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DIGITAL FOOTPRINT TO SOLVE EDUCATIONAL PROBLEMS*

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Abstract. Some aspects of using the digital footprint in education are described. The connection of this approach with the use of expert systems and Big Data technologies is shown. Current trends are described, and the risks and challenges of using digital technologies in education are outlined. It is shown that the role of society and government institutions will only increase. The important role of a priori algorithms and expert judgments in processing digital footprints is demonstrated. Finally, the authors argue that expectations about the prospects for using digital footprints to optimize management decisions in education must be tempered. They suggest focusing on developing digital culture, democratizing digital technologies, and the widespread acceptance of ethics in using Big Data.

Keywords: *digital footprint, Big Data, education, digitization, digitalization, expert systems*

Introduction

Nowadays, education can be described as one of the biggest users of digital technologies. The use of digital technologies, especially Big Data technologies, in education today is both an obvious reality and a necessity [1, 2]. The new technologies make it possible to neglect a number of physical barriers to communication in education (limited time resources, remoteness, pandemic constraints).

The potential applications of digital technologies in education are extremely diverse, and among the most promising are the following:

- Technologies for presenting instructional materials [1]
- The digitalization of administration in education [3]
- The digital footprint of students [4, 5]
- A system for creating a smart environment for students and learners [6, 7]
- The electronic internationalization of scientific and educational activities [8]

Digitization and digitalization affect the content and organization of teaching [9]. The teacher is transformed from a transmitter of knowledge and skills to a navigator who helps to navigate the treasure trove of knowledge. As a result, pedagogical work acquires a new character and is filled with new meanings. Thus, one of the particular issues that attract attention in the pedagogical environment is the optimization of students' choice of educational path. At the same time, it is proposed to give a new meaning to the concept of efficiency and change the approach in favor of recommendation systems based on students' digital footprint [4, 5, 9].

Digitization and digitalization of education with all its benefits are, as national and international experience shows, necessary but not sufficient conditions for increasing the effectiveness of education and educational work. The active introduction of digital technologies

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helps improve individual creative teachers' work but cannot increase the efficiency of the traditionally organized educational process [10].

One of the promising areas of using digitization and digitalization in education in general (and digital footprint in particular) is the creation and analysis of an educational institution's digital communication in the external educational space. Such digital communication and analysis of the totality of the formed digital agenda will make it possible to create a positive brand of educational institutions, integrate into the all-Russian and international scientific and educational Internet communication, and ensure the competitiveness of Russian education [11, 12].

On the other hand, digital technologies can and should be actively used as one of the new tools to optimize educational processes. The most obvious solution in education is an intellectual analysis of educational data to predict students' academic success [13]. In addition, data directly related to the educational process and additional information, including student demographic data, and psychological characteristics of students, teachers, and parents, are helpful [6].

This approach is already being successfully implemented in our country and abroad to varying degrees. For example, in 2013, the English University of Nottingham Trent experimented with and implemented a system for Big Data analysis of various student outcomes in the form of a dashboard [14]. The goal of implementing such a system was to get an overview of student participation in the educational process to reduce the number of dropouts and strengthen the sense of belonging to the university. A specially designed dashboard showed information about a student's engagement compared to his or her peers, time spent in the library, courses taken, attendance, and more. The information was accessible to all students, teachers, and mentors. The three years of using the system showed that 72% of students used it in the first year and rated it positively. Since 2018, the Moscow State Law Academy, named after O.E. Kutafin (Russia), has been using a virtual learning environment that allows students to record their academic results and activities and register for consultations and additional courses [15].

According to the information announced at the online conference "Digital Footprints in Education" (October 13, 2021), Ural Federal University uses its own digital service – Digital Tutor, and, based on the results of educational analysis, manages the process of individualized education. Volga State University of Technology's education portal has organized the collection of a digital footprint of all students to monitor and analyze ongoing education. Predicting academic performance and creating individualized education paths for Tomsk State University is organized by collecting a digital footprint of first-year students before they complete the first session in the VKontakte network (for more details, see [16]).

This paper considers a case of using Big Data technologies to analyze students' digital footprints. In practice, we are concerned with building predictive systems in education based on Big Data processing technologies. The data source is the digital footprint of students. This term refers to the amount of data associated with a particular individual, generated consciously or unconsciously, and collected and processed using Big Data technologies.

In this work, the authors used an integrated approach to analyze the interaction of a large number of actors. The methods of comparative law and formal legal analysis were used to study regulatory documents in the field of high technologies. In order to highlight the specifics of the development of digital technologies, the method of analysis and a systematic approach was used.

In addressing the issue of digital technologies in education, the authors relied on the experience of using unique research facilities in the Russian Federation, based on their work at the National Research Center Kurchatov Institute, which is the scientific coordinator of the Mega Science Class research facilities on the Russian side. The results of studies conducted by other scientific groups on related topics were considered, as well as the conclusions reached by the authors and their colleagues under similar conditions with unique research facilities. Thus, the authors have tried to apply the available information to the educational process and to transfer scientific approaches from science to education. The attempt to consider the specifics of the emergence and use of a digital footprint in education is made exclusively in the context of management decisions and their impact on society. This article does not consider technical and methodological issues (using digital technologies directly in the educational process) and legal regulations (data protection).

The use of a Digital Footprint in the Operation of Unique Research Facilities: an Educational Aspect

Let us briefly describe some features of the use of digital technologies and, in particular, of a digital footprint in the operation of unique research facilities (so-called “digital twin”).

Of course, creating a complete digital twin (as accurate a model as possible) of any Mega Science Class project is a Mega Science Class project itself and requires a comparable level of resources and intellectual activity. Accordingly, such work will also be unique and relatively rare. However, they may be conducted as international projects or privately funded.

As for the pedagogical aspect, creating a digital twin will solve the problem of offering a form of remote work to many professionals in the scientific and pedagogical fields. This democratization of technology will allow easy access (even for non-specialists) to technical and economic knowledge without lengthy or costly training. This policy, called Citizen Access, finds its application in app development, data and analytics, design, and knowledge [17]. To ensure that students from secondary and higher education institutions are involved in complex scientific issues, it is proposed to use existing game shells and complement them with the possibility of modeling the processes under study.

The authors formulated the main requirements for successfully transferring scientific methods to the educational sphere based on the basic principles of working with digital twins of scientific mega-research facilities [18].

- Data sources for the education process are taken from recognized research centers (e.g., PIK, DESY, CERN, EuXFEL, ESRF, ITER). Their data have undergone the necessary verification, falsification, and reduction processes.
- Proven algorithms and approaches tested in real research facilities are used to work with the data. The development of proprietary methods and approaches is based on traditional successful methods and reliable data.
- A high level of digital infrastructure is ensured.
- Technical support for data storage, transmission, and processing (considering implementing the possibility of repeated use) is ensured.
- Links to existing approaches and programs have been established (the research program CERN and ITER, the Russian program of synchrotron research).
- The possibility of updating data, methods, and algorithms was implemented as a continuous process. Therefore, the proposed educational product aims to implement continuing education and skills training.
- The focus of the educational process is on interdisciplinary research.
- There is an opportunity to use cross-transfer technologies and transfer educational practices to the real world.

These approaches have already been implemented in the adaptation for a practical course on synchrotron research using digital twins of megascience facilities in Russia [18, 19]. The proposed course, “Methods based on synchrotron radiation in interdisciplinary research,” was developed using virtual reality technologies, based on which digital twins of unique Mega Class research facilities were developed. Mega facilities already in operation, such as the European X-ray Free Electron Laser (EuXFEL, Hamburg, Germany) and the Synchrotron Center of the National Research Center "Kurchatov Institute" (Moscow), served as a basis.

Specifics of the Emergence of the Student Digital Footprint

Initially, it was assumed that the digital footprint is created based on collecting and analyzing available data about the student [14, 20]. Usually, it is digitized data about academic performance, class attendance, participation in the educational process, the quality of the student's work, and test scores. It is an extended personality test (like the MMPI) translated into a digital format.

However, the pandemic has underscored the need to use new tools to ensure the individualization of education while ensuring continuity of education in the changing realities of the world. As a result, there was a need to create and use a digital footprint consciously. However, a number of difficulties arose in the process. For example, the University 20.35 activities involved organizing data collection during a series of long-term events to create a digital footprint of participants. However, organizers estimated that more than 51% of the uploaded data was useless information. In the initial phase, the percentage was as high as 98% [7].

Based on the studies conducted, one can formulate the requirements for the information needed to create a digital footprint [7]:

1. The maximum objectivity of the model allows for automating the process of selection and analysis of information.
2. The priority of the result (the final "artifact") over the process (teaching in the form of lectures, events in themselves, virtual laboratory work).
3. The ability to divide the acquired skills into hard and soft skills.

It is necessary to regulate the processes that optimize the collection and use of the digital footprint, not only in technical terms (implementation of predictive modeling technologies using neural networks and deep machine learning methods [2, 3, 6, 21]) but also in organizational terms. Therefore, based on the experience of collecting information (both in education [6] and in the operation of sizeable Mega Science Class research facilities that produce vast amounts of information [19]), it was decided to fill the data lake as much as possible in order to extract useful information later with Big Data technologies. At the same time, due to the continuous progress in computing power and the development of new algorithms, it is necessary to provide for the possibility of repeated access to the data (e.g., for data reprocessing). This approach is implemented based on the FAIR principle [22], which is actively used in scientific research and is currently being transferred to the level of practical application. Thus, it becomes possible to ensure the consistency and accuracy of multiple access to information once entered.

The extracted data may become unintentionally generated knowledge, and it is still unclear how to attribute it and distribute the rights for its use.

An important issue is interpreting the extracted data, the models, and the algorithms used [23, 24]. It is well known that a priori assumptions can/should be made to build an appropriate model. For example, in what direction will the student's digital footprints evolve? Can they be predicted? The traditional approach states that the main source for the formation of self-determination (the choice of the direction of development) are strictly defined factors given by the existing social institutions: Society, State, Church, traditions, and customs. In the past, the choice was strictly defined, the number of professions was indeed limited, and their popularity (and, accordingly, the answers received) was in a narrow range, or rather, it was easy to algorithmize this task and largely predict the outcome.

The Higher School of Economics' approach to passive education can be seen as an attempt to break away from this predetermination. It proposes a synthesis of distance learning and autonomous education models that includes the development, testing, and transition to mass deployment starting in 2023 of fundamentally new digital educational and methodological complexes that will partially or fully replace traditional textbooks. Based on AI technologies and expert systems, these complexes adapt to students' main individual cognitive characteristics and ensure successful mastery of the material by students with different levels of knowledge, students with distinctive perceptual characteristics (e.g., predominantly pictorial and predominantly logical thinking) [25]. It should be noted that this system is a tool that helps students or teachers track learning changes and make adjustments. The main advantage of the digital footprint is that it provides systematic and reliable feedback.

However, these approaches do not consider that in the transition era to the innovation economy (where new institutions have not yet emerged), the formulation, design, and implementation of development tasks that affect society are often shifted to businesses and large corporations. Moreover, the role of external actors not associated with the state government is increasing, such as by analogy with the law in the digital economy [26]. As a result, the choice itself becomes situational and spontaneous, under the influence of momentary factors and emotions, to achieve immediate benefits or to be emotionally colored [27].

These tendencies conflict with state interests that aim, among other things, to create a long-term educational environment that provides valuable human resources for the development of strategically important industries. The state is interested in maintaining a "minimal/correct" digital footprint sufficient to exploit Big Data technologies for further processing. Accordingly, there is the prospect of enforced digital footprinting. One of the options is the mandatory switch of all civil servants and state employees to Russian messenger, mail, and video conferencing services. In the future, this initiative will be extended to teachers of schools and universities, who will be able to communicate with parents and students only through Russian IT services [28]. The data obtained in the aggregated and depersonalized form will be used mainly for educational management decisions.

A similar policy is followed by private companies (especially social networks) that sell this information to government officials (or share it at the request of the relevant authorities). For example, according to Clario, in July 2021, Facebook collected 70.59% of personal data from the total amount of data, Instagram – 58.82%, Tinder – 55.88%, and Grindr – 52.94% [29].

In addition to the quantity, the demand for the quality of the collected data is also growing. Therefore, the University 20.35 has proposed two approaches to increase the effectiveness of the digital footprint [30]:

First is creating a dedicated educational environment to facilitate the creation of a digital footprint (a specially designed space where people's activities can be recorded in an accurate and multidimensional digital model). This is the gamification of education or so-called edutainment [31, 32]. Note that similar processes can be observed in the scientific environment when a specific environment (e.g., Minecraft) is used to place a digital footprint of unique research facilities [33].

Second, the evolution of the culture and skills of the creators of the digital footprint and its consumers. This means the emergence of a new ethic of human interaction in the digital environment (primarily developers of algorithms and consumers of digital content) and the optimization of algorithms used for the processing and presentation (primarily visualization) of information. For humans, the second way means nosce te ipsum: "If you want to maintain at least partial control over your life and the future of the world, you need to run faster than Amazon's and the state's algorithms and know yourself before they do" [34].

An unavoidable drawback of Big Data, forcibly generated in the public interest, is the risk of determining the course of a person's perspective too early (a priori). In addition, there is an inevitable delay, both in implementing digital transformation and using the obtained results [9,35]. It is necessary to use special algorithms and technologies to transfer the digital footprint data from the past (retrospective copy) to the future. It turns out that the student's digital footprint is divided into at least two paths: For the pre-digital era, it is enough to study the traditional values that are socially accepted and implemented by students, and for a modern student, it is necessary to create a sequence of images (filmstrips) of the digital world in dynamics.

A characteristic of the modern student is the high lability of thinking, the absence of fixed rules and authorities, flexibility, volume, and ambiguity [27]. In practice, the transition from the real world to the digital world (data digitization) used to work, and now, the reverse dynamics are implemented. However, algorithms (created from the rules, ideas, and assumptions of the pre-digital age) do not work for young people who physically exist in a ubiquitous digital environment. Therefore, the choice of algorithms (models) used a priori for data processing plays a significant role.

Conclusion

In the development of digital technologies, the benefits and risks of using artificial intelligence technologies, Big Data, and related technologies must be taken into account to achieve the goals of balanced development of humanity [36]. In this direction, it seems appropriate to use digital technologies in education. Moreover, the use of a digital footprint will allow:

● develop recommendatory decision-making systems in which a Friendly AI acts as an advisor and navigator for human development

● obtain accurate, systematic, and reliable feedback from students, which is particularly important as the scope of online education expands

● systematically adapting methodological support for the educational process within a reasonable time.

To meet the challenges, it is essential to use a top-down digitization approach while directing creative energy and vitality bottom-up [37].

Education, the key differentiator of our time, is becoming more creative, critical, problem-solving, and decision-making, fostering communication and collaboration, forming new potential tools and using existing technologies, and most importantly, developing social and emotional skills in students.

Awareness of choices becomes an important prerequisite for designing a development strategy. Society (through the state and its institutions) must take away the right of economic actors to set priorities. First and foremost, it is necessary to focus on solving the problems of the state and pursue national interests.

At the same time, the authors are sure that the digital footprint will not solve the problems of optimizing education. As our analysis shows, the use of a digital footprint in education will be accompanied by the following features:

● Big Data technologies have gained the right to be a criterion in the decision-making process for the organization and management of educational processes. The role of collected data and decisions made based on their analysis will only increase in science, education, and everyday life.

●The amount of unstructured data (data lakes) will increase, and this process will only accelerate. In addition, some form of the digital footprint will become mandatory in the near future. Currently, it is unclear what coercive mechanisms will be used (material incentives, persuasion, denial of access to services, mandate).

● We must remember the responsibility that the digital technologies impose on us, and create data consciously. In practice, Big Data must be ethical.

● Similar requirements are placed on the consumer of the data. The state (society) must form the hierarchy of good in addition to the hierarchy of power [38]. Currently, there are active discussions about how this should be implemented: in the form of ideology (conditional checkpoints) or algorithms (a priori knitted models). The United States is pursuing the path of correcting artificially induced solutions, while the PRC focuses on the ideology of programmers and consumers of the algorithms (correct tasks). The EU proposes the introduction of the gradation of algorithms (allowed – partially allowed – prohibited). The Russian Federation has not yet formulated its position [39].

● Too early self-determination of a person may occur with simultaneous ambiguity of conclusions based on a digital footprint.

● A feedback loop between society and technology (primarily through science) is critical. The process of influencing a person through algorithms cannot be considered unidirectional. This means critical thinking and conscious, responsible decision making is essential. One possible solution is to increase the use of expert panels that take collective responsibility in formulating decisions.

The authors believe that all the above difficulties will be successfully overcome and the progress of science and technology will contribute to constructing a balanced, just society, which will be expressed, among other things, in new pedagogical forms and formats.

The introduction of digital technologies into the educational process will also require the refinement of legal documents, which is currently somewhat difficult. At the same time, the gaps in legislation are not insurmountable, and already the Federal Law of December 29, 2012 No. 273-FL On Education in the Russian Federation contains a reference to the possibility of using e-learning, which at least indicates the readiness for transformation. Furthermore, on July 16, 2021, on behalf of Rosstandart GOST R ISO / IEC 20546-2021 – Information Technologies, Big Data, Overview and Vocabulary – a terminological standard was adopted, which became the first domestic regulatory and technical document in the field of Big Data.

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