Data analysis in digital didactics: empowering human development

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Abstract: The article describes a model of didactics formed by the modern situation of changing technological, socio-economic and sociocultural structure (didactics of open education) as a system that maximizes the potential of digital technologies in the education system, turning them into tools for students to construct personal ontologies and models of self-determination.The purpose of the study: to study the changing didactic functions for human development in a digital educational environment.Research methods: the method of theoretical modeling, the method of comparative analysis, the method of structural and functional research of didactic functions, the method of generalization and systematization. The research was carried out on the basis of the methodology of the activity approach in education, on the basis of the theory of developmental education, on the basis of the concept of a person expanded by digital means. As a result of the research: the development of didactic functions of digital education has been revealed, they ensure the formation of the following abilities in students: - analysis and modeling of systems of various complexity; - development of fundamentally significant solutions and modeling of the process of their implementation; - designing your own life trajectory and managing its implementation.Научнаяновизнаиперспективыисследования: 1. Digital resources can be productively used only within the framework of those didactic systems that, in terms of their basic content, structure, and immanent mode of activity, correspond to the basic way of organizing cognitive and transformative activities set by digital platforms; 2. To the greatest extent, the educational potential of digital tools is revealed within the framework of didactic systems, which suppose students' independent reconstruction of complex ideas about reality, formation of self-determination on this basis and solution of fundamentally significant problems and tasks; 3. The use of digital resources in the education system should be organized through a system of programmatically constructed educational tasks.

Key words:ontological practices, technology of thinking, didactics of open education, digital educational technologies, data in education.

Introduction

The sphere of education fulfills an ontological function in relation to a maturing person – it provides the shaping of theirimage of reality (world picture). The fundamental aspect of this function is self-determination as a person's construction of an image of their own existence and action within personallyreconstructed system of activities and relations. Ontologization can be considered a system-forming criterion of educational activity in the proper sense of

the word, in contrast to systems of education, training and preparation similar to it, but differing in their sociocultural function [19].

In this regard, the didactic system is actually an infrastructure that ensures one's development and appropriation of certain type of ontology as a holistic view of the world. However, subject didactics, which is most widespread in the modern world, rather "breaks up" this integrity into separate segments. This situation is associated with the formation of subject didactics during the transition to the industrial era, when such a mechanical logic made it possible to maintain the integrity of the universe. However, for the modern sociocultural situation, the following question becomes urgent: how to combine the objective description of individual aspects of reality and the idea of the World as a whole? Sociocultural dynamics of the last 300-400 years shows that the collision of private ontological representations with a holistic image of the world, and their subsequent synthesis, become necessary and possible during the transition between cultural-historical, socio-economic and technological eras [3; 26]. A significant number of sociological and cultural studies show that at present (the first half of the 21[st]century) just such a transition is taking place [6; 22], forming a need for a holistic perception of the world in maturing people and a didactic system to match it.

The current technological, socio-economic and sociocultural transition is largely based on the explosive development of digital technologies and on their transformation into key tools in most areas of activity. Thus, one of the key trends in the development of the education system is digitalization: the implementation of most of the components on the basis of digital platforms or by using digital tools. But the question remains: to what extent do digital technologies introduced into the field of education determine the formation of a didactic system that allows students to reconstruct the World as a whole? As the data of a number of studies and observations [11; 20; 21] show, in a significant number of cases, the digitalization of education presupposes private improvements in the educational process within the framework of the existing, "segmented" didactics. At the same time, studies of a large number of educational practices show the significant potential of the digital sphere to ensure precisely the ontological function of education [e.g., 21]. In particular, they ensure the formation of the following abilities in students:

- analysis and modeling of systems of varying complexity;

- designing fundamentally significant solutions and modeling the process of their implementation;

- designing one own life trajectory and managing its implementation.

These functions of digital tools in education can be called expanding, that is, providing a transition from students' mastering of culture to the construction of a personally significant ontological model. However, the available materials show that digital technologies realize their expanding functions only when they are used within the framework of a corresponding didactic system.

This article is devoted to the reconstruction of such a didactic system, which would ensure the formation of personal ontologies by students, adequate to the modern economic and sociocultural situation, as well as the analysis of the possible "expanding" function of digital tools within the framework of such a didactic system.

Review of the literature on the article's subject matter

The proposed article is based on the following sets of literature:

1. Literature on the sociocultural foundations and situations of didactic systems construction. On this issue, there is a significant number of scientific works, both classical (for example, PF Kapterev [12]; S.I Gessen [4]) and modern. The latter illuminate both the fundamental principles of the sociocultural genesis of didactics (P.G. Shchedrovitsky[30], V.V. Matskevich [16]) and the models of the formation of its particular aspects (O.G. Grokholskaya [8; 9]; A.L. Mirzagitova [17], A.V. Khutorskoy [26] and others). As the main factors determining the emergence of new didactic systems, the new demands of the labor markets are mainly considered. Few authors, primarily S.I. Gessen[4], showed the presence of a mediating factor between the social determinants of didactic systems and didactic forms that implement the "social order." Such a mediating factor is the "anthropological project," which is simultaneously determined by the culture and the will of a particular person (his "self-image" according to S.I. Gessen).

2. Literature on ontological models of the functioning of the digital sphere

This set of issues has been covered by many social psychologists, philosophers and sociologists. The classics here are B. Latur [15], J. Zittrain [41], B. King [13], K. Anderson [31]. Among Russian authors, it is worth highlighting the works of A.G. and G.A. Asmolov [2], O. A. Grimova [7], I.M. Dzyaloshinsky [10]. Since the mid-1990s, the digital sphere has been analyzed from the point of view of the possibilities of new media and means of communication (M. Castells [32], J. Fornas [36], L. Lievrouw and S. Livingston [37], S. McMillan [38], M. Poster [40]).

In the 2010s, works began to appear showing how digital technologies change not only the communicative, but also material and everyday space of a person's life [34] and, ultimately, formtheirself-image and ideas abouttheirplace in social and sociocultural reality.

3. Literature on the role and place of digital technologies in the formation of new didactic systems.

This area is dominated by publications devoted to particular aspects of using specialized software products and mobile applications in teaching [for example, 33], as well as virtual and augmented reality [see systematized review in 39].

Among the authors of works offering comprehensive models of educational digitalization, can be named S.D. Starygin, N.K.Nurieva [23], M.A. Choshanova [27], S. Denninga [35]. All these authors demonstrate an orientation toward using the basic model of the work of a software engineer in the digital sphere in the general organization of the educational process: students must gain experience in implementing the logic in which digital developments are created in order to turn them into their own tools. This approach is based on the presumption of the dominant role of the teacher in the educational process, which contradicts the basic characteristics of the modern digital environment predicated on the most decentralized system of relations.

Research methodology and methods

Motivation of the authors of the article:

1. The article is intended to describe the main challenges and requirements formed by the modern socio-economic and sociocultural situation for modern didactic models.

2. The article is intended to describe the basic characteristics of a didactic system, which in modern conditions will ensure the formation of a holistic world picture in students (ontologization).

3. The article is intended to describe such conditions and methods of using digital tools in the educational process, under which they will provide the "expanding" nature of didactics.

The purpose of the study: to study the changing didactic functions for human development in a digital educational environment.Research methods: the method of theoretical modeling, the method of comparative analysis, the method of structural and functional research of didactic functions, the method of generalization and systematization. The research was carried out on the basis of the methodology of the activity approach in education, on the basis of the theory of developmental education, on the basis of the concept of a person expanded by digital means.

1. The article is based on the following methodological concepts:

a) The idea of personal ontology as a content-topological description of the space in which a person realizestheirown ideals and strategies based on them

b) Ideas of the relationship of each of the known types of didactics with a specific ontology and about the role of didactics in transforming this ontology into the basis for personal decisions and activities,

c) The idea of an open educational space as a system of resources for the construction of personal ontologemes by students,

d) Ideas of the digital sphere as a system of tools that allow a growing person to independently reconstruct reality, both in the data analysis mode and in the digital modeling mode of various systems of activity (O.A.Fiofanova [42], [43]).

2. To reconstruct the basic characteristics of a didactic system using the expanding potential of digital technologies, the following methods were used:

- systemic genetic and factor analysis;

- system-activity modeling;

- situational modeling.

3. To reconstruct the most productive approach to the use of digital technologies in education, the following methods were used:

- factor analysis of specific educational situations;

- mental modeling of the full cycle of using digital technologies to solve the problems of the educational process.

Research results

The transition between socio-economic, sociocultural and technological orders requiring new didactics is described by the model of "waves of economic development" proposed by N.D. Kondratyev and supplemented by their followers [14]. The average rates of formation, flourishing and decline of each of the economic orders described by

the "waves" make it possible to conclude that the next transition is to begin precisely at the beginning of the 2020s and will continue over the next 10-15 years.
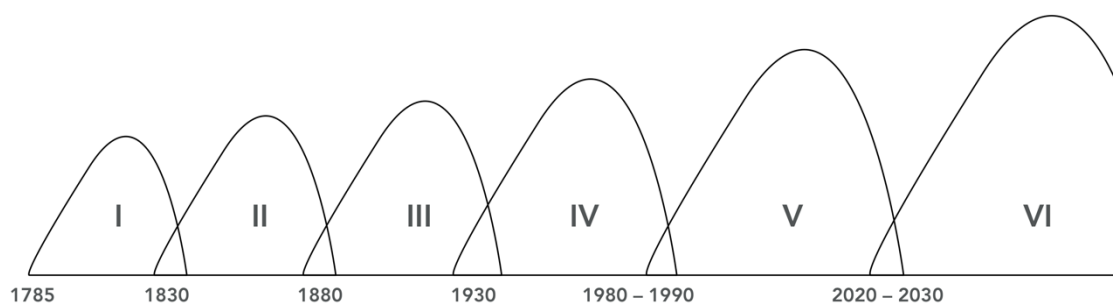

Figure 1. N.D. Kondratiev's economic cycles with an extension for the XX-first half of the XXI century.

Source: [Kondratiev N.D. [14]

According to a number of researchers, for example, V. Averbukh in his article on the prospects of the formation of the sixth technological order in the Russian Federation [1], the "ascending" order will be based on biotechnology, fine chemistry technologies, and space technology. At the same time, many authors [see, e.g., 5] argue that it is within this "wave" that digital technologies will finally form a universal toolkit and infrastructure for production and exchange.

It is important to note that Russian Federation in the near future will have to carry out two transitions between socio-economic orders at once. At present, the basic order of production in our country as a whole corresponds to the IV wave, according to the model of N.D. Kondratyev, and the V wave is just beginning to rise. For the speedy implementation of both transitions, it is necessary, in particular, to transform the basic paradigm on whose basis the education system actually functions: to change the formation of knowledge, abilities and skills for the development of competencies. Modern federal state educational standards (FSES) create a regulatory framework for this [25]. But for the practical implementation of this priority, it is necessary to construct a special didactic system that organizes such activities, within the framework of which, competencies are simultaneously realized and formed.

In turn, the new didactic system can be built only on the basis of the technology of thinking underlying the emerging socio-economic and technological orders. The concept of technologies of thinking as factors of the functioning of orders and transitions between them was formalized by P.G. Shchedrovitsky within the framework of the model of the main technological revolutions of the Modern and Late Modern periods [29].
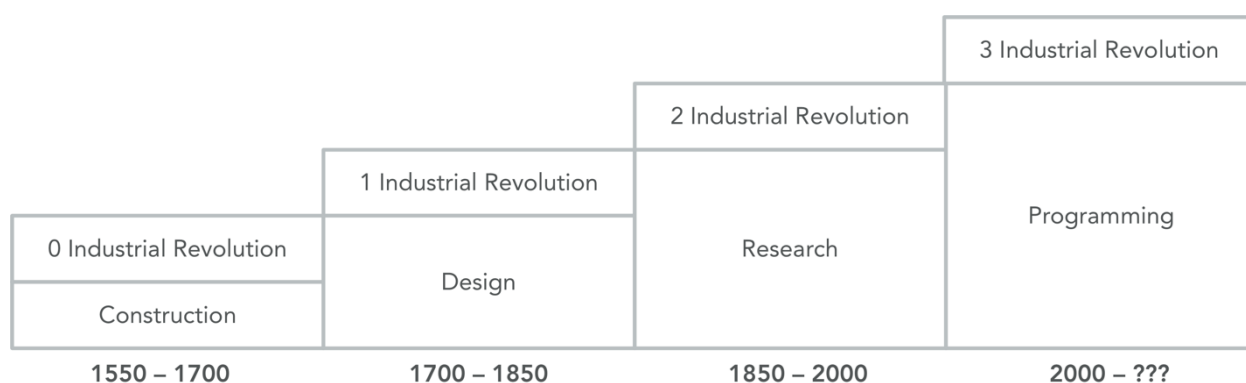
Figure 2. Industrial revolutions and the types of thinking that support them.

The industrial revolutions basically correspond to the "waves" of N.D. Kondratyev, but at the same time they combine several "waves," precisely on the basis of the technologies of thinking that are fundamental for them. For the preliminary technological revolution (1550-1700), the basic type of thinking was construction, that is, mechanical correlation and articulation of elements. The first full-fledged industrial revolution (1700-1850) was based on "design" as a way of generating previously non-existent, but demanded items. The second industrial revolution (1850-2000) was based on an exploratory type of thinking, involving the identification and capitalization of the fundamental laws of reality as factors of maximum economic development. And finally, the third industrial revolution, underway today, relies on programming as the basic technology of thinking.

A generalized scheme describing the integral act of thinking of the "programming" type was proposed by G.P. Shchedrovitsky [28]. It can be seen from it that programming involves the following main stages:
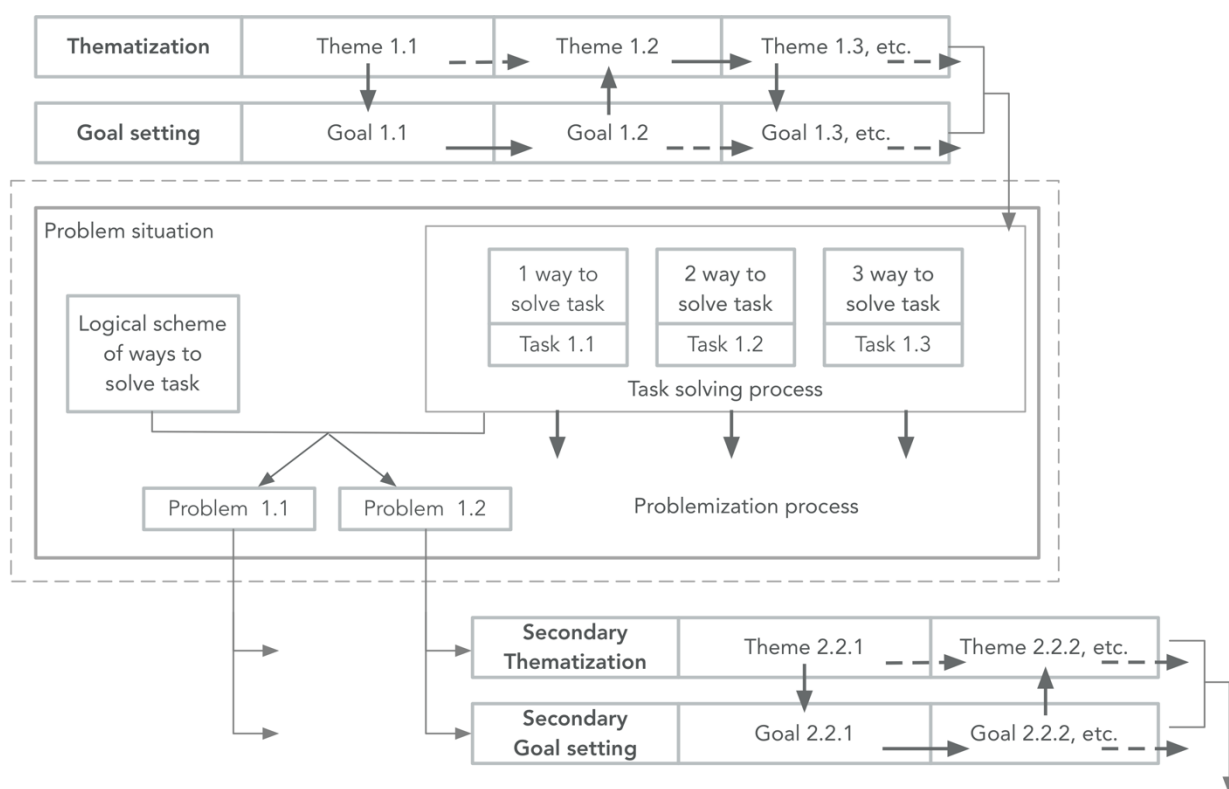
Figure 3. *Full cycle of programming as a type of activity, according to G.P. Shchedrovitsky*

- "conceptual phase": mastering the concepts of a specific subject or subject-practical area, in the mode of their reconstruction;

- "analytical phase," which involves a multidimensional description of the selected research subject; based on this analysis, goal-setting is then carried out;

- "modeling phase," which involves the analysis and design of ways to solve a problem situation.

To the maximum extent, the full cycle of programming as a technology of thinking is provided within the framework of open education didactics. Its main characteristics are the following:

- the basic activity of students is the construction of sociocultural objects – wholistic entities ensuring the design and implementation of fundamental sociocultural meanings and models of activity;

- the basic content of education is ontology construction practices – the implementation of sociocultural principles, components of basic ontology in specific problem situations.

Ontology construction practice as a constant recreation of ontologemes by students in connection with specific problem situations is directly related to the concept of the obviously problematic nature of reality, which is basic for modern ontologies.

The logic of ontology construction practice is shown in Figure 4:
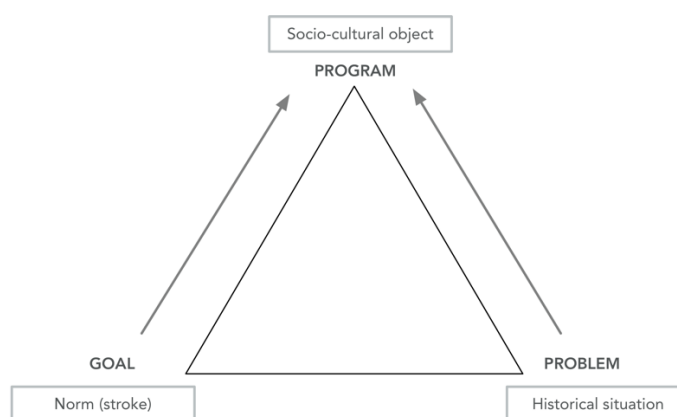

Figure 4. The scheme of the educational situation of development

Source: Popov A.A., Ermakov S.V.[18]

The main subject of mastery and transformation is an aspect of the current historical situation that is significant for students, presented in the form of a problem. This transformation itself is carried out on the basis of the norm of activity formed by the student for herself, on the basis of the ratio of cultural models of activity andtheirown intentions ("norm / stroke" on the diagram), which is formalized in the form of the student's personal goal regarding the problem. The main tool for solving this problem, and at the same time the main mediating link between the norm formed by the student and the basic historical situation, is the educational program, within which students work with sociocultural objects that correspond to their goal and basic problem.

The fundamental possibility of the existence of the didactics of open education was determined precisely by the diverse digital tools that made possible for students a practically unlimited mastering of reality in the greatest number of its aspects.

Digital tools that enable students to construct personal ontologies include:

- datasets representing certain phenomena in tabular format and in the form of images;

- an interactive computing environment for programming and working with data;

- spreadsheets for viewing and editing tabular data;

- programminglibraries for data analysis and visualization, for solving standard machine learning problems (clustering, regression, classification) and natural language processing.

But even these digital tools themselves can have their educational potential realized only within the framework of a didactic system that implements such an ontology that corresponds to the logic of the practical application of software developments. Thus, as shown by a number of examples in the collective monograph "Difficulties and prospects of digital transformation of education" [24], within the framework of classical didactics, digitalization is not only unnecessary, but rather destructive, since it deliberately problematizes the basic principles of this didactics (a single standard, a uniform structure of activity, etc.). On the contrary, within the framework of open education didactics, digital tools maximize their potential, since they are combined with the need to constantly reconstruct the current situation, build models for future action, and independently select optimal tools.

A key tool that turns digital technologies into a source of expanding nature of didactics is a system of educational tasks that actualize for students a certain ontology construction problem. The solution of this problem presumes a comprehensive study of a number of aspects of reality based on the maximum amount of data, followed by building a model and constructing a solution based on it, associated with the construction of a sociocultural object.

Let us consider the main precedents for using digital tools in the framework of open education didactics.

1. The program New Geography of the World, implemented on the basis of the applied information system Geoeconomics, Geopolitics, Geoculture.

This program was developed and implemented in the early 2000s as a tool for students to master the ideas of geographically localized economic, political and cultural systems as a space for designing and implementing their own life strategies focused on record achievements. The information system at the heart of this educational program offered students resources for exploratory analytic actions and for obtaining information needed to build personal strategies. The students operated with large amounts of information about the spatial location of economic, political and cultural processes, about the determinants and the logic of their course. The system ensured the formation of the following competencies:

- the ability to assess the regional / country / world geo-economic situation and, on this basis, make decisions regarding their further educational and then professional mobility;

- the ability to assess the geopolitical situation at different levels and, on this basis, take a productive civic position;

- the ability to assess the geocultural situation at different levels and, on this basis, choose the identification and positioning methods that are most promising in the near future.

2. Educational program Data-Campus, which presupposes the mastery of students of current methods of data processing and solving with their help practically significant tasks in analysis and modeling, combined with the educational program Russian competence Olympiad, which supposes the development of management solutions for urgent problems and models of activity corresponding to them. Such a combination of programs ensured the overcoming the speculative border between students' goal-setting and projects, on the one hand, and digital tools that ensure the solution of applied problems, on the other.

Educational projects of Data Campus relate to both STEM topics and digital humanities. Table 1 gives examples of educational projects implemented by the participants of Data Campus. It allows to assess the degree of complexity of the problems that the students actually solved, their significance in the respective fields of activity and the degree of cultural novelty of the knowledge they formed. It also shows that specific digital tools were not "assigned" to the students by the teachers, but were independently selected by them in accordance with the specifics of the task at hand (column "Methods mastered, Digital libraries").

Table 1Project name&Methodsdigital didactics

Project name	Methods mastered. Digital libraries.	Domain
Representation of regions in the federal news agenda 2009-2019 and thematic modeling of federal news.	Natural language processing	Communications
Screening for pneumonia by X-rays	Classification. Neural network.	Medicine
Identifying the genre of a painting from a photograph.	Computer vision.	Culture
Separate waste sorter	Classification. Neural network.	Ecology
Recommendations for the geographical application of solar panels for power generation	Linear Regression, Random Forest, Nearest Neighbor Methods	Fuels; Ecology
Predicting the winners of digital sports matches	Regression, Random Forest, xgb	Digital ecosystems
Computer vision system for unmanned mining dump truck	Computer vision, image segmentation	Industry, innovation
Analysis of factors affecting the popularity of mass online courses	Regression	Communications, Di ecosystems
Research of genre diversity and lexical complexity of books and statistics of book publishing for different age segments	Natural language processing	Communications

Source: [Compiled by the authors]

The principal didactic component of the educational programs New Geography of the World, Data Campus and other educational programs similar to them in structure and content is the final discussion by the students of their analytical and design-software developments with experts – active professionals in the relevant field. For example, expert evaluation of student projects within Data Campus is carried out by professional data analysts, which allows students to both correlate their trial action with the current norm and the needs of the relevant field, having received a detailed review from an active professional, and gain experience in filling a certain position in this area (or at least the experience of aspiring to one).

Discussion

In this article, in fact, for the first time, the technology of thinking is discussed as a factor mediating the influence of the current socio-economic and technological situation on the basic didactic system (previously, such influence was discussed either as direct or as mediated by a rationally formed social order of the state or parents).

In general, didactics is considered as a system of conditions for working with ontological representations. Such an approach may cause criticism, since, during the late XIX – entire XX century, didactics was considered as rather an epistemological tool, a set of tools for the formation of accurate and functional knowledge. However, initially didactics, in particular, the "Great Didactics" of Ya.A. Komensky [quoted by: 16, 30] assumed an indissoluble connection between ontology and epistemology, within which ontology still played a central role. And if for the most part of Modern times the picture of the world and the life position were constructed at the expense of strictly structured objectified knowledge, then in the modern situation this happens due to the development of complex problems (in a specific sphere or interspheric) and self-determination in relation to them. Similarly, if in Modern times the basic activity of students in the educational process was the development of immutable, standardized knowledge, then in the modern situation - the construction of personally significant socio-cultural objects, which is provided by the didactic model described in the proposed article.

Most of the authors, who previously considered the issues of digitalization of education as a factor of didactic change, proceeded from the fact that digital tools provide students with specific, often private and disparate, facts about reality, or make the process more attractive. In this regard, "by default" there is an idea that digital tools can act as a useful infrastructural "application" to any didactic system, regardless of its specific characteristics. The proposed article proves that in a number of didactic systems, full-scale digitalization turns out to be redundant and even harmful, since it sets different thinking technologies and activity models than those that are the basis of this didactic system and are reproduced by it. The parameters of the didactic system are shown, which, on the one hand, needs digitalization as an instrumental support, and on the other hand, realizes the educational potential of digitalization to the maximum extent. This potential itself, as follows from the materials of the article, consists in the possibility of independent research and modeling by students of complex objects and systems of reality, as well as units of activity, including those related to the implementation of their own plans, interests, values.

Conclusions

The above results of the study allow us to draw the following conclusions about the prospects for the formation of a new didactic system:

1. This system is most likely to rely on programming as the basic technology of thinking.

2. To the greatest extent, programming is cultivated within the framework of open education didactics, which involves the reconstruction and construction of sociocultural objects by students, and ontology construction practices.

The results of the study allow us to make the following assessments of the status of digital tools in the educational process:

1. Digital resources can be productively used only within the framework of those didactic systems that, in terms of their basic content, structure, and immanent mode of activity, correspond to the basic way of organizing cognitive and transformative activities set by digital platforms.

2. To the greatest extent, the educational potential of digital tools is revealed within the framework of didactic systems, which suppose students' independent reconstruction of complex ideas about reality, formation of self-determination on this basis and solution of fundamentally significant problems and tasks.

3. The use of digital resources in the education system should be organized through a system of programmatically constructed educational tasks.

The most obvious further areas of research can be identified as follows:

- correlation of the main characteristics of programming as a technology of thinking with the main models of activity, in the course of which digital tools are implemented; building on this basis the exact requirements for the development of educational tasks;

- to determine the particularities of using digital tools to work with different types of sociocultural objects.

Acknowledgments

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ПИСЬМО О ПРИНЯТИИ РУКОПИСИ К ПУБЛИКАЦИИ

Уважаемый(ая) Ольга Александровна,

Настоящим уведомляем, что рукопись Вашей научной статьи «**Data analysis in digital didactics: empowering human development**» (авторы: О. А. Фиофанова, А. А. Попов, М. Ю. Аверков, А. А. Дерябин, П. П. Глухов) была принята к публикации в материалах следующего научного мероприятия: **BiNE 2021: II Международная научно-практическая конференция «Большие данные в образовании: доказательное развитие образования»** (15 октября 2021 г.). Рукопись научной статьи принята по результатам независимого рецензирования. Рукопись научной статьи будет опубликована в книжной серии международного издательства «Springer Nature» (Германия).

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С глубоким уважением,

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