Examining Biology Teachers' Cognitive Structures Regarding Artificial Intelligence Using a Word Association Test

Sultan Cikrik[1], Tugce Duran[2], Musa Dikmenli[2], Selda Kilic[2]
[1]Gazi University
[2]Necmettin Erbakan University

To cite this article:

Examining Biology Teachers' Cognitive Structures Regarding Artificial Intelligence Using a Word Association Test

Sultan Cikrik, Tugce Duran, Musa Dikmenli, Selda Kilic

Article Info	Abstract
	In recent years, artificial intelligence has attracted great attention worldwide, particularly due to its impact on all areas of human life. The reasons for this interest include the rapid increase in the changes that artificial intelligence applications may bring to individuals' lifestyles and the structure of society, and the potential problems that may accompany these changes. As in many other fields, artificial intelligence has quickly entered educational settings and has become a focal point for both students and teachers. In this respect, revealing teachers' cognitive structures regarding artificial intelligence is of great importance, as their approaches to this development will directly influence their students. The aim of this study is to examine the conceptual frameworks of biology teachers regarding artificial intelligence. The data were collected from 126 participants using a free word association test. The analysis of the free word association test demonstrates various aspects of the participants' conceptual frameworks concerning artificial intelligence. The participants emphasized the potential benefits of artificial intelligence in terms of advanced technologies, education, benefits to humanity, and contributions to the cultural and economic life of society. However, they also expressed the view that artificial intelligence may entail potential drawbacks, including ethical issues, security risks, and the risk of promoting laziness.

Introduction

Artificial intelligence, one of the leading technological developments of the twenty-first century, has become a concept encountered in nearly every aspect of life in recent years. Artificial intelligence is defined as the imitation of human cognitive abilities and skills by machines (Nabiyev, 2010). In this context, the 4-1 victory of AlphaGo, developed by Google DeepMind, over world Go champion Lee Sedol in 2016 marked a global turning point in the field and significantly increased interest in artificial intelligence research (Borowiec, 2016).

The rapid advancement of artificial intelligence technologies has also manifested itself in educational settings. Artificial intelligence tools, used formally and informally in schools and out-of-school learning environments, have become invisible participants in classrooms. While students are expected to conduct research, inquiry, and reasoning processes, many now complete assigned tasks quickly through artificial intelligence tools. This raises questions about the quality of teacher-student interactions: What role will the teacher assume in this evolving learning environment? What are teachers' perceptions and attitudes toward artificial intelligence? How can traditional teaching models be applied within this new technological context? Such questions constitute the current focal points of discussion in educational research.

Artificial intelligence in education (AIEd) is defined not only as a tool forming the basis of "intelligent" educational technologies, but also as a powerful instrument that aims to open the "black box of learning" by revealing how learning actually occurs (Luckin et al., 2016). Stanford University's 2024 Artificial Intelligence Index Report shows that the number of artificial intelligence-related educational programs offered in English has nearly tripled since 2017. This increase indicates a rising demand for and awareness of artificial intelligence literacy in education (Maslej et al., 2024).

According to Zhou and Peng (2025), artificial intelligence has the potential to enhance students' creativity; however, this can only be achieved when it is used in pedagogically meaningful ways by teachers. They further emphasize that AI-supported creativity emerges from human-machine collaboration, and the strength of this effect depends on the extent to which students perceive their teachers as AI-literate.

According to the report of the U.S. Department of Education, artificial intelligence offers significant opportunities for increasing teacher productivity, monitoring student progress, and supporting individualized learning processes. However, unsupervised use of artificial intelligence tools also bring certain risks, such as weakening the teacher's authority in classroom management (USDOE, 2023). Since artificial intelligence cannot perform human-specific functions such as empathy, ethical understanding and actions, and emotional attitudes, teacher control or supervision is of critical importance. The study conducted by Lahdesmäki, Väisänen, and Hyytinen (2025) revealed that teachers who received artificial intelligence training felt much more motivated and confident, showing that openness to learning, rather than experience, makes the real difference. Although teachers have begun to view artificial intelligence as a partner rather than a threat, they continue to emphasize that ethical responsibility ultimately lies with them.

The literature contains numerous studies on the use of artificial intelligence in education. Artificial intelligence provides personalized learning environments, increases the efficiency of learning processes by offering learners instant and adaptive feedback (Shute, 2008), and facilitates assessment and evaluation processes for teachers (Benhamdi, Babouri & Chiky, 2017; Begum, 2024; Chen, Chen & Lin, 2020; González-Calatayud, Prendes-Espinosa & Roig-Vila, 2021; Jukiewicz, 2024). However, challenges remain, such as inadequate infrastructure, poor access to information, insufficient resources, data security and ethical issues, and the fact that teachers have not yet reached the desired level of competencies required to effectively use artificial intelligence pedagogically. In this context, a study (Uygun et al., 2024) reported that teachers' levels of artificial intelligence awareness are moderate and that they require more training and resources for integration. Furthermore, the increasing use of artificial intelligence also raises potential risks, such as the weakening of students' social communication skills (Begum, 2024; Huang, Saleh & Liu, 2021).

It has been noted that preservice teachers perceive artificial intelligence as a "source of information" and often associate it with the metaphor of a "teacher" (Eroğlu, 2024; Gölbaşı & Okul, 2024). However, it has been stated that artificial intelligence cannot replace teachers; rather, the future of education can be enriched through the combination of teachers' unique expertise and the capabilities of artificial intelligence (Crovello, 1974; Luckin et al., 2016).

There is a limited number of studies in literature examining teachers' perceptions of artificial intelligence. Dişlioğlu Ateş, and Medeni (2025) found that the majority of teachers have a positive view of using artificial intelligence in education; however, they also stated that it may negatively affect students due to reasons such as "becoming accustomed to ready-made information and failing to learn how to conduct research." Similarly, Cruz, Duque and Carvalho (2024) reported that teachers generally agree on the integration of artificial intelligence into teaching, while at the same time acknowledging their need for further training in this area. Gökçe (2024), on the other hand, investigated pre-service science teachers' perceptions of artificial intelligence using a word association test and found that artificial intelligence was most frequently associated with the concepts of "robot, convenience, technology, ChatGPT, and smart assistant."

One of the fundamental goals of biology education is to encourage students to understand the nature of the technologies that will shape the future. In this regard, it is known that both teachers and students utilize artificial intelligence tools to develop their scientific knowledge-building practices. Lidiastuti et al. (2025) noted an increasing trend in the use of artificial intelligence in biology education over the years. In this regard, understanding ideas about artificial intelligence technologies can enhance teachers' abilities to participate in future scientific developments and current scientific debates, as well as to benefit from the products of science and technology and critically evaluate scientific claims. Therefore, it is important to examine conventional representations of artificial intelligence and the image of artificial intelligence in people's minds. Biology teachers' images of artificial intelligence can shape their biology teaching methods and, in turn, influence students' perspectives on biology and technology. Considering the strong influence teachers have on students' understanding, revealing the cognitive structures of biology teachers regarding artificial intelligence is expected to provide guidance for possible improvements in teacher training programs.

Significance

Today, artificial intelligence technologies have permeated nearly every aspect of life, and it is inconceivable for the education system to remain outside this transformation. However, achieving technological transformation in schools cannot be accomplished merely by introducing tools such as smart boards or tablets into classrooms. The primary determining factor is the perceptions and approaches of teachers who will use these technologies. At this point, biology teachers hold a unique position. Concepts such as "intelligence," "learning," and "the

nervous system" constitute fundamental areas of study in biology, and the structure of artificial intelligence, which mimics the human mind, may lead biology teachers to interpret artificial intelligence differently from teachers in other subject areas. This study makes an original and valuable contribution to the literature by thoroughly examining biology teachers' cognitive structures related to artificial intelligence using data obtained from both verbal expressions and drawings.

Purpose

The primary purpose of this study is to examine the cognitive structures of biology teachers regarding artificial intelligence through a free word association test. In line with this aim, the following research questions were addressed: (1) *Which concepts do biology teachers associate artificial intelligence with and how frequently?* (2) *Under what categories can these associated concepts be classified?*

Method

This study aims to examine biology teachers' cognitive structures related to "artificial intelligence" through drawing and a free-word association test. In line with this aim, the research was designed in accordance with qualitative research patterns. Qualitative research is defined as an approach that employs qualitative data collection methods such as observation, interview, and document analysis, and follows a qualitative process aimed at revealing perceptions and events in a realistic and holistic manner in natural settings. In other words, qualitative research is an approach that prioritizes investigating and understanding social phenomena within their context, with an approach based on theory formation (Yıldırım and Şimşek, 2016, p. 39). A fundamental principle of qualitative research is the holistic nature of the data collected. Based on the understanding that a whole is more meaningful than the sum of its parts, the research topic is determined through a holistic approach, and the data collected are analyzed accordingly.

Participants

This study was conducted with 126 biology teachers, 97 female and 29 male, working in high schools in Konya province. The average age of the participants was 43, and their average professional experience was 13 years. The research data were collected over a one-month period during the spring semester of the 2024-2025 academic year. Participation in the study was voluntary. A word association test was used as the data collection tool.

Data Collection Tool

In this study, a free word association test was used as the data collection tool to reveal the cognitive structures of biology teachers regarding "artificial intelligence." Before the implementation, participants were verbally informed about the purpose, duration, and procedure of the free word association test, and several examples and practice activities were provided. In the test, the term "artificial intelligence" was presented to the participants as a stimulus term, written 10 times under one another as shown below, and they were asked to respond within 30 seconds.

> Artificial intelligence: …………………………
> Artificial intelligence: …………………………
> Artificial intelligence: …………………………
> Artificial intelligence: …………………………
> Artificial intelligence: …………………………
> Artificial intelligence: …………………………
> Artificial intelligence: …………………………
> Artificial intelligence: …………………………
> Artificial intelligence: …………………………
> Artificial intelligence: …………………………
> Draw the first image that comes to your mind when you think of artificial intelligence and write a sentence   about   it:
> ……...………………………………………………………………………….

The reason for writing the stimulus term ten times consecutively is to prevent the risk of chain reactions. If a participant does not return to the stimulus term after writing a response, they tend to write words associated with their previous response rather than with the stimulus word itself. This undermines the purpose of the test. Participants were asked to write the first ten words that came to mind when they heard or read the term "artificial intelligence." The word association test is a data collection technique used to determine the conceptual structure of an individual or group. This technique involves presenting a stimulus word and asking participants to freely associate it with ideas that come to mind within a short period of time. This stimulus term is assumed to provide relatively unrestricted access to participants' mental representations (Bahar, Johnstone & Sutcliffe, 1999). In its simplest form, participants are presented with a stimulus word, either verbally or in writing. Participants are required to provide feedback using the response words evoked by the stimulus term. Following this procedure, participants were asked to draw the first image that came to mind within 30 seconds when artificial intelligence was mentioned, and then to write one sentence about it within the next 30 seconds. After analyzing the content and calculating the frequency of response words, it becomes possible to derive conclusions about the associative meanings of the stimulus words and thereby describe participants' conceptual structures. The drawings and sentences obtained through association were evaluated together and categorized. Free word association test that reveals the associative meanings of various concepts has been used in several studies (Dikmenli, 2010; Torkar & Bajd, 2006).

Data Analysis

In the free word association test, the analysis and interpretation of the word associations provided for the key word were carried out through the following stages:

1- Coding and extraction stage,
2- Category development stage,
3- Ensuring validity and reliability stage.
4- Transferring the data into the SPSS package program for quantification of the qualitative data.

1- Coding and Extraction Stage: The associations generated by 126 biology teachers for the keyword "artificial intelligence" were coded into concepts. During data analysis, associations that were deemed illogical, unrelated to "artificial intelligence," and were not repeated at least three times were excluded. No response sheets lacking associations were encountered in the study. 208 response words, initially assumed to be valid, were identified in the data collection tools. However, only 113 response words were included in the analysis. The remaining 95 response words were excluded from the study because they were repeated only once or twice. Of the excluded words, 78 were used only once, and 17 were used only twice. For example, the words "Deep seek" and "chip" were excluded because they were used only once, and the word "feedback" was excluded because it was used only twice. Thus, response words that were repeated once or twice were excluded. In addition, drawings and sentences about artificial intelligence from 126 participants were semantically evaluated and categorized.

2-Category development stage: After excluding 95 response words, 113 valid response words were obtained. At this stage, these words were listed from highest to lowest according to their frequency and reviewed for the third time. Semantically similar response words were grouped and categorized into a single cluster. For example, the words "robot," "technology," and "computer" were placed in the same cluster. Through this process, eight distinct categories were created.

The participants' drawings and sentences related to artificial intelligence were grouped according to their similarities, and four separate categories were created: (1) Artificial intelligence is a useful tool for humanity, (2) Artificial intelligence is useful when used correctly but dangerous when used incorrectly, (3) Artificial intelligence is a dangerous tool for humanity, and (4) Artificial intelligence is an ordinary technology.

3-Ensuring Validity and Reliability: Validity and reliability are the two most important criteria used to ensure or increase the credibility of research findings. In this regard, providing a detailed report of the collected data and explaining how the researcher reached the results are considered key indicators of validity in qualitative research (Yıldırım & Şimşek, 2016, p. 270). In this study, two major procedures were carried out to ensure the validity of the research findings: (1) The data analysis process, specifically how the eight separate categories were reached, was explained in detail. (2) The eight categories, consisting of 113 words and 1069 frequencies, were included in the findings section.

Three key strategies were employed to ensure the reliability of the study. First, the four researchers who are the authors of this article studied collaboratively and consistently at every stage of the research process (e.g., developing the research design, formulating the research questions, collecting data, analyzing data, developing categories, and interpreting the results). In the event of disagreement, they sought consensus to reach a decision. The eight conceptual categories developed in the study were submitted to two separate experts for review. Each expert, both of whom are faculty members specializing in biology education, was provided with a list containing the eight conceptual categories along with the associated response words and their frequencies, and they were asked to evaluate whether the response words in each category were semantically appropriate. The categorizations made by the experts were then compared with those of the researchers. In all comparisons, the numbers of agreement and disagreement were determined, and the reliability of the study was calculated using Miles and Huberman's (2016) formula (i.e., [Agreement / (Agreement + Disagreement) x 100]. In the reliability study conducted specifically for this study, an agreement (reliability) rate of 93% and 96% was achieved, respectively. The first expert reported disagreements for eight response words, yielding a reliability score of $(105/113) \times 100 = 93\%$, while the second expert reported disagreements for five response words, yielding a reliability score of $(108/113) \times 100 = 96\%$. These results indicate that the study achieved the desired level of reliability.

The four categories created for the participants' drawings and sentences about artificial intelligence were evaluated by two independent experts. Each expert, both of whom are faculty members specializing in biology education, was provided with a list containing the four categories and their frequencies, along with all 126 participants' drawings and sentences regarding artificial intelligence. The experts were asked to match each drawing and sentence with the categories and to indicate if they had a different opinion outside of these categories. Their categorizations were then compared with those of the researchers, and the numbers of agreements and disagreements were determined. The reliability of these categorizations was calculated using Miles and Huberman's (2016) formula. In the reliability study conducted specifically for this study, agreement (reliability) rates were achieved at 91% and 88%, respectively. The first expert disagreed on 11 drawings or sentences, yielding a reliability coefficient of $(115/126) \times 100 = 91\%$, while the second expert disagreed on 15 items, yielding a reliability coefficient of $(111/126) \times 100 = 88\%$. These calculations indicate that the study achieved the desired level of reliability.

4- Transferring Data to SPSS for Quantification of Qualitative Data: After coding a total of 113 associations and developing eight conceptual categories formed by these associations, all data were transferred to SPSS statistical software. Additionally, the categories obtained through semantic analysis of the participant's drawings and sentences related to artificial intelligence were transferred to SPSS statistical software. Following this process, the number (f) and percentage (%) of concepts representing each category were calculated.

Results

A total of eight response word categories were generated as a result of data analysis: (1) advanced technologies, (2) education and training, (3) benefit, (4) society, culture and economy, (5) human mind and cognition, (6) ethics and safety, (7) personal emotions, and (8) harm. These categories and the response words within each category are shown in Table 1. The participating biology teachers associated artificial intelligence with 113 different response words, producing a total of 1,069 word frequencies. According to the findings, the dominant category associated with artificial intelligence was advanced technologies (398 response words, accounting for 37.23% of all response words). 27 different concepts were represented in this dominant category with 398 frequencies. The most frequently repeated concepts were "Robot" (63), "Technology" (61), "ChatGPT" (44), "Computer" (32), "Internet" (23), "Data Mining" (20), "Coding" (18), "Software" (17), "Informatics" (13), and "Virtual Reality" (13). These results indicate that the participants made direct associations between artificial intelligence and advanced technologies. These mental associations reflect the strong conceptual link between artificial intelligence and technology. The response words obtained reflect participants' expectations that humanity will further advance artificial intelligence technologies both today and in the future.

The second category of response words indicates that the participating teachers associated artificial intelligence with education and training (151 response words, accounting for 14.13% of all response words). 18 different concepts were represented in this category with 151 frequencies. The most frequently repeated concepts were "information" (32), "education" (14), "assignment" (14), "information access" (12), "science" (11), "learning" (10), "research" (9), "inquiry" (8), "idea" (7), "language learning" (5), "accessibility" (5), and "problem solving" (5). In this category, it was observed that many of the participants focused on ways to access information, producing scientific information, and the instructional aspects of artificial intelligence, while others

focused on aspects such as problem solving, satisfying curiosity, and scientific discovery. These results reflect the teachers' ideas, shaped by their profession, regarding the potential impacts of artificial intelligence on biology teaching.

Table 1. Associations with the term "artificial intelligence" (categories and responses included in each category and the cumulative frequency of response words).

	Categories	Associations included in categories and their frequencies	Total frequency of associations in this category	%
1	Advanced Technologies	"Robot" (63), "technology" (61), "ChatGPT" (44), "computer" (32), "internet" (23), "data mining" (20), "coding" (18), "software" (17), "informatics" (13), "virtual reality" (13), "gemini" (12), "smart phone" (10), "machine learning" (7), "system" (7), "application" (7), "information processing" (6), "artificial neural network" (6), "algorithm" (5), "deep learning" (5), "image processing" (5), "space" (4), "robotic coding" (4), "biotechnology (4), "smart home appliances" (3), "siri" (3), "engineering" (3), "augmented reality" (3).	398	37,23
2	Education And Training	"Information" (32), "education" (14), "assignment" (14), "information access" (12), "science" (11), "learning" (10), "research" (9), "inquiry" (8), "idea" (7), "language learning" (5), "accessibility" (5), "problem solving" (5), "instructional" (4), "course" (3), "critical thinking" (3), "encyclopedia" (3), "discovery" (3), "curiosity" (3).	151	14,13
3	Benefit	"Convenience" (63), "assistant" (18), "speed" (16), "quick access" (12), "benefit" (6), "production" (6), "medical assistance" (6), "time saving" (5), "access" (5), "accessibility" (5), "guide" (3).	145	13,56
4	Society, Culture And Economy	"Development" (31), "future" (26), "innovation" (13), "new world order" (9), "progress" (8), "unemployment" (7), "world domination" (5), "loss of profession" (5), "opportunity" (4), "profession" (4), "revolution" (3), "globalization" (3), "economy" (3), "welfare" (3), "social media" (3), "media" (3), "communication" (3).	133	12,44
5	Human Mind And Cognition	"Analysis" (12), "brain" (10), "creativity" (10), "intelligence" (9), "reason" (6), "not thinking" (6), "decision making" (5), "fuzzy logic" (5), "logic" (4), "imagination" (4), "mind" (3), "genius" (3), "reasoning" (3), "visualization" (3), "perception" (3).	86	8,04
6	Ethics And Safety	"Global threat" (18), "security vulnerability" (11), 'misinformation' (8), "end of humanity" (5), "fake" (4), "ethical concern" (4), "control" (4), "inhuman" (4), 'chaos' (3), "dark forces" (3), "threat" (3).	67	6,27
7	Personal Emotions	"Fear" (17), "lack of emotion" (10), "conversation" (7), "confidant" (6), "loneliness" (4), "my everything" (3), "anxiety" (3).	50	4,68
8	Harm	"Laziness" (15), "imitation" (6), "seeking ready-made answers" (5), "fakeness" (4), "atrophy" (3), "humanoid" (3), "harm" (3).	39	3,65
	Total	**113**	**1069**	**100**

The response words in the third category indicate that the participants associated artificial intelligence with the convenience that could benefit humanity (145 response words, accounting for 13.56% of all response words). Eleven different concepts were represented in this category with 154 frequencies. The most frequently repeated concepts were "convenience" (63), "assistant" (18), "speed" (16), "quick access" (12), "benefit" (6), "production" (6), and "medical assistance" (6). In this category, many participants focused on auxiliary services that make human life easier, while others focused on aspects such as time saving and ease of access. These results show that biology teachers take into consideration the facilitating effects of artificial intelligence on individuals' daily lives.

The response words in the fourth category indicate that the participating teachers associated artificial intelligence with terms related to society, culture, and the economy (133 response words, accounting for 12.44% of all response words). Seventeen different concepts were represented in this category with 133 frequencies. The most frequently repeated concepts were "development" (31), "future" (26), "innovation" (13), "new world order" (9), "progress" (8), "unemployment" (7), "world domination" (5), "loss of profession" (5), "opportunity" (4), and "profession" (4). In this category, many participants focused on developments and innovations in the future of society, while others focused on the aspects such as unemployment, loss of profession, and world domination. These results reflect the belief of biology teachers that although artificial intelligence will bring innovations to social dynamics, it may also lead to challenges such as unemployment and loss of professional roles.

The response words in the fifth category indicate that the participating teachers associated artificial intelligence with terms related to mental processes (86 response words, accounting for 8.04% of all response words). Fifteen different concepts were represented in this category with 86 frequencies. The most frequently repeated concepts were "analysis" (12), "brain" (10), "creativity" (10), "intelligence" (9), "mind" (6), and "not thinking" (6). In this category, many participants focused on human brain activities, analysis, and creativity, while others focused on aspects such as logic, imagination, and perception. These results reflect biology teachers' views on the potential innovations artificial intelligence may bring to human mental processes.

The response words in the sixth category indicate that the participants associated artificial intelligence with ethics and potential security risks (67 response words, accounting for 6.27% of all response words). Eleven different concepts were represented in this category with 67 frequencies. The most frequently repeated concepts were "global threat" (18), "security vulnerability" (11), "misinformation" (8), and "the end of humanity" (5). In this category, many participants focused on global threats to the future of humanity, while others focused on the aspects such as ethical concerns and potential inhumane practices. These results reflect biology teachers' belief that artificial intelligence may pose certain risks for the future of humanity.

The response words in the seventh category indicate that the participants associated artificial intelligence with terms related to personal emotions (50 response words, accounting for 4.68% of all response words). Seven different concepts were represented in this category with 50 frequencies. "Fear" (17), "lack of emotion" (10), "Conversation" (7), "Confidant" (6), and "Loneliness" (4) were the most frequently repeated concepts. Many participants in this category focused on emotions such as fear and loneliness. These findings suggest that while artificial intelligence may serve as a companion for lonely individuals, it may also, over time, contribute to emotional desensitization in humans.

The response words in the eighth category indicate that the participants associated artificial intelligence with aspects that could potentially harm humanity (39 response words, accounting for 3.65% of all response words). Seven different concepts were represented in this category with 39 frequencies. "Laziness" (15), "imitation" (6), and "seeking ready-made answers" (5) were the most frequently repeated concepts. Overall, many participants emphasized the idea that artificial intelligence may lead to negative outcomes for humans, particularly by fostering laziness and an overreliance on ready-made answers.

A semantic analysis of participants' drawings and sentences related to artificial intelligence revealed four distinct categories (Table 2). According to the results, the dominant category associated with artificial intelligence was the idea that it is a useful tool for humanity (46.8%). This was followed by the categories suggesting that artificial intelligence is useful only when used correctly but dangerous when used incorrectly (23%), that it is a dangerous tool for humanity (16.7%), and finally, that it is perceived as an ordinary technology (13.5%).

Examples of drawings and sentences related to the dominant category reflecting the idea that artificial intelligence is a useful tool for humanity are presented below (Figures 1, 2, 3, 4).

Table 2. Categorization of drawings and sentences obtained through association

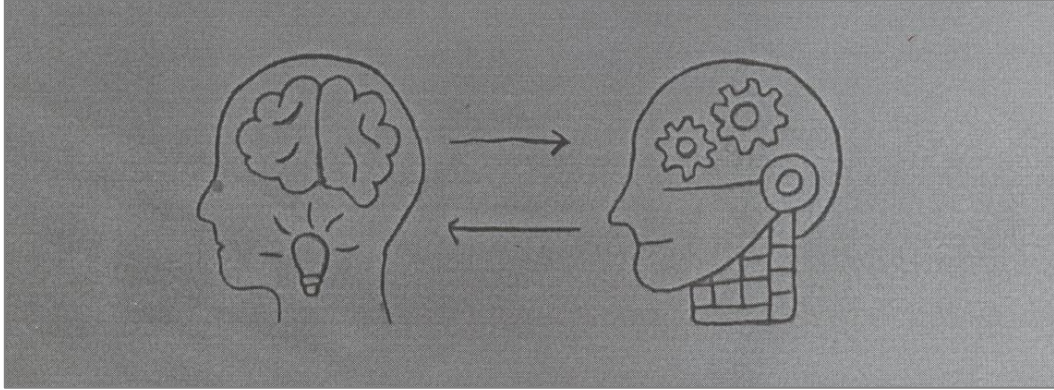|	Categories	n	%
1	Artificial intelligence is a useful tool for humanity	59	46,8
2	Artificial intelligence is useful when used correctly and dangerous when used incorrectly	29	23
3	Artificial intelligence is a dangerous tool for humanity	21	16,7
4	Artificial intelligence is an ordinary technology	17	13,5
	Total	**126**	**100**

Figure 1. *"Artificial intelligence is a technology that enables computers to learn and think like humans"* (Participant 107)
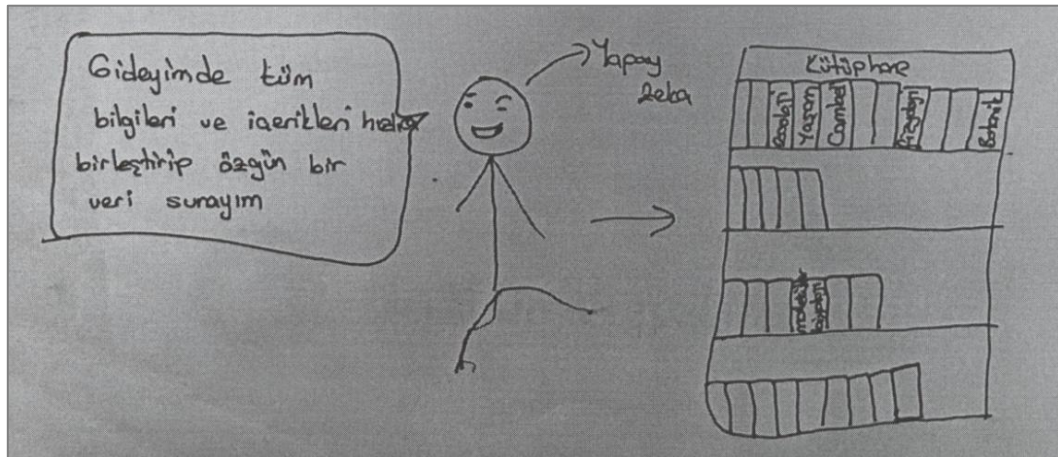
Figure 2. *"My assistant who speeds up my work in every field"* (Participant 110)
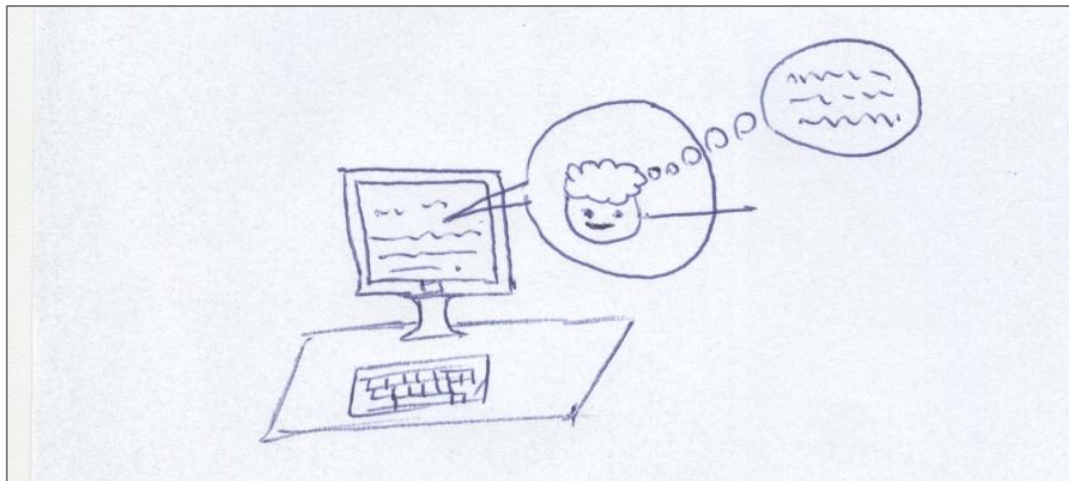
Figure 3. *"When artificial intelligence is used in education, it greatly simplifies the process and enables us to use time efficiently"* (Participant 114)
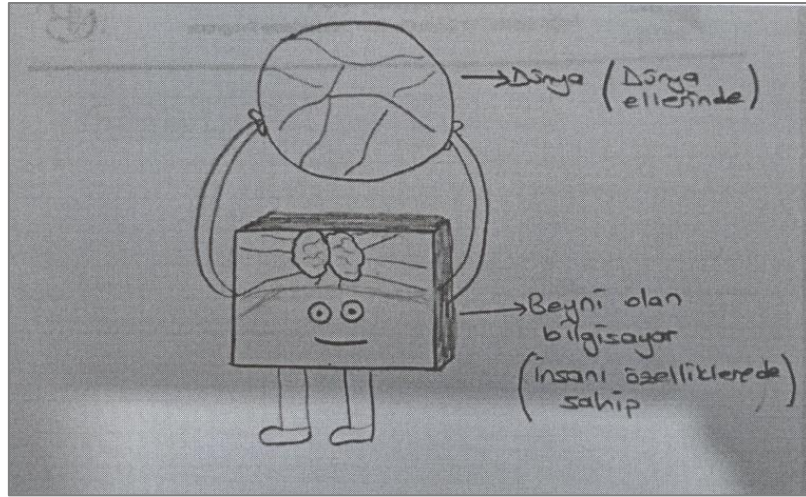
Figure 4. "*Thanks to artificial intelligence, all my daily tasks have become much easier. With artificial intelligence, I can access a lot of information I want*" (Participant 103)

Examples of drawings and sentences reflecting the idea that artificial intelligence is useful when used correctly and dangerous when used incorrectly are presented below (Figures 5 and 6).
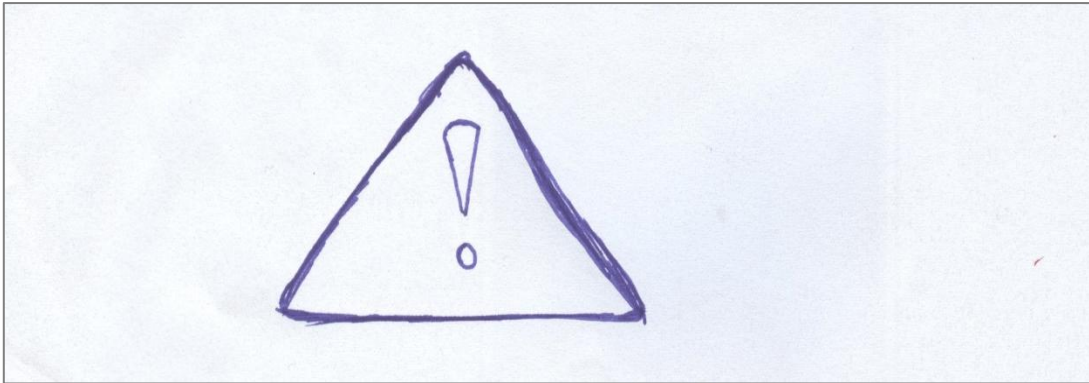

Figure 5. "*Artificial intelligence will be like medicine if used correctly, but like poison if used incorrectly.*" (Participant 105)
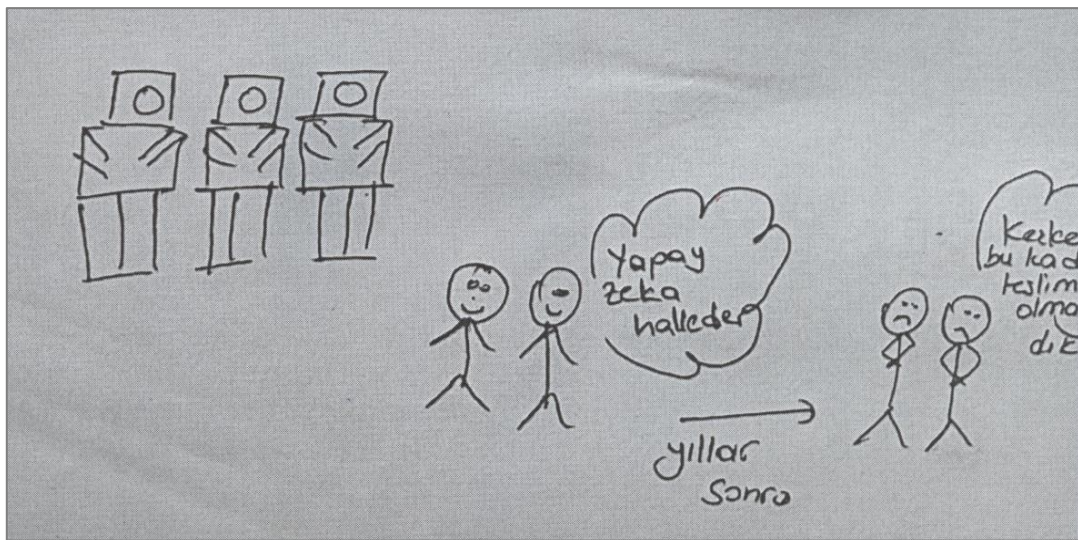

Figure 6. "*The weapon of the future; a good tool when used for the right purpose in the right hands, but a bad tool when used for the wrong purposes in the wrong hands*" (Participant 112)

Examples of drawings and sentences reflecting the idea that artificial intelligence is a dangerous tool for humanity are presented below (Figures 7, 8, 9, 10, 11, 12).
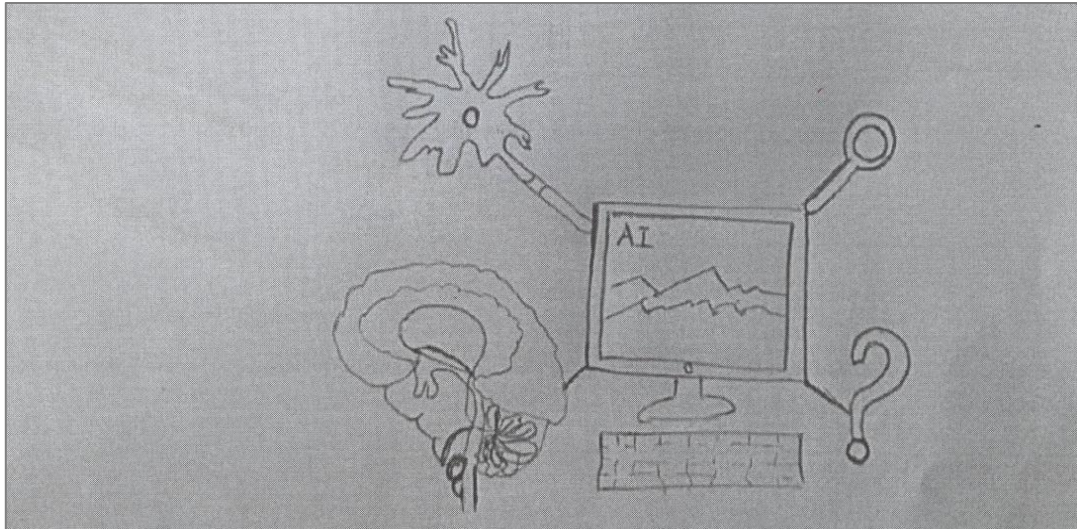
Figure 7. "*As a result of the development of artificial intelligence, humanity may gradually lose its thinking skills and resort to easy solutions, and may also face professional limitations*" (Participant 111)

Figure 8. "*As it makes people's lives easier, it paves the way for ideas that will turn them into robots*" (Participant 123)
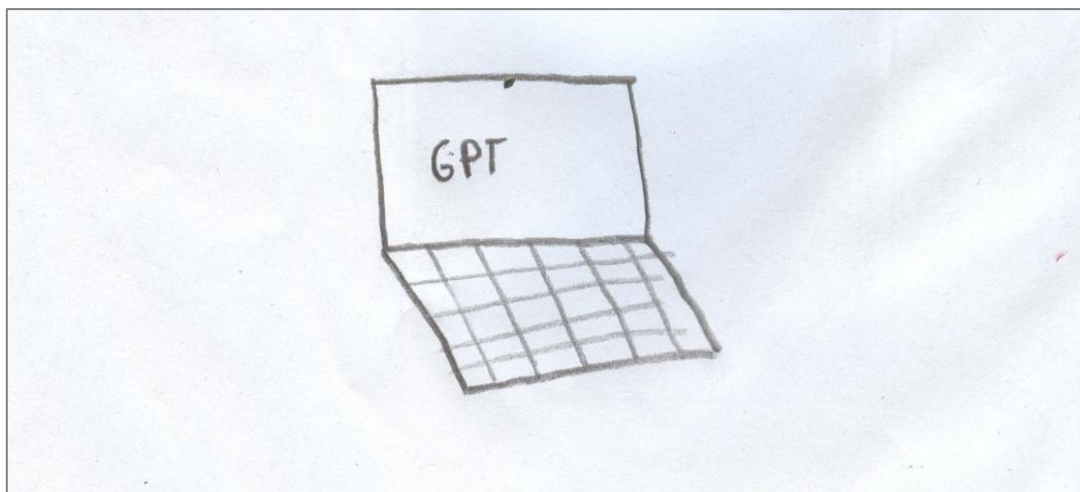

Figure 9. "*One day it may bring about the end of humanity*" (Participant 99)
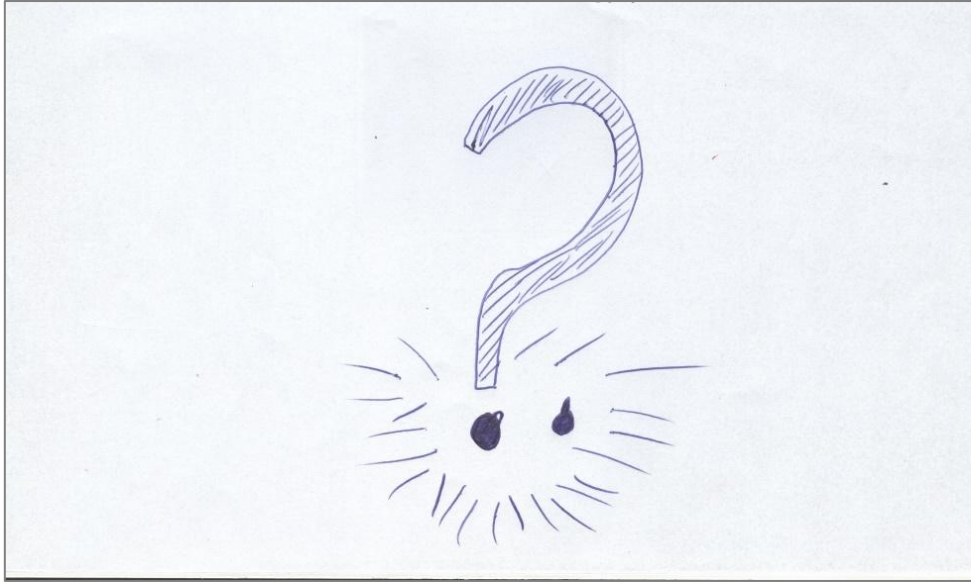
Figure 10. "*In my opinion, it's quite dangerous data mining, an innovation that seeks to abstract the human mind, with unknown forces and plans behind it.*" (Participant 92)
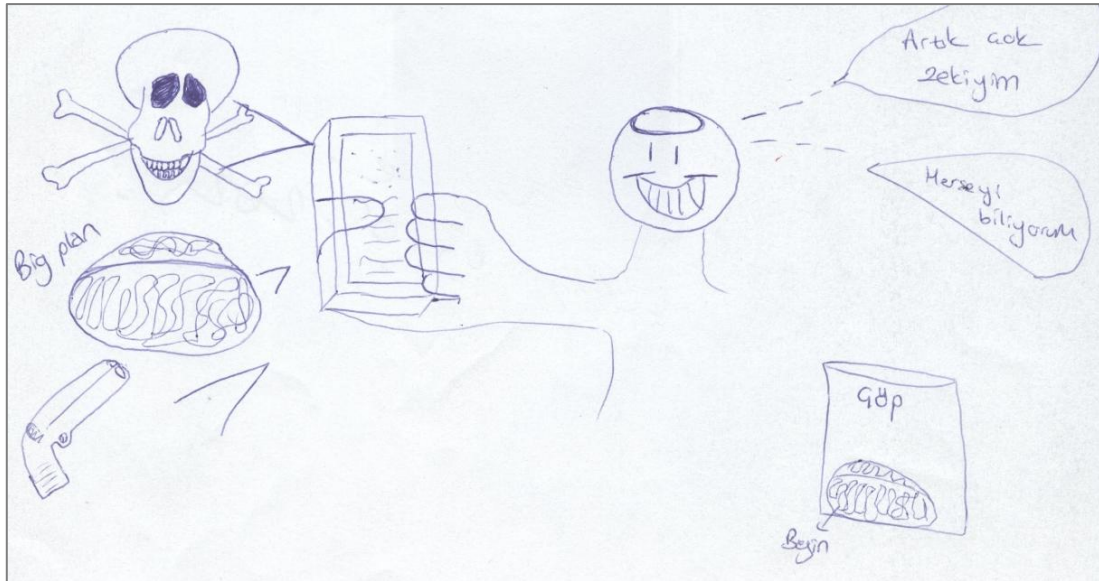

Figure 11. "*The secret weapon of today's modern world, which I think leads to social atrophy and may become the most dangerous force in the future*" (Participant 14)
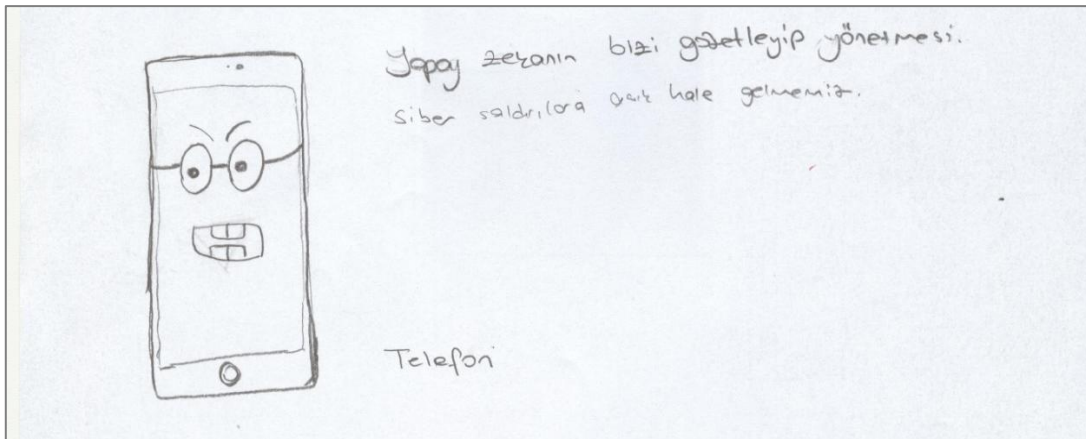

Figure 12. "*Artificial intelligence monitoring and controlling us, making us vulnerable to cyberattacks*" (Participant 37)

Examples of drawings and sentences related to this category, which reflect the idea that artificial intelligence is an ordinary technology, are presented below (Figure 13).
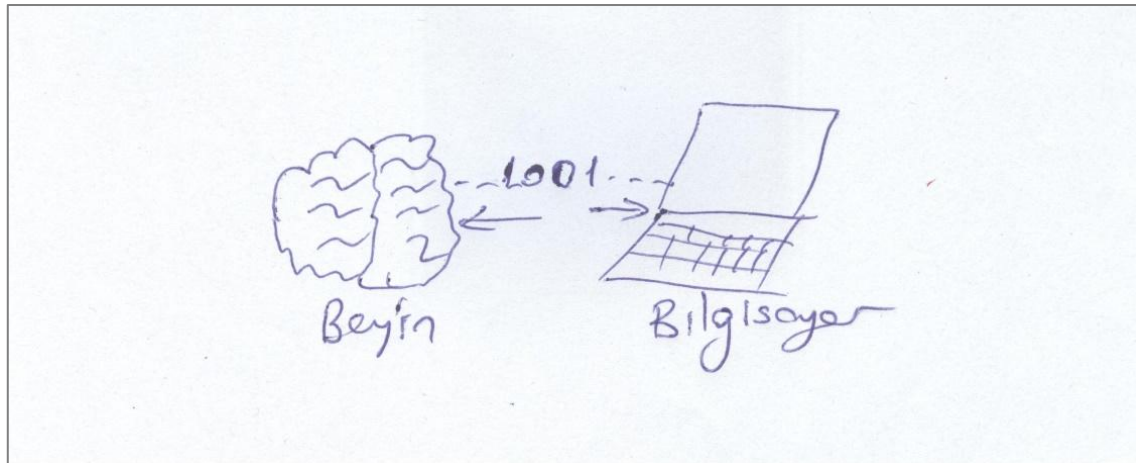

Figure 13. "*It is a computer technology capable of performing behaviors similar to human behaviors*"
(Participant 89)

Conclusion and Discussion

This study aimed to examine the cognitive structures of biology teachers regarding artificial intelligence. The findings revealed that biology teachers evaluate artificial intelligence from a multidimensional perspective, considering technological, educational, socio-cultural, and ethical aspects. A total of 113 response words expressed at a total frequency of 1069 were grouped into eight categories. The analysis of drawings and written explanations further showed that biology teachers' overall perceptions of artificial intelligence clustered around four main themes. Nearly half of the biology teachers (46.8%) viewed artificial intelligence as a useful tool for humanity. However, a significant portion (23%) emphasized that artificial intelligence can be useful only when used correctly but may pose risks when used incorrectly. While 16.7% of participants viewed artificial intelligence as a directly dangerous element, 13.5% viewed it as an ordinary technology.

In this study, biology teachers predominantly (37.23%) coded artificial intelligence under the category of "advanced technologies." The fact that the concepts "robot," "technology," and "ChatGPT" had the highest frequencies indicates that biology teachers define artificial intelligence primarily through technological tools and current applications. This finding is consistent with similar studies in the literature. In a study conducted with pre-service science teachers, participants most frequently associated the concept of artificial intelligence with the concepts of "robot," "convenience," "technology," "ChatGPT," and "smart assistant" (Gökçe, 2024). The high frequency of "ChatGPT" in both groups can be interpreted as a common reflection of the rapid dissemination and acceptance of artificial intelligence tools in the field of education. Similarly, another study conducted with education faculty students (Keleş & Aydın, 2021) reported that, as in the present study, the terms "robot" and "technology" reached the highest frequencies. This trend is further supported by another study by Henrich et al. (2025), which found that the most frequently used term was "robot," followed by "computer" and "ChatGPT," once again confirming the strong semantic association established between artificial intelligence and technological applications.

The education-training category that emerged from the study indicates that biology teachers' professional roles shape their perceptions of artificial intelligence and reveals their potential to integrate artificial intelligence into their professional practices. Biology teachers' emphasis on concepts such as " information," "education," " assignment," "learning," and "information access" suggests that artificial intelligence is particularly associated with aspects that support learning processes. This finding is consistent with findings in the literature suggesting that artificial intelligence has the potential to personalize learning, provide rapid access to information, and enrich teaching materials (Baker et al., 2019; Hashim et al., 2022; Akyel & Tur, 2024).

In this study, biology teachers' perception of artificial intelligence as a tool that provides "convenience," "assistance," and "speed" in human life indicates that the practical benefits of AI in daily life have become embedded in their mental representations. This finding is also consistent with the drawing analysis results, in which "Artificial intelligence is a useful tool" emerged as the dominant category (46.8%). Biology teachers

positioned artificial intelligence as an assistant that accelerates access to information and saves time. This finding is supported by numerous studies demonstrating that artificial intelligence helps individuals save time, particularly by automating routine tasks (Telaumbanua, 2025). Similarly, Poola (2017) emphasized that artificial intelligence saves time, which in turn increases the efficiency of human activities.

The study found it noteworthy that, in the category of social, cultural, and economic impacts, biology teachers focused on concepts of development, innovation, and opportunity, while simultaneously emphasizing concerns such as unemployment, loss of profession, and global domination. This dual structure aligns with the frequently emphasized argument in the literature that "artificial intelligence poses both opportunities and threats" (Groumpos, 2019; Bozkurt & Gursoy, 2025). The apparent presence of concerns about loss of profession and unemployment among teachers demonstrates that the potential of artificial intelligence to transform working life in many areas, including the education sector, has raised teachers' awareness. This economic concern is consistent with other findings in the literature. In a study conducted with university students by Ghotbi, Ho, and Mantello (2022), the term "unemployment" was identified as the most common negative association with artificial intelligence.

One of the noteworthy findings of the study is that biology teachers directly associated artificial intelligence with human mental and cognitive activities (8.04%). The prominence of concepts such as "analysis," "brain," "creativity," "intelligence," and "reason" indicates that teachers perceive artificial intelligence not merely as an external technology but also as an extension of the human mind. Biology teachers' direct engagement with topics such as the functioning of the human brain suggests that associations in this category may be a reflection of their professional knowledge. Chen et al. (2020) argued that future research should not only focus on artificial intelligence itself, but also on innovations that facilitate the development of technologies with human-like intelligent capacities, such as decision-making, adaptive learning abilities, and cognitive functions.

Another important finding of the study is the emphasis biology teachers place on issues related to "Ethics and Safety." Concepts with negative associations such as "global threat," "security vulnerability," "misinformation," and "the end of humanity" indicate that technophobia and ethical concerns are prevalent among biology teachers. These findings suggest that biology teachers perceive artificial intelligence as a force that is difficult to control and potentially capable of endangering the future of the human species. Furthermore, as teachers of a discipline that prioritizes the accuracy and reliability of scientific knowledge, biology teachers also appear to be concerned that fabricated information generated by artificial intelligence could harm scientific literacy. In other words, teachers are not only concerned about physical robot invasion but also about information pollution.

In the literature, this situation is explained through the myth that artificial intelligence could turn into a "malignant" force and turn against humanity (Sheikh et al., 2023). It is noteworthy that views similar to those held by teachers are also shared by some scientists. For example, Prof. Stephen Hawking stated that although the primitive forms of artificial intelligence developed so far have been very useful, he feared the consequences of creating something that could match or surpass human intelligence. According to him, the development of full artificial intelligence could spell the end of the human race (Cellan-Jones, 2014). Similarly, in his speech at the Nobel Prize Ceremony on December 10, 2024, Prof. Geoffrey Hinton emphasized that the rapid advancement of artificial intelligence brings numerous short-term risks and that, in the near future, artificial intelligence could be used to develop terrifying new viruses and lethal weapons that can autonomously decide who to kill or or injure (Hinton, 2024). In a study conducted by Bagir et al. (2022) with science teachers, it was reported that teachers had serious concerns and ethical worries about "malicious individuals entering the system" and the security of personal data. Velander et al. (2024) similarly noted that the characteristics of artificial intelligence may lead to fear and anxiety about the future, causing some teachers to perceive artificial intelligence as "bad" (or threatening) and reducing their professional interest in the subject.

One of the significant findings of the study is that the relationship biology teachers establish with artificial intelligence has not only a technical dimension but also a deep psychological dimension. The fact that "fear" ranked first in this category demonstrates the extent to which teachers' distrust of technology is deeply embedded in their individual emotions. However, the most striking and unique aspect of this category is the coexistence of the concepts of "confidant" and "conversation" with "lack of emotion" and "loneliness" in participants' mental representations. This suggests that teachers tend to perceive artificial intelligence as a nonjudgmental, always-accessible digital confidant with whom one can share thoughts, while at the same time expressing concern that such an artificial bond might gradually desensitize individuals and detach them from genuine social relationships. The predominance of the concept of "fear" in the study findings parallels other studies in literature. For instance, Gökçe (2024) found that preservice teachers associated artificial intelligence with fear and anxiety. The paradoxical coexistence of the "confidant/ conversation" perception and the "lack of

emotion/loneliness" concern observed in this study is also supported by Karslı (2024), who noted that people seek not only information but also a sense of emotional understanding from artificial intelligence, pointing to the psychological roots of this digital-confidant tendency.

According to the results of the study, the "harm" category was characterized particularly by the emphasis on "laziness" and "seeking ready-made answers." This reflects biology teachers' pedagogical concern that students' critical thinking skills may deteriorate. By its nature, biology education requires observing the natural world, analyzing data, and engaging in process-oriented thinking. However, the findings revealed that biology teachers fear that the instant and effortless information provided by artificial intelligence may free students from the burden of thinking, thereby leading them into a state of cognitive laziness. This finding is in full alignment with the theme of "useful when used correctly, dangerous when used incorrectly." Similar concerns have been expressed in literature. For example, Seyrek et al. (2024) found that the use of artificial intelligence in education carries serious risks, such as diminishing creativity, encouraging laziness among students, causing data breaches, and generating inequalities stemming from differences in access to technology. Additionally, the concept of imitation, prominent in this category, reflects a sensitivity to academic honesty and originality. Biology teachers may perceive the direct copying and pasting of AI-generated outputs by students as a threat that undermines productivity and authentic learning. Slimi et al. (2025) warned that excessive reliance on artificial intelligence could hinder the development of students' independent critical thinking skills. Similarly, Uygun's (2024) study with teachers reported concerns that artificial intelligence may render individuals passive, dull their investigative qualities, and potentially contribute to teachers' own professional complacency.

In conclusion, the cognitive perceptions of biology teachers regarding artificial intelligence appear to exhibit a complex structure balanced between benefits and threats. While technological and utilitarian aspects dominated the word association test, traces of pessimistic future-oriented scenarios were also observed in the emotional and ethical dimensions. The drawing analyses further concretized this mental complexity; although the majority of biology teachers positioned artificial intelligence as a functional tool that serves the benefit of humanity, a considerable proportion also expressed serious reservations about the uncontrolled use of the technology.

Recommendations

Artificial intelligence technology should be integrated into educational settings based on data obtained from educational psychology, educational sociology, and contemporary teaching models. An AI system that lacks foundational educational principles may cause more harm than benefit to students; therefore, it should be embedded in ways that align with the field of educational sciences. It is unrealistic to expect humans and educators to detach themselves from technology; however, technology should not overshadow the fundamental aims of education and must be used cautiously. Artificial intelligence should not replace the teacher, who serves as a guide in the learning process.

Scientific Ethics Declaration

Conflict of Interest

Funding

Acknowledgements or Notes

References

Akyel, Y., & Tur, E. (2024). Yapay zekanın potansiyelinin ve eğitim bilimlerindeki uygulamalarının araştırılması ve araştırmalarda beklentiler, zorluklar ve gelecek yönelimleri (Prospects, challenges, and future directions in the research and investigation of artificial intelligence's potential and applications in educational sciences). *Ahi Evran Üniversitesi Kırşehir Eğitim Fakültesi Dergisi*, *25*(1), 645-711. https://doi.org/10.29299/kefad.1322341

Bagir, M., Onal-Karakoyun, G., & Asilturk, E. (2022). Views of science teachers on the use of artificial ıntelligence in education. *International Online Journal of Educational Sciences*, *14*(5), 1223-1234. https://doi.org/10.15345/iojes.2022.05.007

Bahar, M., Johnstone, A. H. & Sutcliffe, R. G. (1999). Investigation of students' cognitive structure in elementary genetics through word association tests. *Journal of Biological Education*, *33*(3), 134-141. https://doi.org/10.1080/00219266.1999.9655653

Baker, T., Smith, L., & Anissa, N. (2019). Educ-AI-tion rebooted? Exploring the future of artificial intelligence in schools and colleges. Nesta Report. Retrieved from https://media.nesta.org.uk/documents/Future_of_AI_and_education_v5_WEB.pdf

Begum, I. U. (2024). Role of artificial intelligence in higher education-an empirical investigation. *International Research Journal on Advanced Engineering and Management (IRJAEM)*, *2*(03), 49-53. https://doi.org/10.47392/IRJAEM.2024.0009

Benhamdi, S., Babouri, A., & Chiky, R. (2017). Personalized recommender system for e-Learning environment. *Education and Information Technologies*, *22*(4), 1455-1477. https://doi.org/10.1007/s10639-016-9504-y

Borowiec, S. (2016). AlphaGo seals 4-1 victory over Go grandmaster Lee Sedol Technology. *The Guardian*, *15*(6).

Bozkurt, V., & Gursoy, D. (2025). The artificial intelligence paradox: Opportunity or threat for humanity?. *International Journal of Human-Computer Interaction*, *41*(1), 174-187. https://doi.org/10.1080/10447318.2023.2297114

Cellan-Jones, R. (2014). Stephen Hawking warns artificial intelligence could end mankind. *BBC news*, *2*(10).

Chen, L., Chen, P., & Lin, Z. (2020). Artificial intelligence in education: A review. *IEEE Access*, 8, 75264-75278. https://doi.org/10.1109/ACCESS.2020.2988510

Crovello, T. J. (1974). Computers in biological teaching. *BioScience*, *24*(1), 20-23

Cruz, S., Duque, D., & Carvalho, V. (2024, May). *STEAM teachers' perceptions of artificial intelligence in education: Preliminary research*. Paper presented at the 16th International Conference on Computer Supported Education, Angers, France.

Dikmenli, M. (2010). Biology student teachers' conceptual frameworks regarding biodiversity. *Education*, *130*(3), 479-489.

Dişlioğlu, T. A., Ateş, V., & Medeni, T. D. (2025). Yapay zeka teknolojilerinin eğitimde kullanılması: Öğretmen değerlendirmeleri (Use of artificial intelligence technologies in education: Teacher evaluations). *Kamu Yönetimi ve Teknoloji Dergisi*, *7*(2), 167-191.

Eroğlu, A. (2024). *Türkçe öğretmeni adaylarının yapay zekaya yönelik metaforik algıları (Metaphorical perceptions of artificial intelligence among prospective Turkish language teachers)*. İçinde F. Dağ (Ed.), Eğitimde yapay zekayla değişen paradigmalar güncel araştırmalar (Changing paradigms in education with artificial intelligence: current research). Anı Publishing.

Ghotbi, N., Ho, M. T., & Mantello, P. (2022). Attitude of college students towards ethical issues of artificial intelligence in an international university in Japan. *AI & Society*, *37*(1), 283-290. https://doi.org/10.1007/s00146-021-01168-2

Gökçe, H. (2024). *Determining the cognitive structures of prospective science teachers regarding the concept of artificial intelligence via word association test*. Educcon 2024 AI and Robotics in Education Proceedings Book, p. 73-82. NEU Press.

Gölbaşı, B., & Okul, Ö. (2024). *Öğretmen adaylarının 'yapay zekâ' kavramına ilişkin metaforik algıları (Teacher candidates' metaphorical perceptions of the concept of 'artificial intelligence')*. In XI. Internatıonal Eurasıan Educatıonal Research Congress (pp. 49-58).

González-Calatayud, V., Prendes-Espinosa, P., & Roig-Vila, R. (2021). Artificial intelligence for student assessment: A systematic review. *Applied Sciences*, *11*(12), 5467. https://doi.org/10.3390/app1112546

Groumpos, P. P. (2019). Artificial intelligence: Issues, challenges, opportunities and threats. In *Conference on Creativity in Intelligent Technologies and Data Science* (pp. 19-33). Cham: Springer International Publishing.

Hashim, S., Omar, M. K., Ab Jalil, H., & Sharef, N. M. (2022). Trends on technologies and artificial intelligence in education for personalized learning: systematic literature. *Journal of Academic Research in Progressive Education and Development*, *12*(1), 884-903. http://dx.doi.org/10.6007/IJARPED/v11-i1/12230

Henrich, M., Formella-Zimmermann, S., Schneider, S., & Dierkes, P. W. (2025). Free word association analysis of students' perception of artificial intelligence. In *Frontiers in Education, 10*, 1543746. https://doi.org/10.3389/feduc.2025.1543746

Hinton, G. (2024). Banquet speech. Nobel Prize in Physics 2024. Retrieved from https://www.nobelprize.org/prizes/physics/2024/hinton/speech/

Huang, J., Saleh, S., & Liu, Y. (2021). A review on artificial intelligence in education. *Academic Journal of Interdisciplinary Studies*, *10*(3), 206-2017. https://doi.org/10.36941/ajis-2021-0077

Jukiewicz, M. (2024). The future of grading programming assignments in education: The role of ChatGPT in automating the assessment and feedback process. *Thinking Skills and Creativity*, 52, 101522 https://doi.org/10.1016/j.tsc.2024.101522

Karslı, T. A. (2024). Yapay zeka ve bilinç: Anlamsal ve duygusal/heyecansal boyutları üzerinden bir değerlendirme (Artificial intelligence and consciousness: An evaluation on semantic and emotional dimensions). *İnsan ve Toplum Bilimleri Araştırmaları Dergisi*, *13*(4), 192-213.

Keleş, P. U., & Aydın, S. (2021). University students' perceptions about artificial intelligence. *Shanlax International Journal of Education*, *9*(S1), 212-220. https://doi.org/10.34293/education.v9iS1-May.4014

Lähdesmäki, S., Väisänen, S., & Hyytinen, H. (2025). University teachers' perspectives on using Artificial Intelligence in teaching and its related aspects. *International Journal on Social and Education Sciences (IJonSES)*, *7*(3), 272-291. https://doi.org/10.46328/ijonses.5036

Lidiastuti, A. E., Herak, R., Darmawan, H., Yuniarti, N., & Yane, S. (2025). The role of artificial intelligence in enhancing biology education: A bibliometric perspective. *BIO-INOVED: Jurnal Biologi-Inovasi Pendidikan*, *7*(2), 298-307.

Luckin, R., Holmes, W., Griffiths, M., & Forcier, L. B. (2016). *Intelligence unleashed: An argument for AI in education*. Pearson.

Maslej, N., Fattorini, L., Perrault, R., Parli, V., Reuel, A., Brynjolfsson, E., ... & Clark, J. (2024). *The AI index 2024 annual report*. Retrieved from https://aiindex.stanford.edu/wp-content/uploads/2024/05/HAI_AI-Index-Report-2024.pdf

Miles, M. B., & Huberman, A. M. (2016). *An extended sourcebook: Qualitative data analysis*. Pegem Akademi Publishing.

Nabiyev, V.V. (2010). *Yapay zekâ: İnsan-bilgisayar etkileşimi (Artificial intelligence human-computer interaction)*. Seçkin Publishing.

Poola, I. (2017). How artificial intelligence in impacting real life everyday. *International Journal for Advance Research and Development*, *2*(10), 96-100.

Seyrek, M., Yıldız, S., Emeksiz, H., Şahin, A., & Türkmen, M. T. (2024). Öğretmenlerin eğitimde yapay zeka kullanımına yönelik algıları (Teachers' perceptions on the use of artificial intelligence in education). *International Journal of Social and Humanities Sciences Research (JSHSR)*, *11*(106), 845-856.

Sheikh, H., Prins, C., & Schrijvers, E. (2023). *Mission AI: The new system technology*. Springer Nature.

Shute, V. J. (2008). Focus on formative feedback. *Review of Educational Research*, *78*(1), 153-189. https://doi.org/10.3102/0034654307313795

Slimi, Z., Benayoune, A., & Alemu, A. E. (2025). Students' perceptions of artificial intelligence integration in higher education. *European Journal of Educational Research*, *14*(2), 471-484. https://doi.org/10.12973/eu-jer.14.2.471

Telaumbanua, D. (2025). The role of artificial intelligence in improving the quality of biology learning. *Cognizance Journal of Multidisciplinary Studies*, *5*(1), 78-84. https://doi.org/10.47760/cognizance.2025.v05i01.007

Torkar, G. & Bajd, B. (2006). Trainee teachers' ideas about endangered birds. *Journal of Biological Education*, *41*(1), 5-8.

USDOE (U.S. Department of Education, Office of Educational Technology). (2023). *Artificial intelligence and the future of teaching and learning: Insights and recommendations*. Retrieved from https://tech.ed.gov/ (17.11.2025).

Uygun, D. (2024). Teachers' perspectives on artificial intelligence in education. *Advances in Mobile Learning Educational Research*, *4*(1), 931-939. https://doi.org/10.25082/AMLER.2024.01.005

Uygun, D., Aktaş, I., Duygulu, İ., & Köseer, N. (2024). Exploring teachers' artificial intelligence awareness. *Advances in Mobile Learning Educational Research*, *4*(2), 1093-1104. 93-1104. https://doi.org/10.25082/AMLER.2024.02.004

Velander, J., Taiye, M. A., Otero, N., & Milrad, M. (2024). Artificial intelligence in K-12 education: Eliciting and reflecting on Swedish teachers' understanding of AI and its implications for teaching & learning. *Education and Information Technologies*, *29*(4), 4085-4105. https://doi.org/10.1007/s10639-023-11990-4

Yıldırım, A., & Şimşek, H. (2016). Sosyal bilimlerde nitel araştırma yöntemleri (*Qualitative research methods in the social sciences)*. Seçkin Publishing.

Zhou, M., & Peng, S. (2025). The usage of AI in teaching and students' creativity: The mediating role of learning engagement and the moderating role of AI literacy. *Behavioral Sciences*, *15*(5), 587. https://doi.org/10.3390/bs15050587

Author(s) Information

Sultan Cikrik
Gazi University, Department of Biology Education, Faculty of Gazi Education, Gazi University, Ankara, Türkiye
ORCID iD: https://orcid.org/0000-0002-6821-7922

Tugce Duran
Necmettin Erbakan University, Department of Biology Education, Ahmet Kelesoglu Faculty of Education, Konya, Türkiye
Contact e-mail: tugce.gulesir@erbakan.edu.tr
ORCID iD: https://orcid.org/0000-0003-2428-7635

Musa Dikmenli
Necmettin Erbakan University, Department of Biology Education, Ahmet Kelesoglu Faculty of Education, Konya, Türkiye
ORCID iD: https://orcid.org/0000-0001-6501-9034

Selda Kilic
Necmettin Erbakan University, Department of Biology Education, Ahmet Kelesoglu, Faculty of Education, Konya, Türkiye
ORCID iD: https://orcid.org/0000-0002-5347-9479