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Formation of Research Vision in Schoolchildren Using Digital Mediation Tools according to Cultural-Historical Psychology. Part 1

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The article sets a task to create and implement models of schoolchildren's development, which are based on the basic ideas of the cultural-historical approach proposed by L.S.Vygotsky's scientific school. The authors of the article believe that such models can help to overcome the limitations of explanatory models, this hypothesis is based on stimulus-reactive algorithmic strategies that negatively affect human development. Using the material of the project "Schoolchildren as Scientific Volunteers", the authors of the article show how this mediation model can be arranged uшmп digital tools and a system with elements of artificial intelligence. The project sets the task of forming a research vision (a new functional organ) in schoolchildren with the help of digital mediating tools. Using a cultural-historical approach to AI as a means of developing thinking and research skills while working with information, we propose to consider ethical AI frames as part of an educational environment that promotes the adaptation of risky technologies.. Critical analysis of risk-generating technologies has been developed in bioethics. As ethical guidelines, we use the principles of precaution and proactive response. This article is the first part, which describes the preparatory phase of the study. The second part will show how the project proceeded, what the first results were and what difficulties were met during the implementation of the tasks.

Keywords: cultural-historical psychology, mediation, functional organ, digital mediating tools, datasets, research vision, the project "Schoolchildren — Scientific Volunteers".

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Формирование исследовательского видения у школьников с использованием цифровых средств-посредников с точки зрения культурно-исторической психологии. Часть 1

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В статье ставится задача, связанная с необходимостью разработки и внедрения таких моделей развития школьников, в основание которых заложены базовые идеи культурно-исторического подхода, предложенные в школе Л.С. Выготского. Авторы статьи полагают, что именно с помощью таких моделей может быть преодолена ограниченность объяснительных моделей, в основание которых закладываются стимул-реактивные алгоритмические стратегии, негативно влияющие на развитие человека. На материале проекта «Школьники — научные волонтеры» авторы статьи показывают то, как может быть устроена модель опосредования, в которой используются цифровые средства и система с элементами искусственного интеллекта. В рамках проекта ставится задача по формированию у школьников исследовательского видения (нового функционального органа) с помощью цифровых средств-посредников. Опираясь на культурно-исторический подход к пониманию искусственного интеллекта в качестве орудия развития мышления и формирования исследовательских способностей и навыков в работе с информацией у школьников — научных волонтеров, мы обосновываем идею о том, что фреймы этического регулирования ИИ могут стать частью знаковой среды, в которой будет происходить культурная адаптация рискогенной технологии. Критический анализ рискогенных технологий разработан в биоэтике. В качестве этических ориентиров мы используем принципы предосторожности и опережающего реагирования. Данная статья является первой частью, в которой описана постановочная часть исследования. Во второй части будет показано, как протекал проект, какие были получены первые результаты и какие были трудности, связанные с выполнением поставленных задач.

Ключевые слова: культурно-историческая психология, опосредование, функциональный орган, цифровые средства-посредники, датасеты, исследовательское видение, проект «Школьники — научные волонтеры».

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Problem

Several contemporary authors have shown recently that in the context of digitalization and virtualization, numerous teachers, psychologists, and researchers studying the process of digital influence on children and adolescents have overwhelmingly relied on the explanatory models based on seemingly obsolete behaviorist ideas describing human actions in the categories of "stimulus-reaction", which have lost their research potency. In these models, students are viewed as reactive, passive individuals suffering from active, aggressive impact of "smart" gadgets. It can be inferred that children must be protected from these "aggressors" and prohibited from using them at school lessons, children's time on the Internet must be limited, etc. Digitalization has revived old behavioral patterns and models, rooting, as Yu.V. Gromyko put it, in the "digital-algorithmic approach", according to which the activity of a person (student and teacher) is first programmed, and then a digital platform is introduced to effectively manage their behavior, enabling the algorithmization of behavior [6].

Thus, a gadget is automatically assigned the role of an active subject. Several studies demonstrate how digital technologies (gadgets, the Internet) negatively and destructively affect children and adolescents, their stress resistance, their well-being, their sleep-wake routines; how the likelihood of suicide increases; how gadgets negatively impact cognitive abilities, significantly reduce verbal intelligence, and also worsen the dynamics of brain maturation in the areas responsible for speech, attention, emotions, etc. [3]. At the same time, however, the active role of a student and the role of an adult mediator are not discussed at all — as we are accustomed to describing the learning situation in terms of interaction between an adult and a schoolchild, through the prism of the "adult-child-psychological tool" mediation model, since development of this model in the pioneering works of L.S. Vygotsky, D.B. Elkonin and other authors of the cultural-historical approach [for more details see: 13; 14].

It is important to devise such learning models where a student is considered as a subject of development overcoming the stimulus-reactive behavior. Methodologically, we base such models on the cultural-historical approach (hereinafter referred to as CHA), developed by the Vygotsky school [6; 11; 12; 13; 14]. This approach has the necessary potential, through which it is possible to build new development models applicable to a mixed social-digital environment. CHA potential has been discussed by numerous Russian and foreign authors [6; 13; 14; 17; 22].

The mediation (a mediacy model developed within CIP framework) shows that with the introduction of digital means, the situation is aggravated precisely in the place that Vygotsky himself pointed out as the place associated with a child's mastery of his or her own behavior (affect) with the help of a psychological tool. L.S. Vygotsky insisted that a psychological tool differs from an external object-tool primarily in its orientation rather than the substrate. A psychological tool-sign is directed inwardly, at a person's mastery over one's passions and affects, one's genuine nature [2, p. 90]. Thus, through numerous acts of mediated mastery of an object and of oneself (starting with a spoon and ending with a number and a word), a person develops new functional activity organs, complex "psychological systems". In a broad sense, people do not have "organs" for reading, writing, counting, just as there are no organs for understanding, reflection, thinking. They are formed as special "functional organs". The latter are not concentrated in the brain. It is not the brain that is responsible for the act of thinking, but the psychological system, built through numerous acts of mastering.

What does it mean — mastering one's behavior? It means that a person (a child), with the help of an adult intermediary, develops a method of action using a tool and, therefore, forms his or her own subjectivity. When mastering a method of action, the latter "enters" a person, becoming his or her new functional organic feature; a new "functional organ" is formed in a person [9]. As B.D. Elkonin wrote, it is important to understand how a stimulus, previously external to a person, turns into an internal means, or how a sign "turns into an internal means of constructing an action" [19, p. 233].

V.P. Zinchenko and N.D. Gordeeva discussed formation of a functional organ based on constructing an objective executive action, while A.N. Leontyev looked at formation of the organ of pitch hearing; however, the studies were done in the pre-digital era [7; 10]. What functional organ is developed in an individual when digital gadgets and digital platforms are introduced into the structure of an objective action?

With the introduction of digital tools, the question arises: what does a digital device in a child's hands mean? What role does it play? O. V. Rubtsova believes that digital tools act simultaneously as both a sign and a tool [11; 12]. This is, in principle, understandable and correct. What is the specification of such a hybrid sign-tool, though? Especially if we are talking about the fact that a gadget in a schoolchild's hands is not only and not so much a tool with a complete set of functions, but rather a window into the virtual world.

This is exactly why they are loved. A shovel or a pen in a person's hands perform a very specific job and nothing else is put into them (with the exception of the play function in children's games, when an object is re-objectified. so that a shovel becomes a horse and a pen becomes a rocket). A symbolic tool also plays a very specific role in the formation of, for example, speech and speech behavior. This has long been described in the literature.

In the case of the gadget, the most important thing is that it is larger than its body and more significant than its function. It is a window into a special virtual world, often replacing the first social world for children and teenagers. The digital not only combines the functions of a sign and a tool, but it also acts as a characteristic of a different type of habitat.

This is why children surrender to its power. When a child uses digital tools and smart gadgets en masse, then, left to his or her own devices (there is no adult in his virtual world), he or she gradually loses the qualities as a subject and becomes an appendix to gadgets, since the desired behavior scenarios are embedded in gadgets (the so-called "script capture" described by the authors earlier [14]. This happens if an adult intermediary abandons the child's field of action. In the child's virtual world, there is no adult or he or she is in the form of an avatar, a digital twin, i.e. a transformed form.

The following questions must be addressed: what does it mean to construct a mediated action that a child constructs with the help of an adult, using digital tools? What is the specificity of this particular act, notably, in two meanings — mediation (child and tool, child and environment) and mediacy (child in relation to oneself), in which gadgets and other digital tools and digital platforms are used? For what purpose are they used in the model of interaction between a teacher-mediator and a student? How does this use affect the attention, vision, perception and other abilities of a student?

Our hypothesis is that when a digital tool is included in the learning process, not only a child but also an adult develops a new vision of an object; tentatively speaking, a third eye or a new functional organ (hereinafter referred to as FO) is formed. A smart system with AI elements that knows more than just processing, storing and transmitting big data, can provide feedback to an adult and a schoolchild that helps them to see things in a way they have never seen before. This effect has already been observed in the example of the introduction of high technologies in medicine to diagnose complex diseases. Experts have noticed that in diagnosing a disease, a medical practitioner receives information from an AI system that was not available previously and could not be obtained without AI, the doctor begins to see the disease, the processes in the body as if he or she has got new eyes, with a new vision opening up. Supplying new combinations and complexes of data, the AI system shows the diagnostician what he has never seen and could not see before.

Functional organ

This new vision, the third eye, can rightfully be called a new functional organ that is formed in a person when he or she carries out complex subject activities using technical means.

The concept of FO was first introduced in physiology by A.A. Ukhtomsky as "... any combination of forces that can lead, all other things being equal, to the same results every time" [16, p. 124], "... any temporary combination of forces that lead to a certain achievement" [16, p. 98]. It referred, obviously, to physical action in which different forces participate, and therefore the coordination and harmonization of the actions of forces, their functional unification, enabling the implementation of a complex action, are important here.

If we translate the concept of FO into activity ontology, then such a neoplasm is formed in a person who performs objective actions using psychological and material tools. For example, a "writing organ" develops, which includes a sign-pen-brush-hand-local zone in the brain-coordination with the entire morphology of the action. In the process of mastering objective actions with a pen, with the help of which a person learns to write signs on paper and comprehend this action, he or she forms a writing organ through multiple operations, the scheme and structure of which are fixed in the brain, where a set of neural ties connections responsible for writing activity is formed.

Following the same logic, there is a temptation to insert a gadget into this chain and assume that it is also built into it and becomes part of a complex functional organ. It is obvious, however, that in this case something more is happening than just performing objective actions. Particularly as a gadget is not a pen, not a shovel, not a hammer, not a spoon. Inherently, as assigned, it acts neither as an objective tool in itself nor as simply a symbolic means, although it performs these functions. A gadget (more broadly, a digital platform) acts as a hybrid means, a way of getting into virtual reality and can be used as a means (map) for navigating this reality. At the same time, a person using it can update it, remake it, fill it with new content.

The "Schoolchildren as Scientific Volunteers" Project

As a case, let us analyze the above-stated problem of FO formation through the "Schoolchildren as Scientific Volunteers" project [18]. It intends, first of all, to form the so-called research vision, a research position in schoolchildren. Curiosity, inquisitiveness and the exploratory nature of learning are certainly present in the ordinary school practice (field experiments, laboratory works in biology and botany). In this project, however, it is suggested that schoolchildren are exposed to the actual format of field scientific research.

The project connects schoolchildren and teachers from different schools in different regions into a certain scientific laboratory network based on the SYNCWOIA digital platform. They undergo training that includes modern digital technologies and tools with elements of artificial intelligence. This is the basis for consistent efforts towards professional orientation of schoolchildren in research activities through a system of scientific volunteering.

In a preliminary survey, schoolchildren showed that they are familiar with simple experiments through school science clubs and have experience of project activities, they like natural sciences. About 70% of them, though, feel the need to expand the diversity of topics and to go beyond the school curriculum. Many schoolchildren want to do real-world field research in situ, outside school, and in project teams. At the same time, they are not aware of what it means to conduct research using information technology, how to check the correctness of the results obtained, etc.

Within the project framework, each participant undergoes training according to a program that includes modules devoted not only to biology and botany, but also to information technology (big data, neural networks, computer vision, etc.). All the materials have been verified by scientists. The training was conducted on the SYNCWOIA online platform, thanks to which students from different regions of Russia were able to join the project.

In the project, children and adults teamed together (each team included 5 schoolchildren and 1 mentor teacher who organized field work). Each team selected locations for conducting research and collecting data on natural objects (birds, mushrooms, soil, plants). One team worked in three locations on average. All the observations were registered in a diary and the objects of observation were photographed. Then the data were entered by the project participants into their own Database. Datasets were formed (using photos, audio descriptions, metrics, location data) based on the Kappa data collection, storage, and management system.

The authors and participants of the project endeavored to understand the place of gadgets and AI elements (datasets) in the formation of the above-mentioned research vision in schoolchildren, the position of a researcher-observer, who has created an artificial cultural formation, a new functional organ. It was essential to figure out how and what kind of a functional organ is formed in a schoolchild who, when studying wildlife, keeps an observation diary, uses a gadget and compiles a collection of observations under supervision of a mentor.

The main results of the project are the activity abilities of students, scientific volunteers associated with gaining new knowledge as to how to conduct research using modern digital technologies. Schoolchildren get hands-on experience of the basics of research work on true-life empirical material and take part in generating a common database.

This article is the first part of our research, stating the problem. Herein, we articulate the problem of forming a research vision in schoolchildren based on the material of the "Schoolchildren — Scientific Volunteers" project and show the role of digital technologies, a digital platform as a training system, with the help of which children undergo self-training and form a vision of natural objects. In the second part of the article, we will present the first conclusions based on the project results.

Project model

Let us show the content of the project in the categories of the main positions, types of work and communications (see the Figure).

Considering the described digitalization problem and the content of the project, we raise the following questions.

1. What role do digital tools, gadgets, and a digital platform play in the project? What is the specificity of their use in the project? What is the intermediary function of digital tools? What are the meaning and purpose of implementing a platform and data sets? How does the performance of previously set learning tasks improve when learning is transferred to the platform?

2. How do the activities that rely on online formats and the digital influence the development of relevant abilities in schoolchildren? In this case, we are talking about the abilities of perception, vision, and hearing. How is such a functional organ as research vision formed in a schoolchild who uses a gadget to conduct research activities within the project framework? How do gad-

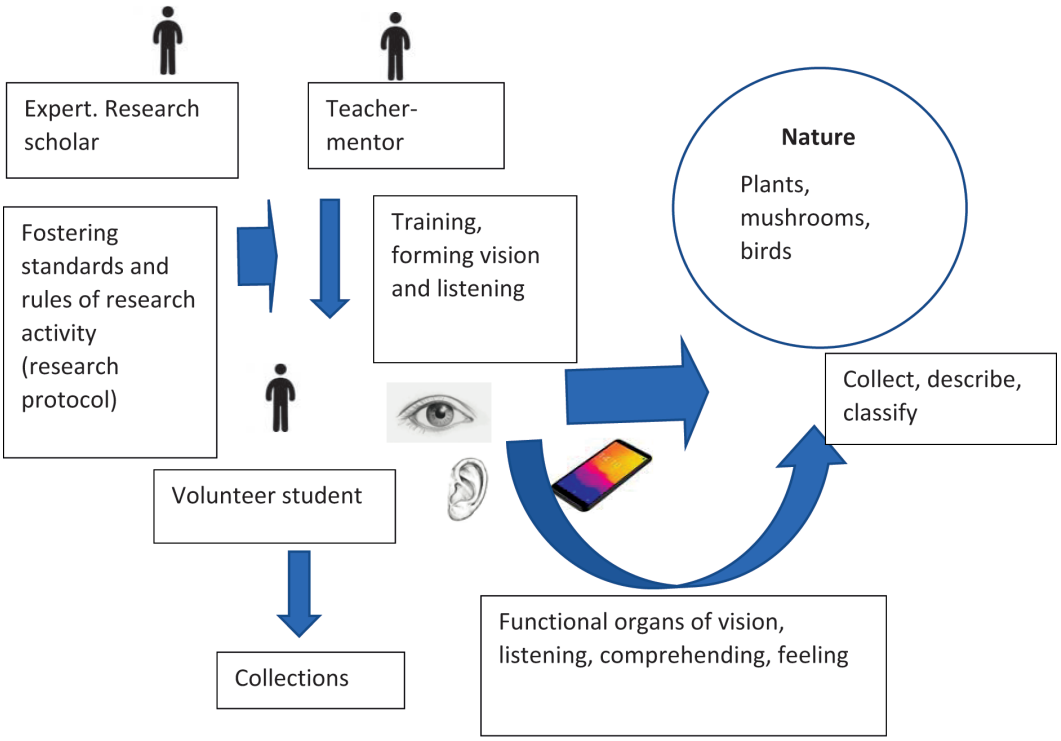

Fig. Project model

gets influence (if they do) attention, perception, imagination, and tactile sensations?

If these organs of vision and hearing are not formed, then a student adapts and uses devices purely automatically, simply collecting information, and himself or herself turns into a functional device for collecting data. He can remember plants and birds, but do not see or hear them.

The key risk of AI is that a person who delegates work to AI, without developing active human organs, turns into a device as such.

Such programming begins even before any gadgets. If a teacher programs students' behavior and does not form human qualities in them, programming takes place before gadgets arrive. Then gadgets intensify it, aggravating the students' subordination to the digital.

In view of the above tasks and risks, the Schoolchildren — Scientific Volunteers project was designed in such a way as to avoid these risks.

The project's aim develop a new organ of vision in schoolchildren, that is, to learn to see, hear, listen and understand nature. It is not just about observing objects; rather, it is about such a vision that corresponds to a certain protocol of scientific observation. Project participants must undergo training in methods of describing locations, mushrooms, animals and birds selected for observation. The difficulty in developing a new view of nature lies in training the ability to see what is important for scientific protocols.

In the development of the modern AI systems, machine-learning models are built on the principle of presenting correct and incorrect examples. Processing them, a model receives feedback on the fallacies of its conclusions and self-corrects. accordingly.

Since AI systems are becoming an integral part of our reality, it is reasonable to introduce practices aimed at understanding the principles of operation of artificial intelligence algorithms into the learning process of schoolchildren [8].

An important part of an AI specialist's job is to compile datasets — sets of labeled data used as a training sample for AI models and for quality control. We follow the well-known definition of a dataset — a set of related observations organized and formatted for a specific purpose [21].

Accordingly, the project proposes to engage schoolchildren and mentors in dataset compilations.

Participants must correctly compile cards for each observation entry in the database. Adding each entry, users pay firm attention to the ethical principles of data collection and labeling (see below). On each type of observation, a consultation is provided by a researcher, who explains which parameters can and should be distinguished in the object of observation. Multiple objects of observation with estimated values of parameters are entered into the database by a mentor and students, and the authorship of the observations is indicated. Subsequently, all the observations are cross-checked by stu-

dents and then the entire database by types of observations is transferred to an expert — a researcher to verify the correctness of the labeling, class definition and description accuracy. In case of an incorrect description, it is returned to students for revision. This generally reflects the process of qualified data labeling in machine learning. It is important that students are assigned the copyright to the objects of intellectual work, assessed by mentor scientists.

Subsequently, a single dataset compiled from all the observation objects provided by schoolchildren can be used to train artificial intelligence models; firstly, by the schoolchildren themselves, and secondly, by scientists. At the same time, the quality of the entire dataset depends both on the contribution of each participant and on the assessment by experts. The better is the quality of the data submitted by a student, the higher is his or her contribution in model training.

How the risk that students become purely suppliers, collectors of data for artificial intelligence systems can be avoided? In fact, it is the students who contribute data for future use, so they are actual data suppliers, but this is not the only or the crucial task faced by them.

A schoolchild needs to complete a project and compare the results with the achievements of peer students, striving for their recognition. The ability to objectively compare own results with those of theother participants is one of the distinctive features of artificial intelligence projects. It is important that datasets created by schoolchildren can have the property of verification — the best labeling can form a dataset, on which other artificial intelligence models will subsequently be verified. Thus, the first risk-avoiding factor is assigning (in the KPI spirit) the result of a particular activity by a schoolchild and its social assessment.

The second important factor in avoiding the risk of becoming an appendage of AI systems is the student's awareness of the data collection acts as part of the overall process of building recognition systems. Participants are not relieved of the need to recognize certain properties of the studied objects (bird species, types of mushrooms, etc.). Therefore, they have a chance to correlate their own ability to recognize new properties, trained in the course of the project, with such an "ability" that is trained in artificial intelligence systems.

Project ethics

A part of research task-setting in this project is ethical regulation as a way of cultural adaptation of risk-generating technology and turning AI into a tool of mediation in cognitive (research) activity.

It is necessary to distinguish between the risks related to AI technology as a type of digital technology and the immediate risks of scientific volunteering, i.e. participation in collecting data for training a neural network. The latter seem insignificant in terms of anthropological and ethical risk labeling. It does not mean, however, that a humanitarian analysis of the risks of involving schoolchildren and other scientific volunteers in developing a technology, the prospects of which make people apprehensive is unnecessary. On the contrary, following the principles of precaution and proactive response [2, p. 234], it is essential to consider what ultimate, currently invisible effects we will encounter with deep immersion of artificial intelligence in human life, in education, in child development. Speaking about the uncertain risks of new technologies, precaution dictates that "the current state of 'no proven harm' should not be interpreted as 'proved absence of harm" [5, p. 55]. New realities and risks generated by science and technology are associated with the danger of k-\o, which not only intensifies the processes of risk multiplication, but also determines the need for a new logic of managing emerging complicated situations — the logic of preventive caution [4, p. 135].

The process of normalizing, habitualizing a new technology can be presented as its transformation into an element of sign- tool mediation. It is assumed that, based on the methodology of cultural-historical psychology, on the one hand, it is possible to trace how innovative search work with digital tools develops research abilities in students, and on the other hand, to evaluate these tools and, above all, artificial intelligence as a tool of mediation. How do thinking, learning activity, and social skills of schoolchildren and scientific volunteers change when the goal of their search efforts is not nature as such, but nature transformed into digital data, and the subject reality is mastered in a new sign-tool environment — on digital platforms and with the help of artificial intelligence?

At the data collection stage of a school project, goal orientation and motivation should be well thought out, it is necessary to explain how data will be used in the future, how important it is that they are as complete and accurate as possible and differentiated, so that volunteers must earnestly work hard before a photo or a description of a plant becomes data rather than just a copy. In order to turn the final result — datasets and the AI model created on their basis — into a tool of mediation that facilitates thinking and personality development, it is important to form a semiotic environment consisting of frames

of a responsible attitude to risk-generating technologies. To become part of the culture genesis, newly created digital tools of activity must undergo value codification, i.e. the meaning of useful, safe, ethically acceptable tools must be assigned to them.

Therefore, starting from the stage of data collection and dataset building, it is necessary to include ethical data support, which implies the use of tools for conscious involvement of a scientific volunteer in the development of a risk-generating technology. Such tools are part of the mediating semiotic environment, the key concepts and principles, that perform the functions of cultural adaptation, "settling in" and "living through" new technologies. An emotional-and-cognitive dominant of the need for ethical support must be created.

Conclusion

In the first, statement-making part of the article, we highlight the problem of the negative impact of digital media on children, and outline the need to develop appropriate KPI-models of mediation, overcoming the limitations of stimulus-reactive algorithmic models. Based on the material of the "Schoolchildren — Scientific Volunteers" project, we propose to develop such a model and describe its structure and tasks associated with formation of the research vision in schoolchildren using digital mediating tools. The second part will show how the project proceeded, present the first results and discuss the difficulties in implementing the tasks.

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