Artificial Intelligence and Intelligent Software in Science Education

Buket GEVİŞ-FARHADZADA

Akdeniz University

Fatih Serdar YILDIRIM

Akdeniz University

What is Artificial Intelligence?

Artificial intelligence (AI) is a field of technology designed to enable computers or machines to think, learn, and solve problems like humans, and AI focuses on the development of systems that mimic cognitive processes and perform skills typical of human intelligence (e.g. decision making, learning, language comprehension, and visual perception) (Russell and Norvig, 2020). This discipline draws from many fields such as computer science, mathematics, psychology, linguistics and neuroscience (Nilsson, 1998).

Definition of Artificial Intelligence

Artificial intelligence is a science developed using software and algorithms to enable machines to exhibit "intelligence" like humans, and the main goal of AI is to create systems that mimic the problem-solving and learning capabilities of the human mind (McCarthy, 2007). For example, an AI system can learn from data and apply what it has learned to new situations (Goodfellow et al., 2016).

With the rapidly developing technology, individuals' orientation towards the tools and equipment supported by the technology encountered in their daily lives is progressing rapidly, and individuals have started to affect their communication with each other, behavior and access to information thanks to this rapidly advancing technology (Chiu, 2021). The concept of artificial intelligence, introduced by John McCarthy, was first mentioned at the Dartmouth Conference in 1956 (Alpaydın, 2013). Artificial intelligence (AI), an interdisciplinary field, aims to develop algorithms and computer systems that can fulfill cognitive capacities such as perception, problem solving, language understanding, human intelligence, learning and decision making (Russell & Norvig, 2021). In simpler terms, artificial intelligence, in which machines are the tools, is defined as an artificial computer system that consists of systems and mechanisms that consist of systems and mechanisms that consistently renew and improve the ways of thinking, decision-making competencies, working principles produced by individuals with the problems they face, and consist of cognitive functions such as "communication, idea and reasoning, comprehension, learning, problem solving, decision making, reconciling plural expressions with each other" or self-managing behaviors (UIB, 2017). Artificial intelligence is defined as the operation of machines as the product of human mind and the commands given to these systems (Zeide, 2019). If we talk about concepts related to artificial intelligence; algorithms, neural networks, language processing, data mining and machine learning (Baker & Smith, 2019). With the advancement of processes, artificial intelligence has a great share in the development of health systems, computer programming, control systems, voice and image recognition systems, decision making or robots (Hwang,, Xie, , Wah, & Gasevic, 2020). Artificial intelligence is intelligent programs that can produce answers not only to predetermined problems but also to an existing situation, helping to solve complex problems (Nabiyev, 2012). According to Nils Nilsson (1990), another leading figure in artificial intelligence, he defined artificial intelligence as a theory that aims to create imitations of natural intelligence.

Types of Artificial Intelligence

AI is generally categorized into three basic types. These are Narrow Artificial Intelligence (ANI), General Artificial Intelligence (AGI) and Super Artificial Intelligence (ASI).

- **Artificial Narrow Intelligence (ANI):** Refers to systems that specialize in a particular task. For example, voice assistants (Siri, Alexa) are in the narrow artificial intelligence category (Searle, 1980).
- **Artificial General Intelligence (AGI):** These are systems with a general intelligence at a similar level to humans, and research in this field is ongoing (Bostrom, 2014).
- **Artificial Super Intelligence (ASI):** Refers to systems that exceed human intelligence and this concept is more of a theoretical discussion area (Tegmark, 2017).

Key Areas of Artificial Intelligence Technologies

AI is enriched with different technologies, and these technologies can be divided into the following key areas:

- **Machine Learning (ML):** A subfield of AI that enables algorithms to learn using data. ML, combined with big data analytics, has been effective in solving complex problems (Mitchell, 1997).
- **Deep Learning (DL):** A subfield of machine learning, deep learning can work with neural networks to identify more complex data patterns (LeCun et al., 2015).
- **Natural Language Processing (NLP):** The development of AI systems that process text and speech data. For example, translation systems and chatbots use this technology (Jurafsky and Martin, 2021).
- **Computer Vision (CV):** It is a field for analyzing and recognizing visual information. Autonomous vehicles are an example of computer vision (Goodfellow et al., 2016).

How Artificial Intelligence Works?

AI systems work by processing data through algorithms and models. This process usually consists of the following stages:

1. **Data Collection:** Large data sets are needed for AI to learn. For example, the data used in the training of autonomous vehicles includes millions of hours of driving videos (Russell and Norvig, 2020).
2. **Model Training:** Algorithms are optimized for specific tasks by working on data. For example, a face recognition system learns from thousands of facial images (Goodfellow et al., 2016).
3. **Prediction and Decision Making:** Trained models make predictions on new data and use them to make decisions (Mitchell, 1997).

Usage Areas of Artificial Intelligence

AI is used in many sectors such as health, education, finance, transportation and agriculture.

- **Health:** AI is used to assist doctors in diagnosis and treatment recommendations (Esteva et al., 2017).

- **Education:** Adaptive learning systems offer personalized content based on students' individual learning pace (Woolf, 2010).
- **Finance:** AI-based algorithms are used in risk analysis and financial forecasting (Ng and Koller, 2015).
- **Transportation:** Autonomous vehicle technologies are one of the most remarkable applications of AI in the transportation sector (Levinson et al., 2011).

The Future of Artificial Intelligence

The future of AI needs to be considered alongside ethical issues and possible risks. For example, the replacement of labor by automation can lead to social and economic problems (Brynjolfsson & McAfee, 2014). However, the debate about the potential of AI to develop consciousness continues among scientists (Tegmark, 2017).

What are the Development Processes of Artificial Intelligence?

Artificial intelligence (AI) development processes have historically gone through several different phases. These processes have been shaped by technological advances, theoretical innovations and the expansion of application areas.

Initial Period: (1950s - 1960s)

The foundations of AI were laid in the mid-1950s with Alan Turing's proposal of the "Turing Test", which provided a theoretical framework on the ability of machines to think like humans and established the first theoretical foundation of AI (Turing, 1950). In the same period, the Dartmouth Conference held by John McCarthy in 1956 symbolized the birth of artificial intelligence and led to the official recognition of AI as a research field (McCarthy, 1956). Initially, AI research was based on logic and symbolic computation methods, which gave rise to the so-called "symbolic artificial intelligence" (Newell and Simon, 1972).

Early Practices and Progress: (1960s - 1970s)

The 1960s and 1970s were the years when the first applications of AI were developed. During this period, the first chatbots such as "ELIZA" were created and early steps were taken in the field of natural language processing (Weizenbaum, 1966). Also, the concept of expert systems emerged in this period and expert systems are computer programs that aim to mimic the decision-making processes of human experts in a given domain (Feigenbaum, 1983). However, the AI systems of this period lacked the ability to generalize and had limited success.

The Rise of Expert Systems: (1980s)

The 1980s marked a period in which AI found a greater place in commercial applications and expert systems became widely used in areas such as medicine, engineering and finance, with data-driven logic and rule-based systems playing an important role (Jackson, 1986). Also during this period, theoretical work on connected neural networks increased, but due to limited computational power, these technologies could not yet be applied efficiently (Rumelhart et al., 1986).

Machine Learning and Deep Learning: (1990s - 2000s)

In the late 1990s, AI research shifted to machine learning (ML) and deep learning (DL) approaches. During this period, AI systems became capable of learning from data. In particular, LeCun's work on deep neural networks made a big leap in this field (LeCun, 1998). Deep learning has played an important role in accomplishing previously difficult tasks (e.g. image recognition)

(Hinton et al., 2006). During this period, the use of large data sets and more powerful computational infrastructures accelerated the pace of development of AI (Bengio et al., 2007).

Big Data and High Performance Computing: (2010s)

The 2010s marked a period of massive development of AI integrated with big data and high-performance computing, and the advancement of deep learning techniques revolutionized areas such as image processing, voice recognition and natural language processing (Silver et al., 2016). During this period, systems such as Google's AlphaGo demonstrated that AI has reached a level that can surpass human intelligence (Silver et al., 2016). In these years, the ethical and societal implications of AI have also become more debated (Brynjolfsson & McAfee, 2014).

Autonomous Systems and Societal Impacts of AI: (2020s and Beyond)

Today, AI has a wide range of applications in autonomous vehicles, smart cities, healthcare, finance and manufacturing sectors, and AI accelerates and optimizes autonomous decision-making processes (Brynjolfsson & McAfee, 2014). However, with the proliferation of AI, societal issues such as ethics, security, and loss of labor force have also come to the fore, and issues such as ethical use of AI, transparency, fairness, and security have been intensively studied by researchers (Binns, 2018).

What is Artificial Intelligence in Education?

Artificial intelligence (AI) in education refers to the application of AI technologies to improve students' learning processes, increase teachers' productivity, and optimize overall education systems. AI in education covers a wide range of application areas such as personalizing learning processes, monitoring student performance with data analytics, automating teaching materials, and making education more accessible (Holmes et al., 2019).

Definition of Artificial Intelligence in Education

Artificial intelligence in education is an interdisciplinary field of study in which computer-based algorithms are used to support educational processes and these systems offer individual learning pathways by analyzing student behaviors and needs (Luckin et al., 2016). For example, adaptive learning systems personalize education by providing content according to each student's learning speed and level (VanLehn, 2011).

Adaptive learning systems and automated skills feedback are concrete reflections of the concept of individualization and continuous improvement in education, and these approaches ensure that students demonstrate knowledge at regular intervals, actively participate in the learning process and are supported until they reach mastery, and these innovative systems, with the opportunities offered by technology in education, provide students with a personalized and continuous feedback-oriented learning experience, both improving the quality of learning and strengthening equal opportunities in education (Beck, Stern & Haugsjaa, 1996).

While constructivist learning theory provides a framework for understanding the essence of human learning processes, modern artificial intelligence technologies reveal the potential to digitize and automate these processes, and these developments show how knowledge construction processes between human and machine can work together and bring new perspectives to education, knowledge management and innovation, but the human ability to create deep meaning based on experience, emotion and creative thinking remains distinct from artificial intelligence (Coiera, 2003).

Looking at the early periods of artificial intelligence (AI) applications in education, the contributions of Sidney L. Pressey, a psychologist and educator working at Ohio University in

the 1920s, mark an important turning point, and Pressey, in particular, worked on developing the concept of "automatic teaching", and although the concept of artificial intelligence was not considered in its current sense due to the lack of computer technologies in this period, the devices developed by Pressey were among the first attempts to promote individualized learning in education (Thorndike, 1927). Sidney L. Pressey's (1950) views on multiple-choice tests indicate that assessment and evaluation processes in education can be used not only to measure achievement but also as a tool to reinforce the learning process, and Pressey argued that tests functioning as a kind of "feedback" mechanism can increase the effectiveness of the learning process, and in this context, Pressey's ideas emphasize the use of tests not only to determine how much knowledge students have acquired, but also to help students correct their mistakes and reinforce correct knowledge (Thorndike, 1927). Today, these ideas led to the development of reinforcement and feedback systems that form the basis of modern educational technologies and artificial intelligence applications. Today's artificial intelligence-based educational software is a system that identifies students' correct answers and provides them with immediate feedback, and supports their learning by personalizing it, which is very similar to Pressey's "machine" concept. Pressey's ideas sowed the first seeds of modern adaptive learning platforms and intelligent instructional technologies (Holmes et al., 2019).

According to Sidney L. Pressey (1950), it was a vision that reshaped the role of technology in education and aimed to make educational processes more efficient, but today, the development of artificial intelligence and learning management systems allows teachers to be freed from time-consuming tasks such as test assessment and interact more with students, which improves the quality of the teaching process, relieves the burden of teachers and provides students with more personalized learning experiences. Pressey's early insights laid the foundation for modern applications of educational technologies and contributed to the development of an innovative governance approach in education (Pressey, 1950). Skinner was particularly noted for his "Pigeon Project" during World War II, which proved that pigeons could be trained to perform certain tasks and demonstrate high levels of accuracy in these tasks. Skinner shaped desired behaviors by rewarding pigeons with positive reinforcement (e.g., food rewards) when they performed certain behaviors, and the basis of this work was operant conditioning, meaning that the behaviors of organisms can be shaped by the consequences of those behaviors (Pressey, 1950). Skinner's teaching machines are the forerunners of modern educational technologies and artificial intelligence applications, and systems such as personalized learning and intelligent tutoring systems are based on an ever-evolving scientific foundation that aims to increase student achievement by supporting individual learning. Skinner's vision demonstrated to Skinner (1958) the importance of both behavioral learning theory and technological innovation in education.

Artificial Intelligence Technologies in Education

Artificial intelligence technologies used in education can be divided into the following main areas:

Adaptive Learning Systems

These systems are AI-based tools that dynamically adjust learning processes by analyzing students' individual needs. For example, ALEKS (Assessment and Learning in Knowledge Spaces) software measures students' knowledge level and provides them with customized math exercises (Falmagne et al., 2013).

Automated Evaluation Systems

AI-based automated assessment tools can quickly and consistently evaluate students' exams and written assignments. For example, a system called "Gradescope" can analyze exams of large groups of students in a short time and provide feedback (Shute, 2008).

Natural Language Processing (NLP) Applications

NLP technologies have been used to improve language learning and writing skills. For example, software such as Grammarly provides feedback on grammar and word choice in students' writing processes (Burstein et al., 2003).

Educational Chatbots

Chatbots are digital assistants that support the learning process by providing instant guidance to students. For example, Jill Watson is an artificial intelligence assistant used to answer students' questions at Georgia Tech University (Goel & Polepeddi, 2016).

Simulation and Virtual Reality

AI-enabled simulation systems support experiential learning, especially in science and engineering. For example, virtual laboratory software such as Labster allows students to conduct experiments without risk (De Jong et al., 2013).

Advantages of Artificial Intelligence in Education

- **Personalized Learning:** Artificial intelligence offers a more effective educational experience by tailoring each student's learning process to individual needs (Luckin et al., 2016).
- **Equity and Accessibility:** AI technologies enable more students to access quality education by reducing geographical or economic constraints (Holmes et al., 2019).
- **Increased Productivity:** It automates teachers' repetitive tasks, allowing them to focus on more creative and pedagogical activities (Shute, 2008).
- **Challenges and Ethical Issues of Artificial Intelligence in Education**
- **Data Privacy:** Collecting and analyzing student data raises privacy and data security issues (Holmes et al., 2019).
- **Inequality Risk:** The high cost of developing and implementing AI systems can lead to inequalities in low-income regions (Luckin et al., 2016).
- **Reduction of the Human Factor:** The overuse of AI can reduce the social and emotional interaction between students and teachers (Selwyn, 2019).

Future of Artificial Intelligence in Education

In the future, AI will be able to take on more complex teaching tasks and more accurately predict students' needs through learning analytics, and with this, the integration of AI into education requires the establishment of ethical guidelines and regulatory frameworks (Luckin et al., 2016).

What Are Artificial Intelligence Applications in Education?

Artificial intelligence (AI) technologies are increasingly taking place in education and transforming educational processes. The applications of AI in education serve a number of purposes such as increasing student achievement, making teaching processes more efficient and personalizing learning experiences.

Personalized Learning

AI can deliver customized educational content based on students' individual learning needs. Based on students' learning pace and preferred learning methods, AI-supported systems propose personalized lesson plans and materials. This approach contributes to the development of a student-centered learning model (VanLehn, 2011; Luckin et al., 2016). Moreover, AI-based applications can monitor student performance and provide additional support in weak areas (Siemens, 2013)

Automated Assessment and Feedback

AI can make student assessments faster and more accurate. Written exams, assignments and even open-ended questions can be automatically analyzed and evaluated by AI systems, saving teachers time. Moreover, such systems provide instant feedback to students, allowing them to correct their mistakes instantly (Baker & Inventado, 2014). This practice reduces the burden on teachers and accelerates the learning process of students.

Language Learning and Comprehension

AI plays an important role in language learning applications. By using natural language processing (NLP) techniques, learners can be provided with language corrections, pronunciation assistance, and the interpretation of written texts in real time. For example, apps can notify learners of language errors, enabling them to speak more accurately and fluently (Godwin-Jones, 2018). Moreover, language learning apps offer students personalized speaking and writing practice (Kukulska-Hulme, 2012).

Intelligence-Based Learning Aids

AI can be used in education in the form of virtual tutors or digital assistants. These tools fulfill the function of answering questions, providing learning materials and general guidance to students. Chatbots allow students to ask questions and get quick answers 24/7. This practice increases student interaction, especially in distance education (Woolf, 2010). Through virtual tutors, students can receive fast and effective feedback whenever they need it (García-Serrano et al., 2019).

Artificial Intelligence Supported Educational Materials

AI is also used in the production of educational content. Educational materials can be automatically shaped according to student needs. For example, teachers can create interactive and entertaining content for students with AI-enabled systems. AI also enables the creation of more engaging and interactive course materials, taking into account students' individual learning styles (Liu et al., 2017). Such materials increase student engagement and make the learning process more efficient.

Student Performance Monitoring and Early Warning Systems

By analyzing students' performance, AI can predict potential difficulties in their educational process. Early warning systems track students' academic achievement and allow for early intervention for underperforming students. Such systems help teachers and schools to provide timely support to students (Siemens, 2013). Moreover, by predicting students' achievement, these applications contribute to shaping educational policies more effectively (Baker & Inventado, 2014).

Gamification and Interactive Education

AI is also used in game-based learning (gamification) applications. While students learn interactively in game environments, AI-supported systems analyze their in-game performance and

suggest personalized learning paths. This increases students' motivation and makes the learning process more enjoyable (Anderson et al., 2016). Moreover, gamification helps students to be more engaged in lessons and achieve their learning goals (Gee, 2003).

What is Smart Software in Education?

Smart software used in education transforms teaching processes by utilizing artificial intelligence (AI), data analytics and adaptive learning technologies. These software are designed to meet the individual learning needs of students, personalize the learning process and improve the teaching effectiveness of teachers.

Adaptive Learning Systems

Adaptive learning systems are intelligent software that dynamically organizes educational content according to students' individual learning pace and needs, and these systems offer a more effective learning experience by adapting content based on students' prior performance and learning needs (VanLehn, 2011). For example, Khan Academy's AI-based platform analyzes students' progress in mathematics and science and suggests personalized exercises (Kerr, 2014).

Artificial Intelligence Assisted Learning Assistants

AI-based teaching assistants support learning processes by providing individualized feedback and guidance to students, help students solve problems they encounter during learning, and provide teachers with information about students' strengths and weaknesses (Graesser et al., 2012). For example, Carnegie Learning's "MATHia" software addresses misconceptions by providing instant feedback to students in mathematics teaching (Woolf, 2010).

Automated Test and Evaluation Software

Automated testing and assessment software are tools that analyze students' exam performance and provide feedback. They evaluate not only correct or incorrect answers, but also students' problem-solving processes. For example, the platform called "Gradescope" provides a quick assessment by automatically scanning exam papers and saves teachers time (Shute, 2008). These software offer an effective solution for assessing large groups of students (VanLehn, 2011).

Simulation and Virtual Reality (VR) Based Educational Software

Simulation and virtual reality-based software provide students with experiential learning opportunities, and these software, which are especially common in science and medical education, allow students to perform real-life experiments in a virtual environment (Savin-Baden & Howell, 2013). For example, the software called "Labster" contributes to the development of students' laboratory skills by providing the opportunity to perform chemistry and biology experiments in a virtual environment (Liu et al., 2011).

Educational Games and Gamification Software

Gamification in education is an approach that uses game elements to increase students' motivation and make the learning process more fun. Educational games help students develop scientific thinking and problem solving skills. For example, "Minecraft: Education Edition" is a software that aims to develop students' collaboration and creativity skills in science and mathematics courses (Gee, 2003). These software programs attract students' attention and make the learning process more effective (Caponetto et al., 2017).

Learning Analytics Based Software

Learning analytics is an approach that uses big data technologies to analyze and understand students' learning processes. This software monitors students' performance and provides teachers

with detailed reports on learning processes (Siemens, 2013). For example, platforms such as "Edmodo" offer teachers the opportunity to better understand the learning needs of each student by tracking student activities (Sherman & McKenna, 2016).

Artificial Intelligence Supported Chatbots

AI-based chatbots in education are digital tools that guide students during learning and answer their questions. These chatbots provide 24/7 support to students, accelerating their learning process and directing them to resources. For example, "Differ" is a chatbot designed to help students understand course materials (Graesser et al., 2012). Chatbots are seen as an effective tool that supports students' individual learning processes (Woolf, 2010).

Artificial Intelligence Based Language Learning Software

AI-based software in language learning helps students improve their language skills by providing instant feedback. For example, "Duolingo" allows students to improve their speaking, listening and writing skills and tracks individual progress (Loewen et al., 2019). Such software offers a more effective language learning experience by personalizing the learning process (VanLehn, 2011).

What are Artificial Intelligence Applications in Science Education?

Artificial intelligence (AI) applications in science education help students better understand scientific concepts, accelerate their learning processes and increase their interest in science. AI increases the effectiveness of science education by offering various benefits to both teachers and students in education.

Intelligent Teaching Assistants

Artificial intelligence is used as intelligent educational assistants to provide individualized feedback and guidance to students. These assistants identify student-specific learning paths, identify gaps and provide personalized content. Especially in science, these assistants constantly monitor student performance and provide teachers with more detailed reports, making the teaching process more efficient (Woolf, 2010). Intelligent teaching assistants identify the subjects in which students struggle and make suggestions to strengthen them in these areas (Graesser et al., 2012).

Adaptive Learning Systems

Adaptive learning systems in science education are AI-based tools that personalize educational content according to students' learning pace and needs. These systems assess students' prior knowledge and provide materials of appropriate difficulty for each student. In science, adaptive learning systems address students' deficiencies by reworking concepts that students do not understand or have difficulty with (VanLehn, 2011). In addition, these systems provide instant feedback to students, allowing them to quickly correct their mistakes (Kerr, 2014).

Simulation and Virtual Laboratory Software

Artificial intelligence supported simulation software has an important place in science education. They enable students to reinforce their theoretical knowledge with hands-on experiments. For example, in sciences such as chemistry or biology, virtual laboratories offer students the opportunity to simulate real-world experiments. These AI-supported applications provide students with the opportunity to manipulate various variables and enhance their understanding of scientific processes (Savin-Baden & Howell, 2013; Liu et al., 2011). Such software enables students to conduct experimental research and learn scientific methods (Tseng et al., 2013).

Games for Artificial Intelligence Supported Science Education

AI is used together with gamification strategies in science education. In science education, educational games help students to solve scientific problems, while at the same time providing students with scientific thinking skills. AI-based games offer dynamically challenging tasks based on students' success in the game, thus increasing students' motivation and encouraging them to learn (Gee, 2003). These games enable students to reinforce their science knowledge and create a learning environment for scientific discovery (Caponetto et al., 2017).

Data Analysis and Modeling Software

AI-based data analysis software in science offers students the opportunity to analyze large data sets. These software provide students with scientific research skills such as data collection, analysis and drawing conclusions. Students can make sense of data and reach scientific conclusions by using data visualization tools in fields such as biology, chemistry or physics (Sherman & McKenna, 2016). AI-supported data analysis software also enables students to formulate their own hypotheses and encourages them to conduct research (Tseng et al., 2013).

Automated Test and Evaluation Systems

In science education, AI-supported automated testing and assessment systems provide students with instant feedback on their individual performance. These systems analyze students' answers on exams, identify errors, and report on the subjects in which students are deficient. Furthermore, AI tracks students' progress in their understanding of scientific concepts and provides teachers with reports specific to each student (Shute, 2008). Such systems save time for teachers and provide continuous feedback to students (VanLehn, 2011).

Intelligent Science Teaching Assistants and Chatbots

Chatbots and intelligent assistants also play an important role in AI-supported science education. This software guides students through science-related topics by providing answers to their questions. Chatbots not only answer students' questions on specific science topics, but also guide them to different resources, enabling them to learn more deeply (Woolf, 2010). These tools especially help students' individual learning processes and enable them to take an active role in the learning process (Graesser et al., 2012).

What is Intelligent Software in Science Education?

Science education plays a critical role in helping students understand the natural sciences and make connections to everyday life. Smart software can improve the effectiveness of science education, especially by using artificial intelligence (AI) and learning analytics. This software supports the learning process by providing customized educational experiences based on students' individual learning needs.

Simulation and Virtual Laboratory Software

Among smart software, the most widely used tools for science education are simulation and virtual laboratory software, which allow students to relate theoretical knowledge to real-world applications. Especially in physics, chemistry and biology courses, students can conduct experiments in a virtual environment and better understand scientific principles by controlling various variables (Savin-Baden & Howell, 2013). Simulation software makes learning environments more interactive, encourages students' active participation and facilitates teachers' classroom management (Liu et al., 2011).

Adaptive Learning Systems

Another type of smart software used in science education is adaptive learning systems, which deliver content based on students' individual learning pace, interests and prior knowledge. Using AI and learning analytics, these software continuously monitor student performance and personalize the teaching process by adapting the course content according to the student's needs (VanLehn, 2011). Such systems enable in-depth learning of concepts, especially in science, and offer additional support in areas where students have difficulties (Kerr, 2014).

Artificial Intelligence Assisted Learning Assistants

AI-supported teaching assistants are an important part of science education, providing instant feedback and guidance to students. They provide question-solving strategies that can help students find the right answer, analyze questions and identify missing concepts, as well as stimulate students' curiosity by asking them engaging questions about science (Woolf, 2010). TAs monitor students' progress over time based on their individual learning process and improve the quality of teaching by providing reports to teachers (Graesser et al., 2012).

Smart Assessment Tools for Science Education

Smart software in science education also plays an important role in assessing students' performance. Smart assessment tools analyze students' thinking processes beyond their performance in exams. They provide instant feedback to students while at the same time monitoring their thinking styles and how they process concepts. This provides teachers with valuable information to more accurately assess what students do and do not understand (Shute, 2008). Based on the teacher's feedback, students can improve their learning strategies and recognize their own shortcomings (VanLehn, 2011).

Gamification and Smart Game Based Software

Smart software that uses gamification elements in science education is effective in increasing students' motivation. These software integrate game elements into learning processes and keep students' interest in science alive. For example, educational games designed for learning science provide students with opportunities to solve, explore and experiment with scientific problems. This type of software makes the learning process more fun and engaging, while at the same time developing students' scientific thinking skills (Gee, 2003). As students progress through the games, they can track their achievements and learning with visual and numerical data (Caponetto et al., 2017).

Data-Based Science Education Software

Data-based software used in science provides students with the opportunity to conduct scientific research by working on large data sets. These software tools provide students with the skills to collect and analyze data, form hypotheses and draw conclusions. Using data visualization tools, students can make sense of scientific data and use data to solve real-world problems (Tseng et al., 2013). Moreover, data-based software provides students with the opportunity to practice analyzing data in different areas of science (e.g., environmental science or astrophysics) (Sherman & McKenna, 2016).

What are the Advantages of Artificial Intelligence?

The development of artificial intelligence (AI) technologies is leading to revolutionary changes in many sectors. The advantages offered by AI can provide a variety of benefits for both individuals and communities.

Efficiency and Speed

AI increases productivity by automating and accelerating tasks. Time-consuming and repetitive tasks that can be performed by humans can be performed much faster and more efficiently by AI systems. This results in significant time savings, especially in areas such as manufacturing, data analysis and customer service (Brynjolfsson & McAfee, 2014). Since AI has the capacity to analyze large data sets, it becomes faster to draw meaningful conclusions from this data (Mayer-Schönberger & Cukier, 2013).

Reducing Human Error

AI systems have the capacity to reduce human error. Especially in critical areas such as medical diagnostics, financial analysis, and production lines, the accuracy and predictability provided by AI minimizes error rates, which both increases safety and improves the quality of results (Rajpurkar et al., 2017; LeCun et al., 2015). The success of AI in these areas stems from its ability to exhibit higher accuracy rates than humans in certain tasks.

Personalized Experiences

AI can provide personalized services by understanding the specific needs of individuals. In the education, health and retail sectors, AI analyzes user behavior and provides content, recommendations and solutions tailored to each individual. For example, in education, AI-based applications provide customized content based on students' learning speed (VanLehn, 2011). Moreover, in the medical field, AI can provide personalized treatment recommendations based on patients' genetic and medical history (Topol, 2019).

Accessibility and Inclusion

AI has the potential to create a more accessible world for people with disabilities. For example, speech recognition and visual recognition technologies can help visually impaired individuals better understand their environment. Furthermore, automatic translation and language processing applications can facilitate communication between individuals of different languages. This contributes to building a more inclusive society on a global scale (Bertelsmann Stiftung, 2017).

Creating New Jobs

AI is creating new jobs and opportunities. With the development of AI, new professions such as data scientists, AI engineers and ethics experts have emerged. This increases the demand for qualified employees in the labor market and brings new educational requirements (Chui et al., 2016). At the same time, new business models are emerging through the application of AI, supporting economic growth.

Autonomy and Robotics

The use of AI in robotic systems reduces the dependence on human intervention and enables the development of autonomous systems. Autonomous vehicles can improve traffic safety by reducing driver errors, while industrial robots enable more efficient and safer production processes. These technologies improve quality of life by removing people from repetitive and dangerous work (Goodall, 2014; Shi et al., 2017).

Finding Solutions to Difficult Problems

AI is a particularly effective tool for solving complex and large-scale problems. For example, in areas such as combating climate change or treating genetic diseases, AI can make more accurate predictions and develop solutions through data analysis and modeling. This allows for accelerated scientific research and more effective solutions (Silver et al., 2016; Esteva et al., 2019).

Advanced Data Analytics and Forecasting

One of the most important advantages of AI is its ability to analyze large data sets and make predictions based on this data. This capability is used in the finance, healthcare, retail and energy sectors. For example, AI-powered analytical tools can predict customers' shopping behavior, enabling companies to develop more efficient marketing strategies. Again, in healthcare, AI can be used for early diagnosis of diseases (Chollet, 2019; Rajpurkar et al., 2017).

What are the Disadvantages of Artificial Intelligence?

Although artificial intelligence (AI) has made significant progress, especially in recent years, it also brings with it various disadvantages and potential risks. These disadvantages can have significant impacts at both technological and societal levels.

Employment Loss and Labor Force Change

One of the biggest disadvantages of AI is the loss of labor. Especially in sectors where automation is increasing, the use of AI can pose serious threats to the working class. Robots and automated systems can replace humans in production, customer service and even in some white-collar jobs, leading to high unemployment and significant changes in the labor market (Brynjolfsson & McAfee, 2014). Moreover, this process can require a major transformation in skills and labor requirements, which can lead to social inequalities (Chui et al., 2016).

Data Privacy and Security Issues

Since AI systems operate using large data sets, data privacy and security is an important risk factor. Such systems collect and process users' personal information, which can be a violation of individuals' privacy. Furthermore, the security of AI-enabled systems can be vulnerable to attacks by malicious actors. Especially in critical areas such as autonomous vehicles or healthcare, such vulnerabilities can have serious consequences (Zeng et al., 2017; Taddeo & Floridi, 2018).

Lack of Transparency in Decision Making Processes

The lack of transparency of AI's decision-making processes is a major drawback. AI is often based on "black box" models, meaning that it is often unclear how and why algorithms make certain decisions. This can lead to trust issues, especially in sensitive areas such as health, finance and law. Moreover, lack of transparency can lead AI to make erroneous or unfair decisions, which can undermine societal trust (Burrell, 2016; Angwin et al., 2016).

Moral and Ethical Issues

The ethical use of AI is also a controversial issue. AI systems need to make ethical decisions, especially in applications such as autonomous vehicles and combat robots. However, AI's decisions are often based on parameters set by humans, which may not fully reflect human values and ethical norms. For example, there is uncertainty about what ethical principles an autonomous vehicle should consider when deciding which people to save in the event of an accident (Lin, 2016). Such decisions can be incompatible with societal norms and lead to ethical problems.

Algorithmic Biases

AI systems may have algorithmic biases depending on the data sets they are developed for. If an AI system learns from historical data, the social biases in that data can also influence its decisions. For example, AI systems used in recruitment processes may reflect past discrimination based on gender or race, which can lead to unfair outcomes, and such algorithmic biases can undermine the social justice principle of AI (O'Neil, 2016; Noble, 2018).

Dependency and Diminishing Human Capabilities

The overuse of AI can make people lazy to develop their own skills and abilities. For example, AI-supported software can prevent students from improving their written language skills because language processing systems provide correct spelling and grammar suggestions. Similarly, overuse of AI can undermine people's own ability to analyze, problem solve and make decisions (Carr, 2014).

Loss of Control and Unpredictable Behavior of AI

With the evolution of AI, it is becoming increasingly difficult to predict the behavior of machines. AI systems are able to evolve by working on big and complex data, but this evolution process cannot be fully controlled by humans. This can have potentially unpredictable and unintended consequences. Especially in areas such as autonomous weapons and military systems powered by artificial intelligence, loss of control can create great dangers (Binns, 2018; Lin, 2016).

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About The Authors

Buket GEVIS FARHADZADA is currently working as a Research Assistant at Akdeniz University, Faculty of Education, Department of Mathematics and Science Education, Department of Science Education. She holds a master's degree in Science Education from Akdeniz University. Her main areas of interest are education, science education, artificial intelligence, augmented reality and STEM applications.

E-mail: buketgevis@akdeniz.edu.tr, **ORCID:** 0000-0003-2871-5377.

Fatih Serdar YILDIRIM is an Associate Professor at Akdeniz University, Faculty of Education, Department of Mathematics and Science Education, Department of Science Education. She holds a PhD degree in Biology Education from Gazi University. His main areas of interest are artificial intelligence, social sciences and humanities, education, science education, life sciences, environmental biology, environmental pollution, basic sciences and augmented reality applications.

E-mail: fsyildirim@akdeniz.edu.tr, **ORCID:** 0000-0003-4080-8488.

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