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COMPARATIVE ANALYSIS OF TEXTS CREATED BY AI AND TEXTS DEVELOPED USING QUANTIZATION TECHNOLOGY

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Abstract. The relevance of this study is determined by the active integration of artificial intelligence technologies into the educational environment and the need to evaluate the quality of generated texts in comparison with traditional pedagogical approaches. In the context of the digitalization of education, there is a growing demand for scientifically grounded methods of developing instructional materials that ensure a high level of comprehension and effective knowledge acquisition among learners. The aim of the study is to assess the degree of similarity between texts generated by artificial intelligence (GPT) and texts developed by humans using text quantization technology (Berber Sardinha, 2024; Avanesov, 2014). Text quantization is understood as a process of transforming educational materials into structured units of information (“quanta”), which facilitates content systematization, highlights key concepts, and improves the accessibility of learning materials for diverse groups of students (Avanesov, 2014). The research methods include a predictive correlational design, a questionnaire survey (n = 100), descriptive statistics, comparative and correlational analysis, as well as SWOT analysis. Texts were evaluated based on several parameters, including structure, style, level of language complexity and formality, compliance with educational standards, and users’ subjective perceptions, such as clarity, readability, and memorability. The results show that quantized texts demonstrate higher levels of

clarity, readability, and memorability, indicating strong pedagogical effectiveness. At the same time, AI-generated texts are characterized by higher informativeness, well-defined logical structure, and the ability to generate content rapidly within limited timeframes. The practical significance of the study lies in substantiating the feasibility of combining artificial intelligence technologies and text quantization in the development of educational materials, which can enhance the quality of education and improve the overall effectiveness of the learning process.

Keywords: artificial intelligence, quantized text, content generation, ChatGPT, digitalization of education, quantum, chatbot

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ЖИ АРҚЫЛЫ ЖАСАЛҒАН МӘТІНДЕР МЕН КВАНТТАУ ТЕХНОЛОГИЯСЫ АРҚЫЛЫ ӘЗІРЛЕНГЕН МӘТІНДЕРДІҢ САЛЫСТЫРМАЛЫ ТАЛДАУЫ

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Аннотация. Зерттеудің өзектілігі білім беру ортасына жасанды интеллект технологияларының белсенді енгізілуімен және генерацияланған мәтіндердің сапасын дәстүрлі педагогикалық тәсілдермен салыстыра отырып бағалау қажеттілігімен негізделеді. Білім беруді цифрландыру жағдайында білім алушылардың ақпаратты түсінуі мен меңгеруінің жоғары деңгейін қамтамасыз ететін оқу материалдарын әзірлеудің ғылыми негізделген әдістеріне сұраныс артып отыр. Зерттеудің мақсаты – жасанды интеллект (GPT) арқылы жасалған мәтіндер мен кванттау технологиясын қолдану арқылы адам әзірлеген мәтіндердің ұқсастық деңгейін бағалау (Berber Sardinha, 2024; Avanesov, 2014). Мәтінді кванттау оқу материалдарын құрылымдалған ақпараттық

бірліктерге («кванттарға») айналдыру процесі ретінде қарастырылады, бұл мазмұнды жүйелеуге, негізгі ұғымдарды бөліп көрсетуге және оқу материалдарының әртүрлі білім алушылар топтары үшін қолжетімділігін арттыруға мүмкіндік береді (Avanesov, 2014). Зерттеу әдістеріне предиктивті корреляциялық дизайн, сауалнама жүргізу ($n = 100$), сипаттамалық статистика, салыстырмалы және корреляциялық талдау, сондай-ақ SWOT-талдау кіреді. Мәтіндер құрылымы, стилі, тілдің күрделілігі мен ресмилік деңгейі, білім беру стандарттарына сәйкестігі, сондай-ақ пайдаланушылардың субъективті қабылдауы (түсініктілік, оқылымдылық, есте сақталу) бойынша бағаланды. Зерттеу нәтижелері квантталған мәтіндердің түсініктілік, оқылымдылық және есте сақталу көрсеткіштері бойынша жоғары нәтижелер көрсететінін, яғни олардың педагогикалық тиімділігі жоғары екенін көрсетті. Ал жасанды интеллект арқылы жасалған мәтіндер ақпараттылығының жоғары деңгейімен, логикалық құрылымдылығымен және қысқа уақыт ішінде контентті жылдам генерациялау қабілетімен ерекшеленеді.

Түйін сөздер: жасанды интеллект, квантталған мәтін, контент генерациясы, ChatGPT, білім беруді цифрландыру, квант, чат-бот

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СРАВНИТЕЛЬНЫЙ АНАЛИЗ ТЕКСТОВ, СОЗДАНЫХ ИИ И ТЕКСТОВ, РАЗРАБОТАННЫХ С ПОМОЩЬЮ ТЕХНОЛОГИИ КВАНТОВАНИЯ

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Аннотация. Актуальность исследования обусловлена активным внедрением технологий искусственного интеллекта в образовательную среду и необходимостью оценки качества генерируемых текстов в сравнении с традиционными педагогическими подходами. В условиях цифровизации образования актуализируется потребность в научно обоснованных методах разработки учебных материалов, обеспечивающих высокий уровень понима-

ния и усвоения информации обучающимися. Цель исследования заключается в оценке степени сходства между текстами, созданными искусственным интеллектом (GPT), и текстами, разработанными человеком с использованием технологии квантования (Berber Sardinha, 2024; Avanesov, 2014). Квантование текстов рассматривается как процесс преобразования учебного материала в структурированные информационные единицы («кванты»), способствующий систематизации содержания, выделению ключевых понятий и повышению доступности информации для различных категорий обучающихся (Avanesov, 2014). Методология исследования включает предиктивный корреляционный дизайн, анкетирование ($n = 100$), методы описательной статистики, сравнительный и корреляционный анализ, а также SWOT-анализ. Оценка текстов проводилась по ряду параметров, включая структуру, стиль, уровень сложности и формальности языка, соответствие образовательным стандартам, а также субъективное восприятие пользователей (понятность, читаемость, запоминаемость). Результаты исследования показали, что тексты, разработанные с использованием технологии квантования, демонстрируют более высокие показатели понятности, читаемости и запоминаемости, что свидетельствует об их высокой педагогической эффективности. В то же время тексты, созданные искусственным интеллектом, характеризуются высокой информативностью, логической структурированностью и способностью к оперативной генерации контента. Практическая значимость исследования заключается в обосновании целесообразности комбинированного использования технологий искусственного интеллекта и квантования текстов при разработке образовательных материалов, что способствует повышению качества обучения и эффективности образовательного процесса.

Ключевые слова: искусственный интеллект, квантованный текст, генерация контента, ChatGPT, цифровизация образования, квант, чат-бот

Introduction. In the era of digital technologies, artificial intelligence (AI) has become an integral part of everyday life, significantly influencing how individuals interact with information across various domains, including medicine, technology, business, and education. While AI offers substantial opportunities, it also raises concerns regarding its broader societal and professional implications (Karimova et al., 2025). The rapid development of generative AI tools, particularly chatbots such as ChatGPT, has intensified debates in both public and academic discourse about the potential replacement of human-authored texts with AI-generated content. These concerns stem from cases in which AI systems produced texts that were indistinguishable from those written by humans, leading to increased public scrutiny and, in some instances, negative attitudes toward the use of artificial intelligence and calls for legislative regulation (Columbia Business School, 2023).

Literary review. Despite ongoing discussions, there is a lack of systematic academic research examining the implications of AI-generated texts in educational and professional contexts. Therefore, the aim of this study is to analyze the impact

of generative artificial intelligence on textual content creation, with particular emphasis on academic writing.

When considering the key aspects of AI-generated text production, the following features can be identified:

1. Flexibility and adaptability – AI systems are trained to compose and generate texts in various styles and for different purposes, providing a high degree of flexibility (Saha, 2025).

2. Natural language processing (NLP) – NLP is a field of research within computer science and artificial intelligence that focuses on interactions between computers and human language. Through NLP techniques, AI systems are able to understand and generate natural language, enabling the production of high-quality textual content (Ramanathan, 2025).

3. Speed and scalability – AI operates at high speed and can process large volumes of data, making it highly efficient for generating texts within short timeframes (Dou et al., 2024).

Owing to advanced algorithms and computational models, artificial intelligence enables computers to emulate human intelligence and judgment. Support for this perspective is provided by prior research (Aghion et al., 2017). As noted by Garud et al., 202: 22), AI can be conceptualized as an intelligent learning system that employs mathematical algorithms to perform tasks traditionally requiring human cognitive abilities.

Within the framework of this study, we sought to determine whether there are differences in students' perceptions of texts generated by artificial intelligence compared with specialized texts (quantized texts) developed by humans.

The quantization technology underlying quantized texts involves the transformation and simplification of educational content to facilitate more efficient use and analysis. This process includes structuring information, identifying key concepts, and dividing the text into manageable units (quanta) (Abdrasilova et al., 2017). The primary objective of quantization is to enhance students' comprehension and retention of learning materials, as well as to support the development of adaptive and personalized educational resources (Avanesov, 2014).

Furthermore, a comparison between texts generated using artificial intelligence (the GPT language model) and texts produced through the quantization approach proposed by V.S. Avanesov is of particular interest with regard to textual structure, semantic richness, and language use. Accordingly, three main analytical dimensions can be identified: text structure, semantic density, and linguistic features employed in text construction.

Models such as GPT generate texts by imitating human language, forming sentences and paragraphs based on statistical relationships between words and phrases. The structure of the generated text is determined by the model in accordance with its training data and the user's prompt. As a result, the produced texts may exhibit logical sequencing; however, they can sometimes lose coherence and overall cohesion, particularly in longer passages (Alawida et al., 2023).

In contrast, text quantization enables the identification of key points, thereby facilitating easier comprehension of the material. The resulting structure is often more explicit and well defined, as quantization requires a deliberate and systematic approach to text construction. Text segmentation and the identification of structural units are especially relevant in the educational context, where clarity and organization play a critical role in supporting learners' understanding and assimilation of complex content (Rodionova, 2008).

Artificial intelligence has the ability to generate natural language text using complex constructions, synonyms, and metaphors. It can adapt the writing style to predefined parameters, such as formal or conversational registers. However, due to its underlying nature, AI may occasionally produce phrases that appear grammatically correct yet convey an unusual or unnatural tone (Bermus, 2024).

In quantized texts, where the primary emphasis is placed on clarity and structural organization, language is employed in a more functional manner. Linguistic constructions in such texts tend to be simpler and are subordinated to the goal of conveying information clearly and precisely. This approach reduces the likelihood of complex metaphors or ambiguous expressions, which may be advantageous for technical or scientific texts.

Analyzing the range of applications for AI-generated texts and quantized texts, it can be concluded that the former are suitable for a wide variety of tasks, from creative writing to business correspondence. AI-generated texts are particularly useful in contexts that require flexibility, creativity, and adaptability of the content. In contrast, quantized texts are ideal for producing clear and structured materials, such as educational resources, instructional manuals, or scientific publications.

Both approaches have distinct strengths and applications. AI-generated texts offer flexibility and diversity but may lack clarity, whereas quantized texts are more structured and precise, though they may be less adaptable in terms of language and style. The choice between these approaches ultimately depends on the intended purpose of the text and the priority given to either creativity or structural clarity.

Materials and methods. The present study was conducted within a predictive correlational research design, which is used to identify statistically significant relationships between variables and to determine their predictive potential without researcher intervention (Bujang et al., 2016: 44). This design was chosen not only to describe the characteristics of learners' perceptions of educational texts, but also to identify factors that make it possible to predict learners' preferences and cognitive responses in the context of the digitalization of the educational environment.

Empirical data were collected through a questionnaire survey among residents of the city of Kokshetau, including undergraduate students, master's students, and doctoral students of Sh. Ualikhanov Kokshetau University. A total of 100 respondents participated in the study, ensuring sufficient variability in age, level of education, and experience with digital technologies. The sample size was calculated to detect moderate correlations ($r \geq 0.3$) at a significance level of $\alpha = 0.05$ (Creswell, 2023).

The questionnaire consisted of structured blocks of questions:

1. Intensity and regularity of AI use;
2. Level of awareness of the technology of quantization of educational texts;
3. Assessment of the perception of educational texts based on cognitive, perceptual, and aesthetic criteria (clarity, readability, memorability, informativeness, and logical structure);
4. Preferences when working with different formats of educational content.

All participants provided informed consent, and the data were processed anonymously and confidentially.

Several statistical and analytical approaches were employed for data analysis. First, descriptive statistics, including the calculation of frequencies and percentage distributions, were used to characterize the sample structure and identify general trends. Next, correlational analysis was conducted to determine significant relationships between the frequency of artificial intelligence use and the evaluation of the cognitive characteristics of educational texts. Comparative analysis was applied to compare quantized texts and AI-generated texts in terms of key indicators of perception and cognitive information processing. Through additive analysis, individual respondents' ratings were integrated into aggregated indicators, enabling the ranking of text characteristics according to their relative significance. The final stage of analysis involved a SWOT analysis, which allowed the research findings to be systematized in terms of their practical applicability in the educational environment. All statistical calculations and data processing were performed using SPSS software version 27 and MS Excel 2019.

Results. The survey materials made it possible to present the collected information in the form of statistical data, which clearly reflect the audience's attitudes toward the use of new technologies in education. For this purpose, both the overall level of respondents' openness to the use of new technologies in the educational sphere and their attitudes specifically toward artificial intelligence and quantized educational texts were identified.

According to the survey results, 62% of respondents regularly use AI, 24% use it occasionally, and 14% have no experience interacting with AI technologies. These findings indicate a high level of AI integration into the educational and professional practices of a significant proportion of respondents (Figure 1).

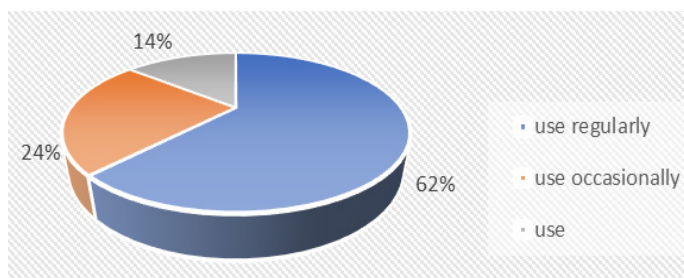


Figure 1 — Respondents' answers to the question «Do you use the capabilities of AI? »

The analysis of the distribution of respondents across age groups revealed notable differences in the use of artificial intelligence (Figure 2). In the 18–25 age group, 74% of respondents use AI regularly, 18% occasionally, and 8% do not use it at all. Among participants aged 26–40, regular use was reported by 68%, occasional use by 20%, while 12% do not use AI. In the 41–60 age group, 45% use AI regularly, 30% occasionally, and 25% do not use it. Finally, among respondents aged 60 years and older, only 23% use AI on a regular basis, 15% use it periodically, and the majority—62%—do not use these technologies.

The age-based analysis demonstrated an inverse relationship between age and the frequency of AI use: the highest intensity of AI application was observed among younger respondents, whereas this indicator consistently declined in older age groups. Correlational analysis confirmed the statistical significance of this relationship ($r = -0.45, p < 0.01$), which allows age to be considered a negative predictive factor for regular AI use and, indirectly, a factor influencing the perception of digital educational content.

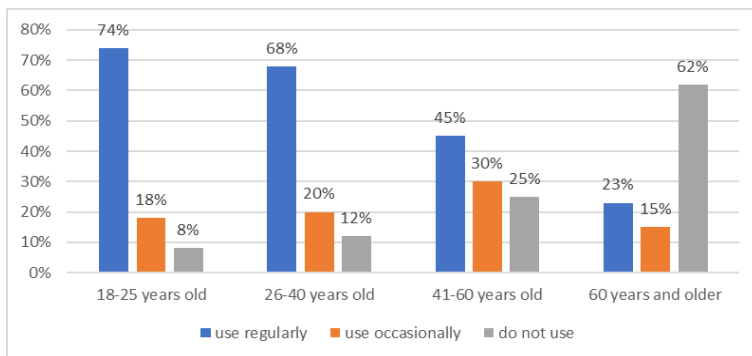


Figure 2 — Use of AI by age group

The gender-based analysis revealed moderate differences: men demonstrate a slightly higher level of regular AI use than women, which may reflect differences in digital practices depending on gender characteristics (Figure 3).

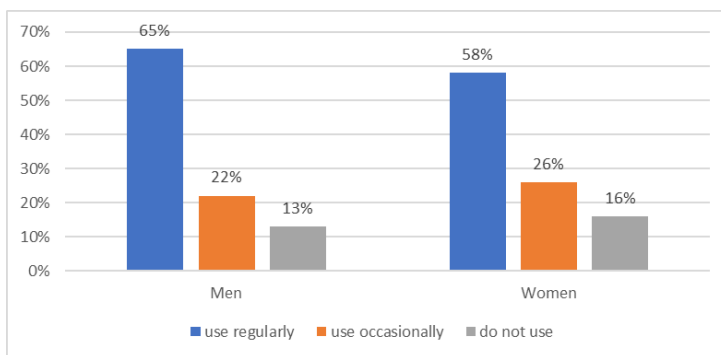


Figure 3 — Use of AI by gender

The study also considered the educational level of respondents (Figure 4). Among participants with secondary education, 45% regularly use AI, 30% use it occasionally, and 25% do not use it. Among those with higher education (bachelor’s degree), 65% regularly use AI, 22% use it occasionally, and 13% do not use it. For respondents with advanced higher education (master’s and doctoral degrees), 72% report regular AI use, 18% occasional use, and 10% no use.

The level of education proved to be a significant factor: respondents with advanced higher education (master’s and doctoral levels) use AI on a regular basis significantly more often ($p < 0.05$). This allows education to be interpreted as a key predictor of digital readiness and receptivity to innovative forms of educational content presentation.

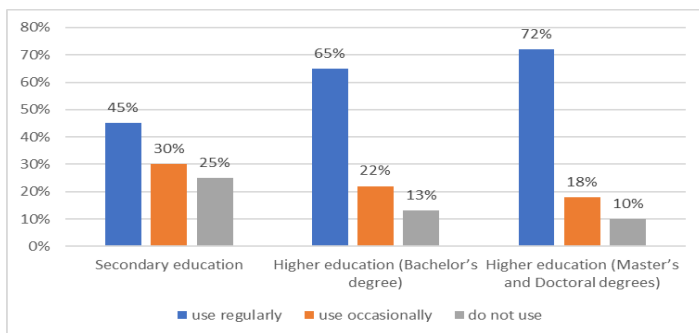


Figure 4 — Use of AI by level of education

According to the respondents’ opinions (in this case, 100% refers to those respondents who answered «regularly use» or «occasionally use» in Question 1), multiple responses were allowed. The most common educational task associated with AI is information processing and analysis, which 71% of respondents are aware of. Content personalization through computer programs is known to 59% of respondents. In contrast, only 34% are aware of text generation capabilities.

These findings indicate that the majority of respondents associate AI use primarily with information processing and analytical functions, whereas the generative capabilities of AI are recognized by only about one third of the participants. This points to a fragmentary understanding of the educational potential of AI. The survey results are presented below (Figure 5).

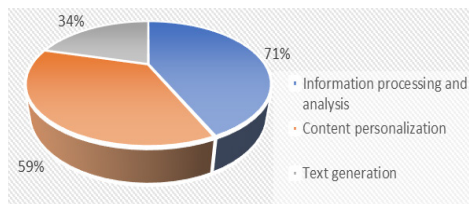


Figure 5 — Respondents’ answers to the question: «Which tasks, in your opinion, does AI most often perform in educational activities?»

Participants were also asked about their familiarity with the concept of «quantization of educational texts», with the aim of assessing their level of awareness of this approach and its potential application for improving information comprehension and structuring. The results showed that the overall level of awareness was 32%, 41% of respondents had a limited understanding of the concept, and 27% had never heard of the quantization of educational materials (Figure 6).

Despite the relatively low level of theoretical familiarity with this technology, comparative analysis demonstrated that respondents consistently rated quantized texts higher on cognitive indicators such as clarity, memorability, and readability, indicating a high pedagogical potential of this approach.

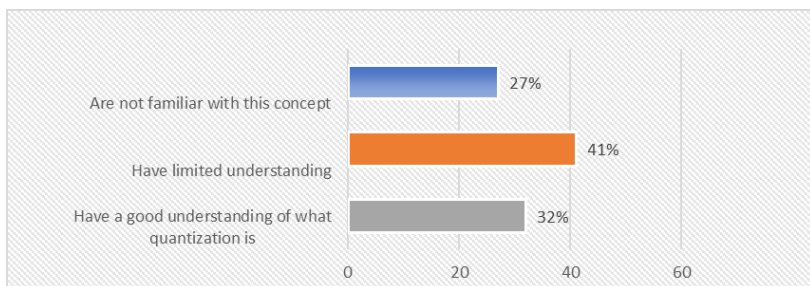


Figure 6 — Overall level of respondents’ awareness of the text quantization method

At the next stage of the study, participants were asked to compare texts (a popular science text, an academic text from a university discipline, and methodological materials) created by a software program and by a teacher, and to evaluate them according to a set of criteria. The experiment showed that each type of text performed better on certain parameters and worse on others.

The quantized text received higher scores on the criteria «well written», «pleasant to read», «clarity», «memorability», and «readability», whereas the computer-generated text scored higher on «clear description», «informativeness», and «logical structure». The results are presented below in table 1.

Table 1 — Comparative data of quantized texts and AI-generated texts

Criterion	Description	Quantized Texts	AI-Generated Texts
Well-written	Indicates the quality of the text in terms of grammatical and stylistic integrity.	68%	32%
Pleasant to read	Reflects how comfortable and easily the text can be read.	72%	28%
Clear description	Represents the clarity and concreteness of the information presented.	30%	70%
Clarity	Assesses how easily the text is understood and assimilated by the reader, especially when terminology or content is complex.	74%	26%
Informativeness	Evaluates how much useful and significant information is contained in the text.	31%	69%

Logical structure	Indicates how well the text is structured and logically organized.	35%	65%
Memorability	Determines how well information from the text is retained after reading.	71%	29%
Readability	Characterizes the overall ease of text comprehension, including sentence length, vocabulary accessibility, and layout convenience for rapid understanding.	76%	24%

As shown in table 1, quantized texts were rated higher on criteria related to readability, clarity, and memorability, indicating their stronger pedagogical effectiveness. In contrast, AI-generated texts received higher scores for informativeness and logical structure, highlighting their advantage in presenting dense and well-organized information. These results suggest that the effectiveness of each text type depends on the intended educational purpose.

Discussion. The results of this study provide important insights into the patterns of artificial intelligence (AI) use in education and the comparative pedagogical effectiveness of AI-generated and quantized texts. Overall, the findings demonstrate a high level of engagement with AI technologies among respondents, while also revealing significant differences depending on age, education level, and awareness of specific instructional approaches such as text quantization.

The high proportion of respondents who regularly (62%) or occasionally (24%) use AI indicates that these technologies are already deeply integrated into educational and professional contexts. This confirms the growing role of AI as a tool for supporting learning processes, information management, and academic productivity. However, the fact that 14% of respondents have no experience with AI suggests the persistence of a digital divide, which may limit equal access to innovative educational resources.

The age-based analysis revealed a clear inverse relationship between age and frequency of AI use. Younger respondents (18–25) demonstrated the highest level of engagement, while older participants, particularly those aged 60 and above, showed significantly lower adoption rates. This finding aligns with broader research on digital literacy, where younger generations tend to be more adaptable to emerging technologies. The statistically significant negative correlation ($r = -0.45$, $p < 0.01$) confirms that age is an important predictor of AI use. Consequently, age-related differences should be considered when designing and implementing AI-based educational tools, ensuring that interfaces and training opportunities are accessible to older users.

Gender differences were less pronounced but still observable, with men demonstrating slightly higher levels of regular AI use than women. Although this gap is not substantial, it may reflect broader socio-cultural patterns in digital engagement and technology use. Further research could explore whether these differences persist across specific disciplines or professional contexts.

A more substantial factor influencing AI adoption was the level of education.

Respondents with advanced higher education (master's and doctoral degrees) reported the highest levels of regular AI use (72%), compared to those with only secondary education (45%). This suggests that educational attainment is strongly associated with digital readiness and openness to innovation. Individuals with higher education levels are likely more familiar with research tools, analytical methods, and digital platforms, which may facilitate the integration of AI into their academic and professional activities.

Despite the widespread use of AI, the results indicate a limited and somewhat fragmented understanding of its educational capabilities. Most respondents associate AI primarily with information processing and analysis (71%), while fewer recognize its potential for content personalization (59%) and especially text generation (34%). This suggests that the transformative potential of generative AI in education remains underutilized. There is a clear need for increasing awareness and training to help educators and students fully exploit the capabilities of AI, particularly in the creation of adaptive and personalized learning materials.

The findings related to text quantization are particularly noteworthy. Although only 32% of respondents reported a clear understanding of this concept, the comparative evaluation demonstrated that quantized texts were consistently rated higher in terms of clarity, readability, and memorability. These characteristics are essential for effective learning, as they directly influence cognitive processing and knowledge retention. The ability of quantized texts to simplify complex information and present it in structured, manageable units appears to significantly enhance comprehension.

In contrast, AI-generated texts were rated higher in terms of informativeness, clarity of description, and logical structure. This suggests that AI excels in producing content that is dense, well-organized, and information-rich. However, such texts may be less accessible to learners, particularly when dealing with complex or unfamiliar material. The lower scores for readability and memorability indicate that AI-generated texts may require additional pedagogical adaptation to meet the needs of diverse learners.

These results highlight the complementary nature of AI-generated and quantized texts. While AI is effective in generating comprehensive and logically structured content, quantization enhances its pedagogical value by improving accessibility and cognitive engagement. Therefore, the integration of these two approaches may represent an optimal strategy for educational content development. For example, AI-generated texts could serve as a basis for creating high-quality content, which is then refined and structured through quantization to improve learning outcomes.

In conclusion, the study demonstrates that both AI technologies and text quantization have significant potential in education, but their effectiveness depends on how they are applied. AI offers efficiency and scalability, while quantization ensures clarity and learner-centered design. The combination of these approaches can contribute to the development of more effective, adaptive, and inclusive educational environments. Future research should focus on practical models for

integrating AI and quantization in real classroom settings, as well as on developing guidelines for educators to maximize their combined benefits.

Conclusion. Based on the survey data, it can be concluded that young people aged 18–25 demonstrate the highest level of AI use, whereas respondents aged over 60 use AI significantly less frequently. Men tend to use AI slightly more actively than women. Respondents with higher education are also more inclined toward regular AI use compared to those with secondary education, which can be explained by the nature of their professional activities and the necessity of using AI in their work. At the same time, the analysis of the collected data showed that only a small number of respondents are familiar with the concept of «quantization»; awareness of this method is mainly observed among students and employees of schools, universities, and other educational institutions, which makes it a relatively unpopular method of information presentation.

The results obtained made it possible to conduct a SWOT analysis of quantized texts and AI-generated texts (table 2). The purpose of this SWOT analysis was to identify the strengths and weaknesses of both approaches, as well as the opportunities and threats that may arise from their use in educational practice. Conducting this analysis was necessary to assess the effectiveness of these methods in the context of contemporary educational needs and requirements, and to help educators make informed decisions when selecting the most appropriate strategies for creating educational content. In the context of continuously evolving educational demands and technologies, it is important to analyze how quantized texts and AI-generated texts can be combined in order to maximize learning effectiveness and enhance the quality of the educational experience.

Table 2 — SWOT Analysis of quantized texts and AI-generated texts

	Quantized texts	Computer texts (AI-generated)
Strengths	High quality of presentation and readability, which promotes better understanding and retention of information.	Objectivity and neutrality in presenting information, important for scientific and academic contexts.
	Higher reader engagement due to clear and structured delivery.	Ability to generate large volumes of text quickly, efficiently covering various topics.
Weaknesses	May require more time and effort to prepare, as they demand deep understanding and careful formulation.	Sometimes lack depth and complexity, reducing comprehension and retention.
	Limited ability to process large volumes of data.	Risk of producing vague or incomplete responses, especially on complex topics, due to lack of true understanding of context.
Opportunities	Growing interest in personalized and interactive learning may increase demand for high-quality educational materials.	Advances in AI technology could lead to more intelligent systems that adapt texts to specific audience needs.
	Potential integration into various educational platforms and programs.	Applicability across different fields, including professional and corporate training.

Threats	Competition from automated tools that can offer similar high-quality content creation services.	Concerns about content quality and accuracy, potentially affecting the reputation of educational programs using such materials.
	Changes in educational standards and preferences may reduce demand for traditional educational materials.	Ethical and legal issues related to AI in education, such as copyright and plagiarism.

Despite the results obtained, the study has several limitations. Its geographical focus on a single city, Kokshetau, limits the generalizability of the findings to broader populations. The sample size ($n = 100$), while sufficient for correlational analysis, does not cover all possible subgroups of users, and the subjective evaluation of texts may influence the interpretation of cognitive indicators. In addition, participants' prior experience with AI could have further affected their perception of educational content.

Considering these limitations, promising directions for future research include conducting experimental studies with control groups to assess the impact of quantized and AI-generated texts on academic performance, investigating the long-term effects of these texts on learners' cognitive development, and expanding the sample across geographical and socio-demographic dimensions. Such approaches would provide more comprehensive data and enhance the generalizability of the findings.

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