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Трансдисциплинарное осмысление фундаментальности и практико-ориентированности педагогического образования

**Актуальность.** Повышение фундаментальности и практико-ориентированности педагогического образования являются двумя важными стратегиями его развития на современном этапе. Фундаментализация обеспечивает формирование системы глубоких базовых знаний, определяет целостную научную картину мира человека. Практико-ориентированность раскрывается в призме приобретения опыта в ходе активной деятельности, готовности личности продуктивно наращивать и использовать свои знания и способы деятельности для решения возникающих в реальной практике задач, ориентация на непрерывное самообразование и саморазвитие.

**Цель статьи** заключается в научном обосновании трансдисциплинарности как стратегии сближения фундаментальности и практико-ориентированности педагогического образования на современном этапе.

**Методология и методики исследования.** Методологическую основу трансдисциплинарности составляют идеи синергетического подхода. В определении сущностных характеристик успешности педагогических действий в аспекте повышения качества профессиональной подготовки педагогов использованы идеи праксиологического подхода. Профессиональная подготовка будущих учителей к решению комплексно поставленных реальных задач на основе сформированной системы знаний и приобретенного опыта деятельности ориентирована на концепцию деятельностного подхода.

**Результаты исследования** представлены научным обоснованием интеграции фундаментальности и практико-ориентированности подготовки будущего учителя на основе трансдисциплинарной стратегии, определением условий формирования трансдисциплинарного мышления педагогов, развития практических умений и навыков решения сложных проблем через призму разнопредметных знаний и способов деятельности: включение педагогов в проектную, исследовательскую, опытно-экспериментальную деятельность, организация непрерывного образования, усиление нелинейности развития образовательной системы и обеспечение дисциплинарной гибкости, рефлексивного осмысления результатов деятельности на основе учета праксиологического знания для обеспечения успешности педагогических действий.

**Заключение.** В основанном на трансдисциплинарной основе педагогическом образовании в тесном взаимодействии глубоких фундаментальных знаний, приобретенных в рамках непосредственной практики навыков и опыта, руководствуясь праксиологическим знанием на основе понимания общей теории успешной деятельности учитель может осуществлять трудовые педагогические действия результативно, эффективно, технологично, безопасно.

Представленные результаты можно использовать при разработке образовательных программ педагогического бакалавриата, программ дополнительного профессионального образования с опорой на возможности цифровой учебной среды.

**Ключевые слова:** фундаментализация образования, практикоо-ориентированность, педагогическое образование, учитель, цифровизация образования

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Transdisciplinary understanding of the fundamental and practice-oriented nature of pedagogical education

Relevance. Increasing of fundamentality and practice-oriented nature are two important strategies for development of pedagogical education at the present stage. Fundamentalization ensures the formation of deep basic knowledge system, defines a holistic scientific picture of the human world. Practice orientation is revealed through a prism of gaining experience in the course of various activities, the willingness of a person to productively increase and use his or her knowledge and methods of activity to solve problems arising in the reality, orientation towards continuous self-education and self-development.

The aim of the article is scientific substantiation of transdisciplinarity as a strategy for bringing together the fundamentality and practice-oriented pedagogical education at the present stage.

Methodology and methods. The methodological basis of transdisciplinarity is based on the ideas of a synergetic approach. The ideas of the praxiological approach are used in determining the essential characteristics of pedagogical actions success in terms of improving the quality of professional training for teachers. The professional training of future teachers to solve comprehensively set real tasks based on the formed knowledge system and acquired experience is focused on the concept of an activity-based approach.

The results of the study. The results are presented by the scientific substantiation of the integration of the fundamentality and practice-oriented training for future teachers on the basis of a transdisciplinary strategy, the definition of conditions for the formation of transdisciplinary thinking among teachers, the development of practical skills and skills for solving complex problems through the prism of diverse knowledge and methods of activity: the inclusion of teachers in project, research, experimental activities, the organization of continuing education, strengthening the nonlinearity of the development in the educational system and ensuring disciplinary flexibility, reflexive understanding of the results for activities based on the consideration of praxiological knowledge to ensure the success of pedagogical actions.

Conclusion. A teacher can carry out labor pedagogical actions effectively, efficiently, technologically and safely using the pedagogical education based on a transdisciplinary basis, in close interaction of deep fundamental knowledge acquired through direct practice of skills and experience, as well as using praxiological knowledge based on an understanding of the general theory of successful activity.

The presented results can be used in the development of educational programmes for pedagogical bachelor’s degree and programmes of additional professional education based on the capabilities of the digital learning environment.

Keywords: fundamentallization of education, practice orientation, teacher education, teacher, digitalization of education

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INTRODUCTION

In 2022, the Roadmap and objectives of Higher education for the period up to 2030 were approved within the framework of the UNESCO World Conference on Higher Education. According to the general concept of this document, higher education is reinterpreted as an inalienable right of everyone in terms of educating well-rounded specialists who are full-fledged citizens able to jointly solve complex problems and act with a formed sense of social responsibility. The new education strategy calls for a renewed mindset based on the transition from disciplinary disunity to interdisciplinarity and transdisciplinarity, to open dialogue and active cooperation, and a transition from a restrictive focus on disciplinary and vocational training to a rich, holistic and diverse student experience. It is noted that universities make an important contribution to the production of knowledge, but disciplinary specialization is not enough to solve complex problems, therefore transdisciplinary approaches are required, as well as the ability to think and work based on various disciplinary perspectives and the full rights of citizens who jointly solve problems.

All concerned parties of higher education are invited to exchange ideas and practices within the framework of a common ecosystem on the terms of cooperation, diversity, flexible learning paths, and openness. All this enriches higher education, serves its sustainable development, and shapes the collective future. Digital technologies perform a supportive and complementary function in ensuring the educational process.

The leading strategy for the development of teacher education in Russia is to increase its fundamentality. On the other hand, today society sets an equally important task for the education system – to increase its practice orientation. In this regard, there is a need to understand the current situation of combining these two trends in the professional training of a future teacher, choosing the appropriate methodology for integration.

The problem of the fundamentalization of education is quite complex and multifaceted. It requires a systematic approach to its consideration. As V. A. Testov emphasizes, the fundamentalization of education is “the acquisition of fundamental knowledge that ensures the comprehension of the basic laws in science evolution and society, and therefore contains the potential of new knowledge and creativity” [34, p. 87]. We consider the fundamentalization of education “as a formation process of solid, deep basic knowledge that determines the scientific picture of the human world and their integration through interdisciplinary connections, allowing the individual to continuously engage in self-education” [39, p. 91]. The scientist A. G. Pashkov said that “the main feature of knowledge is its inseparability from the subject and his or her independent thinking. This feature allows to develop deep systematic and holistic knowledge as the main component of our co-knowledge, ... the knowledge component of consciousness plays a decisive role in thinking and decision making” [27, p. 108]. While general information awareness “causes a poor understanding of the phenomena essence and their cause-and-effect relationships, making mistakes in solving educational and everyday problems [27, p. 109]. Today S. B. Maksyukova and D. S. Trukhmanov note that “society needs professionals with a wealth of fundamental knowledge ..., which will allow them to carry out substantive analysis and make responsible decisions in difficult situations” [21, p. 188].
The educational process in schools and universities is based on the foundation of scientific knowledge, and the content of education is based on fundamental scientific knowledge. At the same time, a deeply thoughtful system of interrelated, feasible but encouraging tasks allows to assimilate the principles of organizing scientific knowledge and form conceptual and logical thinking, experience the conscious application of knowledge to solving problems, attracting the interest in accurate knowledge. The fundamental nature of education can be most vividly represented by the example of mathematics. As V. A. Testov emphasizes [34], it is mathematics that plays a key role in fundamentalization. Mathematics is considered as a kind of coherent, organized structure of knowledge [49]. According to Adem Ekmekci, Danya M. Corkin, Weihua Fan [43], the mathematical knowledge of teachers and their ideas about the methodology of teaching mathematics, the accumulated baggage of academic knowledge and professional experience, motivational beliefs are among the key factors of high academic performance and effective learning of mathematics by schoolchildren. To improve the teaching of mathematics at school, the quality of mathematics teachers professional training should be improved [48]. Such teachers, having deep knowledge, will be able to use them in their teaching practice in a flexible and innovative way. They understand the reasons for students’ individual success, can anticipate potential difficulties, confidently adapt to unexpected situations, and contribute to the growth of students’ academic performance. It is important to implement and strengthen positive feelings among math teachers so that they do not transmit a negative attitude towards mathematics to their students [41]. The role of the teacher is seen in creating a stimulating and positive learning environment [50]. At the same time, in order to develop new practices and projects in teaching mathematics, it is important to ensure the cooperation of teachers [54] and use the communicative skills of students to expand their experience [53]. There is a need to raise the status of a teacher through social networks, which are used for professional communication, story sharing and collegial support [55].

Besides, S. I. Kalinin, L.V. Pankratova [10] note that mathematics is a means of transdisciplinary communication. Its apparatus allows us to describe the general scientific tools for structuring any knowledge. At the same time, mathematical modeling is one of the ways to solve practical problems, the methodological basis of practice-oriented mathematics teaching at school. As information technology develops, its effectiveness increases. In practice-oriented learning, knowledge comes from action and is derived from context and specific structures. Establishing explicit links between theory and practice through the possibility of critical reflection on practical processes is considered especially important for future teachers and their readiness to work in the classroom [40].

When characterizing the fundamental subject knowledge of future math and computer science teachers, scientists talk about their cumulative nature as part of the school mathematical knowledge and academic content knowledge system as a result of studying mathematics and other professional disciplines in colleges and universities. At the same time, the teacher’s general idea of fundamental knowledge system consists of these subsystems based on interdisciplinary and multidisciplinary connections. The baggage of mathematical knowledge allows a mathematics teacher to easily apply them in a wide variety of fields, thereby bringing education closer to practical orientation. It can be assumed that based on the fundamental knowledge of various disciplines, it becomes possible to help fully make education practice-oriented. It remains only to propose an appropriate methodology for the relationship between fundamentality and practice-orientation, which can be, for example, a transdisciplinary understanding of teacher education.
At the UNESCO Symposium on Transdisciplinarity in 1988, it was noted that multidisciplinary and interdisciplinary approaches cannot effectively protect society from the consequences of the ongoing knowledge fragmentation (the problem of non-systemic, uneven information emergence). There is still a need to transform non-systemic knowledge into systemic one. Y. Kimhi notes that there is a need to move from fragmented knowledge within disciplinary courses to integrated interdisciplinary courses. The disadvantage of isolated single-semester courses is their fragmented view of knowledge. Each element is taught in isolation, without emphasizing the various natural connections and without explicitly discussing broader interrelated topics within each discipline or with other disciplines [44]. However, through a simple comparison or combination of disciplinary methods, knowledge does not achieve that deep “integration” that is the fundamental unification of all knowledge forms.

However, sometimes graduates of pedagogical fields who possess a knowledge system are not always ready to solve the complex task from the real sphere set for them by employers. In this regard, it is advisable to assume the need to reconsider the conceptual and methodological tools for the fundamentalization of education using a new scientific basis. As a response to this problem, the transition from interdisciplinarity to transdisciplinarity, as well as the development of cooperation and strengthening of synergy between educational organizations, the state and the sphere of employers, becomes a strategic guideline in science. Today, more and more attention of the scientific community is focused on transdisciplinarity as a research strategy that crosses disciplinary boundaries to create a holistic approach to the object or process being studied [43].

Transdisciplinarity is considered as a modern pedagogical technology of knowledge integration [31], as an approach that contributes to solving real problems [46]. Transdisciplinarity fits well with a competence-based approach, project-based learning, and phenomenon-based learning [42]. The importance of transdisciplinarity as the key to explaining a new, more holistic, less ultra-specialized education is noted. Transdisciplinary thinking defines students’ understanding of the absence of the need to separate content and competencies in different subjects. Another important aspect of transdisciplinarity is creativity, creative thinking. “A reasonable combination of transdisciplinarity principles allows to see the scientific picture of the world in its entirety” [2, p. 9].

The aim of the present study is scientific substantiation of transdisciplinarity as a strategy for bringing together the fundamentality and practice-oriented pedagogical education at the present stage.

The objectives of the study:

1. Substantiation of the need to integrate fundamentality and practical orientation in the preparation of a future teacher as a subject of the educational ecosystem based on the application of a transdisciplinary strategy in teacher education.

2. Consideration of transdisciplinarity essence as a social phenomenon that provides a new level of fundamental knowledge integration to create a holistic picture of the world.

2. Characteristics of the conditions for the formation of practical skills and skills for solving complex problems using diverse knowledge and methods of activity, taking into account praxiological knowledge to ensure the success of the activity.

The problem of this study is the need to understand the transdisciplinary approach in education from the standpoint of ensuring the improvement of professional training quality for future math and computer science teachers through the integration of fundamental and applied aspects.
MATERIALS AND METHODS

General scientific theoretical research methods are used in solving the tasks set: analysis of scientific works by Russian and foreign authors on the subject under consideration, social demands for teacher education in the digital economy, generalization of practical experience in training of mathematics and computer science teachers at the Pushkin Leningrad State University (St. Petersburg). In particular, our research was based on the results of understanding the works of E. M. Akhmedova [33] and T. N. Taranova [33] when clarifying the essential difference between interdisciplinarity and transdisciplinarity of approaches, P. P. Efimov [31] and E.A. Solodova [31] when implementing the principle of transdisciplinarity in education, I. A. Kolesnikova [16] on the development of the methodology of the transdisciplinary approach in education, Y. V. Sorokopud [32] regarding the transdisciplinary methodology in the preparation of a teacher in a master’s degree; research by V. A. Testov and E.A. Perminova on the role of mathematics in the transdisciplinary content of education [34], related to the fundamentalization of teacher education; works by I. V. Levchenko [19], M. V. Egupova [7], devoted to practice-oriented training in mathematics for teachers and schoolchildren.

The monographic study by L. P. Kiyashchenko [15] and V. I. Moiseev [15] is the most in-depth and fundamental research in the field of transdisciplinarity, carrying out a holistic analysis of this social phenomenon origins.

The strategy, which allows a new perspective to look at the essence of the transdisciplinary relationship between the fundamentality and practical orientation of pedagogical education, is considered taking into account the main provisions of the praxiological approach. We pay attention to its role in improving the quality of education. The main conclusions were made by the authors on the basis of the results of observing the realisation of the educational programme for training future teachers of mathematics and computer science by Department of Computer Science and Information Systems of Pushkin Leningrad State University (St. Petersburg) (training code 44.03.05 Pedagogical education (including two profiles, computer science and mathematics), profile: computer science and mathematics). The covered period is twenty years of working with students with regard for digitalisation trends in the educational space of the university.

RESULTS

T. N. Taranova, E. M. Akhmedova note that the transdisciplinary approach is a higher stage of interdisciplinary research. It is not limited to interdisciplinary relations and “exists within a global system without strict boundaries between disciplines” [33, p. 155].

Transdisciplinarity ensures the implementation of one of the leading principles in modern multilevel education: education “in depth” (fundamental) and education “in breadth” (versatile natural science and humanities education based on fundamental knowledge). At the same time, the fundamentalization of an only discipline is not able to significantly affect the quality of professional training, intersubject integration must be carried out simultaneously, the relationship between the processes of fundamentalization and practical orientation of education. Moreover, traditional approaches to teacher education are increasingly being criticized for their limited attitude to the needs of
students and teachers and for their insignificant impact on practice. Many are calling for the creation of a radically new and effective pedagogy of teacher education, in which theory and practice would be effectively linked.

It is worth confidently talking about the possibility of a transdisciplinary understanding for teacher education at the present stage of its development, since digitalization of education creates even more accessible conditions for the implementation of a transdisciplinary concept. It provides an opportunity to use modern information and digital technologies for a comprehensive knowledge of the object at several levels of reality. So, as noted by D. Martinovich and Z.F. Dabaha, digital tools can be used in teaching mathematics to manipulate mathematical objects. It will allow to create individual educational materials to facilitate the perception of content [45].

Characterizing the processes of science cognition in the context of digitalization, O. V. Pashchenko notes, “in modern science, new directions do not just appear, but a combination of socio-humanitarian, technical, economic, natural science knowledge, knowledge in the field of anthropology, etc. occurs, forming a complex system of disciplinary units” [28, p. 56]. Multilevel cognition arises due to the openness of education and its various implementation formats – integrated, mixed [1], hybrid forms of education [30]. Previously impossible collaborative educational practices (within the region, educational organization) are becoming available. They allow us to create unique, transdisciplinary educational programmes organized according to the network principle [38], collaborative technologies in education are developing [51]. Digital educational ecosystems are being created.

Transdisciplinarity is manifested both at the level of analysis of fundamental knowledge formation process and in the organization of practice-oriented learning. For example, on the one hand, it ensures the harmonious integration of various disciplines in vocational education in order to create conditions for students to receive a system of fundamental knowledge and advance on their basis to higher areas of cognitive abilities, the acquisition of stable skills. It can be assumed that, unlike the methodology used at the present stage based on the interdisciplinary idea of math and computer science teachers training, in the context of digitalization in all the spheres of human activity, the opportunity for continuous replenishment of fundamental mathematical knowledge baggage is expanding. It becomes possible to do this systematically, non-linearly, spirally, at different levels, in the course of continuous education and self-education of the teacher, the teacher's applied use of mathematical knowledge in solving a number of pedagogical (processing the results of a pedagogical experiment, etc.) and applied practical tasks (programming, mathematical modeling, big data analysis, understanding artificial intelligence technology, augmented reality and virtual reality, cybersecurity and other aspects of digital reality) (T. Scheiner et al. [52]), i.e. on a transdisciplinary basis.

Transdisciplinarity with practice-based learning, in turn, is revealed in the formation of a person's willingness to solve complexly set real tasks based on the formed knowledge system and acquired experience of activity. The solution of a complex practical problem is based not only on knowledge, but also on understanding as a “process of recursive circular motion, taking into account immersion and work not only at the semantic level, but also on the historical and psychological, taking into account the socio-cultural context” [12, p. 120].

It should be assumed that after studying, for example, the theory of differential equations, having mastered the implementation of algorithms for finding solutions to a classical list of problems, students are not always ready for interdisciplinary research based on them, for example, related to the simulation of a real process or object, requiring the ability to
think, reflect, reflect, and moreover, to use systematically an integrated knowledge from various disciplines: higher mathematics, theory of differential equations (mathematical tools), computer science and ICT, programming (special simulating software tools and programming technologies), fundamentals of systems theory (allowing through analog processes to conduct a targeted study of the structure and functions of a real complex process in computer memory in the “simulation” mode, optimize some of its parameters), optimization theory (choosing the most rational solution).

N. S. Veremchuk [4] notes that today such forms of educational organization are relevant, in which the assimilation of knowledge can be combined not only with the practice-oriented nature of their provision, but also with the need to adapt the acquired knowledge to the needs of practical activity at a specific stage. One of such approximation forms is project activity. However, in our opinion, its essence should be rethought today in terms of paying attention to fundamental knowledge. The transition from conceptual-concrete to abstract-conceptual thinking, understanding of cause and effect relationships, the formation and formulation of detailed, reasoned judgments form the basis for the formation of students’ ability to qualitative analysis, comparison and generalization based on the identification and understanding of the phenomena essence. The foundation for this is the conceptual and logical systematization of educational information, supported by a teacher and appropriate teaching methods, including in a digital educational environment.

Today, mastering many ways and techniques of thinking, distinguishing these methods, and understanding the boundaries of their applicability are in demand. In this sense, scientists suggest paying attention to such ways of organizing educational activities that allow developing a transdisciplinary level of thinking, considering thinking as a tool, as a life skill, as the logic of performing an action, assuming the integration of fundamental knowledge, practical skills, digital competencies and interdisciplinary communication of disciplines [4]. Besides, special attention needs to be paid to the organization of reflection, the search for ways to increase rationalization, productivity, and success of activities. In this regard, we draw attention to the fact that the idea of transdisciplinarity can be traced in the theory of successful activity (praxiology), which at one time became the basis for the formation of the praxiological approach as a special way of analyzing and explaining human activity in terms of its expediency, rationality, effectiveness. Praxiology is positioned as a general theory of effective (“serviceable”) organization of activities, which covers three groups of problems: analytical description, characterization, classification and systematization of practical actions; study of conditions and laws determining the effectiveness of actions; study of the genesis and development of various types of activities, ways of their improvement and regression, driven by the power of tradition and ingenuity. Thus, praxeology has become a discipline synthesizing data from various sciences related to the organization of labor. It combined only what was applicable to any activity and had a universal character. "Praxiology is a typical model of organizational science with a tendency to the development of practical advice, with the assimilation of data from dozens of sciences, with the systematization of these data from the point of this activity field tasks view" [25, p. 18]. For example, transdisciplinarity in the simulation modeling of a process or phenomenon allows to take into account different ways of specification (choosing the type of model) and analyzing the results, building models of almost any real processes. In turn, this requires a baggage of fundamental knowledge from a different range of sciences (natural sciences and humanities), practical experience and observations, knowledge of the functionality of the programming environment, understanding of interdisciplinary interaction. All this in a
complex will allow to solve the problem of mathematical modeling expediently, efficiently, technologically, rationally, valeologically, etc. In this regard, we will adhere to the main provisions of pedagogical praxiology in characterizing the practice-oriented learning in the context of transcendence.

Understanding the essence of transdisciplinarity as a social phenomenon requires paying attention to word formation and the history of this concept emergence. Transdisciplinarity is often identified with interdisciplinarity and multidisciplinarity, since the consonant reading and semantic context of all three concepts presupposes going beyond disciplinary boundaries. Meanwhile, transdisciplinarity is radically different from multidisciplinarity and interdisciplinarity in its purpose. Interdisciplinarity and multidisciplinarity concern the transfer of methods from one discipline to another, allow you to go beyond disciplinary boundaries, but remain within the framework of disciplinary research. In 1988, the Charter of Transdisciplinarity was founded. It notes that reality is multilevel and each discipline studies only one of its levels. In contrast, transdisciplinarity seeks to understand the dynamics of the process at several levels simultaneously, combines fragments of reality studied by specific disciplines into a single picture. The prefix trans- refers to what is simultaneously between different disciplines and beyond each individual discipline. Transdisciplinarity combines disciplinary research on the principle of complementarity. Sometimes it connects what, from the standpoint of private disciplines, would be considered as the opposite. Transdisciplinarity tries to understand reality in its complexity. This approach becomes relevant in a situation where there is a need to implement coordinated actions, achieve mutual understanding, and develop common norms of behavior in solving complex tasks.

Proponents of transdisciplinarity L. P. Knyashchenko, V. I. Moiseev explain the difference between transdisciplinarity and interdisciplinarity as follows: “the situation of transcendence ... implies a violation of the scientific knowledge disciplinary divisions rigidity. They become “passable”, which contributes to the emergence of various kinds of systems “on top of the “disciplinary division”, “intersystem formations, extrasystems, etc.” [15, p. 23]. As B. Nicolescu notes, transdisciplinary research is clearly different from disciplinary one, although they fully complement each other. Disciplinary research concerns, at best, the same level of reality; and in most cases it concerns only fragments of an only reality level. On the contrary, transdisciplinarity concerns the dynamics generated by the action of several levels of reality at once. The discovery of this dynamic necessarily goes through disciplinary knowledge. It is important to realize that disciplinary and transdisciplinary knowledge are not antagonists, but complement each other. Both of their methodologies are based on a scientific approach. The formation of transdisciplinary thinking at the university is our main task today.

In order to study a new, transdisciplinary education, we must understand what a transdisciplinary methodology is [26]. Transdisciplinarity characterizes such studies that go beyond the boundaries of many disciplines, go beyond specific disciplines, which follows from the very nature of the prefix “trans”. At the same time, the disciplinary and transdisciplinary approaches do not contradict, but complement each other. Transdisciplinary are such cognitive situations in which the scientific mind is forced, in search of integrity and its own validity, to “make a transcendental shift into a sphere bordering on the life world” [14, p. 18]. The transdisciplinary approach provides an understanding of the modern world based on the idea of a comprehensive knowledge unity. The integrative tendencies of society expressed in the methodology of transdisciplinary discourse, integral, interval and subject-oriented approaches, the logic of the “included third”, level approach, network models of rationality, unity of fundamental and applied are emphasized in the updated version of the
Charter of Transdisciplinarity from 2009, posted on the web portal of the same name (http://www.td-science.ru/). The authors of this version of the Charter of Transdisciplinarity, L. P. Kiyashchenko and V. I. Moiseev [15], note the emergence of a new dimension – “theoretical-practical” – the poles of which are in constant network relations of mutual foundation, the inclusion of humanitarian values in scientific research.

Thus, the transdisciplinary approach allows to solve poorly structured problems of science and society by forming a unique method for each complex scientific problem. The approach promotes a deeper study of the object, allows you to formulate problems in a new way, opens up new prospects for the study of long-studied, promotes the integration of natural science and humanities knowledge based on a solid methodological foundation as well as opens up new prospects in the study [20]. Transdisciplinary knowledge should help in solving complex problems. They allow us to take into account a variety of ideas about the problem, to link abstract and scientific knowledge, theoretical knowledge and practice. On the basis of such unity, a holistic understanding of reality arises.

Transdisciplinary research is mainly of a project nature. According to A. A. Trifonov [36], in the educational process, design and research activities are the leading means of developing transdisciplinary thinking. The educational project is based on the convergence of theory and practice, knowledge and its application in a particular context, search and research and creative transformative activities.

J. Freissin formulates the principles of transdisciplinarity in his work [37]. They are of interest to our research in terms of understanding possible ways to integrate fundamental and applied aspects in the preparation of a future teacher. Special attention is paid to the synergetic tendency of the principles’ formulations. A similar idea was reflected in the studies conducted by the following scientists: N. N. Davydova [6], who positioned synergetics as the basis for managing educational systems, V. G. Budanov [3], who considered it as the basis for synergetic modeling of the humanitarian sphere, E. N. Knyazeva [13] and S. P. Kurdyumov [13], who choosed synergetics as a means of integrating natural science and humanities knowledge, and other authors who developed ideas about the integration of knowledge from different subject areas and wrote about the need to identify common grounds for their unification. Scientists believe that such basic concepts can be a system, a process, competition, cooperation, self-organization, organization, evolution, etc. (concepts of the system-synergetic approach), applicable to the study of various phenomena and processes to describe the behavior of complex systems. These are the ones that can become integration invariants today, representing a natural basis for understanding the kinship of different nature systems, the common mechanisms of their development and interaction. They are a core and act as integrators in the process of combining different subject areas.

Developing this idea, S.B. Ignatov and V.A. Ignatova [9] state that the adaptation of systemic synergetic approach ideas in the content of education translates the integration of diverse knowledge to a higher methodological level, which gives the content a transdisciplinary character using the concepts, methods and cognitive models of this approach not only in simultaneously studied disciplines, but also and in the subsequent training. L. P. Kiyashchenko, V. I. Moiseev note that the transdisciplinary approach “brings together philosophical, theoretical and practical streams... the concept of transdisciplinarity has not so much an applied aspect as a fundamentally existential one” [15, p. 29].

Today, transdisciplinarity is also discussed in the field of higher education: the general concept of transdisciplinarity of education (I. A. Kolesnikova [16]); creation of transdisciplinary pedagogical education system (O. V. Krezhevskykh [17]), the choice of organizational forms
and models of transdisciplinarity (N. R. Sabanina [29]), qualitative results of a transdisciplinary approach application in education (Y. V. Sorokopud [32]). The issues of transdisciplinarity are also reflected in a number of dissertation studies. Thus, V. V. Vikhman [5] presented the concept of transdisciplinary research for education, built a transdisciplinary theoretical image of education as a complex self-developing research object capable of continuous transformations in conditions of real social changes and challenges of digital transformation.

According to I.A. Kolesnikova, transdisciplinary discourse is a necessary foundation for the construction of a modern theory of continuing education. In her research, she points out the need for a special organization of cognition, logic and structure of referring to other fields of knowledge in the study and description of an object, suggests considering transdisciplinarity as a strategy for studying and describing the phenomenon of the "knowing person", interpreting the nature of modern educational processes and mechanisms of their continuity, designing the content and methods of education for all the ages, oriented the formation of complex (transdisciplinary) thinking and the ability to complex (transdisciplinary) communication [16, p. 20].

O. V. Krezhevskykh justified the transdisciplinary education of future teachers at the university and the development of practical recommendations for universities on its implementation, concluded that transdisciplinary education involves the development of the educational system in the direction of accepting its nonlinearity, strengthening disciplinary flexibility, ethical and cultural diversity in the academic framework, simultaneously with practical orientation to ensure the readiness of future teachers to solve real complex problems that do not have functional sovereignty [18, p. 8].

The autonomous non-profit organization Institute of Transdisciplinary Technologies (Russian School of Transdisciplinarity) has planned to implement the project “Formation of a systemic transdisciplinary worldview in higher education” in 2023-2026. The purpose of this project is to provide students, teachers, scientists and practitioners with information about transdisciplinarity as a modern way of expanding the scientific worldview, allowing them to form a unified image of complex multifactorial problems of modern society and a methodology for solving them.

Transdisciplinarity contributes to a deeper understanding of the object, allows you to formulate problems in a new way, and becomes a methodological basis for the integration of natural science and humanities knowledge. This approach is especially relevant in the context of digitalization, since many issues require understanding in the context of natural sciences and humanities, for example, the use of artificial intelligence technology.

Let’s pay attention to the statements of Y. V. Sorokopud about transdisciplinarity. She says that “the aim of higher professional education is to develop students’ special transdisciplinary worldview, teaching skills of reproduction, explaining disciplinary knowledge through the prism of transdisciplinary patterns and models of reality, gaining experience in applying a transdisciplinary approach to solving complex multifactorial tasks” [32, p. 160]. Future teachers will have the ability to analyze heterogeneous information, achieve unity in mastering the content of academic disciplines, and form an information culture of a special style of thinking. [10]. In this sense, the content of not one academic subject, but the all the disciplines of the block in the curriculum for the training of pedagogical direction graduates should be transformed within the framework of the transdisciplinary model. Thus, it is worth believing that on the basis of a transdisciplinary approach in education, by the formation of a broad scientific outlook, deep knowledge in a specific field, the ability to solve complex problems of a transdisciplinary nature, the fundamental knowledge of students will be ensured.
It should be recognized that the content of academic disciplines only demonstrates the possibilities of a transdisciplinary approach to solving complex problems. The transdisciplinary nature is also evident in the practice-oriented training of future teachers. Authors V. E. Zhabakov, V. G. Makarenko, G. M. Shakamalov notes in a monographic study that “the transdisciplinary approach to practice-oriented training is a system of theoretical, methodological and methodological-technological knowledge based on the position that the transdisciplinary approach is a way of expanding the scientific worldview in the direction of a research object single image, forming in a university graduate and a practicing specialist a conscious moral responsibility for the results and consequences of their professional activities on the basis of objective duty and obligation of elements-fragments of a single world” [8, p. 98]. The combinatoricity of experimental, research and design research activities are highlighted as trends in practice-oriented training of masters; the main idea of transdiscillarity in practice-oriented training, according to the authors, consists in the use of counseling as a special way of interaction between a teacher and a graduate student; the use of a teamwork resource in the implementation of various techniques and technologies in teaching training in the intellectual technology of the implementation of “startups”. The solution of the problem of managing practice-oriented training for university students was carried out through the development of students’ ability to search for values through the use of “personality-oriented situations”, to assessment through the creation of evaluative transdisciplinary situations, to reflection through the creation of moral situations and value choice.

We believe that it is important to additionally provide students with the tools of successful activity. This can be done on the basis of studying the basics of praxiological theory, so that the future teacher can solve the tasks assigned to him or her rationally, efficiently, valeologically, technologically. The task of pedagogical education is to train future teachers to reflexively evaluate the formed practical skills and acquired experience based on the ideas of the praxiological approach, to carry out corrective procedures to increase the productivity of their actions. Such practice-oriented technologies as the creation and conduct of master classes, case studies, project activities, solving non-standard and creative tasks of an integrative type, project activities are becoming relevant. Mentoring, simulation modeling of professional activity, trainings, co-education to expand the opportunities for early immersion of future teachers in the professional environment, and the acquisition of practical experience can be attributed to the relevant practice-oriented formats of interaction of future teachers [47].

We conclude that the transdisciplinary approach in education contributes to the convergence of the fundamentality and practice-oriented orientation of education through a holistic representation of the education system in the context of social development and the transition from views on education as a closed system to a process vision of education development as a response to the challenges of society to the creation of educational environments, including digital educational environments. Education, as a system open to society, appears in the form of a dynamically developing structure, the development of which is carried out in innovative activities, a change of strategic directions, the introduction of modern information and communication and digital technologies. Transdisciplinarity implies the involvement of concerned parties in defining goals and strategies for the development of teacher education on a collaborative basis. In this sense, such an approach finds common ground with the ecosystem approach, which positions teachers as subjects of digital educational environment in the context of digitalization.
The fundamental nature of education presupposes the strengthening of the relationship between theoretical and practical training. The transdisciplinary allows to implement the principle of fundamental and applied orientation of learning, which implies the link between learning and life, the connection of theory with practice. The meaning of the fundamentalization of education involves the transformation of education into a genuine foundation of material and spiritual, theoretical and practical activities of people, including applied, methodological, technological, personal knowledge about actions.

The practice-oriented nature of education focuses on the teacher’s readiness for active professional activity, the formation of skills to use subject knowledge to solve problems arising in practice; the development of the need for continuous self-education, self-improvement, self-realization; the assimilation of independent activity methods.

Summarizing all that has been said, we can represent the interaction of the fundamentality and practice-oriented pedagogical education in a transdisciplinary understanding as follows (see Fig. 1):

![Figure 1](image)

**Figure 1** The scheme of the relationship between the fundamentality and practice-oriented pedagogical education in a transdisciplinary understanding

The results of our study support the idea expressed by I. V. Levchenko that “further development of education is impossible without strengthening its fundamentality, the systemic characteristic of which is the orientation of learning to comprehend and use deep, essential, system-forming foundations and connections between various processes of the surrounding world” [19, p. 2]. It is noted that “fundamental education involves the creation of a holistic picture of the world in the minds of students”. As A. G. Pashkov rightly notes, “the desired changes in reality, the creation of new ideas and images are possible on the basis of a deep understanding of specific subject area essences, reflected in concepts, patterns, principles and other theoretical constructions. This explains the fact that the neglect of fundamental knowledge in favor of applied and practice-oriented breeds amateurs and simply incompetent people” [27, p. 107]. Besides, the processes of fundamentalization of education presuppose that the teacher has appropriate methodological training in order to ensure the his or her activity in teaching students the fundamentals of science, forming
their readiness for the systematic use of knowledge and skills in the field of a particular subject in the study of other disciplines and in subsequent work. The conclusions drawn are logically consistent with the ideas expressed by L. Y. Monakhova, V. S. Fedotova about the praxiological foundations of the teacher’s professional standard through a comparative analysis of its requirements and the fundamental ideas of praxiology – the general theory of successful activity [25], as well as with E. A. Maralova’s assessment of the praxiological approach paradigm as the basis for successful practical professional activity of teachers [22].

CONCLUSION

Our research, devoted to the transdisciplinary understanding of teacher education, led to the conclusion that the fundamentalization and practice-oriented education are linked in the professional training of future mathematics teachers and allowed us to formulate a number of key provisions:

• transdisciplinarity is a modern trend in the development of pedagogical education, it allows us to reveal the phenomena and processes of the educational process and society in unity, integrating and combining fundamental knowledge of subject, psychological, pedagogical, socio-economic and other modules into a system on a single methodological basis;
• transdisciplinarity implies a deeper level of integration, a synthesis of truth-oriented fundamental scientific research and research aimed at obtaining a useful applied effect;
• transdisciplinarity makes a link between theory and practice, knowledge and understanding, touching them in different projections;
• transdisciplinarity ensures the formation of a broad outlook, a comprehensive consideration of problems from the positions of different sciences, to understand their complex nature, to combine theory and practice, the formation of students’ holistic, systematic view of their future profession, the teacher’s place in it and in society, including as part of the educational environment;
• transdisciplinarity allows to strengthen the fundamentality of education by integrating various disciplines with logic, argumentation theory, systems theory, the basics of critical thinking, mastering new cognitive schemes for mastering educational material, develops the skill of searching for a fundamentally different view of the object of study; allows to deepen the practice-oriented training by simultaneously “living” and “understanding” practice, improving the success and productivity of activities based on the theory of successful activity (praxiology) and the praxiological approach;
• transdisciplinarity is considered as a hybrid of fundamental research focused on the knowledge of truth and research aimed at obtaining a useful effect; “a hybrid of a theoretical solution to a problem and its practical application” [24];
• transdisciplinarity allows to integrate two types of knowledge existing in science into the professional training of math and computer science teachers: 1) objectified cultural and historical knowledge, well-founded, reliable, true ideas about the world, practice-tested results of reality cognition, characterized by evidence, certainty, verifiability, consistency, reflexivity, openness to criticism, methodological approach, ability to change and improve; 2) subjective and personal knowledge, which is the result of scientific research and educational and cognitive activity, that is, the intellectual work of an individual. Such knowledge forms within a person, it borns and
grows within a person as an understanding, preservation in memory and the ability to reproduce the facts of science and the concepts, laws, conclusions arising from them. Such knowledge has an activity character, as a result of mental work, it leads a person to creative and productive activities, ensures the success of cognitive and practical actions. This fact once again emphasizes the importance of transdisciplinary convergence for fundamental and practice-oriented aspects of teacher education.

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