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ВЛИЯНИЕ ТЕХНОЛОГИЙ НА РАЗВИТИЕ ОБРАЗОВАНИЯ
EVOLUTION OF TEACHING AND LEARNING THROUGH TECHNOLOGY

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# Phygitalization of educational technologies in Russia: directions, examples, problems

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**Abstract.** *Problem statement*. The modern social and communicative situation requires fundamental changes in didactic models, educational engineering and pedagogical design. The Russian experience has certain specifics in the digital transformation of vocational education. A few years ago, a new trend appeared in the world – the restructuring of educational technologies (EdTech) in the direction of phygitalization. At the junction of the digital and physical worlds, in 2013, such a concept as digital technologies was born. Phygital (physical + digital) is a complex of technologies where students get a unique interactive experience using both traditional material sources of educational information and virtual communication in the educational process. The emergence of such a phenomenon as phygitalization is due to the fact that the boundaries between the physical and digital are becoming increasingly blurred, which opens up new opportunities for socialization and professionalization (including in the higher education system). This area of educational activity is considered a priority and basic direction of the transformation of Russian education. Within the framework of this direction, the main attention is paid to the following aspects: (a) the use of Internet resources for pedagogical purposes, (b) the structuring of the curriculum in accordance with the modular principle, (c) an increase in the amount of study time for solving practical problems, (d) presentation of knowledge in accordance with the level of success of passing the previous blocks of educational information by each student (individual learning paths), (e) evaluation of the effectiveness of learning outcomes. The purpose of the study is to briefly, but, if possible, fully describe the methodological, theoretical and technological foundations of the phygitalization of educational technologies. *Methodology*. Such inter-scientific approaches as system-structural, system-activity, and pedagogical competence approach were used. A content analysis and thematic monitoring of the implementation of phygitalization in universities was carried out. *Results*. 1) The main directions of phygitalization of educational technologies are analyzed: a) use of teachers' personal websites, b) the development of virtual laboratories, c) the use of generative language models of artificial intelligence.; 2) the importance of each component is analyzed and examples of how they can be implemented in practice are given, the main problems are discussed and potential solutions are proposed; 3) an overview of the main functions of the phygitalization of educational technologies is presented, including the definition of this trend, characteristics and main problems; 4) the main methods and tools used in the phygitalization of educational technologies are discussed; 5) the most promising areas of research in this field are determined. *Conclusion*. The phygitalization of educational technologies at universities has the potential to increase the subjectivity of vocational education by providing students with individual learning trajectories and a much more exciting learning experience.

**Keywords:** university, teacher's personal website, virtual educational laboratories, generative artificial intelligence, educational engineering, pedagogical design

**Conflicts of interest.** The author declares that there is no conflict of interest.

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# Фиджитализация образовательных технологий в России: направления, примеры, проблемы

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**Аннотация.** *Постановка проблемы.* Современная социально-коммуникативная ситуация требует кардинальных изменений в дидактических моделях, образовательном инжиниринге и педагогическом дизайне. Российский опыт имеет определенную специфику в цифровой трансформации профессионального образования. Несколько лет назад в мире появился новый тренд – перестройка образовательных технологий (EdTech) в направлении фиджитализации. На стыке цифрового и физического миров в 2013 г. родилась такая концепция, как фиджитал-технологии. Phygital (физический + цифровой) – это комплекс технологий, благодаря которому студенты получают уникальный интерактивный опыт, используя во взаимосвязи как традиционные материальные источники учебной информации, так и виртуальное общение в образовательном процессе. Появление такого явления, как фиджитализация, связано с тем, что границы между физическим и цифровым становятся все более размытыми, что открывает новые возможности для социализации и профессионализации (в том числе в системе высшего образования). Это направление образовательной деятельности считается приоритетным и базовым для трансформации российского образования. В рамках данного направления основное внимание уделяется следующим аспектам: (а) использованию интернет-ресурсов в педагогических целях, (б) структурированию учебной программы в соответствии с модульным принципом, (в) относительному преобладанию практических и лабораторных заданий над теоретическим материалом, (г) разработке индивидуальных траекторий обучения на основе мониторинга успешности освоения обучающимися предыдущих модулей, (д) поискам более эффективных методов оценки результатов обучения. Цель исследования состоит в том, чтобы кратко, но, по возможности, полностью описать методологические, теоретические и технологические основы фиджитализации образовательных технологий. *Методология*. Использовались такие межнаучные подходы, как системно-структурный, системно-деятельностный, а также педагогический компетентностный подход. Был проведен контент-анализ и тематический мониторинг внедрения фиджитализации в университеты. *Результаты*. 1) Проанализированы основные направления фиджитализации образовательных технологий: а) использование персональных веб-сайтов преподавателей, б) развитие виртуальных лабораторий, в) использование генеративных языковых моделей искусственного интеллекта; 2) проанализирована важность каждого компонента и приведены примеры того, как они могут быть реализованы на практике, обсуждены основные проблемы и предложены потенциальные решения; 3) представлен обзор основных функций фиджитализации образовательных технологий, включая определение этой тенденции, характеристики и основные проблемы; 4) обсуждаются основные методы и инструменты, используемые в фиджитализации образовательных технологий; 5) определяются наиболее перспективные направления исследований в этой области. *Заключение*. Фиджитализация образовательных технологий в университетах обладает потенциалом преобразовать высшее образование, предоставляя студентам захватывающий, персонализированный и увлекательный опыт обучения, который может подготовить их к будущей карьере и улучшить их общие результаты обучения.

**Ключевые слова:** университет, фиджитализация, персональный сайт преподавателя, виртуальные образовательные лаборатории, генеративный искусственный интеллект, образовательный инжиниринг, педагогический дизайн

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**Problem statement.** In recent years, there have been significant changes in information consumption associated with revolutionary developments in generative artificial intelligence, which has turned into a powerful technology with applications in educational technologies. However, despite its many advantages, generative artificial intelligence (AI) creates a number of problems that need to be solved, especially in universities. In this article, we will look at the problems of phygitalization in the higher education system and suggest possible ways to solve them.

EdTech phygitalization agenda is especially relevant in Russia today due to the following reasons:

– the geographical, financial and technological diversity of the regions of Russia, the different number of students and teachers, the orientation and distance from the center of universities, including research, the primary task of which is the need for their closer interaction with scientific centers. This is a condition for the further development of the entire system of vocational education in Russia [1];

– global changes caused by the need for every professional to rely on analytics in decision-making [2];
– progress in the development of educational technologies using artificial intelligence systems and allowing for significant personalization of learning [3];
– the transition from centralization of education management to regionalization, where local self-governing network communities arise, including those capable of quickly spreading emerging innovations [4];
– the growing number of educational models and technologies using the capabilities of virtual, augmented and mixed realities (VR, AR, MR) [5–7].

***The main purpose*** of the article is to draw the attention of professional teachers to the new phenomenon of phygitalization of educational technologies, as well as to show some directions of this trend, its functions, practical examples, and problems along this path. Given the above-mentioned specifics the paper tasks are:

– to provide detailed characteristics of the situation in EdTech phygitalization and its correlation with the processes of professionalization, virtualization, digitalization;
– to describe EdTech phygitalization as a multi-dimensional and multi-level process;
– to describe the directions of using teachers' personal websites, virtual laboratories, generative AI as system-forming elements of EdTech phygitalization;
– to specify the functions of EdTech phygitalization;
– to develop teachers' personal websites in accordance with the described technology;
– to develop virtual laboratories, test them;
– to describe opportunities of generative AI in education.

The emergence of such a phenomenon as phygitalization is due to the fact that the boundaries between the physical and digital are becoming increasingly blurred, that opens up new opportunities for socialization and professionalization (including vocational education). This area of educational activity is considered a priority and basic direction of the transformation of Russian education. Within the framework of this direction, the main attention is paid to the following aspects: (a) the use of Internet resources for pedagogical purposes, (b) the structuring of the curriculum in accordance with the modular principle, (c) an increase in the amount of study time for solving practical problems, (d) presentation of knowledge in accordance with the level of success of passing the previous blocks of educational information by each student (individual learning paths), (e) evaluation of the effectiveness of learning outcomes.

**Methodology.** Such inter-scientific approaches as system-structural, system-activity, and pedagogical competence approach were used. The cognitive, semantic, ontological and functional analysis of the implementation of phygitalization in universities was carried out. This article demonstrates the mutual influence of EdTech phygitalization and the integration of traditional pedagogical technologies into the educational process at universities at the present stage. Let's list a number of conditions for digitalization of higher education. It is necessary to systematically manage the goals, subjects, processes and results of education (we call this cognitive management in education). Such cognitive management includes infrastructure management, management of educational content, individual trainees and their groups, university infrastructure management, management of sets of competencies and their assessment, management of motivational structures of the microenvironment, improvement of interaction with employers and partner universities.

***The author's position*** on this issue can be reduced to the following points.

EdTech phygitalization such as mobile learning, teacher's personal website, virtual laboratories, AI elements, cases and dashboards:

– are computer information systems used to complement the full-time educational process;
– structures the learning content more clearly and enhance the personalization of the educational process;
– allows teachers to manage authorized access to individual course modules;
– allows to create and use rich search and navigation capabilities of virtual educational content through CSS menus and hyperlinks, visual models and dashboards;
– visualizes the necessary information using news blocks and content feeds created by the teacher and integrated into the site from other sources;
– improves students' professional collaboration skills by encouraging the exchange of information in virtual groups of students at various conferences and forums;
– have portal capabilities, namely, they take into account the elective capabilities of the educational program; they allow monitoring didactic success, offering the student to choose a module corresponding to the level of his competence at a particular time; they include remote control tools; they provide multimodality and omnichannelity, i.e. active access to information from various user devices, etc.

Nevertheless, in the process of digital transformation of universities, many global challenges arise:

– transition to a completely new type of society with increased interconnectedness of all participants in social and professional communication;
– transition to a new type of culture dominated by on-screen rather than paper information, available for endless replication, modification and transformation on any student's devices;
– transition to a new type of social communication, involving the dominance of virtual contacts over real ones.

We believe that EdTech phygitalization will be successful only if they take into account the motivation of students and are in line with the local cultural traditions of the organization they are implied in.

## Results and discussion

### 1. EdTech phygitalization. Structure and functions

Though today EdTech phygitalization is mostly seen as management of educational processes with the help of Big Data, we define EdTech phygitalization in a far broader sense – as *a creative combination of tangible and virtual products and services in the process of digital transformation of various aspects of education aimed at analyzing challenges and discerning their reasons, setting objectives and goals and reaching these goals*. Thus, it is important to define different levels of EdTech phygitalization, which are presented below (Table 1).

*Table 1*

**Factor model of EdTech phygitalization**

| Aspects / Levels | Subject | Process | Technology | Result | Methods | Means |
|---|---|---|---|---|---|---|
| **Ministry of Science and Higher Education** | Labor market | Management | Prescriptive analytics (as it should be) | Educational policy | Artificial intelligence | NN* & ML** (Alteryx, PowerBI, Loginom, etc.) |
| **High Education Institute** | Employment | Modeling | Predictive analytics (what will happen) | Clusters of specialties | Data mining | Statistica, SPSS, etc. |
| **Department** | Curricula | Planning | Diagnostic analytics (what to do) | Competence patterns | Cloud and portal solutions | Compass, Mattermost, VK Teams, etc. |
| **Teacher** | Course modules | Teaching | Descriptive analytics (how to do) | Learning outcomes | Pedagogical design | AR, VR, MR, AI agents |

*Note:* *NN – neural nets, **ML – machine learning.

*Source:* compiled by Andrey I. Kapterev.

We have identified and justified the following functions of EdTech phygitalization: (a) informational, (b) communicational, (c) motivating, (d) transformational, (e) personalizing, (f) image-building.

Many people note that today, since computer science as a whole is gradually turning from an applied science into a fundamental science, the information function of digitalization is actually multicomponent. The universality of EdTech phygitalization assumes that all educational and information processes are aimed at research tasks, increasing the independence of each student, especially if he uses artificial intelligence agents.

The communicational function manifests itself in consistency, i.e. when creating a teacher's personal website (TPW), its developer pursues the task of creating consolidated multimedia content suitable for all author's courses and types of personal activity. The TPW provides the teacher and the student with a wide range of opportunities, ranging from working with an electronic textbook to audiovisual interactive communication. The TPW combines consistent logically arranged educational content, followed by tests. Apart from it, there is another, even more significant part – auxiliary material (anthologies), placed either in the TPW or outside, with links.

The motivating function of TPW is manifested in the fact that it allows you to solve urgent educational and research tasks, not just by providing access to inexhaustible sources of information, as in conventional browsers, but by structuring specially selected and organized pedagogical content. TPW unwittingly generates professional and educational spaces, stimulating interdisciplinary and cross-cultural research. The primary task is to comply with a reasonable measure of phygitalization, i.e. the balanced use of digital and traditional educational elements. In TPW, this task can be implemented by alternating online and offline modes of interaction with trainees and integrating special collaboration blocks. In general, this approach develops internal discipline in the student, develops teamwork skills.

The transformational function demonstrates the evolution of professional education from a one-sided oral channel of professional communication (teacher – students) to a multidirectional polylogue and multimedia educational content. The TPW attempts to build into a single educational research system most diverse kinds and types of information sources, accompanied by bibliography and videography.

The personalizing function proves itself in characteristic properties of the TPW. Firstly, in terms of didactic variability the TPW serves as a tool of digital educational engineering and provides unlimited access to students and colleagues in various modes (lectures, self-study content, reference support, etc.). With scientific data quickly becoming outdated, educational trajectories have to be developed further, fit-all-sizes ones are no longer appropriate. The individualized educational function implies interactivity, which allows the user to choose the best suitable learning trajectory, the learning rhythm, 'level of immersion' and, of course, opportunity to assess how well the basic blocks of knowledge have been mastered, which the student reports to the teacher.

The image function manifests itself in promoting the ethics of higher education, enhancing the role of the teacher as an enthusiastic researcher, a successful and motivated professional whose achievements are recognized by the scientific community. This function is supported by optional information about the teacher as a person with related hobbies.

## 2. Proposed solutions

### 2.1. *Teacher's personal website (TPW) in EdTech phygitalization*

An author's personal website is a computer educational and research system with a hierarchical structure. On the screen there are always either drop-down menus built on CSS technology, landing technology or frames (content frames and menu frames).

The TPW, developed by the author, contains the following main sections, which are accessed on the main page through drop-down menus:

(a) projects,

(b) career,

(c) tutorials (educational and research complexes for individual courses),

(d) cases,

(e) texts (where some significant publications of the author are placed),

(f) hobbies.

In the projects section the projects implemented by the author are placed, which aims to show the scope of professional interests of the teacher. By clicking the hyperlinks for a particular project the student can get acquainted with it in more detail.

Overall, the upsides of the TPW can be summed up as following:

– TPW provides 24/7 access to information;
– TPW enables users to compartmentalize educational content (professional knowledge) with the help of effective navigation tools;
– TPW gives different groups of students an opportunity to manage the content in the way most convenient for them, either with or without authorized access;
– TPW provides effective search engines coupled with visualizing tools (dropdown menu, custom search tools, visual tools);
– TPW is a quick delivery system, which gets across necessary information though news blocks, data feeds, either created by the teacher or integrated from other sources;
– TPW encourages information exchange in the group of learners due to different conferences and forums, helps get access to other web-services for in-house and outside work;
– TPW provides services of customization, allocation of resources, client's place arrangement, tracking the works completed, etc.

TPWs offer numerous advantages in the realm of EdTech phygitalization:

1. TPWs not only facilitate the exchange of professional information, but also significantly save students' and teachers' time searching for and using content for control and laboratory tasks, fostering the exchange of ideas, feedback, and collaborative problem-solving.

2. TPWs help teachers and students keep up to date with the latest trends, tools, and best practices in the field. Teachers can use their websites to create headings, develop assessments, and monitor student progress. This can enhance the overall effectiveness of digital learning environments.

3. TPWs simultaneously act as a virtual platform for teachers to collaborate, where they can share their teaching experience. This contributes to the formation of a sense of common purpose and support, which is especially valuable for teachers who may feel isolated or disconnected from their peers due to various barriers such as age, experience or level of digital culture.

Overall, TPWs are a valuable resource for teachers interested in modeling digital professional spaces, providing opportunities for collaboration, professional development, assessment, and community building. Detailed possibilities of using TPWs in EdTech phygitalization are further explored in the referenced monograph [8].

2.2. *Virtual laboratories in EdTech phygitalization*

In our research, we employ virtual laboratories (VLs) – specially designed sites for gathering, analyzing, and visualizing thematic information.

1. Our VL "PROFSILA" (http://profsila.wixsite.com/profsila) includes various functional elements designed for intuitive navigation, transition to tests, visualization of test results and a block of career guidance recommendations. The system is an interactive website compatible with major browsers that support HTML 5.0.

2. The "ELLIPSE" VL (http://www.mediagnosis.ru/Autorun/Our/Other/Kapterev/Elips/Elips.htm) focuses on diagnosing various substructures of professional consciousness in Master's degree students. It measures professional interests, needs, values, norms, and activity structures using a cloud-based analysis tool within the Master's degree in Pedagogy program.

3. The "RISKS" VL (http://riski.mediagnosis.ru/) uses socio-psychological technologies to diagnose levels of information and network competence. The system includes an interface block, a testing block, an information sources block, and a feedback block, accessible through any HTML 5.0 compliant browser.

4. VL "SHIVA: School Innovations and Visual Analytics" (http://shiva.mediagnosis.ru/) is designed for remote study of innovative activities in Moscow's general education institutions. It supports organizational decision-making by teachers through a consistent, complex, adaptable, and multidimensional system accessible without prior payment or registration.

We see that VLs are a powerful element in EdTech phygitalization, providing both students and teachers with continuous access to scientific theories, concepts, and personalized educational experiences across various training areas.

Virtual laboratories provide ***significant benefits*** in EdTech phygitalization:

– VLs are accessible from any location with an internet connection, making them ideal for students lacking access to physical labs or face-to-face classes;
– VLs save on expensive equipment and reduce the risk of student injuries compared to physical laboratories;
– VLs can be tailored to specific course needs and individual learning styles;
– VLs offer engaging and immersive learning experiences, potentially incorporating game elements to boost motivation;
– VLs enable the collection and analysis of experimental data, helping students develop analytical skills and understanding of scientific concepts;
– VLs facilitate collaborative learning by allowing students to work together on experiments and projects, regardless of their physical locations.

Virtual laboratories are thus becoming a cornerstone of EdTech phygitalization. They provide several key benefits for both teachers and students:

1. Enhanced learning opportunities:

– VLs allow students to engage in complex and otherwise costly or dangerous experiments safely and repeatedly until concepts are fully understood;

– students can use virtual tools and technologies that might not be available in their physical classrooms, providing exposure to advanced equipment and methodologies.

2. Inclusivity and accessibility:

– students from under-resourced schools or remote locations can access the same high-quality laboratory experiences as those from more affluent areas;

– VLs are accessible at any time, accommodating different learning schedules and paces.

3. Interactive and personalized learning:

– VLs can adapt to individual learning speeds and styles, offering personalized feedback and tailored learning experiences;

– incorporating game mechanics can make learning more engaging, motivating students to achieve higher levels of understanding through rewards and progress tracking.

For virtual laboratories to be ***effectively integrated into EdTech***, several considerations need to be addressed:

1. Technological infrastructure:

– ensuring all students have reliable Internet access and appropriate devices to engage with VLs;

– developing VLs that are compatible across various operating systems and devices to maximize accessibility.

2. Teacher training and support, including demonstrating how to effectively use VLs in their classes; providing ongoing technical and pedagogical support, not only to students, but also to colleagues teaching the same course.

As technology continues to evolve, the potential applications of VLs in education are expected to expand further.

Some ***emerging trends and future directions*** include:

1. Artificial intelligence and machine learning:

– AI-powered tutors can provide personalized guidance and support to students as they navigate virtual lab activities;

– machine learning algorithms can analyze student performance data to predict learning outcomes and identify areas where students may need additional support.

2. Virtual and augmented reality:

– expanding the use of virtual, augmented and mixed reality (VR, AR, MR) for educational and cultural programs;

– integration with artificial intelligence systems for personalized recommendations and assistance in finding information, which implies,

for example, in the future providing access to paid AI services to students affiliated with this university;
- expanding the scope of digital curation, i.e. thematic support for students' research and educational projects;
- development of tools for collaboration and learning in a digital environment;
- improving the accessibility and usability of digital resources for students with disabilities;
- widespread dissemination of courses to improve digital literacy and information and network competence of students and teachers;
- hosting virtual events where students can showcase their work and engage with peers worldwide.

3. Sustainability and scalability:
- VLs reduce the need for physical resources and chemicals, contributing to more sustainable educational practices;
- VLs can be scaled to accommodate large numbers of students, making them an efficient solution for growing educational needs.

Thus virtual laboratories represent a significant advancement in the phygitalization of education, offering a myriad of benefits that enhance learning, accessibility, and teacher support. By carefully considering implementation strategies and future trends, teachers can harness the full potential of VLs to provide enriched, personalized, and immersive learning experiences. As we continue to integrate digital and physical learning environments, virtual laboratories will undoubtedly play a crucial role in shaping the future of education, making scientific exploration and discovery more accessible and engaging for all students.

2.3. *Artificial intelligence in EdTech phygitalization*

Artificial intelligence (AI) is a rapidly developing field that is transforming many industries and changing the way people live and work. In general, research in the field of digital modeling of the professional environment is still in its early stages, and there is great potential for future development and innovation in this area. At the same time, some studies have shown promising results. Thus, the focus of English-speaking authors is on the prospects of using such technologies as: a) digital twins [9–11], b) virtual reality and the Internet of Things [12], c) 3D models [13]. In Russian literature, in addition to those mentioned, the following are studied: a) knowledge representation in information systems [14], b) methodologies and technologies for designing information systems [15], c) business modeling and data mining [16].

AI holds the promise of fundamentally transforming university operations and the delivery of educational services to students. However, the application of AI in vocational training is still emerging, with its full potential yet to be realized. Generative AI stands as a potent tool with wide-ranging applications across various sectors, poised to bring about significant changes. A key strategy to counter the unchecked use of AI language models involves tailoring educational paths and customizing assessment tasks. For instance, our platform (www.mediagnosis.ru) has developed over 150 lab exercises featuring individualized task variants.

In the realm of EdTech phygitalization, AI systems can play multiple roles, including:

(a) AI prompt intervention can thus be made to aid their learning journey.

(b) Through predictive analysis, AI can forecast future outcomes based on existing data, allowing teachers to foresee potential issues or opportunities and proactively adjust to refine the digital learning landscape.

(c) AI can offer mechanisms for feedback and evaluation, helping teachers monitor student progress and assess the effectiveness of teaching strategies. This ensures that learning achievements align with the educational aims and objectives.

(d) Teachers can receive alerts from AI systems when a student's activity deviates from expected patterns, such as a drop in participation or missed deadlines, enabling them to offer support when needed.

(e) Some advanced AI systems can use facial and emotional recognition to gauge student engagement and emotional states during synchronous online sessions, although this use raises privacy concerns and requires careful ethical consideration.

(f) AI can use real-time data to predict student outcomes, allowing teachers to proactively address potential academic risks.

Overall, AI systems emerge as a crucial component of EdTech phygitalization, equipping teachers with data-driven insights into student performance and engagement, fostering personalized learning experiences and facilitating timely interventions to enhance student success.

Besides that, AI systems can assist in real-time monitoring of students' activities in several ways, enhancing the educational experience and providing valuable support for both students and teachers.

By leveraging these capabilities, AI systems can significantly contribute to a more responsive and supportive educational environment, helping to ensure that students receive the attention and resources they need to succeed.

If the tools we discussed earlier can be mainly useful to students, then next we will look at tools aimed primarily at teachers.

There are dozens of systems that focus mainly on the intellectual analysis of documents and the extraction of conceptual (conceptographic) information from them, i.e. on the intellectual analysis of texts and their summarization. The most common are the following: Mon key Learn, UPDF, Thematic, Lexalytics, Chattermill, QDA Miner, MS Azure AILanguage, InMoment Text Analytics, Lang.ai, Aylien. These tools offer different levels of complexity and functionality, and the choice of the appropriate one depends on the specific needs and tasks facing the organization or the user.

Text mining systems are designed to help obtain high-quality information from the input text. It is estimated that about 80 % of management-related information comes from unstructured data, most of which is text messages such as emails, reports, and even social media posts.

There is a lot of valuable information hidden inside this unstructured data, but without technological tools to organize the data in any way, it can be very difficult to find it. This is where the intellectual analysis of texts is needed. Text mining systems are a powerful tool that helps individual users and corporate structures extract valuable information from unstructured data. These systems differ in functions and capabilities, but the goal remains the same: to help understand unstructured data. Text mining systems help analyze text data and sort it to make it easier to identify relationships. When talking about text analytics, there are several concepts that should be distinguished: taxonomy, folksonomy, natural language processing and large language models.

Natural Language Processing (NLP) is a branch of artificial intelligence that studies the human-machine interface. After all, despite the fact that the WIMP[1] interface has been familiar to all of us for more than 50 years, we continue to use it, but we dream of communicating with technical devices as with people. With the improvement of computer technology, the spread of tablets and smartphones, the SILK interface appeared, where S (speech), I (image), L (language), K (knowledge). Modern speech recognition systems (Speech-to-Text), large language models (LLM), universal pre-trained transformers (GPT) integrated into artificial intelligence systems using neural network algorithms have become an everyday partner of millions of users, including students and schoolchildren all over the world. NLP focuses on allowing computer programs to recognize, interpret, and generate natural language in a way that is both understandable and useful to the user.

The main goal of NLP is to bridge the gap between human communication, which often includes unstructured and polysemic text, and the structured and precise nature of computer languages. NLP allows computer programs to process, analyze, and extract information from huge amounts of text data in the same way that humans do, but often better and faster.

Large Language Models (LLM) are a class of artificial intelligence models that have the ability to interpret and generate natural language. These models are trained on huge amounts of textual data to develop the 'skills' of extracting meaning from language patterns and structures using deep learning methods.

And what is the difference between taxonomy and folksonomy? A taxonomy is a hierarchical classification system in which content is divided into a structured and predefined set of categories. It uses tables where categories and subcategories are defined by developers. Librarians are very familiar with the classification tables used in all countries.

Folksonomy is the practice of co-categorizing information through randomly selected labels called tags. It is known as co-tagging, social classification, social indexing, and social tagging. This is a bottom-up approach, as users assign their own tags based on their understanding and context, without a predefined structure.

[1] WIMP is an abbreviation of Windows, Icons, Menus, Pointer

Text mining systems can be compared according to a number of criteria that will help assess their effectiveness and applicability to specific tasks. There are quite a lot of such criteria. Here are some of them:

(a) accuracy of the analysis, i.e. the ability of the system to correctly interpret and analyze the text, including understanding the context, semantics and syntax;

(b) NLP, i.e. determining the quality and depth of natural language processing algorithms, including sentence parsing, entity recognition, relationship extraction and sentiment analysis;

(c) scalability, i.e. the ability of the system to work effectively with large volumes of text and scale to various loads;

(d) language support, i.e. the number of supported languages and the quality of analysis for each of them;

(e) integration with other systems, i.e. the possibility of integration with other software products and services.

(e) user interface and usability;

(g) customization, i.e. the ability to adapt the system to the specific needs of the user or project;

(h) security and confidentiality, i.e. measures taken to protect data and ensure the confidentiality of information;

(i) processing speed, i.e. the time required for the system to analyze the text and provide the results;

(j) availability of detailed documentation and quality of technical support;

(k) total cost of ownership of the system, including licensing, support and updates;

(l) ability of the system to learn from new data and adapt to changes in language and context.

We can see how wide the functionality of these systems is.

If we try to compare some of the mentioned text mining tools by four main parameters (accessibility, interface, compatibility and functionality), we get the following table (Table 2).

*Table 2*

**Comparison of text mining tools**

| **Characteristics**<br><br>**Instrument** | **Availability** | **Interface** | **Compatibility** | **Functionality** |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |
| **Monkey-Learn** (https://monkeylearn.com/) | Paid and free plans are available | Intuitive, with a visual editor for creating models | API for integration with other services and applications | Text classification, sentiment analysis, entity extraction |
| **ASReview** (https://asreview.nl/) | Free and open source software | Intuitive | Local installation or server installation | Selects, analyzes, and sorts resources based on the user's selection history and places them in such a way that the most relevant works are first in line. Complies with the checklist of requirements for systematic reviews using AI |

*Table 2, continuation*

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| **Iris.ai** (https://iris.ai/features/#workspace) | Paid service with a demo version | Intuitive | Cloud-based solution | It helps to analyze literature, create annotations and organize information |
| **Elicit** (https://elicit.com/?redirected=true) | The resource is free; registration is required | Intuitive | Cloud-based solution | Searches for scientific articles. Ask a research question and get a list of relevant articles from a database of 125 million texts in response<br>Extracts detailed information from articles into an ordered table |
| **Keenious** (https://keenious.com/) | The resource is paid, but there is a demo version; registration is not required to access basic functions, but registration can provide additional features | Intuitive | Cloud-based solution, but can be added as a sidebar in Microsoft Word or Google Docs or used on a website | Analyzes the user's article, recommends relevant research papers and research topics |
| **Azure AI Language** (https://azure.microsoft.com/en-us/products/ai-services/ai-language) | Paid services with different pricing levels | A cloud platform with developer tools | Extensive integration capabilities with other Microsoft products and third-party services | Advanced NLP features, including text analysis, translation, and speech recognition |
| **InMoment Text Analytics** (https://inmoment.com/text-analytics/) | Paid solutions aimed at the corporate sector | Focus on user-friendliness | The ability to integrate with feedback collection and CRM systems | Customer feedback analysis, insight extraction, sentiment analysis |
| **WordStat** | Proprietary software | It is aimed at researchers and data analysts | Compatibility with other statistical packages and data analysis tools. | Quantitative text analysis, dictionary creation, thematic modeling |
| **Yandex Wordstat** (https://wordstat.yandex.ru/) | The app is free with the possibility of subscription | It is aimed at all users | Registration in Yandex ID is required | According to this data, you can find out the popularity of user search queries, seasonality, geography of demand, devices used by users, and trends |
| **Chatter-mill** (https://chattermill.com/) | Paid solutions aimed at the corporate sector | User interface for analyzing customer data | Integration with customer feedback and data collection platforms | In-depth analysis of customer reviews, sentiment analysis, insight extraction |
| **Textrics** (https://www.textrics.ai/) | Paid and free plans are available | Simple and intuitive interface | API for integration with other systems | Text analysis, sentiment analysis, feedback and survey processing |
| **Bitext** (https://www.bitext.com/methodology/) | Paid solutions | API-oriented service for developers | The ability to integrate with chatbots and AI systems | Deep semantic analysis, natural language processing |
| **Lang.ai** (https://www.lang.ai/) | Paid solutions | A platform with an emphasis on NLP automation | API for integration with business platforms | Extracting structured data from unstructured text |

*Table 2, ending*

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| **Aylien** (https://aylien.com/) | Paid solutions, 14 days of testing | API and a set of tools for developers | Easily integrates with other systems and applications | Text analysis, summarization, classification, media monitoring |
| **Papers** (https://www.papersapp.com/) | Paid, with the possibility of trial use | Modern and user-friendly | Integration with search engines and databases | Organization of research materials, reading and annotating, management of research materials, which helps to organize, read, annotate and share scientific articles. |
| **Open Calais** (https://www.w3.org/2001/sw/wiki/Open_Calais) | The web service is free for commercial and non-commercial use | A cloud-based tool that helps you post content. It automatically creates rich semantic metadata for the content you send | Integration of the Thomson Reuters Calais web service via the Definitive Intelligent Tagging API into the Drupal platform | Recognition of relationships between various objects in unstructured data and their corresponding organization with identification of causes and effects |

*Source:* compiled by Andrey I. Kapterev.

Since the field of AI is developing very rapidly, it is impossible to accurately determine all the possibilities of its use in educational engineering, but today we propose to indicate some prospects for further development of AI algorithms, calling them potential opportunities for EdTech phygitalization, such as:

1) proficient in multimodal comprehension, analysis, and creation of context-driven constructs across various media formats, leading to the rise of autonomously generated personalized media;

4) ability to plan, reason and predict, use logic in solving intellectual problems, and predicting future outcomes with unprecedented precision;

5) providing access beyond the internet to diverse platforms, enabling artificial neural network agents to engage with an extensive array of resources and services;

6) utilizing multiple agents (as seen in GPT models) through APIs, where each agent addresses specific tasks but also collaborates and critiques others, fostering the development of competitive artificial neural networks;

7) operating without user intervention to achieve full autonomy, functioning continuously;

8) development of a GPTs that seamlessly integrates into all aspects of our lives, demonstrates general AI in many areas, contributes to the achievement of personal goals and adapts to the devices with which we interact.

**3. Prospects for EdTech phygitalization development**

EdTech phygitalization has all the possibilities to significantly change the educational landscape of vocational education. Currently, scientists all over the world are actively researching the digital transformation of educational institutions using statistical methods and modern business intelligence platforms [16].

Here are some future directions for EdTech phygitalization in higher education:

1. EdTech phygitalization can broaden access to higher education by offering adaptable remote learning alternatives for students unable to participate in conventional on-campus classes. It can also foster inclusion by creating opportunities for individuals with disabilities and lowering educational barriers [17].

2. EdTech phygitalization can tailor educational trajectories for each student based on their specific needs, interests, and learning styles. This can be accomplished through adaptive learning technologies and personalized assessments that leverage data analytics to track student progress and provide individualized feedback and resource recommendations.

3. EdTech phygitalization can also include gamification to increase student engagement and motivation. This increased interactivity can make the learning process more fun and improve the memorization of information.

4. EdTech phygitalization can promote global learning by connecting students and teachers from different parts of the world. This can provide opportunities for cross-cultural exchange, collaboration and exposure to best practices and promising ideas [18].

5. EdTech phygitalization can be used to study human behavior and decision-making, and data analytics can be used to analyze large amounts of data and identify ideas and trends.

**Conclusion.** The main features of proposed information system can be reduced to the following. Firstly, its main advantage is the unity of all the elements of the educational and research complex. Secondly, the system model is not of instructional, prescription character, it is a knowledge space that can be used for various purposes and training scenarios. The variants of virtual laboratories, described in the paper, demonstrate wide opportunities for collecting, analyzing and visualizing different information directly or indirectly related to the pedagogical process, and can be considered as one of the numerous digital platforms in the transformation of education.

Thus, the main advantage of digitalization in comparison with total digitalization is a more reasonable setting of goals, prioritization of digital transformation of educational processes, organization of interconnection of all components of the educational system in a single digital space. Naturally, for the success of digitalization, it is necessary to unite all subjects of the educational space, including students, teachers, methodologists, managers, employers and manufacturers of equipment for digitalization of education. The development of EdTech in general and the use of digitalization in particular imply a rethinking of the key roles of all subjects of educational systems in the direction of educational engineering.

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