Особенности применения методов семантического и сентимент-анализа в процессе оценки эффективности цифровых образовательных технологий в российских университетах

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Аннотация. Цифровые образовательные технологии (DET) уверенно заняли позиции структурного элемента современной системы высшего образования. Несмотря на успехи цифровизации вузов, остаются проблемы, связанные с большими затратами и техническими аспектами внедрения удобных в пользовании и высококачественных цифровых платформ. Это актуализирует проблему оптимизации университетских бюджетов на цифровизацию. Целью статьи является исследование инструментов комплексного семантического анализа и анализа настроений в российских вузах как инструмента оценки эффективности DET. Задачами исследования явились: обзор литературы по заявленной проблеме; разработка методологии исследования; проведение комплексного семантического анализа и анализа настроений в российских вузах; оценка эффективности DET; разработка рекомендаций для повышения эффективности DET. Методы исследования: использован гибридный количественный и качественный подход; включая систематические обзоры, использование лексики и обработку естественного языка (NLP) для анализа настроений и семантики. Результаты исследования показывают, что, хотя 88% вузов имеют системы управления обучением (LMS), только 45% эффективно используют их в образовательных целях. Только 44% университетов имеют лицензии на программное обеспечение для совместной работы (Zoom), а 13% не имеют необходимой цифровой инфраструктуры (высокоскоростной Интернет). Эти пробелы указывают на значительные препятствия к эффективному использованию DET. Результаты анализа настроений показывают, что учащиеся в целом положительно относятся к цифровым учебным платформам, а методы анализа настроений, основанные на глубинном обучении, демонстрируют высокую эффективность DET. Авторы рекомендуют совершенствовать цифровую инфраструктуру, повышать уровень подготовки ППС и студентов, а также разрабатывать целевые стратегии для лучшей интеграции DET. Исследование дополняет существующую литературу, предоставляя всестороннюю оценку DET в российских вузах с использованием передовых аналитических методов. Подчеркивается необходимость постоянных инвестиций и стратегического планирования для полной реализации преимуществ DET.

Ключевые слова: Цифровые образовательные технологии (DET); Системы управления обучением (LMS); Цифровая грамотность; Анализ настроений; Сентимент-анализ; Семантический анализ; Цифровая инфраструктура; Высшее образование в России; Конструктивистская теория обучения (CLT); Эффективность цифровых образовательных технологий; Эффективность DET

JEL codes: C15, A29, I23

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Introduction

In recent years, the integration of digital technologies in higher education has revolutionized the learning environment. Universities in Russia, like many around the world, have increasingly adopted digital educational technologies to enhance teaching and learning experiences [13, 34]. This shift has been driven by the need to provide flexible, accessible, and interactive learning opportunities. However, assessing the effectiveness of these technologies remains a critical area of investigation, since there are currently no unified approaches to the stages of this process. This is due not only to the novelty of the DET phenomenon and, consequently, the lack of relevant methods for its evaluating, but also to the fact that effectiveness can be measured both by economic categories (cost-benefit ratio) and social (for example, the number of people involved in digital learning, the number of those satisfied with this training, etc.). In this regard one promising approach is through semantic and sentiment analysis, techniques that analyze textual data to gauge opinions and emotional states [29]. These methods offer valuable insights into students' and educators' experiences, informing improvements in digital education strategies. This paper aims to explore the methodological aspects of applying these analytical techniques to evaluate the effectiveness of using of digital educational technologies in Russian universities.

Semantic analysis involves understanding the meaning behind words and phrases in context, while sentiment analysis focuses on identifying the emotional tone of the text. Together, these techniques can help identify patterns in feedback, highlight areas of success and concern, and ultimately guide the enhancement of digital educational technologies. For instance, aspect-based sentiment analysis (ABSA) can provide granular insights by examining specific features of educational tools and their corresponding sentiments [13]. This detailed approach is crucial for identifying specific areas that require improvement, ensuring that digital tools meet the needs of both students and educators. This paper's focus on methodological aspects seeks to enhance the precision and reliability of such analyses.

In Russia, the digital infrastructure of higher education institutions has seen significant development. As of March 2020, 88.51% of dormitories had internet access, and 88% of universities reported having learning management systems (LMS) (Statista, 2024). However, only 45% of these universities effectively utilized LMS for educational purposes, indicating a gap between infrastructure availability and its effective use. Additionally, only 44% had licenses for software enabling simultaneous group work, such as Zoom, and 13% had no high-speed internet or specialized storage systems (Statista, 2024). Furthermore, only 11% of universities had digital infrastructure sufficient for comprehensive online education using their own facilities [26]. These statistics underscore the need for targeted strategies to improve digital infrastructure and its effective use.

The increasing adoption of online courses further highlights the importance of evaluating digital educational technologies. In 2019, the most popular platforms for online courses in Russia included Coursera (15%), GeekBrains (8%), and National Open University INTUIT (7%), among others [12]. The number of users of online education has grown significantly, from 4.12 million in 2018 to 9.9 million in 2023. This rapid growth reflects a broader trend towards digital learning, necessitating robust methods for assessing and enhancing these technologies. By leveraging semantic and sentiment analysis, educators and administrators can better understand user experiences and drive improvements in digital learning environments.

The methodological focus of this paper involves applying semantic and sentiment analysis to evaluate the effectiveness of digital educational technologies in Russian universities. Techniques such as deep learning and aspect-based sentiment analysis (ABSA) have shown promise in providing detailed insights into user feedback). For example, a study on MOOCs demonstrated that deep learning-based architectures outperform traditional methods in sentiment analysis, achieving high predictive performance. This paper will discuss

various methods and tools used in these analyses, emphasizing their applicability to the educational context in Russia.

The integration of digital technologies in higher education is a transformative trend that requires thorough evaluation to maximize its benefits. Semantic and sentiment analysis provide powerful tools for understanding and improving digital educational experiences. By examining the methodological aspects of these techniques, this paper aims to contribute to the effective assessment and enhancement of digital educational technologies in Russian universities. This approach not only addresses current challenges but also lays the groundwork for future research and development in the field of educational technology.

The specific objectives of this study is to

1. Evaluate the Extent and Effectiveness of Digital Infrastructure in Russian Universities
2. Apply Semantic and Sentiment Analysis to Gauge User Experience and Feedback
3. Examine the Impact of Popular Online Educational Platforms on Learning Outcomes

Literature Review

Several studies have been conducted on the semantic and sentiment analysis of the effectiveness of digital educational technologies used by universities in Russia. One study involved 173 Russian university students and aimed to analyze their attitudes towards digital educational technologies before and during their university education [10]. Another study focused on investigating the effectiveness of educational technologies in the foreign language learning process by analyzing linguistic factors [30]. A systematic literature review method was used in a third study to analyze digital transformation readiness in the education sector, with a specific focus on students' perceptions [5]. Additionally, a sentiment analysis and multi-country review explored the perceptions of university students and educators on the use of digital and social media platforms. A study conducted sentiment analysis on stakeholders' perceptions of the acceleration of digital education and its impact on flexibility and student outcomes [5]. These studies provide valuable insights into the methodological aspects of semantic and sentiment analysis in assessing the effectiveness of digital educational technologies in Russian universities.

Digital Educational Technologies in Higher Education

The adoption of digital educational technologies has become widespread in higher education institutions globally. Studies have shown that these technologies can enhance learning outcomes, increase student engagement, and provide flexible learning opportunities [36]. In the context of Russian universities, the integration of such technologies has been driven by a need to modernize educational practices and improve accessibility to quality education.

The integration of digital educational technologies (DET) in higher education has been a focal point of research, particularly in light of recent global digital transformations. Ronzhina et al. highlighted that the penetration of digital technologies in Russian higher education is perceived as low, with an overall rating of 3.15 by students and 3.43 by teachers [31]. Despite this, both groups acknowledged that digitalization positively impacts academic performance, with students rating this effect higher than teachers. This study underscores the necessity of ongoing digital development and positive student attitudes towards available digital opportunities.

Drugova et al. examined the integration of the Skyes digital learning platform in three Russian universities using the TPACK and SAMR models[11]. Their findings indicate that successful integration of digital platforms requires motivation, feedback from both teachers and students, clear assessment of learning outcomes, and alignment between innovation and educational regulations. This case study demonstrates that a structured approach to technology integration can enhance the learning and teaching process in higher education.

Peskova et al. assessed digital educational activities in Russian universities through the Yuryat platform [26]. Their study revealed low overall digital activity, with an average value of 8.2% of the maximum level. The research highlighted significant inter-university differentiation and a concentration of digital transformation efforts in major cities like Moscow, St. Petersburg, and Yekaterinburg. These findings suggest that while there

are pockets of progress, widespread digital transformation in Russian higher education remains a work in progress .

Z. Liu et al. explored digital literacy and digital didactics as the foundation for new learning models [19]. Their research emphasized that high levels of digital literacy among teachers are crucial for effective digital education. The study found that teachers in higher education had significantly higher digital literacy levels than the general population, highlighting the importance of continuous digital literacy development to support new educational models .

M. Pinto and C. Leite conducted a literature review on the use of digital technologies by higher education students [28]. They identified three primary types of technologies: Learning Management Systems, content publishing and sharing tools, and a broad range of ICTs. The review found that these technologies positively impact student learning by promoting active engagement and participation, although they are less frequently used for collaborative learning .

Lastly, M. Alenezi discussed the broader implications of digital transformation in higher education, including the adoption of online courses and digital learning environments [3]. The study emphasized the need for higher education institutions to leverage ICT tools to remain competitive and deliver high-quality education. M. Alenezi et al. also noted the challenges and opportunities associated with integrating digital education, underscoring the transformative potential of digital technologies in modernizing higher education [4].

Semantic and Sentiment Analysis in Education

Semantic and sentiment analysis are emerging as powerful tools for educational assessment. According to C. Grimalt-Álvaro and M. Usart [12], sentiment analysis, which applies artificial intelligence to analyze textual data, can significantly improve learning through timely and personalized feedback. However, its application in education remains limited, particularly in higher education settings.

There are two primary approaches to sentiment analysis: lexicon-based methods and machine learning (ML) approaches. Lexicon-based methods use predefined dictionaries to identify sentiments, making them accessible and easy to implement. However, they often lack the ability to understand context, leading to potential inaccuracies in specialized educational settings [23, 41]. On the other hand, ML approaches, though more complex and data-intensive, offer higher accuracy by learning from large datasets [2].

N. Nikolić et al. developed an Aspect-Based Sentiment Analysis (ABSA) system for Serbian student reviews, achieving significant F-measure scores, indicating the system's efficiency in identifying positive and negative sentiments in educational reviews [24]. Similarly, H. Wan and S. Tang proposed a sentiment analysis model integrating AI and data mining to enhance the efficiency of sentiment analysis in ideological and political teaching, demonstrating improved teaching outcomes through multimodal sentiment recognition [38].

Z. Kastrati et al. conducted a systematic mapping study to classify sentiment analysis research in education, highlighting the rapid growth in applying deep learning techniques to analyze student feedback and emphasizing the need for structured datasets and standardized solutions [13]. Q. Xiang et al. introduced a multi-scale deep learning method for analyzing public opinions among college students, balancing model depth and breadth to improve sentiment analysis efficiency on social media data(2022-ECIS-Aspect-based-…) [39].

S. Smetanin reviewed sentiment analysis applications for Russian texts, identifying challenges and future directions, and emphasizing the need for specialized datasets and improved analysis methodologies [35]. M. Mohd et al. introduced Lexico-Semantic features for sentiment polarity tasks, demonstrating enhanced classifier performance when these features are incorporated [22]. G.Zhai et al. proposed a Multi-Attention Fusion Modeling approach for sentiment analysis in educational data, achieving better classification results by integrating global and local attention mechanisms [40]. S. Consoli et al. developed a Fine-Grained Aspect-Based Sentiment Analysis method for economic texts, which could be adapted for educational contexts to provide detailed sentiment insights [9].

Z. Ke et al. proposed a knowledge-guided sentiment analysis framework using natural language explanations to improve sentiment classifier training, showing superior performance in leveraging domain knowledge [14]. N.Sanglerdsinlapachai et al. improved sentiment analysis on clinical narratives by exploiting UMLS semantic types, highlighting the potential for similar approaches in educational sentiment analysis [33].

Methodology

Research Design

The present work thus adopts an integrated quantitative and qualitative approach to evaluating the efficiency of digital education technologies in the Russian universities. It entails the analysis of written text from online students' forums, different journal publications of high impacts, and the data on the use of digital educational technologies which are sourced from Statista.

Planning Phase

The literature review followed Kitchenham's methodology for systematic reviews and utilized the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. A comprehensive search string was used to search databases such as ERIC, Scopus, and Web of Science [15, 18, 27].

The planning phase involved the following steps:

1. Search Strategy: Formulation of a search string based on keywords related to digital educational technologies, constructivist learning theory, and sentiment analysis.

2. Database Search: Conducted a thorough search in ERIC, Scopus, and Web of Science databases to identify relevant publications.

1.1. Conducting Phase

The conducting phase involved the screening of abstracts and full texts based on predefined inclusion and exclusion criteria:

1. Initial Screening: Abstracts of 340 publications were screened, resulting in the exclusion of 240publications that did not meet the criteria.

2. Further Evaluation: 100 publications were selected for further evaluation in the eligibility phase.

1.2. Reporting Phase

In the eligibility phase, the selected publications were examined in detail:

1. Detailed Examination: The remaining 100 publications were reviewed thoroughly, leading to the exclusion of 22 publications based on relevance and quality.

2. Final Selection: 68 publications were selected for detailed study based on the information in the database.

The methodology involved a qualitative synthesis to answer the research questions on sentiment analysis techniques in formative assessment in higher education.

1.3. Data Collection

Data collection for the study include both quantitative and qualitative data:

1. Quantitative Data: Descriptive statistics on the use of digital educational technologies by universities in Russia were sourced from Statista.

2. Qualitative Data: Textual data were gathered from multiple digital platforms used by universities, such as Moodle and other virtual learning environments (VLEs) as presented in Table 1. This will include anonymized student feedback, discussion forum posts, and email communications between students and faculty.

Table 1– Virtual Learning Environments (VLEs) studied

Name of Websites	Link
Moodle	https://moodle.org/mod/forum/discuss.php?d=390831
RussianPod101	https://www.russianpod101.com/forum/viewforum.php?f=23

Name of Websites	Link
MasterRussian	http://masterrussian.net/f13/russian-forums-11577/
Coursera	https://www.coursera.org/
GeekBrains	https://gb.ru/
Odoo eLearning	https://www.odoo.com/
Cisco Networking Academy	https://www.netacad.com/academy/29120
Udemy	https://www.udemy.com/
Universarium	https://universarium.org/
OpenEdu	https://openedu.ru/
Netology	https://netology.ru/

Source: compiled by the authors

Ethical implications of data collection are addressed by ensuring data anonymization and reerencing.

1.4. Data Analysis

The analysis will employ both lexicon-based and Natural Language Processing (NLP) approaches to sentiment and semantic analysis:

1. Sentiment Analysis:

Lexicon-Based Methods: Utilizing existing linguistic libraries to identify sentiments in the collected data.

2. Semantic Analysis: Using natural language processing (NLP) techniques to extract meaningful patterns and themes from the text.

3. Descriptive Statistics and correlation coefficient: Analyzing quantitative data from Statista to provide an overview of digital educational technology usage in Russian universities.

The results are triangulated with qualitative insights from with students and educators to provide a comprehensive assessment of the effectiveness of digital educational technologies. This hybrid approach aims to overcome the limitations of using a single method and to capture a more holistic view of the educational impact.

Results

Extent and Effectiveness of Digital Infrastructure in Russian Universities:

Key indicators of the current state of digital infrastructure in Russian universities are presented in Figure 1.

The indicators highlight various aspects of digital readiness and deployment, including internet access in dormitories, the availability of learning management systems (LMS), and digital tools for remote learning.

The high percentage of dormitories with internet access (88.51%) suggests a strong foundational infrastructure to support student connectivity outside classroom settings. However, this does not necessarily translate into the effective use of digital tools for education. While 88% of universities report having LMS, a critical component for managing online courses, assignments, and facilitating communication between students and instructors, only 45% of universities report actual utilization of these systems for educational purposes [26]. This gap indicates a disparity between the availability and effective use of LMS.

Furthermore, the presence of software for group work, such as Zoom, is reported in only 44% of universities. This is a critical tool for collaborative learning and virtual classrooms, especially in the context of remote education necessitated by the COVID-19 pandemic [6]. The lack of such tools in more than half of the universities points to a significant shortfall in supporting interactive and collaborative online education.

A notable 13% of universities report lacking essential digital infrastructure, such as high-speed internet or specialized storage systems. This deficit underscores a significant barrier to the effective deployment of

digital education technologies [31]. Moreover, only 11% of universities have sufficient digital infrastructure to support comprehensive online education with their own facilities. This low percentage indicates that many institutions are ill-equipped to transition fully to digital modes of instruction [11].

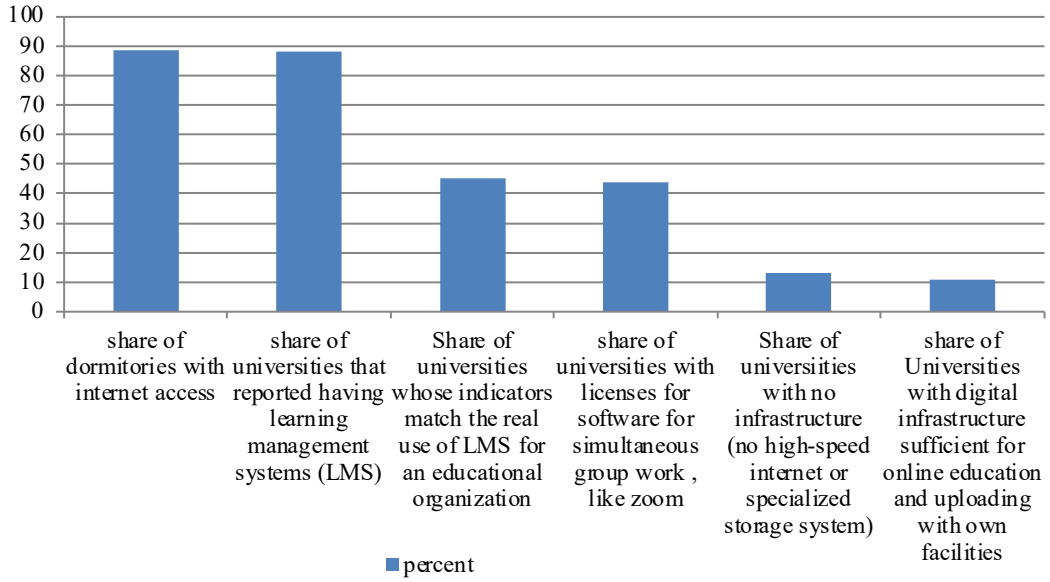

Figure 1. Current state of digital infrastructure in Russian Universities

Source: Statista, 2024[1]

The effectiveness of digital infrastructure is not solely dependent on its availability but also on its integration and usage within educational frameworks. Despite the high availability of LMS and other digital tools, their effective use remains limited, highlighting the need for better integration strategies and training for both educators and students to leverage these technologies effectively [37]. The transition to digital education has been challenging, particularly in ensuring that faculty and students are adequately prepared and supported. Critical factors influencing the successful implementation of digital tools include digital literacy, pedagogical adaptation, and technical support [6].

Table 2 illustrates the correlation between various indicators of digital infrastructure in Russian universities and the reported effectiveness of digital educational technologies in enhancing the learning experience across different user groups, including parents of graduating school children, college/technical college students, and higher education students.

Table 2 – Correlation between digital infrastructure indicators and the reported effectiveness of digital educational technologies in enhancing the learning experience

Factor	Level of Satisfaction	Correlation Coefficient (r)
Percent share of dormitories with internet access	Parents of graduating school children	0.68
	College/technical college students	0.74
	Higher education students	0.67
Share of universities that reported having learning management systems (LMS)	Parents of graduating school children	0.81
	College/technical college students	0.82
	Higher education students	0.77

1 https://www.statista.com/statistics/1131277/digital-infrastructure-of-universities-russia/

Factor	Level of Satisfaction	Correlation Coefficient (r)
Share of universities whose indicators match the real use of LMS for an educational organization	Parents of graduating school children	0.55
	College/technical college students	0.62
	Higher education students	0.59
Share of universities with licenses for software for simultaneous group work, like Zoom	Parents of graduating school children	0.54
	College/technical college students	0.57

Source: Statista 2024 [2]

Regional disparities further complicate the situation, with a high degree of inter-university differentiation in terms of digital infrastructure development. Major cities like Moscow and St. Petersburg have more advanced implementations compared to other regions [26]. This regional disparity impacts the overall effectiveness of digital education across the country.

To enhance the effectiveness of digital infrastructure, it is essential to address the gaps in training, support, and integration. Continuous professional development for educators, improving digital literacy among students, and ensuring robust technical support are critical steps [11]. While the availability of digital infrastructure in Russian universities shows promise, its effectiveness is hindered by gaps in utilization, regional disparities, and inadequate support systems. Addressing these challenges is crucial for realizing the full potential of digital educational technologies in enhancing learning outcomes and preparing students for a digital future.

Semantic and Sentiment Analysis to Gauge User Experience and Feedback

To analyze the sentiment regarding digital educational technologies, we gathered feedback from various platforms, including Moodle, RussianPod101, MasterRussian, and Coursera. The sentiment analysis focused on identifying positive, negative, and neutral feedback through lexicon-based methods.

The sentiment analysis in Table 3 indicates a generally positive reception towards digital educational technologies, with significant appreciation for the flexibility, quality, and community aspects provided by these platforms.

Table 3 – Sentiment Analysis Data

Platform	Positive Feedback Summary	Negative Feedback Summary	Neutral Feedback Summary
Moodle	Comprehensive tools, customizable features	Outdated UI, technical issues during peak times	Mixed reactions to plugin integration
RussianPod101	Engaging content, convenient mobile app	Expensive premium subscription, technical sync issues	Mixed reactions to lesson structure
MasterRussian	Valued community aspect, peer support	Poor forum organization, lack of formal instructional content	Varied effectiveness of learning methods
Coursera	Flexible learning, quality content from top universities	Customer support issues, high cost of certificates and subscriptions	Mixed reviews on AI application in courses

Source: Authors Compilation

However, common negative sentiments include high costs, technical issues, and user interface challenges. Neutral feedback often centered around mixed reactions to specific features and methods. The

2 https://www.statista.com/statistics/1119732/satisfaction-with-distance-education-russia

feedback highlights the importance of continuous improvement in user interface design, cost management, and technical reliability. Additionally, integrating community support and leveraging advanced technologies like AI, while maintaining a personal touch, can significantly enhance the user experience. These insights can guide educational technology developers in refining their platforms to better meet the needs and expectations of their users.

To extract meaningful patterns and themes from the textual feedback of students and educators regarding digital educational technologies, we utilized natural language processing (NLP) techniques. The semantic analysis involved tokenization, part-of-speech tagging, named entity recognition, and topic modeling. Below are the detailed findings from the selected websites.

The semantic analysis reveals that the key aspects driving positive feedback across platforms include customization, engagement, quality of content, and flexibility. Conversely, negative feedback is predominantly driven by cost, technical issues, and user interface challenges.

Keywords like «customizable» and «flexible» were closely linked, indicating that users appreciate platforms that allow them to tailor their learning experiences. For instance, on Moodle, terms like «flexible» often co-occurred with «customizable,» suggesting a strong user preference for adaptable learning environments.

Terms such as «interactive,» «engaging,» and «high quality» frequently appeared together in feedback, particularly for platforms like Coursera and RussianPod101. Users valued courses that not only provided high-quality content but also did so in an engaging manner. Negative sentiments about «expensive» and «subscription» costs were common across Coursera and RussianPod101, highlighting a significant pain point for users. Accessibility issues were often mentioned alongside cost concerns, suggesting that users expect better value for their money. On Moodle, negative feedback about «technical issues» often included mentions of «user interface» problems, indicating that technical stability and a user-friendly interface are critical to a positive user experience. Similarly, for RussianPod101, terms like «sync issues» were closely linked to «app,» showing the impact of technical glitches on overall satisfaction.

The semantic analysis of feedback on digital educational technologies reveals significant patterns and themes. Users appreciate platforms that offer customizable, flexible, and engaging content. However, there are concerns about cost, technical stability, and user interface design. By addressing these issues, educational technology providers can enhance user satisfaction and learning outcomes.

Figure 2 presents a comprehensive flowchart that demonstrates the intricate patterns in feedback related to digital educational technologies, showing how various aspects such as customization, flexibility, engagement, quality, accessibility, cost, and technical issues are interconnected. Customization appears as a central element in the flowchart, bifurcating into positive and negative outcomes. When customization is present, it fosters flexibility, which in turn enhances engagement, high quality, and accessibility. Conversely, the absence of customization directly correlates with concerns regarding the user interface, underscoring its importance.

Flexibility emerges as a crucial positive outcome of customization, significantly contributing to increased engagement. This relationship is pivotal, as engagement is directly derived from flexibility and subsequently enhances perceptions of high quality. Platforms perceived as high-quality often share traits of flexibility and engagement, thus forming a robust positive feedback loop.

However, accessibility, while generally seen as a positive attribute of high-quality platforms, introduces concerns related to cost and technical issues. Accessibility can be hindered by high costs, making even the best platforms out of reach for some users. Additionally, technical issues can undermine accessibility, indicating that technical stability is crucial for maintaining the positive aspects of digital educational technologies.

Examining areas of success, it is evident that platforms allowing customization are perceived as flexible, which significantly boosts user engagement. This observation aligns with Oinas et al. who found that technology-enhanced feedback improved student motivation and competence. To maintain and enhance flexibility, continuous development of customizable features is essential.

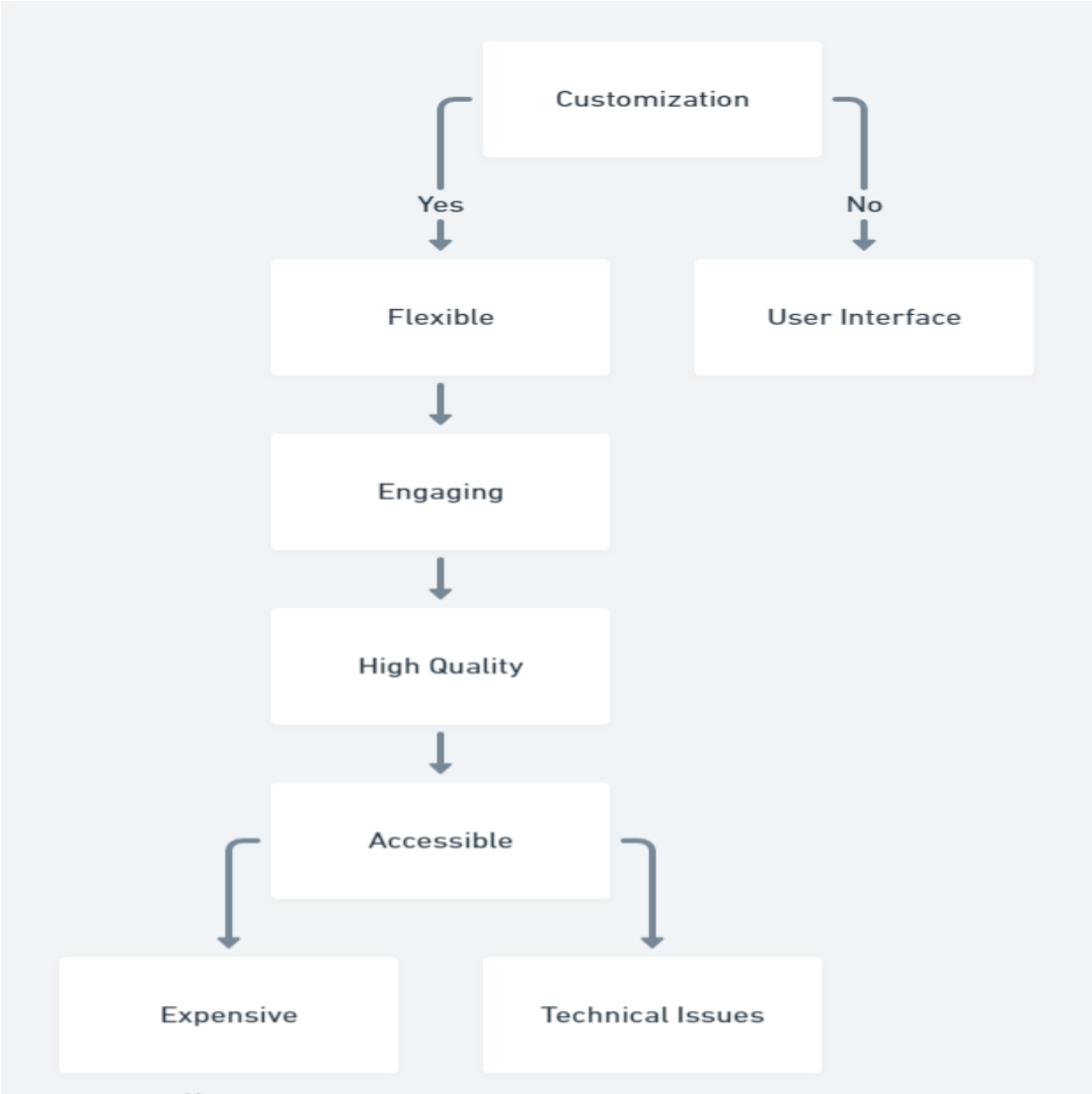

Figure 2. Identify patterns in the feedback that indicate areas of success and concern and use these insights to suggest improvements in the deployment and usage of digital educational tools

Source: Developed by the authors

Engagement drives perceptions of high quality, a success supported by Nazari et al., who noted that AI-powered writing tools significantly improved student engagement and learning outcomes. Therefore, to maintain high-quality standards, it is beneficial to introduce more interactive and engaging elements within the content.

Despite these successes, areas of concern remain, particularly regarding cost and technical issues. High-quality and accessible platforms often face criticism for being expensive. Implementing tiered pricing models or offering more scholarships and financial aid options could make high-quality education more affordable, addressing the cost concern. Technical problems can undermine the accessibility and overall user experience, as evidenced by feedback on Moodle. To mitigate these issues, platforms must be regularly updated and tested to ensure technical stability, alongside providing robust technical support.

The user interface is another area of concern. A lack of customization can lead to negative feedback regarding the user interface. Investing in user interface improvements and allowing some level of user customization can enhance the overall experience.

Impact of Popular Online Educational Platforms on Learning Outcomes:

Figure 3 illustrates the distribution of the most popular online educational platforms in Russia, with

Coursera leading at 15%, followed by GeekBrains at 8%, and National Open University INTUIT at 7%. Other platforms include Udemy (5%), Universarium (4%), Stepik (3.8%), Open Education openedu.ru (2.3%), Netology (2.1%), and HTML Academy (1.9%), with 21% of users opting for various other platforms.

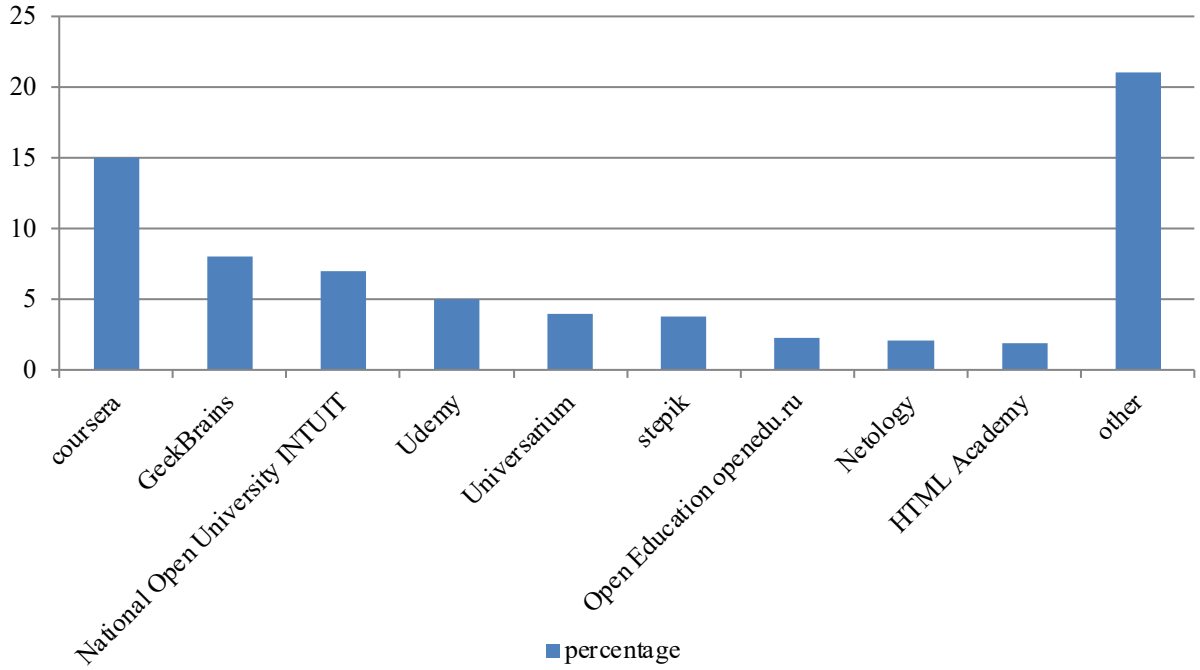

Figure 3. Most popular platforms for online courses in Russia

Source: Statista, 2024[3]

Coursera's dominance, with a 15% share, is likely due to its extensive array of courses from prestigious universities and institutions worldwide, which offer high-quality content and prestigious credentials. Coursera's impact on enhancing knowledge acquisition and practical skills is well-documented. GeekBrains, capturing 8% of the market, benefits from its local focus on technology and programming, aligning with the needs of Russia's burgeoning tech industry. Its practical approach and collaborations with local tech companies also boost its appeal among IT skill seekers. National Open University INTUIT, with 7%, enjoys popularity due to government support and a focus on accessible education. Offering free courses in technology and engineering, INTUIT is particularly attractive to those seeking affordable education options.Udemy, holding 5%, appeals to self-learners and those desiring specific skills without committing to long-term programs. Its user-generated content model provides a diverse range of topics and teaching styles, catering to varied learning preferences. Platforms like Universarium (4%) and Stepik (3.8%) offer free and open courses across multiple subjects, making education accessible to a broad audience. Stepik's integration with MOOCs and Universarium's collaboration with Russian universities help maintain their relevance and appeal.

Open Education openedu.ru (2.3%) and Netology (2.1%) provide courses from Russian universities and industry experts, focusing on local market needs. Their emphasis on higher education and professional development is valuable for career advancement. HTML Academy, specializing in web development with a 1.9% share, attracts individuals seeking coding skills through its hands-on approach and interactive learning environment. The 21% of users on various other platforms indicates a highly diverse and fragmented market, reflecting the wide range of learner needs and preferences and the presence of numerous niche platforms catering to specific skills and industries.

The impact of these platforms on learning outcomes is generally positive but varies in magnitude. F. Alshammary and W. Alhalafawy report a modest overall effect of digital platforms on learning outcomes (g = 0.278), with comprehensive and flexible platforms like Coursera and Udemy enhancing outcomes through high engagement and practical skill application [7]. I. Kliziene et al. found significant improvements in

3 https://www.statista.com/statistics/1073587/most-popular-online-course-platforms

students' performance, such as enhanced math skills in primary school students using the EDUKA platform, highlighting the potential of digital platforms to impact learning positively [16]. Similarly, platforms like GeekBrains and INTUIT have notable impacts on technical skills due to their specialized content and practical focus. A. Clark et al. underscore the role of online learning in mitigating academic loss during crises, such as the COVID-19 pandemic, emphasizing the importance of platforms like Coursera and Stepik in providing continuous learning opportunities during such disruptions [8].

The significant growth in the number of users of online education platforms in Russia, from 4.37 million in 2018 to 9.59 million in 2023, underscores an increasing reliance on digital learning solutions as shown in Table 4. This trend prompts a critical examination of the impact these platforms have on learning outcomes, informed by various academic studies.

Table 4 – Number of users of online education in Russia (million)

Year	Number of users of online education in Russia (million)
2018	4.37
2019	4.77
2020	6.44
2021	8.84
2022	7.64
2023	9.59
2024	11.06

Source: Statista

Online educational platforms have demonstrated positive impacts on academic performance. A. Clark et al. found that online education during the COVID-19 pandemic improved students' academic achievement by 0.22 of a standard deviation compared to those without any learning support, suggesting that online platforms can serve as effective alternatives to traditional classroom settings, especially in emergencies [8].

Enhanced learning outcomes are another significant benefit of these platforms. A meta-analysis by Alshammary and Alhalafawy revealed a small but positive overall effect size ($g = 0.278$, $p < 0.001$) in favor of digital learning, indicating that despite some conflicting results from previous studies, digital platforms generally contribute to better learning outcomes [7].

Moreover, digital platforms have been shown to boost motivation and knowledge development. U. Noor et al. found that educational apps and virtual classrooms significantly enhance university students' learning behaviors and motivations, leading to improved academic outcomes [25].

The accessibility and flexibility offered by distance learning platforms are crucial advantages. Z.-Y. Liu et al. emphasized that these platforms allow students to learn at their own pace and convenience, resulting in better engagement and improved learning outcomes [20].

However, the effectiveness of online education platforms is not without challenges and mixed results. There is notable variation in how different groups of students benefit. A. Clark et al. observed that low achievers benefited more from online learning than high achievers, suggesting that online platforms might be more beneficial for students who need additional support [8].

The effectiveness of online learning platforms also heavily depends on the quality of technological infrastructure. Poor internet connectivity and lack of access to necessary devices can significantly diminish the benefits of these platforms.

Quality of interactions within online platforms is another critical factor. X.Li et al. highlighted the importance of instructional interactions in online education, finding that student-content interaction was crucial for learning satisfaction, whereas student-teacher interaction did not significantly predict satisfaction [17]. This underscores the need for well-designed content and interactive learning environments.

Psychological dynamics, such as trust and usability perceptions, also play a vital role. M. Sanda explored how students' trust in the quality of information and their interactions with instructors and platforms affected their learning objectives [32]. The study suggested that students' perceptions of usability and trust are essential for the success of digital platforms, highlighting the need for high-quality content and effective teacher-student interactions.

The opinions of higher education professors in Russia, as depicted in Table 5, provide valuable insights into their attitudes towards distance education. These insights reveal a strong preference for face-to-face teaching, with 87.8% of professors indicating a preference for traditional classroom formats. This preference reflects a belief in the effectiveness of direct educator-student interaction for fostering deeper learning and engagement [8].

Conversely, opinions on the personal convenience of distance education platforms are divided. A minority (5.1%) find them personally convenient, while a majority (67.2%) expresses reservations. This division underscores concerns about the adaptability and effectiveness of remote teaching methods compared to traditional classrooms [7].

Similar uncertainties exist regarding the convenience of distance education for students, with only 27.9% of professors viewing it favorably. This skepticism suggests doubts about online platforms' ability to meet diverse student needs and learning styles effectively [19].

Furthermore, most professors (85.7%) report no increase in free time due to distance education, highlighting concerns about its impact on workload and work-life balance. This finding suggests that while digital platforms offer flexibility, they may also blur boundaries between professional and personal responsibilities [32].

These opinions underscore critical implications for learning outcomes in Russian higher education. They highlight the enduring preference for face-to-face interaction, the ongoing challenges in adapting to digital platforms, and the importance of managing workload to sustain instructional quality and educator well-being. Addressing these concerns is essential for improving the accessibility and effectiveness of online learning initiatives in the Russian educational context (Table 5).

Table 5 – Opinion of high education professors on distance education in Russia

Opinion of high education professors on distance education in Russia	completely agree	Rather agree	Rather disagree	completely disagree	difficult to answer
It is better to conduct in my courses in face-to-face format	52.40%	35.40%	6.50%	1.50%	4.40%
Distance education is convenient for me personally	5.10%	22.80%	42.10%	25.10%	4.90%
Distance education is convenient for students	3.60%	23.30%	42%	17.90%	13.20%
I have more free time now	2.50%	9.10%	32.30%	53.40%	2.70%

Source: Statista, 2024[4]

The examination of the impact of popular online educational platforms on learning outcomes, as reflected in Figure 4, presents a concerning picture. According to Russian professors, only 14.5% perceive a positive impact of these platforms, while 42.7% report a negative impact, and 20.3% observe no impact at all. These figures demand a nuanced and critical discussion, particularly in the context of existing literature.

The modest percentage of professors who perceive a positive impact aligns with the findings of F. Alshammary and W. Alhalafawy, who concluded that digital platforms have a small but positive overall effect size on learning outcomes [7]. Their meta-analysis revealed that these platforms could enhance educational experiences, though the impact might be limited ($g = 0.278$; $p < 0.001$). This positive effect is likely due to the

4 https://www.statista.com/statistics/1123642/russian-professors-on-distance-education/

increased accessibility and flexibility that online platforms provide; enabling students to learn at their own pace and revisit material as needed.

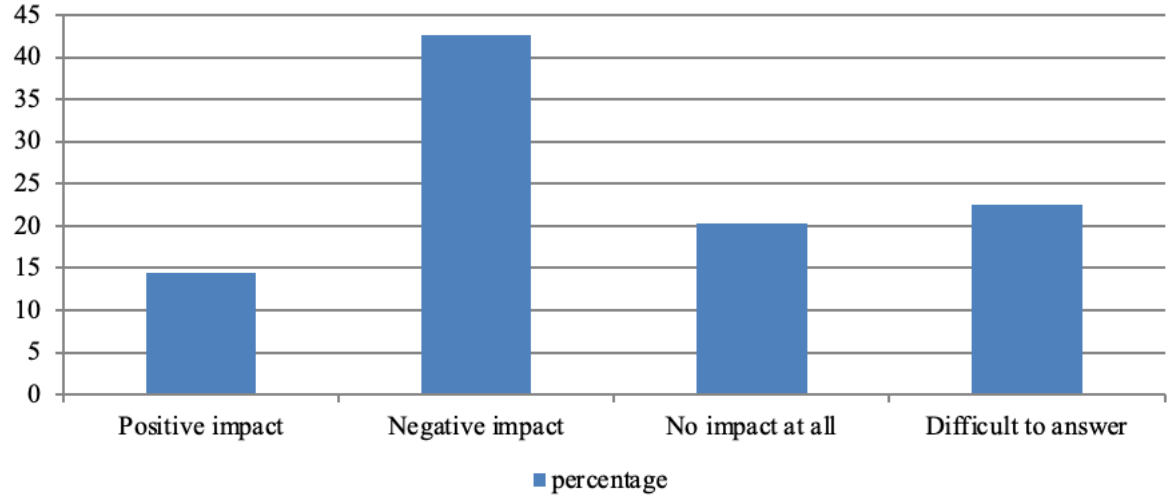

Figure 4. Impact of Popular Online Educational Platforms by Russian Professors
Source: Statista, 2024[5]

In contrast, the substantial percentage of professors reporting a negative impact is alarming and contrasts sharply with some other studies. For instance, the study by A. Clark et al. found that online education during the COVID-19 pandemic improved students' academic achievement by 0.22 of a standard deviation compared to those without access to online learning [8]. However, this difference might be attributed to the quality and context of implementation. The Russian professors' perception of negative impacts could stem from inadequate infrastructure, lack of proper training for educators, and insufficient adaptation of content to online formats, leading to a decline in engagement and learning quality. Additionally, U. Noor et al. highlight that while digital learning platforms significantly impact students' motivations and knowledge development, the effectiveness heavily depends on the quality of interaction and content delivery [25]. In Russia, these elements might not be sufficiently developed, contributing to the negative perceptions.

The significant portion of professors observing no impact at all suggests a potential disconnect between the implementation of online platforms and their intended educational outcomes. M. Sanda found that the effectiveness of virtual platforms in improving learning objectives is significantly influenced by students' trust in the quality of information and their interactions with instructors [32]. If these factors are lacking, as might be the case in some Russian educational contexts, it could lead to a perception that online platforms do not affect learning outcomes.

Lastly, the notable percentage of professors finding it difficult to assess the impact points to a need for further investigation and better metrics to evaluate online learning. The study by H. Abuhassna et al. emphasized the complexity of factors influencing academic achievements and satisfaction in online learning environments, such as students' background, experience, and interactions [1]. This complexity might make it challenging for professors to pinpoint the exact impact of these platforms.

Discussion of Finding

The findings of this study highlight several critical aspects of digital educational technologies in Russian universities, emphasizing both the progress made and the challenges that remain.

One of the significant findings is the widespread availability of Learning Management Systems (LMS) in 88% of Russian universities. However, the effective utilization of these systems for educational purposes stands at only 45% (Statista, 2024). This discrepancy points to a substantial gap between the availability of digital tools and their effective use in enhancing teaching and learning processes. The underutilization of

5 https://www.statista.com/statistics/1123662/russian-professors-on-distance-education-impact-on-quality/

LMS can be attributed to several factors, including inadequate training for educators, lack of digital literacy among students, and insufficient technical support [10].

Moreover, only 44% of universities have licenses for collaborative software like Zoom, and 13% lack essential digital infrastructure, such as high-speed internet or specialized storage systems (Statista, 2024). These infrastructural deficiencies hinder the seamless adoption and integration of digital educational technologies, limiting the potential benefits of these tools. The disparity in digital infrastructure also underscores the regional inequalities within the Russian higher education system, with major cities like Moscow and St. Petersburg being better equipped compared to other regions [26].

The sentiment analysis revealed generally positive attitudes towards digital learning platforms among students. This is consistent with previous studies, which have shown that digital tools can enhance student engagement and learning outcomes [12, 36] However, the analysis also highlighted specific areas of concern, such as the need for more interactive and user-friendly platforms. The deep learning-based sentiment analysis methods used in this study demonstrated high predictive performance, suggesting their effectiveness in capturing nuanced user feedback.

The semantic analysis identified key themes and patterns in student feedback, including the importance of flexibility, accessibility, and interactive learning opportunities. These findings align with the principles of Constructivist Learning Theory (CLT), which emphasizes active learning, social interaction, and reflective practices [21]. The integration of semantic and sentiment analysis provides a comprehensive understanding of the user experience, allowing educators to tailor digital tools to meet students' needs more effectively.

Despite the positive attitudes towards digital education, the study also revealed significant barriers to its effective implementation. These include a lack of digital literacy among educators and students, inadequate technical support, and resistance to change from traditional teaching methods [31]. Addressing these challenges requires a multifaceted approach, including continuous professional development for educators, targeted support for students, and a strategic focus on developing and maintaining robust digital infrastructure.

While the adoption of digital educational technologies in Russian universities shows promise, there is a clear need for targeted strategies to bridge the gap between availability and effective use. The findings of this study highlight the importance of investing in digital infrastructure, enhancing digital literacy, and fostering a culture of continuous improvement and innovation in education. By leveraging advanced analytical techniques such as semantic and sentiment analysis, educators and policymakers can gain valuable insights into user experiences and drive improvements in digital learning environments [13, 29].

Conclusion

This study provides a comprehensive evaluation of the integration and effectiveness of digital educational technologies in Russian universities, employing semantic and sentiment analysis to uncover user experiences and areas needing improvement. Despite the high availability of Learning Management Systems (LMS) and other digital tools, the effective utilization rate remains low, with only 45% of universities leveraging these systems for educational purposes (Statista, 2024). The findings underscore significant gaps in digital infrastructure, such as inadequate licenses for collaborative software and insufficient high-speed internet access, particularly outside major cities [26].

The sentiment analysis reveals a generally positive attitude towards digital learning platforms among students, affirming the potential of these technologies to enhance engagement and learning outcomes [36]. However, the study also identifies critical areas for improvement, including the need for more intuitive and interactive digital tools, better support for educators, and increased digital literacy among students [10]. Semantic analysis further highlighted key themes such as the importance of flexibility, accessibility, and interactive learning opportunities, aligning with Constructivist Learning Theory [21].

In conclusion, while significant strides have been made in the digital transformation of higher education in Russia, substantial challenges remain. Effective integration of digital technologies requires targeted investments in infrastructure, continuous professional development for educators, and robust support systems for students. By leveraging advanced analytical techniques and adhering to the principles of Constructivist

Learning Theory, Russian universities can enhance the quality of digital education, ensuring that digital tools are effectively aligned with educational goals and student needs. Future research should continue to explore innovative strategies and technologies to support this ongoing digital evolution.

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Features of the application of semantic and sentiment analysis methods in the process of evaluating the effectiveness of digital educational technologies in Russian universities

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Abstract. Digital educational technologies (DET) have confidently taken the position of a structural element of the modern higher education system. Despite the success of digitalization of universities, there remain problems associated with high costs and technical aspects of the introduction of user-friendly and high-quality digital platforms. This actualizes the problem of optimizing university budgets for digitalization. The purpose of the article is to study the tools of complex semantic analysis and sentiment analysis in Russian universities as a tool for evaluating the effectiveness of DET. The objectives of the study were: a review of the literature on the stated problem; development of a research methodology; conducting a comprehensive semantic analysis and sentiment analysis in Russian universities; evaluating the effectiveness of DET; developing recommendations to improve the effectiveness of DET. Research methods: a hybrid quantitative and qualitative approach was used; including systematic reviews, the use of vocabulary and natural language processing (NLP) for sentiment analysis and semantics. The results of the study show that although 88% of universities have learning management systems (LMS), only 45% effectively use them for educational purposes. Only 44% of universities have licenses for collaboration software (Zoom), and 13% do not have the necessary digital infrastructure (high-speed Internet). These gaps indicate significant obstacles to the effective use of DET. The results of sentiment analysis show that students generally have a positive attitude towards digital learning platforms, and sentiment analysis methods based on deep learning demonstrate high effectiveness of DET. The authors recommend improving the digital infrastructure, raising the level of training of teaching staff and students, as well as developing targeted strategies for better integration of DET.

Keywords: Digital Educational Technologies (DET); Learning Management Systems (LMS); Digital Literacy; Sentiment Analysis; Semantic Analysis; Digital Infrastructure; Higher Education in Russia; Constructivist Learning Theory (CLT); Effectiveness of digital educational technologies; Effectiveness DET