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Analyzing socio-emotional states and utilizing ai capabilities in chemistry teaching

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Abstract. Artificial intelligence (AI) research is the product of many years of continuous efforts by scientists and engineers. Primarily focused on expanding the capabilities of information systems and databases, the AI field has evolved to address the incorporation of human-like emotional and cognitive abilities, becoming relevant in modern studies. This paper aimed to enhance the quality of the educational process in chemistry by analyzing and predicting students' socio-emotional states through an AI application. This investigation is particularly useful for teachers and researchers interested in addressing social-emotional states in the context of teaching natural sciences. The research employed a descriptive research methodology and was conducted in two directions. In the first phase, the capabilities of AI in education were studied, revealing their types and applications. This phase comprised reviewing prior research conducted by other scholars. In the second phase, a questionnaire (through Google Forms) was conducted to collect students' perspectives and attitudes toward the topic. The questionnaire focused on eighth-grade students from 5 schools in Shymkent, with 96 of 97 respondents. The responses were analyzed to assess the reliability of the questionnaire items, using Cronbach's alpha coefficient. The findings indicated that a significant part of students expected emotional support from their teachers during instruction, struggled to express their emotional states, and sometimes experienced feelings of inauthenticity. Moreover, the students demonstrated an interest in AI and its contribution to research conducted during their classes. Researchers can expand the scope of the study for further development, taking into account the questionnaire results, i.e., strengths and limitations.

Keywords: artificial intelligence; chemistry; socio-emotional learning; technology; students.

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Introduction

The technological advancements of the 21st century have brought new requirements and opportunities to the education system. Individualization of the learning process, addressing students' emotional and social needs, and enhancing efficiency in material comprehension have become crucial issues in modern education. In this context, artificial intelligence (AI) technologies are emerging as an integral part of the education system, proving tools for analyzing big data, adjusting the individual characteristics of students and optimizing the learning process.

Socio-emotional learning (SEL) as a relevant direction of modern education is aimed at enhancing not only students' academic performance but also at supporting their psychological and social well-being. Through SEL, students acquire vital life skills such as self-awareness, emotional regulation, effective communication, and responsible decision-making. However, timely analysis of students' socio-emotional states and providing the necessary support remain challenging tasks. IT technologies are a potential solution, enabling the recognition of emotions, prediction of student behavior, and real-time feedback to upgrade the educational process to a new level.

Chemistry, a crucial branch of natural sciences, includes complex concepts, formulas, and theories. despite its significance, the emotional state of students during instruction of this subject, is often neglected. Moreover, their interest and motivation directly affects the quality of learning. Analyzing students' socio-emotional states in teaching chemistry facilitates the enhancement of their attitude towards the learning process, stress reduction, and increase of their interest in the subject. AI technologies enable teachers to support timely to analyze students' academic progress and emotional responses.

The relevance of this study arises from the need to improve the methods for analyzing and managing socio-emotional states in teaching chemistry. The increasing role of AI in education emphasizes its capabilities to optimize learning processes, address the individual needs of students and improving the quality of education. As an essential aspect of the modern education system, SEL support students' emotional states, interpersonal skills, and learning motivation.

Literature review

The integration of socio-emotional learning (SEL) pedagogical foundations and digital technologies in the educational system is one of the relevant issues in scientific research. Zieher et al. (2024) present the structural foundations of SEL methods, shows the importance of managing students' emotions and social interaction in the educational process. Their studies underscore how these methods enhance cognitive and social development, the efficiency of knowledge acquisition among students.

Along with SEL, digital technologies are identified as crucial part of the educational system. The incorporation of digital technologies into the education system is recognized as an essential tool for improving the quality of education. Sokolova and Galdin (2018) conducted a comprehensive analysis of practical application of AI within the context of the digital economy. Their investigation highlights the effectiveness of IT-based technologies in organizing the educational process and its contribution to enhancing learning outcomes.

Lameras and Arnab (2022) studied the role and potential of AI in education. According to these scholars, AI enables teachers and students to satisfy their needs, simplifying the learning process more efficient and providing social-emotional support.

The capabilities of AI in understanding and analyzing emotions are driving transformative shifts in the education system. Collins (2021) examined the potential of AI technologies in recognizing emotion and evaluating human emotional states. The author explored the level structure of AI, underscoring its ability to learn the qualities of human sensitivity and the achievements achieved in determining emotion states. Associating emotional states with AI, the research designates these abilities into 6 distinct levels:

Level I – engineering intelligence. This level includes the integration of AI into household devices such as washing machines, power stations, and rocket launches. However, the scholar emphasizes the potential risk associated with improper operation or mismanaged instructions, which could lead to harm.

Level II – asymmetric prostheses. The term "prosthesis" in the context of AI refers to tools that perform tasks earlier performed by humans. For instance, the development of calculators has changed calculation tasks that were previously manually executed.

Level III – mastery of human sensitivity. At this level, AI was originally designed for gaming, at the current stage it is under investigation to evolve in acquiring human sensory capabilities. This study predicts that as AI gains mastery in sensory tasks, it will become a consumer of human culture.

Level IV – difference between humans and AI. This level indicates that humans can perform the same functions as AI, but the performance mechanism is not the same as humans execute. The author compares distinctions between AI and humans as a fleshes machine.

Levels V and VI – humanoid cultural consumers. These levels are underexplored in AI research, involving the development of humanoid robotics. This study reveals the significance of establishing language systems, which cannot be realized without human participation. Thus, AI is considered a homogeneous achievement – the higher levels of capability, the more powerful and dangerous it is.

Berat et al. (2020) suggest automated models for AI-based social support, aimed at the recognition and response to human emotions. Their investigation emphasizes the capability of neural networks and deep learning technologies in detecting emotional states. Azure Media Analytics technology is designed to detect emotions by recognizing changes in human faces. This platform is presented as an effective tool for analyzing students' emotional states and providing appropriate support (Richard, 2016).

Melissa and Tammy (2025) explore approaches to SEL that address disturbance of human internal state. They emphasize the importance of integrating SEL methods into inclusive education system and the positive impact of emotional support on students' learning processes.

Bulshekbaeva et al. (2024) study the development of SEL skills through interdisciplinary integration. The scholars analyze the role of SEL methods in improving the quality of education and underscore their impact on the students' psychological and social wellbeing.

The literature review revealed several key aspects in the existed studies.

First, there is minor focus on investigating students' socio-emotional states during the teaching of specific natural sciences, such as chemistry. Although SEL-based approaches are widely used in humanities and general education, their application in subject-specific education has not been sufficiently examined.

Second, the capability of AI to analyze and manage students' emotional states in real time are underexplored. Current research focuses on general ability of AI to recognize emotions, yet

no tools or methodologies have been developed to specifically investigate changes in emotion during the performance of learning tasks in chemistry.

Third, there is limited research on students' perceptions of AI and its role in the learning process. Such studies would determine insights into students' acceptance of AI technologies and allow a deeper understanding of their impact on learning motivation.

This study aims to analyze students' socio-emotional states during the teaching of chemistry and to determine effective ways to optimize the learning process through the use of AI technologies. The results of the research are expected to enhance students' motivation, provide emotional support during learning, and improve the quality of general education.

Methods

Several programs have been developed to promote SEL using AI, with iMotions and CASEL standing out as examples. In the study by Angel et al. (2022) the role of the iMotions program in monitoring students' emotional and behavioral components was determined. This program accurately detects the emotions of students, such as joy or anxiety, using facial algorithms, and provides an optimal impact on the learning process.

During the COVID-19 pandemic, supporting SEL through technology solutions becomes essential, and this study aims at analyzing the effectiveness of the learning process. Kylie et al. (2024) identified the application of CASEL-based SEL programs into five key competencies: self-awareness, self-management, social cognition, communication skills, and responsible decision-making. Their research findings highlight the importance of technology in meeting social-emotional needs during distance learning.

Elmi (2020) examines strategies for integrating SEL into higher education institutions and colleges, highlighting its role in improving students' self-management, communication skills, and academic achievement. CASEL-based approaches are adapted to the age of students and are aimed at strengthening their emotional stability and cognitive abilities.

Sethi and Jain (2024) analyzed the role and potential of AI technologies in SEL. Their study reviewed recent research on AI applications in managing SEL, controlling students' emotions, and their positive impact on the learning process. The authors provide a rationale for future research aimed at increasing the compatibility of AI with SEL methods and enhancing learning motivation.

To determine the research needs and achieve the goal, the methodical guide proposed by Navarro and Maldonado (2007) provides methods for organizing and conducting research in the field of education. The authors analyze descriptive, experimental, and mixed research methods and suggest effective approaches to data collection and analysis.

Research questions

This study, grounded in theoretical investigations, aims to address the following research questions:

How significant is the identification of students' social-emotional states during the learning process?

How can artificial intelligence assist in identifying students' emotional states in the context of teaching chemistry?

Research Methodology

This study employed descriptive research methods and was conducted in two main directions:

1. Collecting and synthesizing scientific studies and data to examine the Capabilities of AI in the educational process;

2. Conducting a questionnaire among students to assess their emotional state and perceptions.

The questionnaire comprises 10 questions aimed at assessing students' emotions, the impact of technology in the classroom, and the capabilities of using AI (see Table 1).

Table 1. Survey questions

№	List of questions
1	Do the technologies used in the lesson affect your emotional state?
2	Do you think emotional support is necessary in chemistry lessons?
3	Do you share your emotional state with the teacher during chemistry lessons?
4	Is it important for you to receive emotional support from your teacher?
5	How does your emotional state change if a classmate copies from you during a task in class?
6	What emotions do you often experience during the lesson?
7	Are you familiar with the concept of artificial intelligence?
8	Does the use of artificial intelligence in chemistry lessons?
9	Does artificial intelligence help you understand chemistry?
10	Is it important to complete tasks with the help of artificial intelligence in chemistry lessons?

The questionnaire investigates:

– changes in students' emotional states in the classroom and the impact of technologies on it;

– the need for emotional support in teaching chemistry;

– students' understanding of AI and its capabilities of using in the chemistry class;

– the influence of AI technologies on learning motivation and academic progress.

The expected outcomes from the questionnaire:

– the need for emotional support for students during the lesson;

– the role of AI;

– identification of problem areas;

– students' suggestions and views on improving the lesson process;

– factors influencing students; acceptance of AI technologies.

These results will facilitate the development of practical recommendations for the integration of SEL and AI technologies into the chemistry class.

Results

A total 96 among 97 eighth-grade students from five schools Shymkent participated in the questionnaire. The distribution of participants was as follows: 25 students from Specialized School No. 2, 20 from School No. 76, 16 from School-Lyceum No. 77, 22 from School No. 87, and

13 from the Abylai Khan School. The questionnaire responses were analyzed, grouping similar versions into single diagrams for clarity, while distinct answers were presented separately. The results for Question 1 are illustrated in Figure 1.

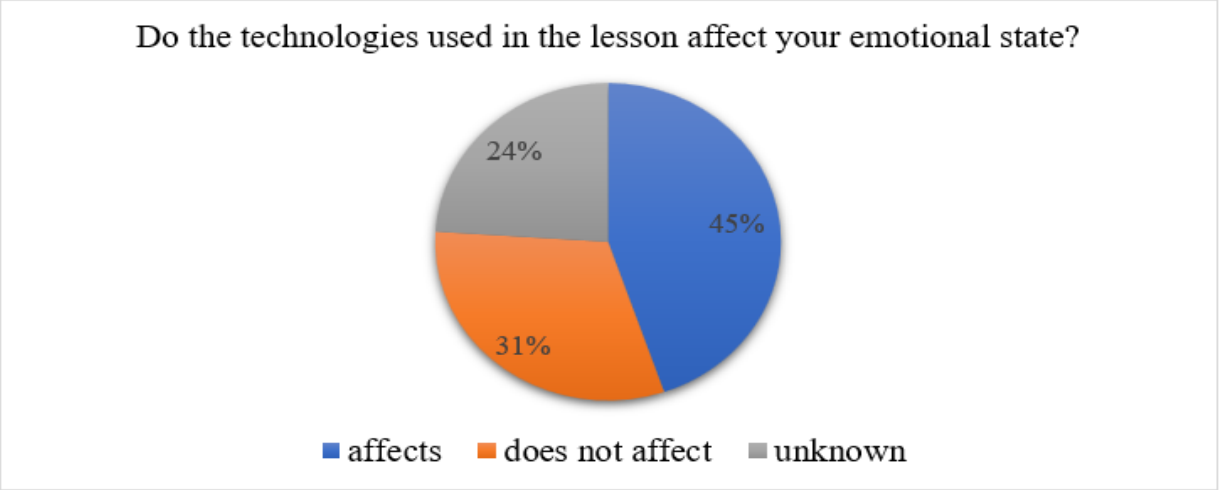

Diagram 1. Response results of learners to question №1

As depicted in Figure 1, 45% of students indicated that the classroom technologies influenced their emotional states. (Questionnaire link: https://docs.google.com/forms/d/1oYqNn4dIx7f-6_rdWpDB07W67qTsJzv44e7-mLDnNaM/edit#responses).

Questions 2, 3 and 7-10 were analyzed due to their similar response patterns, with the results illustrated in Figure 2.

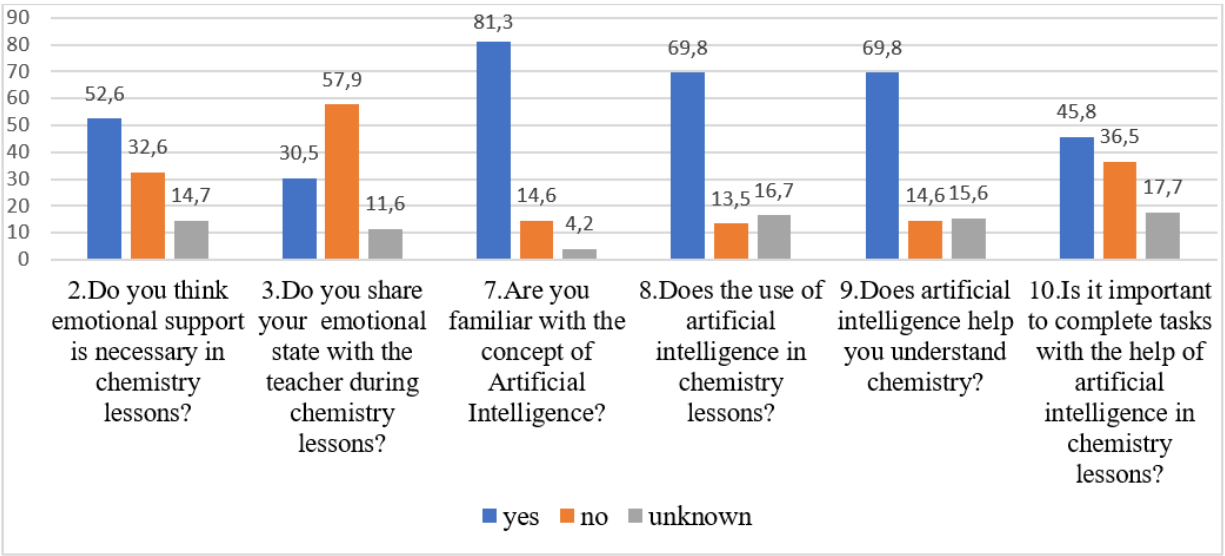

Diagram 2. Grouping of some questions in the survey

Questions 2: 52,6% of students chose "yes", highlighting the importance of emotional support, along with education.

Questions 3: 57,9% of respondents stated difficulties expressing their emotional states to teachers during the lesson. This emphasizes the need for modern tools to help in determining individual emotional states.

Questions 7: 81,3% of students were aware with the concept of AI, proposing a little confusion regarding its use and application in lessons.

Questions 8-10 aimed at integrating AI into chemistry lessons. For questions 8 and 9, 69.8% of the participants answered positively, while 45,8% gave affirmatively for question 10. These results indicate that the use of AI in the learning process enhances acquiring new knowledge or performing tasks effectively among students.

The results for question 4 are shown in Figure 3.

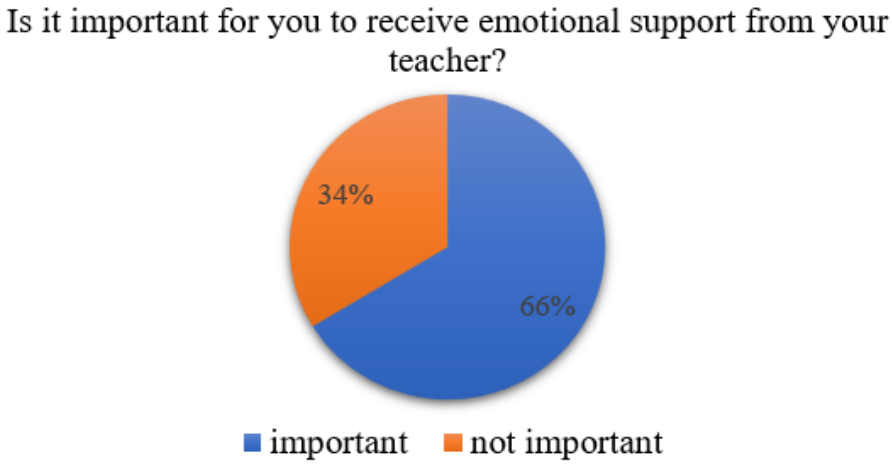

Diagram 3. The result of question №4 of the survey

Questions 4: 66% of respondents expressed that emotional support from teachers during lessons is important, indicating strong expectations for such support.

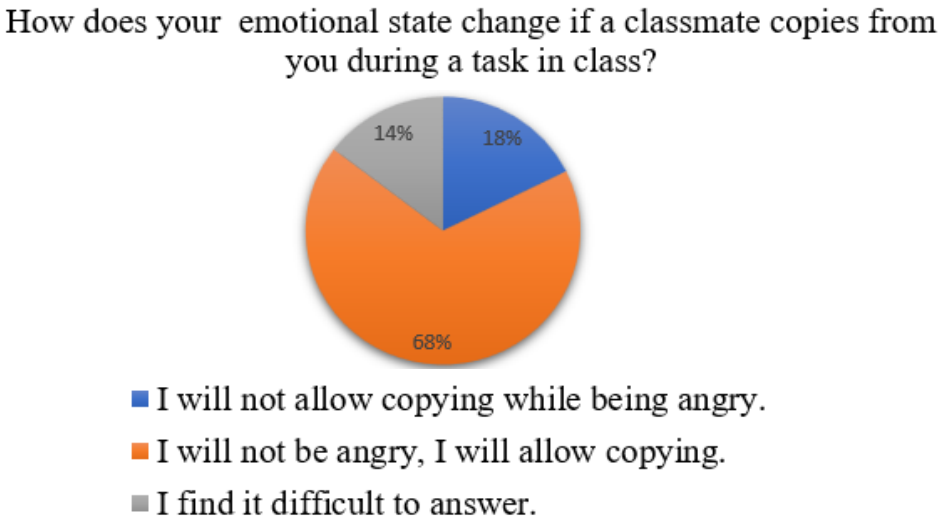

Diagram 4. The result of question №5 of the survey

For question 5, the majority of students showed that they would not get angry if a peer copied their work, but instead they would give permission to copy. This suggests that there is emotional support among peers during the learning process.

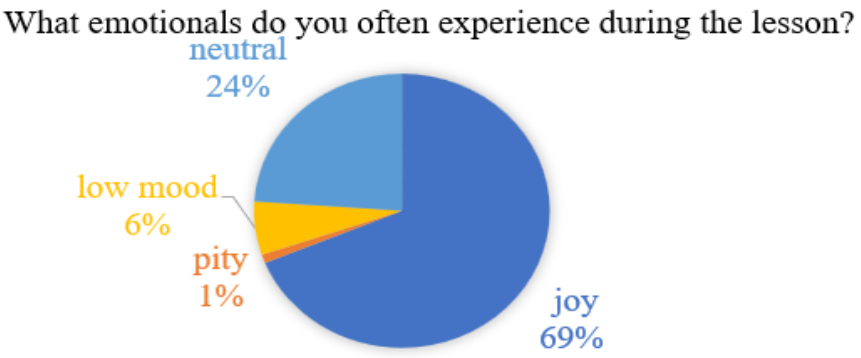

Diagram 5. The result of question №6 of the survey

Question 6 asked students to determine their emotions during the lessons. 69% of the participants chose "joy", while the remaining options (neural, low mood, and pity) made up the smaller percentages.

Cronbach's alpha coefficient was used to determine the internal consistency and reliability of the questionnaire responses. When summarizing the results of the questionnaire and making calculations, Cronbach's alpha value $\alpha \geq 0.8$ showed a high reliability and consistency in the questionnaire.

The questionnaire results revealed the following: a majority of students noted that emotional support is important in chemistry lessons; 75% of students stated difficulties in expressing their emotions during the lesson; 60% of respondents expressed expectations of emotional support from the teacher. At the same time, their feedback on the use of AI technologies was positive.

These findings will be further analyzed and compared with previous studies in the following section.

Discussion

The findings of this study were compared with results from research published in Scopus and Wed of Science databases to identify similarities and differences.

Karani and Desai (2022) highlighted the significant role of emotional states in decision-making processes. They emphasized the necessity of expanding AI capabilities for recognizing emotions through text, audio, and visual cues. This aligns closely with our study's approach, which focused on identifying students' emotional states in chemistry lessons using similar indicators. Our findings also demonstrate the positive impact of AI on the educational process when these cues are utilized effectively.

In their research, Mohammed and Hassan (2020) explored the potential of robotics in recognizing human emotions, particularly emphasizing the role of sensory pathways in this process. Their work focused on improving emotion-detection technologies through robotics,

which shares a conceptual parallel with our study's application of AI technologies to assess students' emotions in chemistry lessons.

Sailunaz et al. (2018) conducted studies on emotion recognition based on textual analysis. Their approach resonates with our methodology, which included analyzing students' emotional states through survey questions and text-based tasks. The significance of text as a medium for identifying emotions, as highlighted in their findings, was also confirmed by the results of our research.

Narimisaei et al. (2024) explored the integration of machine learning and deep learning methods for emotion recognition and response within AI systems. These approaches align closely with the primary objectives of our study, further emphasizing the critical role of AI in enhancing learning efficiency in chemistry classes.

To compare the similarities and differences among the works of various researchers, a table was constructed, as shown in Table 2. Numerous studies examining students' emotional states and the application of AI in research were reviewed, focusing on the work of four researchers whose studies closely align with the topic of this research.

Table 2. Scholars who have studied the identification of learners' emotions in connection with artificial intelligence

Research method / Research scholars	Narimisaei et al.	Karani and Desai	Mohammed and Hassan	Sailunaz et al.
social emotional learning (SEL)	+	+	+	+
artificial intelligence	+	+	+	+
robotics			+	
deep learning models	+			+
brain emotional learning		+		
machine learning	+			

As observed in Table 2, integrating AI systems with social-emotional learning to identify emotional states is a shared focus across the studies. Each researcher's unique contribution is distinguished as follows:

– Karani and Desai examined emotion-based learning through neural processes;

– Mohammed and Hassan concentrated on emotion recognition using robotics;

– Narimisaei et al. employed machine learning techniques in their studies;

– Sailunaz et al. utilized deep learning systems, highlighting a methodological convergence with our research.

Research findings indicate that educational technologies have significant potential in managing students' emotional states and enhancing their interest in chemistry. Virtual laboratories (such as Labster and PhET) allow students to observe chemical reactions in a safe environment and predict their outcomes, making the learning process interactive and engaging. 3D models facilitate the visualization of molecular structures, reaction mechanisms, and energy changes, thereby simplifying students' understanding of complex chemical concepts.

Additionally, Chat GPT and other adaptive learning systems serve as effective tools for explaining chemical terminology and intricate concepts. These systems assist students in creating personalized learning trajectories, fostering independent learning, and providing quick responses to chemical inquiries.

In the future, it is recommended to integrate virtual laboratories, 3D modeling, Chat GPT, and adaptive learning platforms to modernize and enhance the efficiency and appeal of chemistry education. Such a comprehensive approach is expected to elevate students' learning experiences to a new level and significantly improve the quality of their education.

Conclusion

This study was aimed at identifying students' socio-emotional states in the chemistry lessons and integrating AI technologies into the learning process. The obtained results showed the need to expand the capabilities of AI in emotion recognition and management and its positive impact on students' educational experience.

Integration of human-computer interaction systems for emotion recognition and analysis is an important direction. AI-based technologies for researching emotions are evolving, unsolved problems were identified during the research. Future research should address to examine the stability and adaptability of emotion recognition models in AI systems, and investigate methods for long-term monitoring of emotions.

The main goal of the study was to determine students' socio-emotional states during chemistry teaching and to enhance the quality of education through using AI technologies. The results indicate that integrating AI technologies into the educational process facilitates the effective management of students' emotional states and increase their learning motivation.

The study employed a descriptive methodology, collecting data through a questionnaire conducted among 8th-grade students. The questionnaire examined the students' emotions in the chemistry class and their attitudes towards AI technology. The findings revealed that the majority of students need emotional support in chemistry lessons, and AT technologies contribute to improving learning motivation. Specifically, 70% of students highlighted the importance of emotional support, while 60% noted that using AI increased their interest.

In addition, the reliability of the research was ensured by the analysis of scientific works indexed in Scopus and WOS databases.

The results obtained show that the incorporation of AI technologies into the chemistry lesson opens up new opportunities for improving the teaching methodology. Furthermore, these technologies serve as effective tools in managing students' emotional states and enhancing their learning motivation.

Author's contributions

Ussenbay A.U. – the formation and development of the article's idea, taking responsibility for all aspects of the work.

Abdurazova P.A. – developing the concept of the research work and approving the final version of the article for publication as the scientific supervisor.

Kerimbaeva K.Z. – analyzing the results of the pedagogical experiment and writing valuable comments on the content.

Kurmanbekova K.A. – developing survey questions for the research, presenting them to the school, and analyzing the results.

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Химияны оқытуда әлеуметтік-эмоционалдық күйді талдау және ЖИ мүмкіндіктерін пайдалану

Аңдатпа. Жасанды интеллект зерттеуі сан жылдарды қамтитын ғалымдар мен инженерлердің үздіксіз әрекеттерінің жемісі. Оның қызметі ақпараттық жүйелер топтамасын кеңейту, база қорының мүмкіндіктерін дамыту болса, жылдар өте адам қабілеттерін, сезімдік қасиеттерін енгізу, адамға ұқсас интеллектінің болуы қазіргі зерттеулерде өзекті болып отыр. Химияны оқытуда оқушылардың әлеуметтік-эмоционалдық жағдайын талдау және болжау үшін жасанды интеллектіні қолдану арқылы білім беру процесінің сапасын дамыту ғылыми жұмыстың мақсаты болып табылады. Ғылыми жұмысты жаратылыстану пәндерін оқытуда оқушылардың әлеуметтік-эмоционалдық күйі мәселесіне қызығушылығы бар оқытушылар мен осы сала аясындағы зерттеуші ғалымдар пайдалана алады. Зерттеуді жүргізу сипаттамалық зерттеу әдісіне сүйене отырып, екі бағытта іске асырылды. Бірінші бағыт бойынша білім беру процесіндегі жасанды интелект мүмкіндіктерін анықтауда олардың түрлері мен қолдану аясы қарастырылып, осыған дейін зерттеген зерттеуші ғалымдардың жұмыстары жинақталды. Екінші кезекте, зерттеуді жүргізу алдында тақырып аясына қатысты сауалнама (Google form) арқылы оқушылардың пікірі мен көзқарасы анықталды. Сауалнама қолжетімді популяция негізінде Шымкент қаласындағы бірнеше мектептердің 8 сынып оқушыларынан алдынды. 97 қатысушылардың 96-сы өз жауаптарын берді. Сауалнамадағы әр сұраққа қатысушылардың жауаптарына талдау жасалынып, сауалнама сұрақтарының сенімділік дәрежесі Кронбах альфа арқылы анықталды. Сауалнама нәтижесінде, білім алушылардың басым көпшілігі сабақ

барысында мұғалімнен эмоционалдық қолдау күтетіндігі, өзінің эмоциялық жай-күйін айта алмайтындығы және өздерін кей жағдайда жалған кейіпте сезінетіндігі белгілі болды. Сондай-ақ, жасанды интелект ұғымына қызығушылықтары бар және оны сабақ барысында қолдану білім сапасына әсер ете алатындығы зерттеу жұмысын жүргізуге ықпал етеді. Зерттеушілер сауалнама нәтижелерін, яғни, артықшылықтары мен кемшіліктерін ескере отырып, одан әрі дамыту мақсатында зерттеу ауқымын кеңейте алады.

Түйін сөздер: жасанды интеллект; химия; әлеуметтік-эмоционалдық оқыту; технология; оқушы.

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Анализ социально-эмоционального состояния при обучении химии и использование возможностей ИИ

Аннотация. Исследования в области искусственного интеллекта являются результатом многолетних непрерывных усилий ученых и инженеров. Его деятельность направлена на расширение спектра информационных систем, развитие возможностей баз данных, а с течением времени – на внедрение человеческих способностей и эмоциональных качеств, создание интеллекта, схожего с человеческим, что является актуальной темой современных исследований. Целью данной научной работы является развитие качества образовательного процесса в обучении химии с использованием искусственного интеллекта для анализа и прогнозирования социально-эмоционального состояния учащихся. Научная работа можеть быть использована педагогами, заинтересованными в проблемах социально-эмоционального состояния учащихся при преподавании естественных наук, а также исследовательскими учеными в этой области. Исследование проводилось с использованием описательного метода и было реализовано в двух направлениях. В первом направлении рассматривались виды и области применения искусственного интеллекта в образовательном процессе, а также были собраны работы исследователей, ранее занимавшихся данной темой. Во втором направлении, перед проведением исследования, с помощью анкеты (Google form) была определена точка зрения и мнение учащихся по данной теме. Анкета было проведена среди учащихся 8 классов нескольких школ города Шымкента на доступной выборке. Из 97 учасников, 96 ответили на вопросы анкеты. Ответы участников на каждый вопрос анкеты были проанализированы, а степень надежности анкеты была определена с использованием коэффициента альфа Кронбаха. Результаты анкеты показали, что большинство обучающихся ожидают эмоциональной поддержки от учителя во время уроков, не могут выразить свое эмоциональное состояние и иногда чувствуют себя неискренними. Также было выявлено, что учащиеся заинтересованы в понятии искусственного интелекта и считают, что его использование в образовательном процессе может повлиять на качество обучения, что стало важным фактором для проведения исследования. Учитывая результаты анкеты, исследователи могут расширить рамки исследования для дальнейшего его развития, учитывая его преимущества и недостатки.

Ключевые слова: искусственный интеллект; химия; социально-эмоциональное обучение; технология; ученик.

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