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Фундаментализация профессиональной подготовки будущих учителей математики и информатики в условиях цифровизации

Актуальность. Учителя математики и информатики играют важную роль в формировании у школьников фундаментальных знаний, которые проявляются в виде глубоких теоретических знаний, готовности применять их на практике, критическом отношении к информации, творческим подходом к выполнению действий. В условиях цифровой трансформации фундаментальные знания позволяют личности принимать активное участие в жизни современного общества и генерировать новые решения в незнакомой ситуации.

Цель статьи заключается в определении стратегий профессиональной подготовки учителей математики и информатики в условиях цифровизации образования, готовых к реализации учебного процесса в школе с уклоном на передачу фундаментальных знаний.

Методология и методики исследования. Методологическую основу исследования составляют: идеи системного подхода при определении новой роли учителя как субъекта цифровых образовательных экосистем; идеи средового подхода в характеристике потенциала цифровой образовательной среды; идеи деятельностного подхода в подготовке будущих учителей математики и информатики к формированию у школьников системы фундаментальных знаний.

Результаты исследования представлены описанием цифровизации как современного тренда модернизации образования, определением сущности фундаментализации образования, установлением взаимосвязи между этими процессами. Приоритетами цифрового образовательного пространства, позволяющими сделать работу учителя математики и информатики по формированию у школьников системы фундаментальных знаний более результативной, рациональной, динамичной и творческой, обозначены непрерывная онлайн-поддержка образовательного процесса, доступность качественного, верифицированного и вариативного образовательного контента, персонализация образовательной траектории каждого обучаемого, оперативная обратная связь и мониторинг его учебных достижений, гибкость образовательных программ, возможность создания устойчивой мотивации и поддержки вовлеченности обучающихся в активную познавательную деятельность за счет использования новых учебных средств (виртуальные тренажеры и лаборатории), интерактивность, мультимедийность и гипертекстовость среды, автоматизация рутинной деятельности педагога и другие.

Заключение. Фундаментализация образования рассматривается как процесс формирования прочных, глубоких базовых знаний, определяющих научную картину мира человека и их интеграцию через межпредметные связи, позволяющих личности непрерывно заниматься самообразованием. Представленные результаты можно использовать при разработке образовательных программ педагогического бакалавриата, программ дополнительного профессионального образования, обеспечивающих обучение учителей математики и информатики, развитие их готовности к формированию у школьников системы фундаментальных знаний с опорой на возможности цифровой учебной среды.

Ключевые слова: цифровизация образования, фундаментальные знания, учитель математики и информатики, цифровая образовательная экосистема

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Fundamentalisation of professional training of future teachers of mathematics and computer science in the conditions of digitalisation

Relevance. Teachers of mathematics and computer science play an important role in shaping the fundamental knowledge of students. This knowledge manifests itself in the form of in-depth theoretical knowledge, readiness to apply it in practice, critical attitude to information, creativity in their actions. In the conditions of digital transformation, fundamental knowledge enables an individual to take an active part in the life of the modern society and generate new decisions in unfamiliar situations.

The aim of the article is to identify due strategies for professional training of mathematics and computer science teachers in the conditions of digitalisation of education, those who are ready to implement the educational process at school with a focus on transfer of fundamental knowledge.

Methodology and methods. The methodological basis of the research involves: systemic approach in defining the new role of the teacher as a subject of digital educational ecosystems; environmental approach in characterising the potential of digital educational environment; activity-based approach in training future teachers of mathematics and computer science towards enhancing their ability to form a system of fundamental knowledge in students.

The results of the study are presented by describing digitalisation as a modern trend towards modernisation of education, defining the essence of fundamentalisation of education, establishing the interrelation between these processes. The priorities of digital educational space helping to improve the work of mathematics and computer science teachers aimed at the formation of students’ system of fundamental knowledge, to make it more efficient, rational, dynamic and creative, include: continuous online support of educational process, availability of high-quality verified and variable educational content, personalisation of educational trajectory of each student, operational feedback and monitoring of learners’ academic achievements, flexibility of educational programmes, due potential to create sustainable motivation, support of students’ involvement in active learning through the use of new educational tools (virtual simulators and laboratories), interactivity, multimediaility and hypertextuality of the environment, automation of teacher’s routine activities, etc.

Conclusion. Fundamentalisation of education is viewed as a process of formation of solid, profound basic knowledge defining a person’s scientific worldview and allowing for integration of this knowledge through interdisciplinary links, enabling a person to continuously engage in self-education. The presented results can be used for the development of educational programmes of pedagogical baccalaureate, programmes of supplementary professional education providing for due training of teachers of mathematics and computer science, development of their readiness to form a system of fundamental knowledge in students relying of the digital learning environment resource.

Keywords: digitalisation of education, fundamental knowledge, mathematics and computer science teacher, digital education ecosystem

For Reference:
UNESCO pays marked attention to teachers and their professional development as a pillar for achieving the goal of sustainable educational development. At the September 2022 Education Transformation Summit, it was noted in the report “Transforming the education starts with teachers” (https://www.unesco.org/en/articles/transformation-education-begins-teachers) that high-quality education enables one to design flexible, adaptive educational systems. Qualified teachers are key agents of change in this direction. It is therefore important to make the teaching profession more attractive for the younger generation, thus addressing the teacher shortage problem, while older teachers can become mentors for new entrants. To this end, teachers should be provided with a comfortable working environment, a possibility of continuous advanced training, professional and personal development, to be able to engage in social dialogue and participate in decision-making in the sphere of education.

The proclamation of this year as a Year of Teacher and Mentor confirms the recognition of the social significance of pedagogical education at the current stage of social development. A number of planned activities (forums, film projects, conferences, competitions, exhibitions) are intended to enhance the prestige of the teaching profession, to recognise the special status of pedagogues, to multiply the traditions and popularise the heritage of pedagogical education, revive the interest in teaching and mentoring.

Against the background of general digitalisation which covers as well the educational space, an increasing number of scholars are aware of the need to return to fundamental education [20]. For instance, S.B. Maksyukova and D.S. Trukhmanov note that “the society needs professionals with a store of fundamental knowledge not only in their specialty but also in natural and socio-humanitarian sciences, which will allow them to engage in concept analysis and take responsible decisions in complicated situations” [17, p. 188].

The integration of new learning tools and educational technologies in the educational process – the facilities that have become possible in the digital educational environment (virtual trainers and simulators, virtual and augmented reality, cloud-based educational resources, etc.) – extends the options for presentation of training materials and their assimilation, diversifies communication and interaction methods. V. Shurygin and co-authors [38] note that mathematics teachers increasingly incorporate new learning materials in their classes: mobile applications, virtual reality and other achievements of global digital development. Modern schools are equipped with high-tech teaching facilities, broadband Internet and interactive teaching materials. It might seem that the level of acquisition of fundamental knowledge should naturally go up due to the provided opportunities and newly-created conditions in the modern information and education environment.

However, the actual practice of training mathematics and computer science teachers at the university demonstrates that a great number of future teachers who enter the university after school have gaps in basic knowledge. Consequently, the next, university-period stage of supplementing the basic knowledge in mathematics and computer science has no proper framework, has a poor foundation. Still, L.V. Konstantinova, A.M. Petrov, D.A. Shtykhno believe that, with a competent approach, the fundamental training disciplines at higher educational establishments can eliminate the shortcomings of the secondary education [9]. Professional training of a future teacher of mathematics and computer
science is a purposeful, specially organised educational process providing achievement of an appropriate level of pedagogical and subject-specific knowledge in mathematics and computer science, due abilities and skills as well as the development of future pedagogues’ personal qualities towards formation of their professional competence. At the same time, T. Scheiner et al. [39] note that, when assessing the level of fundamental mathematical knowledge acquired by a teacher of mathematics and computer science, one should remember of the cumulative nature of this knowledge, as concerns school-based mathematical training and academic knowledge gained from studying mathematics at higher educational establishments.

Fundamental mathematical knowledge represents a basis for programming skills, big data analysis, mathematical modelling, etc.; mathematics is viewed as a basis of digital-age competences [18] that allow in-depth understanding of the essence of digital transformation, promote logical thinking, the ability to separate key aspects from secondary ones, to abstract from unnecessary facts, to understand better the nature of various problems and the ways of their resolution, etc. [2]. Thus these competences represent a basis for assimilating the prevailing majority of core disciplines.

F.Ya. Ibrokhimovich [36] states that mathematics is a basis for the formation of a number of skills: analysis, synthesis, generalisation, comparison, abstracting and others. It contributes to the development of memory, attention, assiduity, perseverance.

It should be assumed that the fundamental nature of education presupposes continuity of general education and higher education programmes. The school provides one with a basis for understanding and commencement of work in a subject area, while higher education allows students to deepen their knowledge and develop the ability to apply it for the solution of specific tasks. The basic knowledge acquired at school becomes a basis for subsequent adjustment and complementation by new knowledge throughout one’s life. It is no coincidence that it is referred to as “fundamental” since it constitutes a foundation (solid and sturdy framework, reliable, thorough, profound wealth, inner asset of the individual). The both levels of education are interconnected and complement each other, providing a comprehensive basis for successful work in the professional sphere – teaching of mathematics and computer science. The system of supplementary professional education is an auxiliary step in complementing and updating the teacher’s professional store of knowledge, enabling the pedagogue to upgrade his/her qualification if necessary, to change professional orientation in accordance with the labour market needs.

The objective of the present study is the need for research towards identifying the promising areas of professional schooling of mathematics and computer science teachers with a focus on fundamentalisation of education against the background of digitalisation and development of digital education ecosystems.

Proceeding from the assumption that the teacher’s role is becoming more important in the digital educational environment, along with his/her responsibility for the results of educational activities and ensuring the appropriate quality of education as well as the formation of students’ fundamental knowledge, there is a need to conceptualise the methodological basis of modern pedagogical education. The authors refer to the essential characteristics of digitisation and fundamentalisation of education in order to establish the relationship between these processes and to gain scientific understanding of the issues involving professional training of future teachers of mathematics and computer science in the new conditions. Digitisation as a present-day trend in modernisation of education is considered against the need to preserve the fundamentality of education. The digitalisation
of education is treated as a new condition of professional activity set by the digital epoch, developing against the background of digital transformation of economy and social life. Based on the analysis of psychological and pedagogical literature, the authors define the essence of the concept “fundamental knowledge” as a set of basic acquired knowledge forming a person’s asset, providing a reliable support and appropriate level of general and professional culture, fostering methodologically significant concepts about the world and the laws of its functioning and development. “Fundamental education” is a process of acquisition of well-established and universal knowledge defining a person’s scientific worldview, stimulating commitment to continuous self-education, constructive activity, innovative thinking, promoting integration of knowledge through interdisciplinary links.

The aim of the research is to identify due strategies for professional training of mathematics and computer science teachers in the conditions of digitalisation of education, those who are ready to implement the educational process at school with a focus on transfer of fundamental knowledge.

The study addresses the following complex of objectives: 1) to outline the prospects of digitalisation of education on the basis of analysis of the potential of digital educational environment; 2) to characterise the distinctive features of fundamentalisation of education; 3) to explore the specifics of teacher’s professional activity in the conditions of generated digital educational ecosystems; 4) to formulate proposals for the use of digital educational environment at higher education institutions towards formation of fundamental knowledge.

**Materials and methods**

To solve the above-listed tasks, the following general scientific methods of theoretical research were used: analysis of scholarly papers by Russian and foreign authors on the given subject matter, analysis of social demands on pedagogical education in the conditions of digital economy, generalisation of practical experience of training mathematics and computer science teachers at Pushkin Leningrad State University (St. Petersburg). In particular, this study was based on conceptualisation of works by M.M. Abdurazakov, V.I. Antonov, D.D. Gadzhiev, E.I. Deza, L.S. Elgina, V.V. Laptev, N.I. Ryzhova, V.N. Maksimova, S.B. Maksyukova, D.S. Trukhmanov, E.A. Perminov, Yu.V. Romanov, N.V. Sadovnikov, A.I. Subetto and other authors, devoted to fundamentalisation of education; the papers by E.I. Skafa, E.G. Evseeva, Yu.V. Abramenkova, I.V. Goncharova devoted to training of new-generation mathematics teachers.

The teacher education development strategy was considered with regard for the main provisions of systemic, environmental and activity-based approaches allowing for new treatment of digitalisation towards making it useful for school education fundamentalisation through positioning the teacher as a subject of digital educational ecosystem. 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). The covered period is twenty years of working with students with regard for digitalisation trends in the educational space of the university.
It should be acknowledged that all necessary prerequisites and conditions for the introduction and subsequent development of digitalisation of education have already been created in Russia. According to the national programme “Digital Economy of the Russian Federation” and the state programme of the Russian Federation “Development of Education”, including the project “Modern Digital Educational Environment”, one of the national goals for the development of Russian education is the creation of modern comfortable and safe digital educational environment aimed to form due conditions for high-quality education and to secure proper training of highly qualified human resource for the digital economy. The purpose of digital transformation is to provide effective information support for the participants of educational relations within the framework of educational process organisation and management of educational activities. Digitalisation is positioned as a new stage in automation and computerisation of activities and their management, transition to digital technologies, their use for solving practical tasks, accumulation and analysis of big data for anticipatory measures, optimisation of interaction processes.

The strategic directions of digital transformation of education engender the need to create necessary conditions for due functioning of the electronic information and education environment that would include electronic information resources, electronic educational resources, a pool of information technologies, telecommunication technologies, appropriate technological tools. This environment would also ensure the learners’ full-scope mastering of educational programmes regardless of students’ location, as well as the use and creation of necessary unified services, including those based on the infrastructure of the federal state information system “Single portal of state and municipal services (functions)”. Today one can observed the development and realisation of the national technological online education platforms, with electronic information and education environment being supported and maintained for educational institutions. A unified digital educational environment has been created, with the core represented by the Federal State Information System “My School” which integrates disparate federal and regional educational services by becoming a single entry point to them.

In addition, the introduction of advanced digital technologies in education brings forth the idea of creating recommender systems and intelligent decision support systems as well as some promising methods and technologies (“Digital Student’s Assistant”, “Digital Parent’s Assistant”, “Digital Teacher’s Assistant”) based on artificial intelligence; use of the methods for intelligent analysis of significant information volumes towards support of managerial decision-making and data quality improvement (“Creation and Introduction of Management System in Educational Organisation”) involving big data technology; creating a student’s digital portfolio based on distributed registry systems and a digital educational content library grounded on cloud technologies.

Despite the problems discussed by the scholars [13], those faced by the educators in the process of digitalisation of education, one should note the technological capacity and didactic potential of digital learning environments [34]. Digital educational content is distinguished by interactivity, multimediality and hypertextuality, variety and mobility. As
Interactivity can support motivation and engagement, but interaction should be aimed at gaining fundamental knowledge. In the new digital environment, the psychological features of schoolchildren's perception of digital content are a subject of investigation. The didactic resources of digital platforms are outlined through solving the goals for intensification of students’ cognitive activity and their motivation for learning, diversifying the options for presenting educational information, ensuring the possibility of continuous self-education, designing individual educational trajectories, personalisation based on studying each child's digital footprint, creating adaptive learning environments using artificial intelligence technology, securing prompt feedback.

Owing to modern information and communication technologies, one can get access to integrated, blended and hybrid forms of education. Information and communications technologies are viewed as a technological basis for fundamentalisation of education, which results in renewal of forms, means, technologies and methods of teaching. Collaborative educational practices, earlier impossible, are emerging (within a region or an educational organisation) at different levels, allowing for the development of unique, transdisciplinary educational programmes organised according to the network principle. Network interaction arranges horizontal and vertical integration of different modifications into a single collaboration.

All these priorities of digital learning space make the teacher’s work more efficient, rational, dynamic and creative if their competent combination and meaningful use is provided. The modern educator has to work in this intensively changing digital educational environment. Modern society shapes the digital information character, social networking of different levels and purpose, strengthens horizontal and vertical interaction; heterogeneous network elements are in collaboration; multidirectional cooperation takes place. It becomes possible to create new networked communities, modern ecosystems capable of resolving important and complex problems. For instance, the “University 360” concept, as a modern model of educational ecosystem, brings together universities, educational organisations and providers of diverse educational content. The educational ecosystem in a networked society represents a large communication platform that is a host to intensive interaction and information exchange with a great number of subjects having common interests. There is an obvious need, in connection with the creation of digital educational ecosystems, to position the teacher as their subject. It has been noted the educational ecosystem creates an additional opportunity to meet the needs for multifaceted knowledge, skills and experience, including those provided by professionals and practical specialists.

The educational ecosystems as defined by I.G. Khangeldieva are treated as a new trend in educational development, a specific instance of ecosystems that “characterise organisational structures of modern business in the epoch of globalisation as designed on the principles of integration and cooperation” [32, p. 68]. The scholar considers them as instruments transforming the traditional educational paradigm and education model in the context of the coordinate system change and transition from sustainable, predictable, simple world to unstable, vague, complex and ambiguous community.

The digital learning environment provides a broad range of opportunities for globalisation of communication, diversification of learning tools, self-development and knowledge replenishment. However, vigorous and conscious activity in digital environment can only be based on fundamental knowledge which encompasses the
generalised theoretical knowledge revealing the content structure of a fundamental scientific discipline and due activity of presenting this knowledge. The problem of ensuring fundamentalisation of education in respect of strategies for digitalisation of education is becoming more relevant.

N.V. Sadovnikov characterises fundamental knowledge as “pivotal, system-forming, methodologically significant concepts, rooted in the origins of cognoscence, of primary essence” [24, p. 785]. At the same time, the author believes that fundamentalisation of education within the modern framework means orientation of education towards this generalised and universal knowledge, towards formation of general culture and development of generalised ways of thinking and acting as well as integration of education and science. In general, he is a proponent of balance and integration of fundamentality and professional orientation of education.

Of interest is the definition of fundamentality presented by A.I. Subetto who treats fundamentalisation of education in its essence as a “process of shaping the individual's framework of fundamental knowledge (the core of one's knowledge system) that determines the most important knowledge components forming a worldview at a personal level. This worldview forms the basic functions of orientation, forecasting, planning, designing, managing the future, communicating, interacting with people and also ensures a person’s ability for self-education within the framework of the continuing education “technology” and thus forming the personal adaptability potential, including professional adaptability, in the rapidly changing world” [26, p. 85].

V.V. Laptev and N.I. Ryzhova developed a concept for fundamentalisation of computer education and proposed its realisation at a pedagogical university. At the same time, the authors keep to the opinion that “fundamental knowledge reflects the foundations of the subject area within a taught discipline which include ideals and cognition norms of this subject area, its philosophical foundations and local worldview” [11, 126]. They note that today, due to the need for students to master digital literacy, “the role of fundamental sections of computer science within the content of academic subjects ... at higher education institutions and in the structure of school computer science course is increasing” [7, p. 16].

Fundamentalisation of education is viewed as acquisition of most stable and universal knowledge. The principle of fundamentalisation is traditionally linked with assimilation of theories revealing the main provisions of an educational discipline and constituting a system of theoretical knowledge [15]. The federal state standards of higher education offer an integrated combination of fundamentality and professional orientation of education. At the same time, fundamentalisation of education is aimed at fostering the students’ ability to independently set and efficiently solve any problems arising in uncertain conditions in different fields, on the basis of unchanging and systematised knowledge and developed skills. Fundamentalisation of education implies integration of courses and interdisciplinary links [17].

Against the background of automation, networking, platformisation, datatisation, robotisation, i.e. in the conditions of interdisciplinary integration of different sciences, the issues of fundamentalisation of education become particularly relevant [20]. This issue is particularly topical for future teachers of mathematics and computer science since the pedagogues will not only have to transfer the subject-specific educational information but also to coordinate the students’ lifelong learning trajectories in the digital environment, which would be impossible without solid basic knowledge. In this sense, fundamental knowledge represents their basic universal research toolkit.
According to V.I. Antonov, “regretfully, the school education reform undertaken in recent years has considerably downgraded the graduates’ level of schooling. By focusing on purely secondary matters, mainly on the forms and methods of objective knowledge control, we have stopped fostering students’ inclination for independent creative activity based on knowledge rather than familiarity with a discipline. However, whether we like it or not, life itself stirs a person’s urge for permanent self-improvement in conjunction with pro-active attitude. Otherwise, we would not be able to avoid mass-scale cataclysms (technology-driven disasters, road accidents) caused by unprofessional attitude” [2, p. 217].

Today, many authors [21] contemplate revision of the concept of “fundamentality”. They doubt that its scope can be described only by synonymous words of evaluation like “thoroughness”, “solidity”, “stability” and suggest that understanding of fundamentalisation of education should not focus too much on the level of acquisition of a particular qualification. Instead, targeted attention should be paid to the formation of independent social responsibility and the ability to take competent decisions by a person characterised by high professionalism and oriented towards humanistic ideals.

L.A. Trubina, E.L. Erokhina [28] call for a new treatment of fundamentality of pedagogical education, upraise fundamentality to a different, higher and professionally-oriented level implying not only sound profile schooling but also psychological, pedagogical, methodological and general cultural training. It is fundamentality of training that allows an individual to take active position in any environment: to take initiative, strive for self-improvement and self-development, be self-confident, be able to cope with difficult situations, “work productively in modern conditions of level- and profile-specific differentiation, variability of work programmes and manuals, widespread introduction and change of new digital technologies” [7, p. 17].

L.S. Elgina’s study [5] presents a similar idea of fundamentalisation of education as an optimal balance between theoretical and practical training of students in the process of education, which implies mastering the fundamental principles and laws of science along with compulsory study of the theory and methodology of an academic discipline.

I.V. Fotieva and T.A. Artamonova note that “rejecting the fundamentality of education, schools and universities do not provide a holistic worldview, but present a set of fragmented knowledge instead. At the same time, the ultimate goal of education does not suppose rearing a creative, knowledgeable, independently reasoning, morally mature and socially responsible personality” [31, p. 153].

Fundamental training implies mastery of general activities that provide solution to many specific problems in a profile field and help to describe the worldview through a subject area endowing one with specific knowledge. It promotes formation of a scientific worldview, fostering a person’s urge for self-education and constructive activity in the areas boosting scientific and technological progress, innovative thinking. The education structured on this basis has an anticipatory character since universal fundamental knowledge by its nature allows one to adapt quickly to changing situations, independently and promptly obtain the basic knowledge necessary for self-education, supplementing the existing system of scientific knowledge with the gained store. At the same time, the fundamental knowledge acquired in the process of education retains its relevance relative to both the future profile area and the whole range of related sciences, including natural sciences and humanities that form due professional skills, personal needs and responsibility to science and the society. The focus on fundamentalisation of education
sets the tradition for lifelong learning, develops the need for new discoveries, a person’s ability to navigate in the enormous flow of information inherent in the information society at the present stage of its development.

The research by E.I. Deza addresses improvement of fundamentalisation of mathematics teachers’ professional training. She notes that, while accentuating the issues of shaping a new-formation individual, we cannot forget about the need to provide him/her with a sound store of fundamental knowledge... Therefore, it is necessary to preserve the fundamentality of education" [4, p. 116].

I.I. Sokolova emphasises that “education is a socio-cultural phenomenon of great priority both for an individual and in terms of preservation and development of the society. Pedagogical education shapes a strategic resource for education as such – human resource; it is an accumulator and translator of socio-cultural values of the society... Modernisation of education as an institute should rely on preservation of its fundamentality and compliance with the needs of people, the society, the state and the demands of time” [25, p. 9].

O.N. Golubeva, A.D. Sukhanov [3] see the goal of fundamental education in providing optimal conditions for the development of flexible and versatile scientific mentality, for mastering the basics of scientific information and modern methods of cognising the reality, formation of internal needs for self-development and self-education throughout one’s life.

As is known, in order to ensure unified approaches to the content of practical, methodological and subject-specific teacher training, a harmonising foundation should be built, with the knowledge base and professional skills to be possessed by a graduate of a pedagogical field regardless of a profile. The authors provide a key list of modules that enable the teacher to meet the pedagogical challenges connected with education and development of the learner’s personality. It is necessary to note in the context of this document that professional training of future teachers of mathematics and computer science in the new environment should be aimed at teacher’s mastering the fundamental knowledge and the methodological means of designing pedagogical activities in the conditions of uncertainty, as well as the technologies for realisation of educational and pedagogical projects, the methods of handling specific pedagogical tasks through digital technologies and online services.

In the conditions of digitalisation and the trend towards fundamentalisation of education, professional training of future teachers of mathematics and computer science acquires new perspectives. It is necessary to focus on the strategy of teacher training development in terms of the ecosystem approach. This approach defines the transformational nature of digitalisation as development of digital educational ecosystems, involves dissemination of new forms of collective interaction and networking cooperation for lifelong learning, adaptation of education to modern realities of the digital society. At the same time, fundamental education remains a pivotal component of educational programmes, setting the prospects for the Russian education. Having a common basis – in-depth fundamental knowledge – fundamentality is a starting point for construction of individual educational trajectories. Their diversity is provided for by unlimited options of interdisciplinary links with regard for individual capacities, needs and abilities of an individual, permanently changing demand for qualified professionals having due skills in a situation of rapid professional upgrade. It is the fundamentality of knowledge that contributes to successful digital socialisation of the individual.
Considering digitalisation and fundamentalisation of education in conjunction, the authors agree with S.E. Mansurov’s thesis about “the transition of the teaching profession from conservative to a creative type, emergence of numerous new professional competencies for an educator, as concerns creation of personalised teaching scenarios, construction of network interaction paths in the information/educational environment, development of non-linear learning assignments” [16, p. 62], intended for providing due conditions for the formation of the fundamental knowledge system. Active realisation of modern information, communication and digital technologies as well as digital educational platforms in the context of their methodologically expedient application in education creates favourable conditions for fundamentalisation of professional training of future mathematics and computer science teachers. The teacher of mathematics and computer science, as a subject of digital educational ecosystems, will be able to successfully combine modern educational technologies with digital environment resources, ensure individualisation of student’s personal development on the basis of effective forms of interaction of digital environment components. In this situation, the role of digital educational ecosystems is secured by creation of individual personally-assimilated educational space contributing to manifestation of such qualitative characteristics of schoolchildren’s character as self-organisation, self-regulation and self-development. The educational infrastructure based on using the potential of digital environment aims at active inculcation of modern learning technologies in the educational process involving continuous monitoring and quality control of mathematics and computer science teaching – with the purpose to objectively evaluate the extent of learning materials acquisition and their influence on the results required for completing the curriculum, in order to timely update the subject content and organise corrective procedures towards improving the quality of assimilation of the basic knowledge. Fundamentalisation of education makes it possible to structure the educational process in such a way that students can develop new knowledge and skills independently on the grounds of basic, solid and systemic knowledge [23]. Fundamentalisation of education is realised through continuous self-education.

One can state, with regard to the school, that teachers are a driving force of the school education fundamentalisation process. Exercising the teacher’s mission implies a combination of high professionalism and fundamental education, which will enable a pedagogue to provide support for child’s ascent to the pinnacle of his/her development. In order to develop the creativity component in solving professional tasks, it is necessary to include future teachers of mathematics in project activities, including those involving the use of dynamic mathematics software [38, p. 212]. Moreover, as noted by S.S. Kulikova and O.V. Yakovleva, a teacher has to learn in the new digital environment how to organise, support and maintain the students’ educational activities, arrange network interaction, exercise control and assessment, create flexible personalised learning [10]. The digital educational environment in these terms is a means for training human resource for the digital society. In this regard E.Yu. Levina and co-authors [12] talk of today’s need to create educational ecosystems in which human congruity is the main principle of organising the educational processes towards providing appropriate conditions for training a teacher who is able to secure due quality of fundamental education at school.

The dissemination and widespread introduction of digital technologies nowadays makes one think of complementing this semantic structure with the adjective “digital” and talk about digital educational ecosystems. Digital technologies, with the help of
information systems and global data exchange, make it possible to pool the developers and the consumers of educational content into virtual groups, build cooperative vertical and horizontal links between the participants, use advanced pedagogical technologies and present high-quality educational content in accessible way. Thus, digital educational ecosystems allow to practically organise socio-professional partnerships in teacher training [29], turn the basic educational programmes and technologies of their realisation towards the needs of the modern school by extending the area of responsibility of officials interested in teacher training; arrange for future teachers’ mastering the techniques of efficient interaction with different actors of the educational process (students, parents, colleagues, administration), securing their readiness to design and organise the educational process in the conditions of digital environment.

It should be assumed that pedagogical education, in the context of general trend for globalisation of processes, transition to big data processing, use of distributed registry and artificial intelligence technologies as well as virtual and augmented reality and other digital innovations in the high-tech information environment, will develop in terms of the ecosystem approach which suggests that digital educational environment can become a kind of a “boiler” for continuous replenishment and acquisition of human knowledge in accordance with current demands of the society, being based on the system of fundamental knowledge. The creation of digital educational ecosystems becomes a prerequisite for the realisation of fundamentalisation of education. At the same time, digital tools are not a substitute for traditional tools. They are helpful for the organisation of educational process, secure a continuous educational process; moreover, they are used for acquiring supplementary education. The formation of digital educational ecosystems aims at continuous human development in line with modern realities and demands of the society in the conditions of comfortable and safe environment where subjects share knowledge continually and become sources of each other’s development. Knowledge is a holistic system that cannot exist without theories, ideas and facts. Knowledge holders are able to analyse, corroborate, generalise, deduce patterns, establish trends, etc. In turn, this means not only professional knowledge but also proper logical thinking and acquisition of research experience. The digital education instruments within their structure reduce the teachers’ workload in handling different systems, minimise manual data input, integrate disparate verified educational content by creating a single point of access to it, introduce digital technologies in the learning process accurately and precisely, ensure collection and processing of big data due to the integration of different information systems towards reaching informed managerial decisions, design individual educational trajectories, form a digital portfolio according to the principle of distributed register technology – in order to focus the teacher’s attention on fundamentalisation of education and transfer of fundamental knowledge. The leading principles of fundamentalisation of education in the conditions of educational ecosystems comprise self-actualisation of knowledge, creative nature of activity, interest in development of every member forming the ecosystem towards ensuring its sustainable existence.

The educational ecosystem represents a dynamically developing interconnected network of educational spaces; it encompasses individual and institutional education providers rendering a variety of learning materials for individual or collective learning formats throughout the whole cycle of the organisational learning process. At the same time, every individual is deemed to be unique, and his/her development is individualised,
being shaped simultaneously at several levels through personal experience, combining individual and team work. An ecosystem is an interconnected network that organises the lifelong learning process. Such systems are diverse, dynamic, evolving; they interlink the learners and the society and help to develop every learner’s abilities. The more important is the role of digital educational ecosystems in the support of multilevel cooperation and networking, since involvement of leading scholars and practitioners in the realisation of educational processes makes it possible to concentrate necessary scientific and methodological resources and create unique educational spaces [6].

The pedagogue, in the conditions of digital educational ecosystem, not only acts as a translator of the learning content but also sets due conditions for the formation of fundamental knowledge. The digital educational environment enables a future teacher of mathematics and computer science to maintain operational feedback with the students, provides an opportunity to build on the previous material that is shaped as a supplement to the traditional lecture course in the form of electronic learning aids; to refer to reputable manuals contained in digital library systems, to demonstrate practical application of knowledge in virtual laboratories, visualise the learning material in dynamic mathematical environment, take part in network projects and studies. Using the digital education-environment instruments in mathematical education promotes the formation of fundamental knowledge. For instance, the use of the dynamic mathematical environment GeoGebra contributes to the development of basic knowledge through improved understanding of mathematics, use of visualisation effects, construction of dynamic models, simulation of problem situations, search and interpretation of their solutions [37]. The issue of introducing augmented reality in mathematical education is becoming a trend [33]. Against this background, the activity of students immersed in the digital educational environment is not limited to searching and finding necessary information for getting answers to arising questions, but also involves reaching scientific substantiation, identification of logical connections; it is subjected to analysis, generalisation, formulation of own conclusions. The format of online conferences and streaming lectures through translation in social media enables the pedagogues to freely share their knowledge with a wide audience within the framework of popular science lectures on the key issues in mathematics and computer science. The basis of the listed actions is represented by the system of fundamental knowledge.

In general, the schooling of future mathematics and computer science teachers based on their mastery and subsequent use of fundamental knowledge [15, p. 189] will allow them to be ready to solve innovative digitalisation tasks under the condition of their continuous self-development as subjects of digital educational ecosystems. The following option can serve as an example: a person competent in fundamental mathematical knowledge can easily adapt to the labour market both in the profile field and at the interdisciplinary level, demonstrating the possibility of applying mathematical methods and models in practical spheres. Having due knowledge in computer science one can easily master digital technologies of virtual and augmented reality, artificial intelligence, Internet of things and other areas. Fundamentalisation of education in the conditions of digitalisation ensures flexible education and continuous demand for individuals having fundamental knowledge in the labour market. Teacher’s active and pragmatic position in the digital environment, evidencing his/her conscious use of its functional features, allows him/her to achieve high-quality educational results.
Discussion

The authors support V.A. Testov’s viewpoint that “fundamental education is a versatile schooling based on mastery of fundamental knowledge providing understanding of the most general basic laws of evolution, as concerns science and the society, and therefore immanently containing the potential for new knowledge and creativity” [27, p. 29]. Fundamentalisation of education provides the proper quality of knowledge, determining due social development progress and excluding the risk of civilisation disasters associated with low level of scholarship and culture in the society. In this regard, L.S. Elgina’s observation regarding fundamentalisation of education is noteworthy: she considers it as “an educational trend aimed at the formation of integral, generalising knowledge which represents the core and basis of all acquired knowledge and which integrates the knowledge obtained in the process of learning into a single world outlook system based on modern methodology” [5, p. 90].

We also agree with the opinion of M.M. Abdurazakov and co-authors [1] stating that mathematics itself as a subject is a universal language of analytical research, a tool for learners’ development and their adaptation in scientific, educational and practical spheres; it is deemed to be a school of rational thinking, in particular for pedagogues whose specialty is not on the surface connected with mathematics. Mathematics teaching process includes realisation of links with various disciplines; digital educational environment engenders new opportunities for demonstration of these links, which imposes additional requirements to teaching mathematics and to its systemic character, depth, completeness, relevance of the content – forming in the aggregate the fundamental nature of knowledge. Computer science has a general educational significance, contributes to the formation of information and computer literacy, development of information culture, establishment of moral, ethical and legal norms of working with information; formation of sound scientific world outlook and holistic scientific worldview, development of general academic and cultural skills of working with information; helps to prepare schoolchildren for life in the digital society and efficient professional activity, for acquiring mastery in information and communication technologies.

The present research is in line with the position of E. Wijaya et al. [40] on the need to train a new generation of mathematics teachers proficient in fundamental mathematical knowledge combined with well-developed methodological competence and advanced digital skills.

The present research is consistent with the principle of fundamentalisation of education which envisages selection of educational content at an appropriate level for due teacher training [30]; it agrees as well with the concept of fundamentalisation of mathematical education pointing at the need for interrelation of fundamental knowledge and practical experience [8].

V.A. Vasiliev, academician of the Russian Academy of Sciences, states that fundamental education is indispensable, reasoning that a narrowly focused specialist is orientated at actions practiced in fairly standard situations, at working with his/her subject area as a black box on the basis of empirical prescriptions; meanwhile unfamiliar situations require handling by people who know how this black box works (https://www.hse.ru).

The conceptual basis of the formulated conclusions in respect of the need to turn to the concept of “ecosystem” when considering the teacher of mathematics and computer
science as a subject of digital educational ecosystems, echoes the position of E.B. Puchkova and co-authors [22] who consider the ecosystem as a consistent interconnection of all subjects involved in the process of teaching and education.

The present research investigating the relationship between fundamentalisation and digitalisation, along with the conceptualisation of the issues addressing professional training of future mathematics and computer science teachers in the new conditions, makes it possible to draw the following conclusions:

- equal and unimpeded access to verified digital educational content proves to be a basis for students’ acquisition of profound and sound knowledge, which becomes possible in a digital environment thoroughly developed by specialists in a relevant field within digital learning ecosystems; unrestricted access to necessary information in real time;
- the present innovations engender the possibility to diversify educational technologies, learning tools, means of monitoring and assessment of learning outcomes in the conditions of digital educational environment, which provides multiple in-depth study of the educational material;
- fundamentalisation of education creates a unified system of views in respect of the need to master the system of fundamental knowledge; secures continuity of education towards achieving professional tasks solution efficiency and provides for individual’s creative lifelong development with predominance of self-education and individualisation of learning in line with the derived findings;
- digital learning ecosystems create favourable conditions for continuous self-education of teachers according to actualised needs of the society;
- the teacher of mathematics and computer science, as a subject of digital educational ecosystems, acquires a set of new digital competencies enabling him/her to productively use the digital educational environment tools towards formation of the learners’ fundamental knowledge and continuous self-education system, unlocking each student’s abilities, development of analytical abilities and critical mentality, formation of a personality ready for living in the high-tech digital world;
- the digital environment enables mathematics and computer science teachers to build networking communities based on the use of fundamental knowledge as a primary universal research toolkit;
- the future teacher of mathematics and computer science gains an opportunity to master new related activities pertinent for the digital society and to develop relevant digital skills in school learners on the basis of the formed system of fundamental knowledge.

Conclusion

The digitalisation of all spheres of human life requires revision of the model for training future teachers of mathematics and computer science in terms of preparing them for the realisation of fundamental knowledge. Fundamental education promotes the development of critical thinking, teaches to analyse information, see causal relationships and develop one’s own position on any issue. Shifting the focus from the instrumental and technological aspect of educational interaction to the content-value component is supposed to contribute to fundamentalisation of education, as concerns professional
training of mathematics and computer science teachers in the conditions of digitalisation. This is due to the fact that knowledge is absorbed and becomes an asset for an individual, acquires soundness and depth, when it is perceived with due meaning and understanding. The instruments and online services of digital educational environment can be used by the pedagogue expeditiously in terms of methodology for the purpose of conveying the system of fundamental knowledge and forming a value-based attitude towards the subject and content of mathematics and computer science. This knowledge is built on the study of historical aspects and aims to form students’ critical thinking, creativity and proper worldview, to explore the interaction of knowledge with other domains and its impact on cultural development and intellectual potential of the personality. In this process, the educator relies on general patterns and principles of teaching, skilfully chooses due methods, tools and forms of presenting the educational material that breed the students’ interest and desire to master it. Using the digital education environment tools, the teacher consolidates due application of knowledge in practice and controls the assimilation of basic knowledge by evaluating the student’s mastery of concepts, facts, scientific problem areas, theories, regularities and rules, methods and procedures; assesses the ability to design operational algorithms for the performance of specific actions, to model effectuation of actions, execute a set of assigned actions, engage in self-analysis in the realisation of different actions.

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