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The Effectiveness of Artificial Intelligence Tools in Science Education: Comparative Case Study

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Abstract: The purpose of this study is to comparatively examine the effectiveness of two distinct artificial intelligence tools, ChatGPT and DeepSeek, on students' learning process related to the 5th grade science unit entitled “Nature of Matter”. This research, conducted within the framework of a comparative case study design, involved two students selected through purposive sampling. Each student was given the opportunity to engage in the learning process through interaction with artificial intelligence tools and observations were conducted throughout the process. After the implementation, the perspectives of the students were obtained through semi-structured interviews. The data were evaluated by thematic analysis method and were categorized under four main themes: Concept understanding of artificial intelligence applications, depth of interaction, ease of use and student motivation. The findings showed that ChatGPT was more advantageous in terms of students' motivation, interaction level, adequacy of conceptual explanation and ease of use. The study suggests that artificial intelligence-supported learning environments can serve as effective complementary tools in classroom instruction.

Keywords: Artificial intelligence, ChatGPT, DeepSeek, Science education, Comparative case study.

Introduction

Education is a bridge between society and developing technology. In order for a society to adopt a technological change, technology must first be integrated into education. The 1960s marked an important beginning in the use of artificial intelligence in education, with programmed lessons and automatic feedback as part of Skinner's “teaching machines” project (Arslan, 2020). In recent years, rapid developments in artificial intelligence (AI) technologies have enabled the emergence of new teaching strategies and digital learning environments in education. Especially in disciplines that require conceptual depth and problem-solving skills, such as science education, the pedagogical effectiveness of AI-supported tools has been increasingly investigated (Luckin et al., 2016; Holmes et al., 2019).

AI-based systems can provide customized learning experiences by adapting to students' individual learning styles; they also have the potential to improve the teaching process by providing data-driven feedback to teachers (Baker & Inventado, 2014; Chen et al., 2020). Artificial intelligence has the potential to revolutionize teaching and learning methods and is already being used in various educational settings in educational settings in a wide range of scenarios (Rudolph et al., 2023). Artificial intelligence is an important aid for users to personalize their learning experience and create their own learning style (Sajja et al., 2023). By supporting

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educational materials with artificial intelligence technologies today and in the future, many skills such as abstract thinking, adaptation to new situations and interaction can be supported (Uğur & Kınacı, 2006).

It is predicted that artificial intelligence applications will completely change the way students access information. It is predicted that teachers will use artificial intelligence as explanatory and illustrative when teaching new concepts to students or eliminating existing misconceptions. At the same time, it is thought that it will encourage students to work as a team, increase student motivation and encourage students to engage more in research and investigation studies (Zhai, 2023).

Artificial intelligence-supported applications used in science teaching come in various forms such as intelligent tutoring systems that encourage learning, virtual laboratory applications, adaptive testing systems, and natural language processing-based interactive learning environments. Studies evaluating the impact of these tools on students' academic achievement generally point to positive results (VanLehn, 2011; Nye, 2015).

Today, the integration of technology into educational environments is gradually increasing, and especially artificial intelligence-based applications stand out as an innovative tool in teaching processes. In this context, the main objective of this study is to determine whether AI-powered applications such as ChatGPT and DeepSeek have the potential to contribute to students' learning processes in science education. However, the effective use of these technologies is not only limited to their capacity to provide information but also depends on multidimensional factors such as the extent to which they improve students' conceptual understanding, how much active participation they provide in the learning process, and how accessible and understandable they are for the user. In addition, it should not be ignored that these tools may have affective consequences such as increasing or decreasing students' motivation to learn. Accordingly, the effects of artificial intelligence applications such as ChatGPT and DeepSeek on interaction depth, ease of use and students' motivation in science teaching should be systematically examined. It is believed that the research will provide teachers with important data regarding the use of educational technologies in the classroom.

The purpose of this study is to examine the effectiveness of artificial intelligence-supported educational tools used in science courses within the framework of a comparative case study. The effects of AI-based tools on conceptual understanding, depth of interaction, ease of use and student motivation were analyzed. In addition, the opportunities and challenges encountered in the context of integrating these tools into the teaching process were evaluated in line with student views.

In this context, the evaluation of pedagogical effectiveness at the intersection of artificial intelligence technologies with science education is important in terms of contributing to both theoretical and applied educational research. The findings are expected to contribute to the development of recommendations for designing and implementing artificial intelligence-based teaching tools in a more effective and inclusive manner.

Theoretical Framework

The theoretical basis of this research is artificial intelligence-based learning environments. In particular, the role of large language models such as ChatGPT and DeepSeek in learning processes is evaluated in this framework.

Artificial Intelligence Supported Learning Environments

In recent years, chat-based artificial intelligence applications developed with Large Language Models (LLMs) contribute to the creation of individualized learning environments (Holmes et al., 2019). Models such as ChatGPT and DeepSeek have the capacity to provide meaningful, contextual and explanatory answers to students' natural language questions. These models help students build scientifically accurate conceptual structures by providing alternative explanations (Zhai, 2023).

The Educational Role of ChatGPT and DeepSeek

Artificial intelligence applications play an important role in digitalizing student-teacher interaction. In particular, language models such as ChatGPT support the learning process by generating natural and meaningful answers to students' questions. When the interactive nature of such systems is evaluated within the framework

of Vygotsky's (1978) social constructivist learning theory, it contributes to the cognitive development of the individual in a way that supports the zone of proximal development. These models help students establish correct conceptual structures by offering alternative explanations (Holmes et al., 2022). In this context, the quality of the feedback provided by both artificial intelligence models and their effectiveness in the learning process constitute the main area of investigation of this study.

Problem Statement

How do artificial intelligence applications such as ChatGPT and DeepSeek affect the learning processes of 5th grade middle school students in science education?

Sub Problems:

1. Is there a significant difference in the effects of ChatGPT and DeepSeek applications on students' conceptual understanding?
2. Is there a significant difference in the depth of student interaction with the applications between ChatGPT and DeepSeek?
3. Is there a significant difference in the effects of ChatGPT and DeepSeek applications on students' motivation?
4. Is there a significant difference between ChatGPT and DeepSeek applications in terms of ease of use?

Method

Research Design

In this study, qualitative research method was used and case study method was employed. According to Creswell (2007), case study is a qualitative research approach in which the researcher examines one or more situations limited in time in depth with data collection tools (observations, interviews, audiovisuals, documents, reports) involving multiple sources, and defines situations and themes related to the situation.

Comparative case study is a qualitative research design that aims to understand a specific phenomenon by examining one or more cases in depth, without disrupting the context in which the individuals or situations are embedded. This method is especially used to understand how different approaches, practices or individuals produce results under similar conditions (Bartlett & Vavrus, 2017). Stake (1995) and Yin (2018) state that comparative case studies provide a multidimensional perspective in the research process and allow in-depth analysis of case studies. In this context, each student was considered as a separate case in the study and their responses to artificial intelligence applications were evaluated comparatively.

Working Group

In the study, participants were selected through purposive sampling in line with the case study method. Purposive sampling method is based on the aim of examining a particular situation or topic in depth. In this method, it is of great importance to select the most appropriate and information-rich individuals or situations for the purpose of the study. Conducting detailed analyses on small sample groups is the basic approach of this method. When determining the sample size, criteria such as contributing to the purpose of the research, increasing the reliability of the data obtained, as well as being practical and economical should be taken into consideration. This method is based on selecting participants who can provide the most valuable information in terms of achieving the objectives of the study (Patton, 2014).

Two students attending a middle school science course were selected as participants. Demographic information (age, grade level, etc.) of the participants was recorded. At the end of the study, their names were kept confidential in the interviews with the students, and the principles of confidentiality and voluntariness were complied with in the entire data collection process.

Data Collection Tools

In this study, semi-structured student interviews and in-class observations were used. Semi-structured interview technique is a method that has pre-prepared guiding questions but also allows the flexibility to ask additional questions according to the participant's answers (Kvale & Brinkmann, 2015).

At the end of the research, individual interviews were conducted with each student; the interview was designed to include open-ended questions about students' awareness of their level of understanding of the 'Nature of Matter' unit, their motivation and their experiences with artificial intelligence tools. In-class observations were recorded by the researchers, and students' problem-solving approaches, the ways they asked questions and motivational attitudes were noted in the interactions in which both artificial intelligence applications were used (Table 1). The use of multiple data sources in case studies increases the integrity of the collected findings and the fact that two researchers analyze the data provides credibility.

Table 1. Observation criteria

Criterion	Description
Level of concept understanding	Accuracy of responses and inclusion of scientific explanations
Depth of interaction	Quality of questions asked to the AI, presence of follow-up questions
Student interest/motivation	Eye contact, level of engagement, curious behaviors
Openness to feedback	Degree of attentiveness and receptiveness to AI-generated responses

Planning

While planning, it was aimed to increase students' motivation through interactive and fun learning experiences. The study was designed for a total of two class hours (approximately 80 minutes). A timetable was created to implement ChatGPT and DeepSeek applications in the first class hour. Each lesson lasted approximately 40 minutes. Each activity lasted approximately 20 minutes. Students were interviewed during the second class hour.

Lesson 1 (Using ChatGPT, ~20 minutes): The teacher first reminded some known concepts about the 'Nature of Matter' and briefly question students' prior knowledge (possible misconceptions) on this subject. Then, students interacted with ChatGPT one-on-one and ask questions. Students took notes on ChatGPT's responses and discussed answers containing misunderstandings under the guidance of their teacher. During this process, the researcher and the teacher observed the student's questioning behavior, emotional and cognitive reactions during the interaction with ChatGPT and take notes. At the end of the lesson, a learning assessment made based on the answers of ChatGPT.

Lesson 1 (Using DeepSeek, ~20 min): The other half of the first class period conducted with the DeepSeek application using similar content. Students asked DeepSeek questions related to the same 'Nature of Matter' unit and discussed their answers. The responses were analyzed under the supervision of teachers and researchers, and the correct concepts were discussed. In this session, researchers observed student interactions and took observation notes on motivation and learning attitude.

Data Collection and Observation: Throughout both lessons, data on students' engagement, their approaches to the questions, and their responses to feedback provided by the AI tools were systematically recorded using researcher-designed observation forms. Between and at the end of the lessons, the teacher observed the students' thoughts by giving them short verbal feedback about the activities. In addition, individual semi-structured interviews were conducted with the students immediately after both lessons or at an appropriate time.

Conducting the Interviews: Individual semi-structured interviews were conducted with each student by the researcher. The interview questions will include questions about the student's experience of using ChatGPT/ DeepSeek, how they perceive the learning process, and their motivational status.

Timetable and Setting: All lessons took place in the same classroom environment during school hours. The students interacted with ChatGPT and DeepSeek in turns using individual tablets or computers. The researcher and the teacher provided technical support when needed and addressed questions that arose during the lesson.

Thanks to the interactive activities carried out in line with this plan, students' cognitive and affective-oriented learning was provided and the effect of artificial intelligence-supported applications on motivation was examined. The interview and observation data were evaluated by applying thematic analysis after the research was completed and the results were interpreted.

Data Analysis

The collected qualitative data were analyzed using thematic analysis method. Thematic analysis is a flexible analysis method used to discover recurring patterns of meaning in qualitative data, to make sense of these patterns by examining them, and to present the findings in a systematic way. This method allows in-depth interpretation of the data and structuring the content through themes (Braun & Clark, 2006). Accordingly, all interview records and observation notes were read and analyzed in detail. The researchers categorized the relevant text several times. By making comparisons between the categories, themes were identified and data were organized under these themes. Finally, in the interpretation phase, the researcher established cause-effect relationships between the findings and interpreted the results in the light of the data obtained in the context of students' interactions with artificial intelligence.

Validity and Reliability

Validity and reliability in qualitative research are related to the credibility, depth and completeness of the data obtained. In this study, various strategies were adopted to ensure the reliability and validity of the data. To enhance the reliability and validity of the study, the data were supported through multiple data collection methods. Throughout the process, student observations, semi-structured interviews and activity outputs were evaluated together to ensure data diversity. This diversity strengthened the consistency of the findings. At the same time, participant statements were directly quoted to ensure that the participant's perspective was reflected in the text.

In order to increase the reliability of the study, the research process was conducted in a clear and systematic manner, and the role of the researcher and the position of the observer were clearly defined. The thematic analysis method was used to analyze the data and the codes created were associated with the themes and reported transparently. In addition, the data obtained were compared with another expert opinion and the coding process was reviewed independently.

In terms of validity, although the findings obtained in the study are specific to a particular context (5th grade students, matter and heat topic, ChatGPT and DeepSeek use), they are reported in a way that can serve as an example in similar classes and situations. Since the participants were selected through purposive sampling, emphasis was placed on the in-depth interpretability of the findings rather than their generalizability. In this framework, the study was structured in accordance with qualitative research principles, and the data were obtained and analyzed in a holistic, consistent and reliable manner.

Findings

In this section, the data obtained from the qualitative case study conducted with two 5th grade students to examine the impact of the ChatGPT and DeepSeek AI applications in the "Nature of Matter" unit were analyzed using thematic analysis. The findings were categorized under four main themes:

- Concept Understanding of AI Applications
- Depth of Interaction of AI Applications
- Student Motivation
- Ease of Use

Theme 1: Concept Understanding of AI Applications

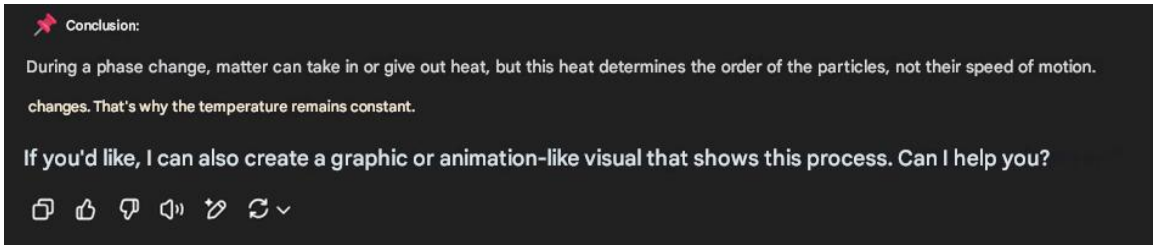
After the application, both students stated that both artificial intelligence applications contributed to their learning processes in different ways. The students stated that the concepts were explained in simpler, clearer and shorter sentences in their interactions with ChatGPT and that the support of the explanations with examples

from daily life facilitated learning. It was reflected in the students' own statements that these features helped the concepts to be structured more clearly mentally. Regarding the DeepSeek application, students stated that the answers given contained longer, detailed and scientific expressions, which caused them to have difficulty in understanding some concepts. Especially the intensive use of technical terms made it difficult for students to follow the explanations at times. In general, students stated that they found ChatGPT's explanations more understandable, while DeepSeek offered a more detailed learning experience that required more cognitive effort. Students' opinions regarding ChatGPT are as follows:

"I used to think that ice melts only when the temperature increases, but now I realized that there is heat exchange." (S1)

"Thanks to the summary or conclusion section under each answer, I better understood what was on my mind. When ChatGPT asked if I should explain with a visual, it became more permanent with the example of a teapot." (S2)

The image below shows an example of a screenshot of the student's ChatGPT search:

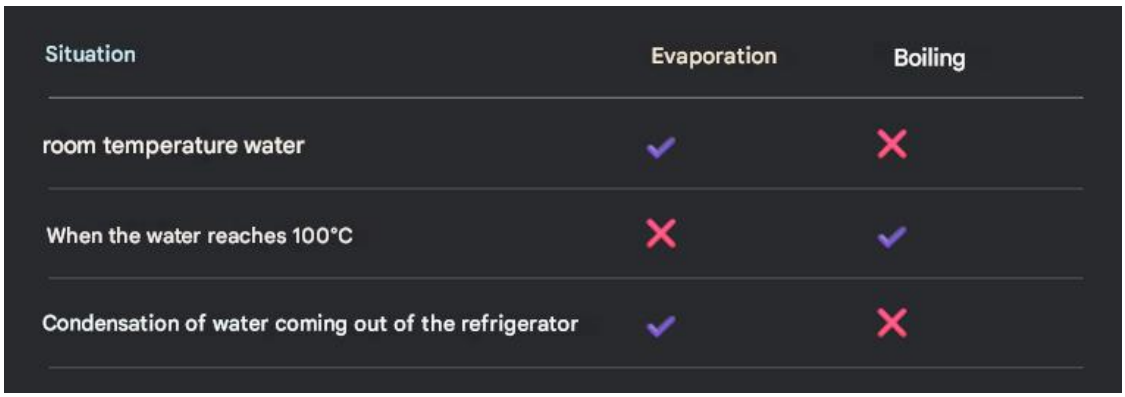


Students' opinions regarding DeepSeek are as follows:

"...I liked that it gave a table in the answers and made comparisons. But it was complicated because it gave detailed explanations, I didn't want to read it." (S1)

"I did not know that boiling is at a certain temperature. Thanks to the comparison table of the DeepSeek application, I understood the difference with evaporation. While looking at DeepSeek answers, the tables attracted my attention the most. I didn't want to read the rest." (S2)

The screenshot of the student's DeepSeek search is given in the image below:



Theme 2: Depth of Interaction of AI Applications

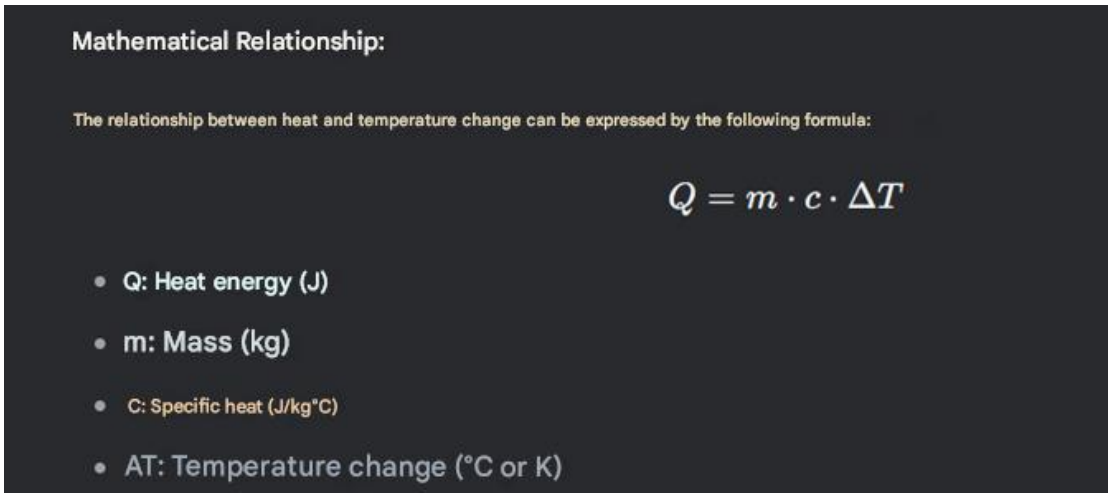
In the students' statements based on their experiences related to the applications, it was emphasized that the interactions with ChatGPT included shorter, concise and clearer explanations. Students stated that ChatGPT often asked alternative questions at the end of their answers and continued their explanations in a conversational manner. It was observed that this approach created the impression of being in a dialog with a guide and increased their interest in the process. Students' opinions regarding ChatGPT are as follows:

"ChatGPT was more effective. Because it was like a conversation, he was constantly asking me something. If I didn't understand, he explained it in different ways. In DeepSeek, he did not ask me questions, he just gave me information. It was more fun to work with ChatGPT." (S1)

In the DeepSeek application, it was observed that the answers were longer and more academic; the explanations were supported by formulas, but there was no interaction with the students. Student expressions that DeepSeek offers scientific explanations but does not create a sense of one-to-one communication with the student are noteworthy. In this direction, the students stated that they adopted the ChatGPT application, which they found more interactive and guiding in the learning process. Students' opinions regarding DeepSeek are as follows:

"When I wrote something, the answer came, but sometimes I didn't understand what it meant. I didn't continue because it gives long answers and there are concepts I don't know." (S2)

Below is a screenshot of the student's search using the DeepSeek application:



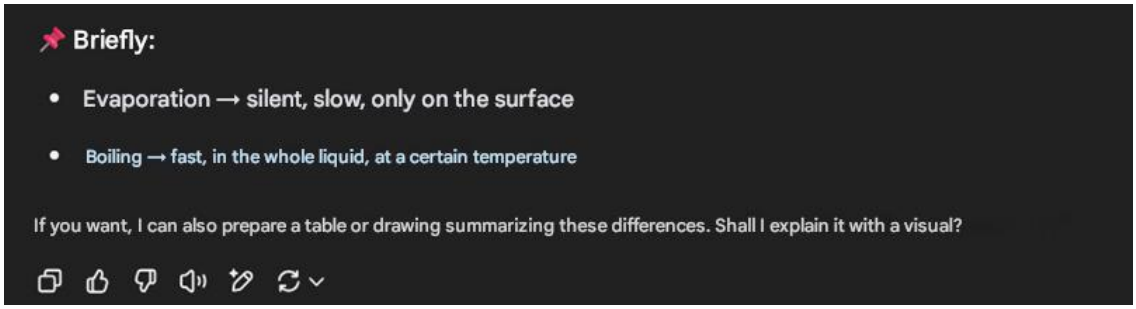
Theme 3: Student Motivation

Both students stated that they found the AI-supported lesson process engaging, motivating and fun. Students stated that especially the opportunity to communicate one-to-one with a digital tool made the learning process more interesting. In the interactions with ChatGPT, it was observed that students focused on the lesson for longer, actively responded to the feedback given and participated in the process with high motivation. On the other hand, in the studies conducted with DeepSeek, students' attention was distracted from time to time, interaction levels decreased and participation became passive. This situation shows that ChatGPT's structure that establishes a dialog with the student has positive effects on attention and motivation. Students' opinions regarding ChatGPT are as follows:

"It is as if I am talking to someone, I like this very much." (S1)

"It made it easier for me to proceed by indicating the questions I wanted to ask under the answers. This made me happy while doing the activity." (S2)

The image below shows an example of a screenshot of the ChatGPT search related to the student's opinion:



Students' opinions regarding DeepSeek are as follows:

"It's nice, but sometimes I didn't know what to write." (S2)

"DeepSeek is nice, but it gives too much detailed information. It doesn't guide me." (S1)

Theme 4: Ease of Use

When students used the ChatGPT and DeepSeek interfaces, they could easily navigate the application and did not have difficulty in expressing their questions in their own words. However, it was observed that students needed more teacher guidance when they used the DeepSeek application. Students' opinions regarding ChatGPT are as follows:

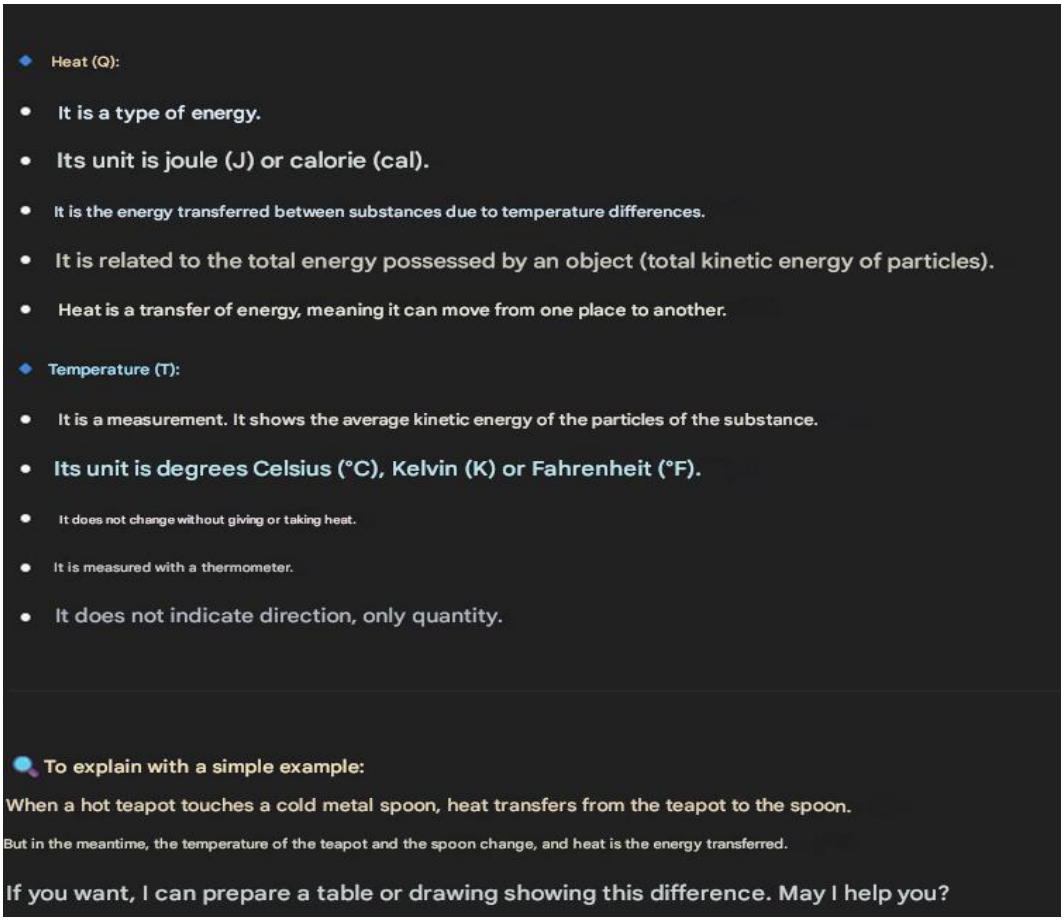
"When I wrote the question, it answered immediately, I also asked other things myself." (S1)

"ChatGPT was easier. DeepSeek did not guide me, I had difficulty." (S2)

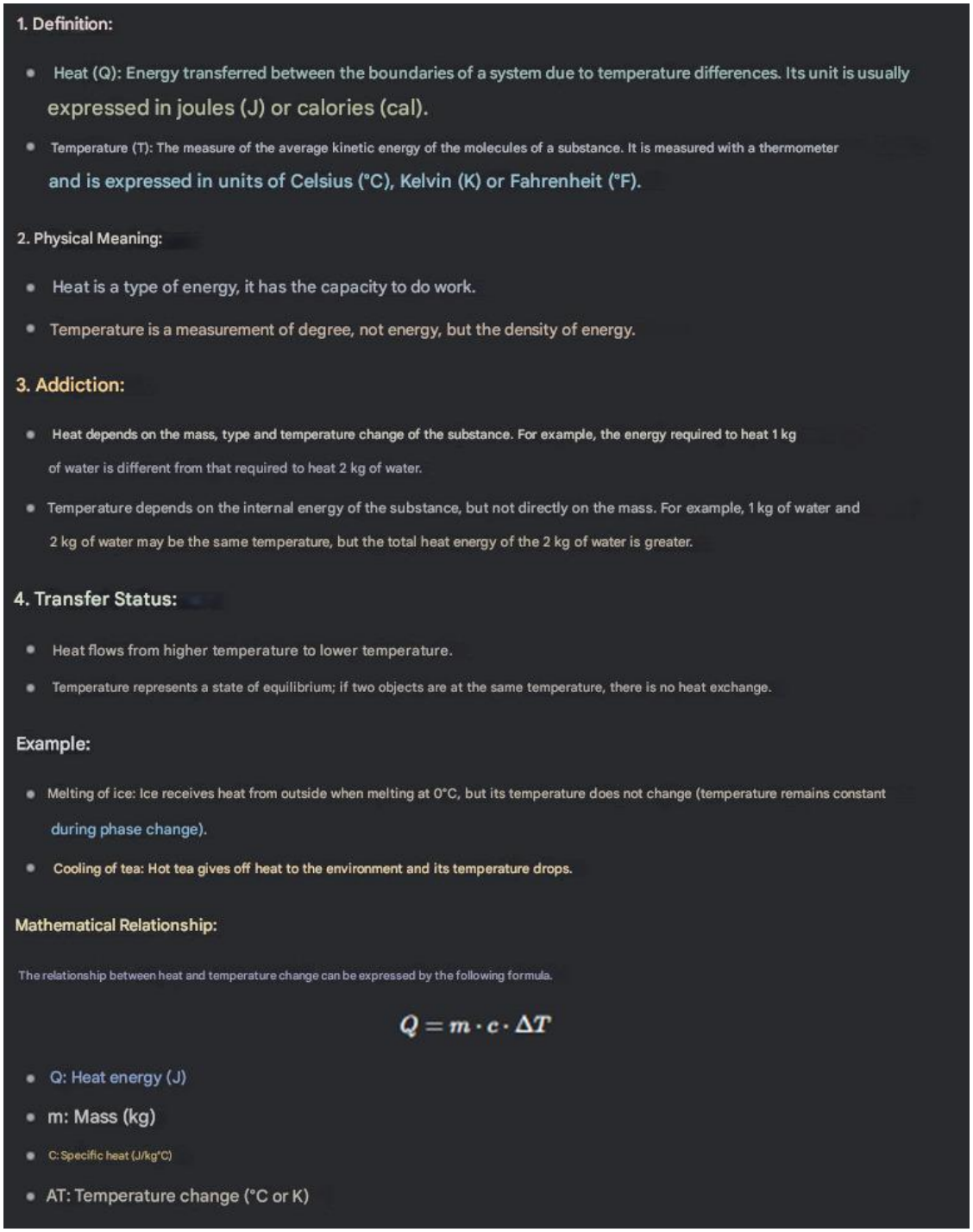
Students' opinions regarding DeepSeek are as follows:

"Some of the explanations were too long and I could not fully understand them at first, so I had to go back and read them several times. Only then I could comprehend the subject better." (S2)

Below is a screenshot of the student's search from the ChatGPT application with question 1:



Below is a screenshot of the student's search on the DeepSeek application for the first question:



As a result of the comparative activity with two different artificial intelligence applications, it was observed that the ChatGPT application contributed more to the conceptual development, motivation and interaction skills of the students. Although DeepSeek also has instructive aspects, it is thought that it can become more effective with more structured guidance and the use of plain language.

Discussion, Conclusion and Recommendations

The findings of this study show that AI-based applications can support students' conceptual understanding and make the learning process more interactive and motivating. Similarly, as noted by researchers such as Woolf (2021) and Luckin (2018), AI-supported learning environments support deep learning by providing adaptive feedback according to students' individual needs.

ChatGPT provided shorter and clearer answers than DeepSeek, which positively affected student learning. DeepSeek negatively impacted learning by providing longer answers and using scientific terms more frequently. ChatGPT can be used in a variety of ways to enhance research and science in academia. ChatGPT can become a useful tool for instructors and academics by providing a basis for creating course content, teaching materials and assessment methods (Lo, 2023).

Although both applications increased student motivation but a higher level of curiosity and desire to learn was observed in the use of ChatGPT. This can be attributed to the fact that the student sees the application as a learning partner. Polak et al. (2022) stated in their study that the use of artificial intelligence led to an increase in motivation. In another study, Roll et al. (2016) stated that artificial intelligence-based systems increase students' motivation to learn and contribute to their ability to continue their learning processes more effectively individually. In addition, it was stated that students' interest in the course was positively affected by the integrity of the materials offered by these systems with the course content.

The ChatGPT interface was found to be more intuitive and user-friendly by the students. While using DeepSeek, it was noted that students needed more teacher guidance. The fact that ChatGPT was found to be more effective can be attributed to the natural language processing power of the application and the feeling of having a conversation with the student. This finding is in line with the study of Selçuk and Yıldırım (2023) that artificial intelligence-supported teaching tools facilitate student-centered learning.

However, it should not be forgotten that applications such as DeepSeek can also be effective teaching materials when equipped with appropriate guidance and simple content. Teacher guidance is of great importance especially for students with low technology literacy. Similarly, Soegoto et al. (2019) indicated in their study that adapting to artificial intelligence content is challenging.

The findings of the study revealed that students were able to use both ChatGPT and DeepSeek applications easily in general and that they did not have any serious difficulty in directing their questions in their own words. However, when evaluated in depth, it was observed that ChatGPT provided a more effective interaction with students because it had a more intuitive and user-friendly structure. In this application, students could easily ask their questions without the need for guidance and receive meaningful feedback. On the other hand, it was observed that students needed more teacher support when using DeepSeek. This may be due to the more technical or complex nature of the application. It was also reported that students had difficulty in understanding some concepts and hesitated in determining how to ask questions. These findings show that not only content but also ease of use and guiding features are important for the effective use of AI-supported tools in education.

According to the research findings, ChatGPT application contributed more to students' learning, motivation and interaction skills than DeepSeek. In this direction, the following suggestions were developed:

- Considering the supportive effect of ChatGPT on students' conceptual understanding, teachers should be encouraged to integrate this application into the teaching process, especially in science courses.
- DeepSeek's use of a simpler language and the development of structured guidance features can enable students to use the application more effectively. For this purpose, educational content should be simplified and guiding artificial intelligence interactions should be increased.
- For students with low motivation towards the science course, it is important to adapt artificial intelligence-based applications according to individual learning needs in order to strengthen the supportive and motivating functions of these tools.

Scientific Ethics Declaration

* The authors declare that the scientific ethical and legal responsibility of this article published in EPESS journal belongs to the authors.

Conflict of Interest

* The authors declare that they have no conflicts of interest

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* We firmly believe that such academic platforms play a vital role in encouraging interdisciplinary collaboration and deepening academic inquiry within the field of education. We look forward to meeting again at future scholarly events.

References

Arslan, K. (2020). Eğitimde yapay zekâ ve uygulamaları. *Batı Anadolu Eğitim Bilimleri Dergisi*, *11*(1), 71–88.

Baker, R. S., & Inventado, P. S. (2014). Educational data mining and learning analytics. In J. A. Larusson & B. White (Eds.), *Learning analytics: from research to practice* (pp. 61–75). Springer.

Bartlett, L., & Vavrus, F. (2017). Comparative case studies: An innovative approach. *Nordic Journal of Comparative and International Education (NJCIE)*, *1*(1),1929.

Braun, V., & Clarke, V. (2006). Psikolojide tematik analizin kullanımı. *Journal of Qualitative Research in Education*, *3*(2), 77–101.

Chen, L., Chen, P., & Lin, Z. (2020). Artificial intelligence in education: A Review. *IEEE Access*, *8*, 75264–75278.

Creswell, J. W. (2007). *Qualitative inquiry and research design*: *Choosing among five approaches* (2nd ed.). Thousand Oaks, CA: Sage Publications.

Creswell, J. W. (2016). *Qualitative inquiry and research design: Qualitative research and research design according to five approaches* (M. Bütün & S. B. Demir, Trans.). Ankara: Siyasal Kitabevi.

Holmes, W., Bialik, M., & Fadel, C. (2019). Artificial intelligence in education: Promises and implications for teaching and learning. Center for Curriculum Redesign. Retrieved from https://curriculumredesign.org/wp-content/uploads/AI-in-Education.pdf

Holmes, W., Bialik, M., & Fadel, C. (2022). *Artificial intelligence in education: Promises and implications for teaching and learning*. Center for Curriculum Redesign.

Kvale, S., & Brinkmann, S. (2015). *Interviews: Learning the craft of qualitative research interviewing* (3rd ed.). Thousand Oaks, CA: Sage Publications.

Lo, C. K. (2023). ChatGPT and the future of higher education assessment. *Education and Information Technologies*, *28*, 1965–1984.

Luckin, R. (2018). *Machine learning and human intelligence: The future of education for the 21st century*. UCL Institute of Education Press.

Luckin, R., Holmes, W., Griffiths, M., & Forcier, L. B. (2016). *Intelligence unleashed: An argument for AI in education*. Pearson Education. Retrieved from https://www.pearson.com/content/dam/one-dot-com/one-dot-com/global/Files/about-pearson/innovation/open-ideas/Intelligence-Unleashed-Publication.pdf

Nye, B. D. (2015). *Intelligent tutoring systems by the numbers: A meta-analysis of meta-analyses.* In R. Sottilare, A. Graesser, X. Hu, & H. Holden (Eds.), Design recommendations for intelligent tutoring systems (Vol. 3, pp. 197–206). Army Research Laboratory.

Patton, M. Q. (2014). *Qualitative research & evaluation methods: Integrating theory and practice* (4th ed.). Thousand Oaks, CA: Sage Publications.

Polak, S., Schiavo, G., & Zancanaro, M. (2022). Teachers' perspective on artificial intelligence education: An initial investigation. In *CHI Conference on Human Factors in Computing Systems Extended Abstracts* (pp. 1–7).

Roll, I., & Wylie, R. (2016). Evolution and revolution in artificial intelligence in education. *International Journal of Artificial Intelligence in Education*, *26*, 582-599.

Rudolph, J., Tan, S., Huang, X., & Zhang, L. (2023). Artificial intelligence in education: Applications and implications. *Journal of Educational Research and Practice*, *13*(2), 112–130.

Selçuk, G., & Yıldırım, A. (2023). Ortaokul düzeyinde yapay zekâ destekli öğrenmenin öğrenci başarısına etkisi. *Eğitimde Yeni Yönelimler Dergisi*, *7*(2), 101–117.

Soegoto, M., Suryani, E., & Nugroho, H. (2019). Challenges in adapting to AI-based educational content: A case study in Indonesian schools. *Journal of Educational Technology & Society*, 22(4), 45-58.

Southgate, E., Smith, S. P., Cividino, C., Saxby, S., Kilham, J., Eather, G., ... & Bergin, C. (2018). Embedding immersive virtual reality in classrooms: Ethical, organisational and educational lessons in bridging research and practice. *International Journal of Child-Computer Interaction*, *19*, 19–29. Retrieved from

Stake, R. E. (1995). *The art of case study research*. Thousand Oaks, CA: Sage Publications.

Uğur, A., & Kınacı, Ş. (2006). Yapay zekâ destekli öğretim materyallerinin etkileşim, soyut düşünme ve uyum becerilerine etkisi. *Milli Eğitim Dergisi*, *171*, 30–45.

VanLehn, K. (2011). The relative effectiveness of human tutoring, intelligent tutoring systems, and other tutoring systems. *Educational Psychologist*, *46*(4), 197–221.

Yin, R. K. (2018). *Case study research and applications: Design and methods* (6th ed.). Thousand Oaks, CA: Sage Publications.

Zhai, X. (2023). ChatGPT for supporting scientific argumentation: Opportunities and challenges. *Science & Education*, *32*(2), 451–463.

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