels of methodological analysis: philosophical, general scientific, specific scientific, technological which form a complicated subordinate system.

A philosophical level consists of generally recognized principles of knowledge and scientific categories, worldview approaches to the cognitive process, advancement of abstract theorems and transformation of reality. The second level – general scientific methodology – includes general scientific concepts and forms a basis for theoretical and practical activity. Specific scientific methodology allows specifying a research problem from the point of view of a definite set of methods and procedures typical of the given scientific field. The fourth level – technological methodology – includes methods and techniques of research, provides the receiving of reliable empiric material based on definite procedures peculiar for the given science.

In respect to the problem of the development of the adaptive system of mathematical training of HEI students this complex of levels of methodological approach may be defined to the full extent, and the corresponding methodological approaches are considered at different levels as mutually supportive ones at the same time (fig. 1).

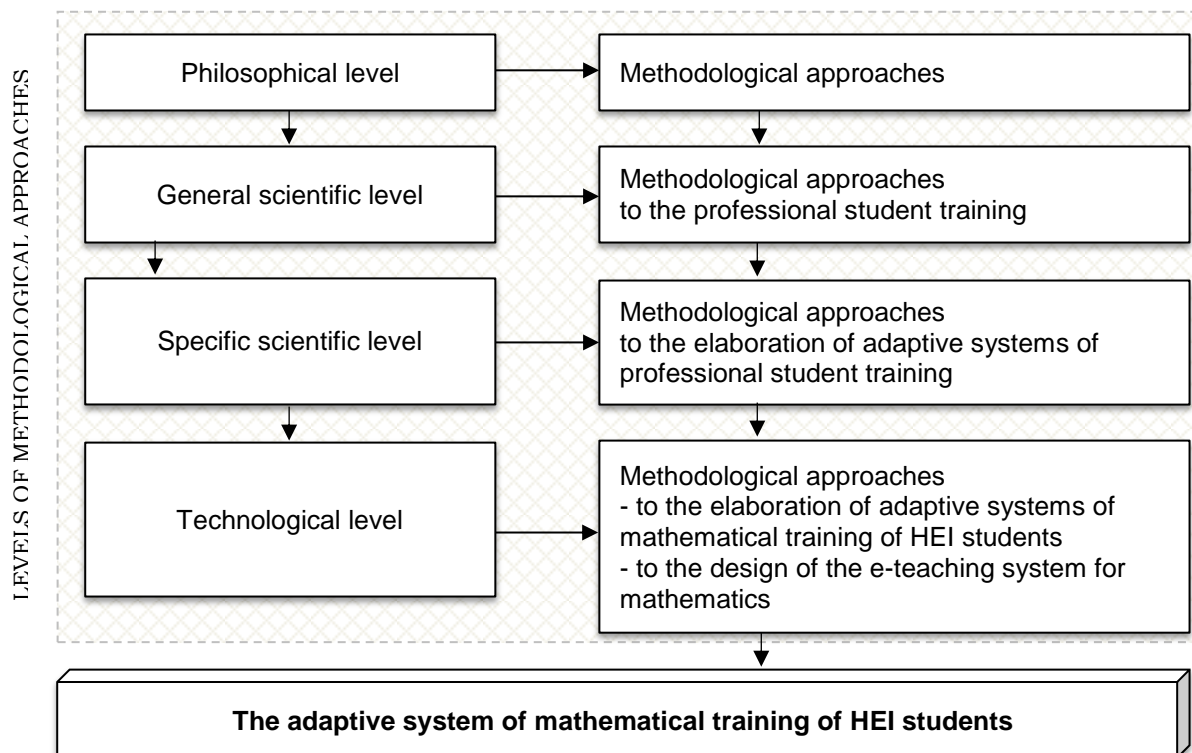


Fig. 1. The hierarchy of methodological approaches in respect to the problem of design of the adaptive system of mathematical training of HEI students.

2. METHODOLOGICAL SUPPORT OF THE DESIGN OF THE ADAPTIVE SYSTEM OF MATHEMATICAL TRAINING OF STUDENTS

On the assumption of common positions, let's consider the ideas of system, synergetic, environmental, person-centered, competency building, activity, context, process, axiological, and cultural approaches as a methodological basis for the research of the design of the adaptive system of mathematical training of students. In the modern conditions it is impossible to build one universal approach which includes a whole complex of necessary procedures. In connexion with it we will rest against the functional and content-related and conceptual integration of ideas of different methodological approaches.

The basic approach to the investigation of the problem of design and development of the adaptive systems of professional training of students is a **system approach**, the main idea of which is to use a fundamental notion of a system as a complex of elements being in interaction.

The study of the adaptation process from the perspective of the system approach also supposes its representation in the form of a system. At the same time its specific feature is a wholeness with continuous motion of all its elements: on the one hand, contradictions appeared inside the system due to the pressure of external factors, on the other hand, internal contradictions initiating the change of external connections, as a result of which there is a counterbalance with external environment by acquiring new system property.

The system approach to the design and development of the adaptive system of mathematical training of HEI students allows representing the whole learning process in the form of a system, defining and characterizing its components and subjects, eliciting interconnections and interdependencies, using teaching methods and means in an integrated and balanced manner. At the same time it will provide true information on the rules and regularities of system behaviour while interacting with environment, allow proving the criteria of quality assessment of development options under the optimality principle, making decisions taking into account multiple factors, analysing the results of the influence on the managing system. From the positions of system approach it is possible to present the teaching process in the whole and elaborate optimal strategies and ways of its implementation being oriented to the integral perception of system subjects and students' results received in the process of teaching.

Considering the structural and content-based characteristic of pedagogical systems, a **synergetic approach** shall not be overlooked, as it is directed to the investigation of self-organizing systems.

Self-organization is a process of spatial and time ordering of system elements and parts by transforming the existing connections and creating the new ones between system elements and their internal close interaction (Ignatova, 1999). We shall note that pedagogical and educational systems are synergetic in nature and functions, and the use of synergetics as a methodological principle promotes forming a personality as a subject of self-development. Thus, synergetics ideas are connected with such processes as self-education, self-study, self-upbringing, personality self-development.

The significance taking into account a synergetic approach in our investigation is proved by the design of adaptive mechanisms – adaptation of a system to the internal and external changes which makes it unstable (unbalanced). Both an individual student (a group of students) and the whole pedagogical system may be considered as a system. At the same time a person may be considered as a complex social and biological-system having the ability of self-development. In this case, the process of personality adaptation will be characterised by fluctuations (random deviations) because of its nonequilibrium; the processes of adaptation of both a system and its subsystems increase the deviation amplitude, strengthen system nonequilibrium making it closer to the bifurcation (branching) points. By virtue of randomness of self-organising systems, in the moment of reaching the bifurcation point it is difficult to forecast the evolution direction for the new-formed systems or their elements, at the same time nonlinearity of synergetic processes provides a polyvariable way of their development.

An **environmental approach** is closely connected with system approach and synergetic approaches. It is connected with understanding of education as an open self-organizing nonlinear system and presents a combination of principles and ways of using the potential of the environment, guaranteeing the reaching the goals determined by the system.

From the point of view of building the adaptive system of training of students the environmental approach is especially acute as there are new requirements for the arrangement of educational process of HEI to be oriented to the use of electronic information educational environment in higher educational institutions. Information and educational environment (IEE) is a heterogeneous educational space functioning within the frameworks of state educational standards, created with the use of integrated complex of means, tools, devices, carriers, and conveyors of knowledge, as well as the taught subjects themselves connected by functional multilateral interconnections (Romanov, 2009).

The environmental approach supposes the creation of a substance which, when surrounding the student, creates the conditions necessary for his/her development. Thus, when designing and elaborating the adaptive system of mathematical training of students in conditions of HEI IEE, the necessary condition is finding, taking into account and developing the individual peculiarities of students, their way of thinking and perception, achieving the high level of knowledge and training. The provision of principles of personalization provides the formation of high technological information and educational environment allowing the students to study taking into account the adaptive opportunities.

As the process of adaptation is a complex and multi-aspect phenomenon and touches upon a wide range of personal features of a student, during the educational process it is necessary to take into account a **person-centered approach**.

The person-centered education implies the orienting on the education, upbringing, and development of students taking into account their individual features (physiological, psychological, age-related, etc.) and demands (educational, social, etc.). In respect to the high school the aim of the educational process is to create the conditions for the development of an integral personality oriented towards his/her professional activity and the need to perfect themselves in it. In the course of adaptation an individual style of student's

activity is formed which helps to accomplish a preset professional and functional role successfully (Klimov,1969).

For our research it is important to use a process toolkit of the person-centered approach when designing the adaptive system of mathematical training of students which will allow providing every student with an opportunity to study taking into account their cognitive abilities, individual features, motives and aims; promoting an implementation of the efficient process of e-learning; not to create contradictions with the principles and regularities of traditional pedagogics and didactics.

Strengthening of a person-centered aspect of students, provision the development of their personal elements, formation of their active professional and life philosophy is the main focus of a **competency building approach** as well. From the point of view of the competency building approach the main result of studying in HEI is forming a competent specialist who has a set of definite competencies allowing to achieve professional and personally important goals.

The competency building approach keeps focus on the results of the study; this is not a complex of familiar information, but a personal ability to act in different problem-based situations, his/her competency. It strengthens a practice-oriented principle of education, its subject and professional direction. We shall note that the competency building approach is proved by the need of HEI graduate to adapt to the changeable production technologies, supposes context-dependent role self-organising, self-positioning, self-management, self-control, self-assessment, and self-correction.

The acute character of the use of competency building approach in our research is based on statutory regulations in the field of higher education implementation. In particular, the Conception of Long-term Socio-economic Development of the Russian Federation for the Period up to 2020 (Conception, 2008) underlines the necessity to provide the competency building approach, interrelations of academic knowledge, and practical skills. One of the important reasons of the decrease of the level of mathematical training of students is isolation of the content of mathematical education from future professional activity of a graduate (Fedorova and Toktarova, 2016). Functional purpose of mathematics is determined by its applied character and a possibility of implementing the mathematical tools in solving the tasks, the content of which reflects the specifics of future professional activity.

Considering the provisions of the competency building approach, it should not go unmentioned the ideas of an **activity approach** which make an essence of implementation of practice-oriented principles and subject professional character of education.

The activity approach is connected with the search of possibilities to connect students' theoretical knowledge with their practical implementation, ways to use theoretical knowledge in practice-oriented professional activity. It is directed to the creation of such conditions of learning activity which make students to apply actively their theoretical knowledge to solve practical tasks.

A fundamental basis for adaptation is active involving of students into activity which allows a more efficient acquisition of a system of necessary competencies. An advantage of applying the activity approach for mathematical training of HEI students is a solution of the task of knowledge-action integration, provision of practice-oriented professional education. The process of taking decisions is determined by personal experience of an active and responsible specialist.

The content component of practice-oriented education is reflected in the **context approach**. Context is a system of internal and external conditions of personal life and activity which influences directly on the perception, understanding and transforming by him a definite situation, giving a sense and meaning to this situation and its components. At the same time an internal context includes personal individual and psychological peculiarities, knowledge, experience; while an external context includes objective, social and cultural, and other effects of the educational system.

According to the works of A.A. Verbickij (1991), the arrangement of the learning process within the context means phased transition of students to the activity of higher level: from lectures and seminars (academic learning activity) to business and didactic games (quasiprofessional activity), then to practices and internships (educational and professional activity). It is also important to mention the necessity of complex approach to the use of different methods, means and forms of active learning, combining it naturally with traditional methods. The principle of «learning by doing» is the main thing in the context approach.

The design of the adaptive system of mathematical training of students is impossible without the principles of the **process approach**. The essence of the process approach consists of complete controllability by the

educational process directed to the achievement of a fixed goal, feedback establishment, result assessment, being a basis for the correction of the educational process.

Describing the provisions of the process approach V.M. Monahov (2012) talks about the necessity to take into account the following factors: transformation of pedagogical intention into the process sequence of pedagogical influence; functioning of pedagogical technology as an interdependent activity of a teacher and students; stage design and the following implementation of elements of pedagogical technology; inclusion of diagnostic procedures containing criteria, parameters, tools to measure activity results into the pedagogical technology.

Within the aspect of the problem under study the process approach envisages the development of a technology and a corresponding model when planning and organizing the educational process, assessing their efficiency, optimising the process of students' professional training, carrying out the diagnostic procedures for learning results during the design and implementation of the adaptive system of mathematical training of students in conditions of functioning of HEI information and educational environment.

Student's professional development, saturation of his/her activity with intellectual, worldview, aesthetic, moral values happen on the basis of an **axiological approach** based on the relation to a person as a subject of communication, knowledge, and creation. The values are considered as unique determinants of individual and collective choice defining the perspective of the development of a personality and society as a whole. In this connection education as an element of culture acquires special significance and is considered as the main means of development of humanistic character of a person (Lishhinskaja, 2012).

Within the frameworks of the axiological approach the priority tasks of professional education are to discover the values promoting the implementation of personal essential strengths; to develop its intellectual, creative, and moral potentials appearing in the ability to orientate freely in difficult professional and social situations, to percept and implement innovations.

The acute character of the axiological approach application for our research is determined by the characteristic of adaptation as a means of subject's success to implement own goals, inspirations and values. Such adaptation is observed in any professional activity and is characterized by display of initiative, clear representation of own future and successful decision making. A value-conscious basis of the design of the adaptive system of mathematical training of students is the following groups of values: student's personal values, professional values, and values of national culture. Their limited and optimal combination will contribute into the rise of implementation efficiency of the educational process and professional development of every student.

The ideas of the axiological approach resonate with the provisions of the **cultural approach**. The cultural approach is a methodological position disclosing a united character of activity and individual and creative aspects of culture and considering a person as the main actor.

When designing the system of mathematical training, a function of teaching mathematics is of great importance: the development of mathematical literacy and culture of a person, orientation in the environment, formation of student's worldview, and personality upbringing. It is important to show the application of mathematical knowledge not only with the applied meaning, but in the formation of an ability to see the world around by means of mathematics as science and art. The learning process supposes student's development in the multicultural angle when every student shall not only receive qualitative knowledge, but also present the whole worldview, be a well-bred and esthetically developed person, be able to apply the achievements of any subculture in everyday life, in practice, and in future professional activity.

3. CONCLUSION

While solving the problem of design and elaboration of the adaptive system of mathematical training of students, it is necessary to use principles of different methodological approaches as methodological support taking into account their functional and content-related and conceptual integration. Thus, a system approach adds to an activity one, the framework of which supposes a setting of goal and strategy and the receiving of the planned result. The system approach investigates an object as a wholeness and unity of its components, while a context one considers an object in specific conditions of real life and professional situation. A synergetic approach adds to a system one taking into account a dynamics of system development and influence of external (non-systemic) factors on it. An axiological approach enriches with a synergetic one allowing to consider personality development through the adoption of system of values. As a result of such integration the modern pedagogical practice has and widely uses such approaches as "person-centered-

activity”, “axiological-process”, “system-activity”, “system-environmental”, “context-competency building” and others.

Therefore, main provisions of the analysed methodological approaches, complementing and enriching each other, act as a methodological foundation for the design and elaboration of the adaptive system of mathematical training of HEI students.

4. ACKNOWLEDGEMENT

This research was financially supported by the Ministry of Education and Science of the Russian Federation (Grant № 27.8640.2017/БЧ).

REFERENCE LIST

- Judin, Je.G. (1978). *System approach and principle of activity*. M.: Nauka.
- Ignatova, V. A. (1999). Synergetics as a method of knowledge of nature and society. *Ecology and Life*, N2, 29-32.
- Romanov, A.M. (2009). *Pedagogical conditions for the formation of the meaning motivation of university students in the electronic educational environment*. M.: Elit, 344 p.
- Klimov, E. A. (1969). *Individual style of activity, depending on the typological properties of the nervous system*. Kazan, 280 p.
- The Conception of Long-term Socio-economic Development of the Russian Federation for the Period up to 2020. (2008). Retrieved from <http://www.consultant.ru>.
- Verbickij, A.A. (1991). *Active learning in higher education: contextual approach*. M.: Vysshaja shkola, 207 p.
- Monahov, V.M. (2012). Competence and context format of education and design of educational modules. *Bulletin of the Moscow State University of Humanities named after MA Sholokhov*, N1, Pp. 49-60.
- Lishhinskaja, N. A. (2012). *Implementation of the axiological approach in the process of forming a culture of thinking for students- future managers*. Vladikavkaz, 24 p.
- Fedorova, S.N. and Toktarova, V.I. (2016). Mathematical Background of Students at the Present Stage of Society Development: Importance, Model, Quality. *Proceedings of ADVED 2016 2nd International Conference on Advances in Education and Social Sciences*, pp.489-492.