REIMAGINING EDUCATION WITH GENERATIVE ARTIFICIAL INTELLIGENCE

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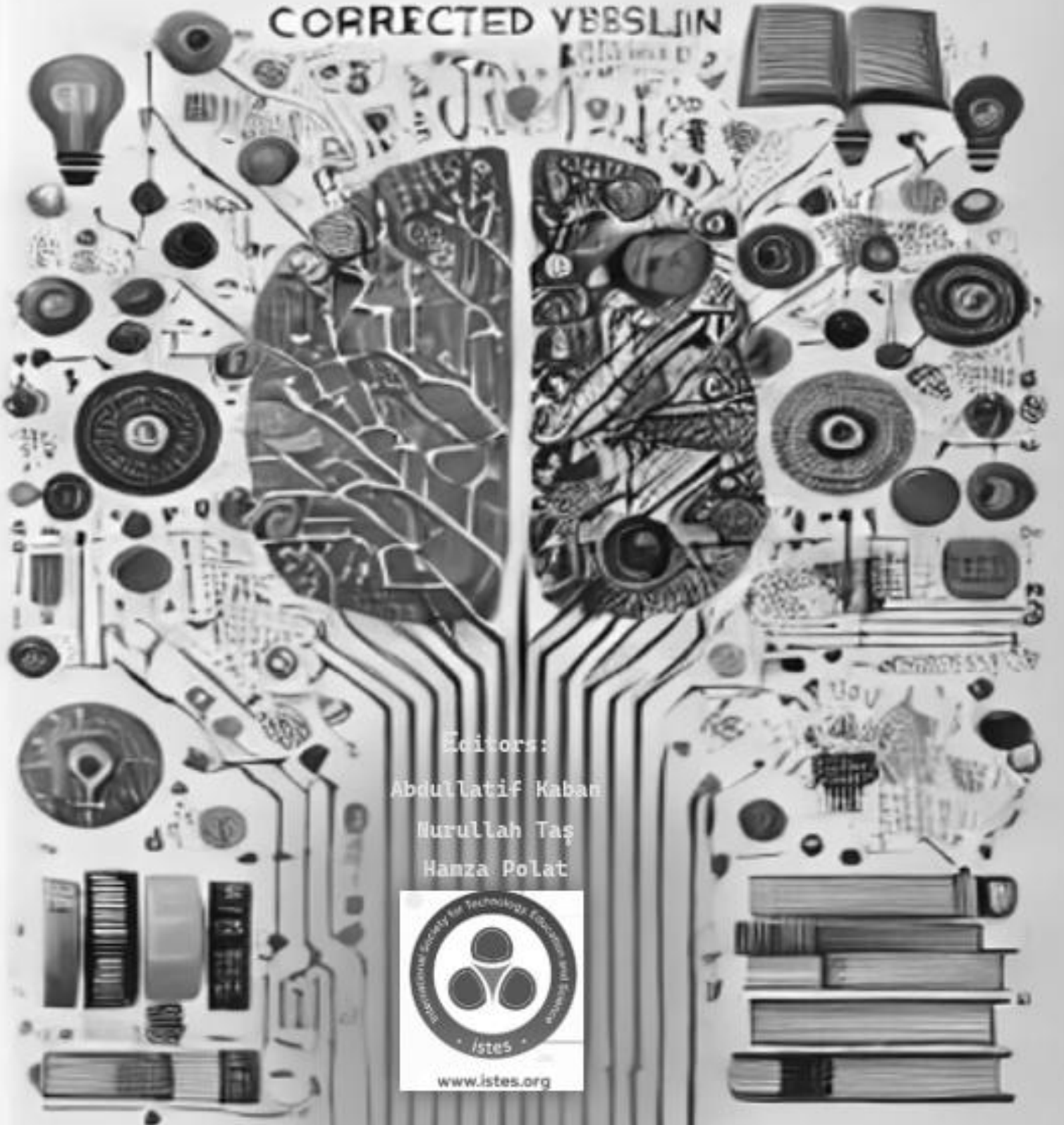

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Chapters

İçindekiler

PREFACE

Education is one of the most powerful tools shaping the future of humanity. However, the true impact of this tool can only be realized when it is supported by innovative approaches and technologies that meet the demands of the era. Today, generative artificial intelligence (Generative AI) presents unprecedented opportunities to rethink and transform educational processes. "Reimagining Education with Generative Artificial Intelligence" has been prepared to deeply explore these opportunities and to address the benefits and challenges of artificial intelligence in education comprehensively.

This book provides a broad framework, covering the history of generative AI technologies in education, their current applications, and their future potential. From tools that personalize learning processes for students to applications that enhance teachers' pedagogical skills, the role of artificial intelligence in education is examined in detail. Moreover, critical issues such as ethics, security, and social impacts are also thoroughly discussed.

Each chapter offers both theoretical and practical insights, appealing to academics, teachers, education leaders, and policymakers. The content includes a variety of topics, from designing AI-enhanced materials to applications in STEM and programming education; from new approaches in language learning to personalized learning platforms. We believe this book will serve as a guiding resource for effectively and responsibly utilizing artificial intelligence technologies in education.

This work has been shaped by the collaboration and dedicated efforts of experts from various disciplines. Every page reflects this collective effort. Furthermore, we aim to provide a starting point for future studies on the transformative role of AI in education.

We hope this book will help you better understand the transformative power of artificial intelligence in education and make the most of the opportunities it offers. Wishing you an inspiring and informative reading experience on this journey.

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Chapter 1 - Education and Artificial Intelligence: Basic Concepts and History

Ömer BİLEN

Introduction

Human beings, whose history on earth cannot be dated exactly, have struggled very hard until today. In order to survive, he has pushed his own limits to the extent permitted by the conditions of the period. In this process, he first utilised his own means and then natural resources. He tried to use the power of water, soil and wind to survive and improve the conditions in which he lived. In this process, it has sought ways to utilise the power of other living things in nature and gradually sought ways to evaluate the nature in which it lives and the opportunities it offers. With the progression of time, human beings started to improve their living conditions, were not satisfied with the given nature and started to make tools. With the tools he made, he actually started to search for the possibilities of a better life and started to take important steps in his journey to reveal his own potential. Man, who initially struggled to survive by sheltering and protecting himself from the attacks of wild animals, succeeded in overcoming many natural conditions that threatened his existence. With the transition to settled life using the natural tools he developed, he entered a new stage in terms of nutrition as well as shelter. However, the curiosity of not being satisfied with the current situation and trying new things has led him to other channels. Man, who initially benefited from the power of water, later found himself on the threshold of a new world when he used the power of its steam form. With the use of steam machines, life, which was static, began to become dynamic, and the circulation of manufactured goods and products began to gain speed. Man, who started to move from naturalness to mechanisation, started to find something to wear on his back thanks to the looms after he had fed himself to a certain extent. Approximately 100 years after these developments, humanity, illuminating its dark world with the discovery of electricity, is about to open a new threshold that will radically change its life. The spread of electricity has radically changed industry, communication and daily life. Electricity has transformed life from mechanical to electro-mechanical form and at the same time transformed the way factories work, the speed of transport and every aspect of modern life. Just as the printing press transformed access to information, the spread of electricity has reshaped the global economy and society. The widespread adoption of electricity is recognised as a turning point in human history, and electricity forms the basis of modern life today.

Major technological advances in electronics after the Second World War led to the development of computers and

telecommunications, and the Internet emerged in the last three decades of the twentieth century. The world, which was previously connected to each other by roads and power lines, has been connected to each other by information networks with the emergence of the Internet, and as a result, it has become easier to access information and knowledge located in certain centres. Information has become the most important capital in economy and production by instantly circulating the information produced and offering it to the service of people in need. Developments in information and communication technologies have deeply affected people's relations, communication, socialisation processes and lifestyles. Today, at the centre of this change are the Internet, wireless network technologies, smart phones, tablets, laptops and similar mobile communication tools.

On the one hand, man utilised the opportunities offered by these technologies that he produced with his own intelligence, and on the other hand, especially after the 1950s, he occasionally pondered the question of whether machines could think, and searched for the answer to this question for many years. As a result, computers, which have been used for information-counting, calculation and storage purposes for many years, have now succeeded in taking them to the next level and have raised them to a level that can learn from data sets, extract meaning, and understand what is spoken/written. The name of this level and the new wave of technology is "Artificial Intelligence". Artificial intelligence (AI) is revolutionising many areas from education to health, from finance to agriculture. In education, it supports learning processes with personalised learning and intelligent teaching systems, while in health, it improves the quality of care with applications such as disease diagnosis, treatment planning and robotic surgery. It offers innovations such as fraud detection and algorithmic trading in the finance sector, and personalised product recommendations and inventory management in retail. It is also widely used in areas such as autonomous vehicles in transportation, content recommendations in media and entertainment, facial recognition and cyber security in security, autonomous machines in agriculture and smart grids in the energy sector. Artificial intelligence also offers innovative solutions by optimising processes in sectors such as industry, law and space exploration.

Artificial intelligence (AI) is a technology that has the potential to revolutionise education. It offers applications that increase individualised learning opportunities in education, optimise teaching methods and make educational processes more efficient. The integration of technological advances into education makes learning processes more accessible and inclusive, and promotes equal opportunities in education (L. Chen et al., 2020a).

The role of AI in education transforms not only the presentation of learning materials but also the assessment and feedback processes. Artificial intelligence-based tools that enable the development of teaching strategies suitable for the individual needs of students contribute to the evolution of education away from the traditional classroom-based model to a more student-centred structure (Ifenthaler et al., 2024).

Historical developments regarding the use of AI in education emphasise the importance of this technology. AI, which was first used in the automation of curricula, is now used in many areas ranging from personalised learning systems to intelligent teaching aids. For example, technologies such as natural language processing and learning analytics make the teaching process more effective and interactive (L. Chen et al., 2020a).

In addition to its contributions to education, AI also raises some ethical and social questions. Concerns such as

deepening inequalities in education or violating individuals' privacy rights require careful design and implementation of this technology. However, despite these concerns, the role of AI in the future of education is undeniably important (Ifenthaler et al., 2024). As a result, the role of AI in education not only transforms learning processes but also contributes to individual and societal development by providing a more accessible and effective educational environment (Ifenthaler et al., 2024; Onesi-Ozigagun et al., 2024).

Basic Concepts

Artificial Intelligence (AI): Definition and Components

Artificial intelligence (AI) is defined as the ability of machines to perform tasks that usually require human intelligence. This technology covers processes such as data processing, learning, problem solving, language understanding and decision making. John McCarthy defined AI as "the science and engineering of building intelligent machines" in 1955 (McCarthy, 2004). AI is generally divided into two main categories, namely "narrow artificial intelligence" (ANI) and "general artificial intelligence" (AGI). ANI are systems that fulfil a specific task with high accuracy, e.g. face recognition; AGI aims to achieve more complex, human-like intelligence, but this is still a theoretical concept (Grodniewicz & Hohol, 2023).

The components of AI form the cornerstones of this technology. Machine learning (ML), as a subfield of AI, enables machines to learn from experience (Dinçman, 2023). Deep learning (DL), a subset of ML, learns more complex patterns from large amounts of data using multi-layered artificial neural networks (Aydın, 2023). Furthermore, technologies such as natural language processing (NLP) allow machines to understand and produce human language (Kanat & Akoğuz, 2024). Algorithms play a fundamental role in the functioning of AI. An algorithm is a description of the steps that must be followed to achieve a certain result. However, modern AI systems are characterised by the ability to learn from data and experience rather than only fixed algorithms. This is considered a major shift from the previous paradigm of software engineering and enables the emergence of more flexible, customisable systems. Finally, the development of AI involves both benefits and challenges. For example, while it can offer personalised solutions in healthcare and education, ethical issues such as data privacy and algorithmic bias are also raised. Therefore, the impacts of AI need to be carefully assessed.

Machine Learning and Deep Learning

Machine learning (ML) enables systems to learn from data analysis in the context of a specific problem and develop models with this learning. Through various algorithms, it works on structured data to achieve a predefined goal. For example, an algorithm can learn the difference between an apple and an orange based on characteristics such as the weight, colour or texture of an apple. ML usually works with a small number of data points and relies on manually designed feature engineering (L. Zhou et al., 2017). Therefore, it is ideal for getting faster results or working with small amounts of data.

Deep learning (DL) is a sub-branch of machine learning and works through multi-layered artificial neural networks like in the human brain (Aktürk & Serbest, 2022). The main difference of Deep Learning from machine

learning is that it can learn directly from data without requiring customised feature engineering. It works more effectively with large data sets and provides high success in complex problems such as image recognition and natural language processing (NLP). Deep learning allows algorithms to discover previously unidentified patterns and trends, not just produce predetermined results (Jordan & Mitchell, 2015).

Machine learning and deep learning are both based on artificial intelligence and statistics. Both use algorithms and data analysis techniques in the model development process. However, deep learning is a sub-discipline that is more complex than machine learning and can work with large data sets. Both technologies can be improved with a continuous flow of data, which enables systems to produce more accurate results over time (Janiesch et al., 2021).

In the field of education, machine learning offers personalised learning experiences by analysing students' learning tendencies, while deep learning provides advanced content recommendations or instructor support by analysing complex data structures. For example, deep learning-based systems can be used for applications such as automatic feedback or speech recognition in language learning (Deng, 2016).

Generative AI: Definition and Relevance to Education

Generative AI (GAI) refers to artificial intelligence systems that can generate new content using methods such as machine learning and deep learning. This technology can create various types of content such as text, images, audio and even video. In the educational context, the main potential of GAI lies in functions such as creating instructional materials, providing tailored feedback to students and personalising learning experiences. In these aspects, GAI has the potential to reshape teaching and learning processes (Bahroun et al., 2023; Batista et al., 2024).

GAI applications in education are not limited to intelligent tutoring systems and learning support tools that respond to learners' individual needs. For example, models such as ChatGPT can guide students by explaining complex topics in understandable language. At the same time, they offer teachers the possibility to enrich lesson plans and automate time-consuming tasks. This allows educators to focus on higher-level skills such as creative and critical thinking (Searson et al., 2024; X. Zhou et al., 2024).

However, the widespread use of GAI in education brings with it challenges such as ethical questions and academic integrity. In particular, the ability to generate automated content may increase the risk of students favouring GAI-derived products over original work. This situation necessitates a reconsideration of educational policies and assessment strategies for both students and teachers (Farrelly & Baker, 2023).

In conclusion, GAI presents both great opportunities and complex challenges in education. The integration of technology into education should be considered in a broader perspective, such as ethical principles, pedagogical approaches and student-teacher interactions, rather than only technical applications. Interdisciplinary collaborations and continuous research are necessary to fully utilise the potential of GAI (Batista et al., 2024).as

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History of Artificial Intelligence and Education

First Use Cases of AI in Education

The applications of artificial intelligence (AI) in education take their roots from various innovations dating back to the mid-20th century. Early on, the potential of AI in education was demonstrated by programmes designed to personalise learning processes and respond to the individual needs of learners. In particular, computer-based instructional systems such as PLATO, developed at Stanford University in the 1970s, enabled learning materials to be presented automatically, allowing many students to learn at their individual pace.

In the 1980s, Intelligent Tutoring Systems (ITS), one of the pioneering examples of AI in educational technologies, were developed as systems that analysed student performance and provided individual feedback. For example, the system called SCHOLAR guided students in their geography learning, answered their questions and measured their level of knowledge. These systems are designed to support individual learning pathways and reduce the burden on teachers (Pedro et al., 2019).

In the 1990s, AI-supported educational tools were further developed and enriched with systems supported by natural language processing techniques. In this period, systems such as AutoTutor tried to understand and answer students' questions, aiming to provide a human-like interaction with the student. These systems offered interactive learning scenarios to increase students' understanding and encouraged active learning (Slimi, 2023).

Since the 2000s, the applications of AI in education have spread to a wide range. In particular, online learning platforms and adaptive learning technologies started to use data analytics and AI algorithms to identify students' strengths and weaknesses. These tools have made significant strides in optimising students' learning paths and individualising learning resources. For example, platforms such as Knewton have reshaped learning materials according to users' needs (Walter, 2024).

Educational Technologies from Century to Present

Since the 20th century, educational technologies have developed rapidly and radically changed teaching processes (Molenda, 2022). At the beginning of the century, the basic tools used in education consisted of simple materials such as blackboard and chalk. However, the introduction of radio broadcasts in the 1920s provided an important innovation in education; thus, students had the opportunity to access teaching materials outside the classroom environment. By the 1930s, overhead projectors brought a new dimension to teaching processes by popularising the use of visual materials in classrooms (Cuban, 1986; Saettler, 2004).

After the Second World War, technological developments gained great momentum. In the 1950s, headphones and

video recorders diversified learning processes by providing students with individual learning opportunities. In the 1980s, the use of personal computers in education enabled the digitalisation of teaching materials. Especially the first personal computer launched by IBM in 1981 was a turning point in educational technologies. In the 1990s, information sharing accelerated as the internet reached large masses, greatly facilitating the integration of educational technologies into classrooms (Reiser & Dempsey, 2012).

In the early 2000s, smart boards, tablets and e-learning platforms became widespread. Students gained access to digital textbooks and interactive applications, making learning processes more flexible and interactive. In addition, platforms such as Massive Open Online Courses (MOOCs) have created equitable educational opportunities around the world. In this period, the accessibility of technology has increased inclusiveness in education (Selwyn, 2021).

Today, advanced technologies such as artificial intelligence (AI) and augmented reality (AR) are transforming educational processes. AI can adapt to the pace of learning and individual goals by providing personalised learning experiences according to student needs. Augmented reality (AR) and virtual reality (VR) technologies help students to embody knowledge by creating more interactive and immersive learning environments. These technological innovations will improve the quality of learning experiences in the future by making education more accessible, individualised and interactive (Huang et al., 2010).

The Rise of Generative AI

Generative AI (GAI), especially in the early 2020s, developed rapidly and started an important transformation in the field of education. In 2022, the introduction of ChatGPT by OpenAI was a milestone symbolising progress in this field. In just a few months, this technology reached more than 100 million users, demonstrating the rapid adoption of artificial intelligence technologies. The development of generative AI tools has opened up many new possibilities, such as empowering personalised learning experiences, automatic generation of educational materials and increasing student engagement (Grassini, 2023).

The use of generative AI in education has had groundbreaking effects on material creation and learning processes. For example, software and intelligent guidance systems that provide personal feedback to students have both accelerated and individualised learning processes. These tools have enabled educators to develop more creative and effective course content, while optimising educational processes. At the same time, generative AI technologies have increased equity in education by providing adaptive content according to different learning styles (Bandi et al., 2023).

With the rise of this technology, some challenges have also come to the fore. For example, issues such as academic integrity, ethical uses and model biases have become more visible with the proliferation of generative AI. The integration of such technologies into education has necessitated not only a change in pedagogical strategies, but also a reorganisation in terms of policies and regulations. In particular, there have been calls for transparent model development and responsible use (Al-kfairy et al., 2024).

The impact of Generative AI has not only been limited to classroom applications; it has also led to a reshaping of educational policies. Educators and researchers are encouraging interdisciplinary studies to examine the long-term effects and enhance the pedagogical benefits of these technologies. In this context, GAI has become a critical tool for redesigning future education models and preparing students for the future workforce.

Development of AI Based Educational Technologies

Personalised Learning Systems

Personalised learning refers to teaching processes that are tailored to the individual needs, interests and learning styles of students. This approach represents a shift away from traditional teacher-centred models to a student-centred paradigm. Artificial intelligence (AI)-based systems offer dynamic and adaptive educational pathways, taking into account individuals' knowledge levels, learning speeds and preferences (Halkiopoulos & Gkintoni, 2024). Such systems increase both academic achievement and students' motivation, especially through features such as individual feedback and tracking learning progress.

AI-based personalised learning platforms provide real-time feedback by continuously analysing student performance. For example, intelligent tutoring systems monitor students' learning processes, identify their deficiencies and offer specialised resources to address these gaps. This ensures that learning gaps are closed quickly and students develop a deeper understanding. Moreover, such adaptive solutions offered by AI not only improve individual learning experiences, but also give instructors the opportunity to develop more effective teaching strategies (Luckin & Holmes, 2016).

AI-based learning platforms offer great advantages with the ability to address different learning styles. Students with visual, auditory or kinaesthetic preferences can access content suitable for their learning styles thanks to AI tools. This provides a more inclusive and effective learning process. However, overuse of these systems can negatively affect dynamics such as the development of social skills and group work. The use of AI in education can both improve individual learning and weaken interaction within the community (Holmes et al., 2019).

Personalised learning systems also offer important opportunities for lifelong learning. In particular, AI-based tools facilitate the learning journey of individuals in their professional development or in the process of acquiring new skills. Dynamic analyses and continuously updated learning paths help individuals adapt to changes in the business world. This shows that education is a critical tool not only for individual development but also for societal and economic benefits (Zawacki-Richter et al., 2019a).

Intelligent Teaching Systems and Robotic Teachers

Personalised learning refers to teaching processes that are tailored to the individual needs, interests and learning

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AI-based personalised learning platforms provide real-time feedback by continuously analysing student performance. For example, intelligent tutoring systems monitor students' learning processes, identify gaps, and provide tailored resources to address these gaps. This ensures that learning gaps are closed quickly and students develop a deeper understanding. Moreover, such adaptive solutions offered by AI not only improve individual learning experiences, but also give instructors the opportunity to develop more effective teaching strategies (Zawacki-Richter et al., 2019b).

Another important advantage of these systems is that they can cater for different learning styles. Students with visual, auditory or kinesthetic learning preferences can work with materials in a format suitable for them thanks to AI-based tools. As a result, a more inclusive educational environment is provided and the learning process becomes both more effective and more enjoyable. However, challenges such as the development of social skills and weakening of group work dynamics may also arise during the implementation of these systems (X. Chen et al., 2020).

Personalized learning systems also offer important opportunities for lifelong learning (Shemshack & Spector, 2020). In particular, AI-based tools facilitate the learning journey of individuals in their professional development or in the process of acquiring new skills. Dynamic analyses and continuously updated learning paths help individuals adapt to changes in the business world. This shows that education is a critical tool not only for individual development but also for societal and economic benefits.

Data Analytics in Education

Artificial intelligence (AI)-supported intelligent tutoring systems (ITS) and robotic tutors stand out as innovative technologies to improve student performance (Luckin & Holmes, 2016). ITSs are equipped with algorithms that can be tailored to individual student needs, customise educational content and optimise students' learning processes (Kukulska-Hulme, 2021). These systems offer personalised support by identifying subjects in which students are weak and thus fill learning gaps more effectively. Moreover, thanks to AI, PDSs make education more efficient by continuously monitoring students' progress through learning analytics (Siemens, 2013).

Robotic teachers have started to play an active role in both in-class and distance education environments. Social robots enrich learning experiences by interacting with students on an emotional and cognitive level (Belpaeme et al., 2018). Especially in STEM (science, technology, engineering and maths) education, robots offer interactive methods to facilitate the understanding of complex concepts. The contribution of robotics teachers to education has the potential to make learning more fun by increasing students' motivation and gamifying boring learning

processes (van den Berghe et al., 2019).

The integration of PDS and robotic teachers requires a complete redesign of teacher-student relationships. These technologies automate teachers' routine tasks, allowing them to focus more on pedagogical strategies. However, they also support students to develop their capacity for independent learning. However, the effective implementation of these systems requires teachers to adapt to the technology and acquire the necessary skills (Adel, 2024).

The success of these technologies depends on addressing ethical responsibilities and technical challenges. Issues such as data privacy, impartiality of AI systems, and accessibility are factors that limit the wider use of ATS and robotics teachers in education. Since the human element will always play an important role in education, these technologies should be seen as complementary tools (Haleem et al., 2022).

Education and Artificial Intelligence

Existing Applications and Platforms

Artificial intelligence (AI) based applications and platforms continue to revolutionise education. Adaptive learning systems increase students' motivation and success rate by providing customised content according to individual learning needs. These systems analyse student data to provide instant feedback and optimise learning pathways. For example, platforms such as Pearson and Knewton are among the leading platforms offering such customised learning experiences (Conklin, 2016).

AI also offers impressive innovations in language learning and assessment. Duolingo and Rosetta Stone use AI algorithms to help learners improve their language skills. These applications provide personalised feedback by analysing learners' errors and accelerate language learning processes (Kalsoom et al., 2024). Moreover, automated assessment systems that facilitate teaching and assessment processes ease the workload of teachers.

Chatbots and virtual assistants play an important role in student support services. For example, Ivy.ai and Watson Tutor provide 24/7 information access to students and provide quick solutions to their academic and administrative questions. These tools improve the quality of education in many areas, from access to teaching materials to lesson planning (Y. Chen et al., 2023).

E-learning platforms have also accelerated the growth of the impact of AI in education. Platforms such as Coursera and EdX use AI-supported learning analytics and recommendation systems to improve the user experience. These systems support students in achieving their learning goals, making education more flexible and accessible (Saqr et al., 2024).

Opportunities and Limitations

The integration of generative artificial intelligence (AI) and other AI technologies into education offers unique

opportunities but also carries several limitations. These technologies have great potential, especially in areas such as personalized learning, increasing student productivity, and optimizing teaching processes. For example, AI-based systems can deliver content according to individual learning needs and thus make the learning process more effective (Murtaza et al., 2022).

However, these opportunities are accompanied by significant limitations. In particular, data privacy and security issues come to the fore. Large amounts of student data are being collected and processed through the use of AI technologies. This requires a careful approach in terms of protecting students' privacy and compliance with ethical standards. Also, attention should be paid to the risk of algorithmic bias during the use of these technologies. For example, an AI system may misrepresent or discriminate against certain socio-economic or cultural groups (Roche et al., 2023).

The lack of the necessary infrastructure and digital literacy to increase the impact of AI in education is also a major problem. Especially in developing countries, digital inequality and lack of resources can hinder the effective use of these technologies. Comprehensive trainings are needed for educational institutions, teachers and students to understand and work with AI technologies (Pedro et al., 2019). In conclusion, the use of AI in education has the potential to bring great innovations, but it is important that this process is carried out in accordance with the principles of ethics and equity. Relevant stakeholders should develop strategies to both maximise the opportunities and minimise the limitations of these technologies.

Future Perspectives

The Future Potential of AI in Education

As artificial intelligence (AI) becomes an increasingly effective tool in education, its future potential is taking fascinating shape. The future of AI in education offers opportunities ranging from personalised learning experiences to increasing digital equity. One of the biggest promises of AI is the personalisation of learning. In the future, AI-enabled tools can create more effective and engaging learning environments by adapting to students' learning pace, strengths and weaknesses (Bușu, 2024). Such technologies can optimise the learning process and achieve better academic results by recommending content that suits students' individual needs.

Furthermore, AI has significant potential to support and strengthen the role of teachers. Automation of routine administrative tasks can allow teachers to spend more time on one-to-one interaction with students. Besides, AI can make teaching processes more efficient by using data analytics to improve teaching materials, analyse classroom dynamics and optimise teaching methods (Tedre et al., 2021).

The goal of achieving digital equity in education is another critical area of AI. In developing countries, AI can increase access to educational resources and can be an effective tool in overcoming barriers such as language, geography or economic status (Goswami & Sharma, 2024). For example, AI-enabled digital textbooks and virtual

teachers can provide quality learning opportunities to students even in under-resourced regions.

However, the full realisation of this potential requires overcoming various challenges. Issues such as data privacy, algorithmic bias, and technological infrastructure deficiencies may limit the future role of AI in education (Luan et al., 2020). Therefore, multi-stakeholder collaborations and policy frameworks are of great importance for an ethical and sustainable AI implementation.

Ethical and Social Issues

The rapid spread of artificial intelligence in the field of education brings with it some important ethical and social issues. One of these issues is data privacy and security. Educational institutions collect and analyse large amounts of data from students using artificial intelligence systems. However, the question of how and by whom this data is used is still controversial. Data breaches and unauthorised access threaten students' privacy and raise a serious ethical issue (Eden et al., 2024).

The use of AI in education also risks deepening digital inequality. While access to technology is still a major problem in regions with limited economic resources, the fact that artificial intelligence tools become a luxury application that only a certain segment of society can benefit from may further increase inequalities in education. This situation may create a picture contrary to the principle of equal opportunity and widen the digital divide in education (Wargo & Anderson, 2024).

Biases in artificial intelligence algorithms are also an important ethical problem. Since artificial intelligence systems learn from existing data sets, they may tend to replicate social, cultural or racial biases in these data (Olteanu et al., 2019). This may lead to unfair results in student assessments or learning processes. For example, some algorithms may incorrectly predict students' academic performance, limiting their opportunities and contributing to social segregation.

Finally, the concern that AI tools could replace teachers is fuelling a social debate. Although AI-based systems can perform routine tasks, they cannot fully replace the empathy, guidance and social interaction that human teachers offer. Maintaining a human-centred approach in education is critical to ensure that the emotional and social needs of students are not ignored (Eden et al., 2024).

Conclusion

Summary and Recommendations

Artificial intelligence (AI) technologies have the potential to create major transformations in the education system. The topics covered throughout this book detail how AI is being applied in critical areas such as personalised learning, data analytics, instructional systems and educational justice. AI is enabling individualised educational

experiences by supporting teachers in improving learning processes in education. However, these opportunities become more meaningful and sustainable, especially when considered within a framework where ethical and social issues need to be addressed.

For more effective use of AI in education, active participation of educators in the process should be ensured as a priority. By adopting human-centred approaches in technology development processes, "human-in-the-loop" designs that strengthen the roles of teachers should be emphasised (Kumar et al., 2024). Moreover, analysing students' learning needs in a data-driven manner and integrating these analyses with personalised learning platforms are among the key strategies that will increase success in education.

Evaluating the ethical and social impacts of AI is also an important need. Especially issues such as algorithmic biases and data security necessitate the development of educational technologies in a fair and inclusive manner. In this context, it is essential that educational policy-making institutions guide the use of AI by establishing strong ethical standards (Porayska-Pomsta et al., 2023).

Finally, strategic planning for the future needs to be realised through the joint work of researchers, educators, technology developers and policy makers. Sustainable and effective integration of AI in education systems will only be possible through multi-stakeholder collaborations and inclusive education policies. Thus, the transformative potential of AI in education can be fully realised, ensuring that every student has access to equal opportunities.

Suggestions for More Effective Use of AI in Education

Strategies to be developed for the effective use of artificial intelligence in education should aim at the transformation of teaching methodologies and the improvement of students' individual learning experiences. In this context, firstly, ethical and responsible use of AI in education should be emphasised. A fair learning environment should be offered to students by ensuring transparency, data privacy and unbiased decision-making mechanisms of AI systems. This can be realised by incorporating ethical guidelines into educational policies.

Secondly, the adaptation of educators to AI technologies should be supported. Teachers should understand the tools provided by AI and be trained to use them effectively. For example, teachers can use personalised learning systems and analytics tools to assess students' performance and provide individualised feedback. This adaptation process can be supported by training programmes that strengthen teachers' digital literacy skills.

Thirdly, learning processes need to be redesigned. Instead of traditional assessment methods, practices that emphasise students' critical thinking and problem-solving skills with AI-supported analytical tools should be implemented. Furthermore, the creation of dynamic curricula according to learning objectives allows for continuous monitoring of students' progress and adaptation according to their individual needs.

Finally, strengthening the technological infrastructure is of great importance. Schools and universities should have

access to the necessary technical equipment for the effective use of AI-supported educational tools. In this direction, digital transformation projects can be initiated in cooperation with governments and the private sector to ensure equal opportunities in education. These infrastructure investments should focus on educational institutions, especially in economically disadvantaged regions.

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Chapter 2 - What is Generative Artificial Intelligence? Potential and Limits in Education

Nurullah Taş, Eda Tör

The Concept and Definition of Generative Artificial Intelligence

Generative artificial intelligence (GAI) is a type of artificial intelligence that can mimic creative processes and produce new content. This concept includes the ability of AI to not only analyse data, but also to create new ideas, designs or solutions. AI plays an important role especially in areas such as art, music, software development and content creation (Liao & Ji, 2023).

The definition of GAI may differ across various disciplines. For example, some studies focus on the ability of AI to mimic human-like creativity, while others emphasise the mathematical and engineering foundations of this technology (Goertzel, 2014; Monett et al., 2020). While defining artificial intelligence, Wang emphasises the potential of such systems to reach the level of general intelligence (Wang, 2019). Moreover, the application areas of UIC include creative processes such as image design and content creation (Liao & Ji, 2023).

The development of GAI brings with it ethical and legal issues. In this context, it is important to determine the responsibilities for the use of AI and to manage the potential risks of this technology. It is stated that comprehensive management systems and forensic standards should be established to ensure the security of artificial intelligence applications (Goh & Vinuesa, 2021; Ling, 2023). Moreover, the impacts of AI on society and how to harmonise this technology with sustainable development goals is also an important topic of discussion (Goh & Vinuesa, 2021).

In conclusion, as a technology that supports creative processes and can generate new content, GAI offers both opportunities and challenges. Supporting developments in this field with ethical and legal frameworks is critical for the healthy and sustainable progress of the technology (Ling, 2023; Ng et al., 2021).

The Importance of Generative Artificial Intelligence in Education

The use of GAI in education plays an important role in the transformation of today's education systems. By providing students with personalised learning experiences, GAI makes teaching processes more effective and

improves the quality of learning outcomes (Akkaya & Şengün, 2023; Elçiçek, 2024). Artificial intelligence applications in education make the learning process more interactive and interesting by providing content tailored to the individual needs of students (Sincar, 2023; Tapan-Broutin, 2023). For example, chatbots and virtual teachers support the learning process by answering students' questions instantly and increase students' motivation (Akkaya & Şengün, 2023; Dülger & Gümüşeli, 2023).

GAI also allows teachers to take part in educational processes more efficiently. Thanks to artificial intelligence-supported tools, teachers can better follow the progress of students and intervene when necessary (Bozkurt, 2023; Buluş & Elmas, 2024). This situation allows teachers to use their time more efficiently and interact with more students one-to-one. In addition, artificial intelligence applications help teachers enrich course content and develop innovative teaching methods (Sincar, 2023; Tonbuloğlu, 2023).

However, the use of GAI in education also has some challenges. School leaders and teachers should have the necessary knowledge and skills to overcome the difficulties they may encounter during the integration of these new technologies (Sincar, 2023; Dülger & Gümüşeli, 2023). The ethical and legal dimensions of artificial intelligence applications in education should also be carefully considered. Issues such as the security and privacy of students' data and how these data will be used are critical for the success of AI applications in education (Çolak Yazıcı & Erkoç, 2023; Tosun, 2023).

As a result, the use of GAI in education offers many opportunities for students and teachers, but also poses challenges and ethical issues that need attention. In order for education systems to effectively integrate this technology, teachers and school leaders need to have sufficient knowledge and skills (Kılınç, 2024; Yılmaz et al., 2021). In this context, it is important to ensure a continuous training and development process to make the most of the potential of artificial intelligence applications in education (Adıguzel et al., 2022).

Basics of Generative Artificial Intelligence Technology

GAI is a type of artificial intelligence that can generate new content from existing data, and this technology has the potential to revolutionise many fields. GAI draws attention especially with its ability to create content in various formats such as text, visual and audio. These systems learn from large data sets using deep learning and machine learning techniques and generate new examples from these data (Bozkurt, 2023; Gözet et al. 2023). For example, language models such as ChatGPT are used in many fields such as education, marketing and content production with the ability to create human-like texts (Bozkurt, 2023; Bulut, 2023).

The working mechanism of GAI usually consists of two main phases: data collection and model training. In the first phase, the system collects a large data set on a specific topic or domain. This data set forms the basis for the model to learn. In the second phase, the model uses algorithms to generate new content by learning from this data. For example, structures such as Generative Adversarial Networks (GANs) work in an environment where two models compete against each other to produce more realistic and high quality content (Gözet, 2023). While this process encourages both creativity and innovation, it also increases the capacity to offer customised solutions

according to the needs of users (Durmuş Şenyapar, 2024; Yastıoğlu, 2023).

GAI also plays an important role in businesses. By using this technology, businesses can personalise customer experiences, improve marketing strategies and increase operational efficiency (Durmuş Şenyapar, 2024; Yastıoğlu, 2023). However, the integration of this technology brings some challenges. In particular, issues such as ethical issues, data security and user privacy may pose significant barriers to the adoption of GAI (Doruköz & Uslu, 2023; Ünal & Kılınç, 2024). Therefore, the development of GAI applications within an ethical and sustainable framework will both increase user confidence and ensure the best utilisation of the potential of this technology (Goh & Vinuesa, 2021).

As a result, GAI stands out as a technology that offers great opportunities for both individuals and businesses. Its working mechanisms are based on the collection and processing of data and the production of new content. However, ethical and security issues need to be considered for the successful implementation of this technology. In the future, it is predicted that GAI will be used in more areas and will produce new solutions by collaborating with human creativity (Bozkurt, 2023; Ünal & Kılınç, 2024; Yastıoğlu, 2023).

Language Models: GPT

Language models are artificial intelligence systems that have an important place in the field of natural language processing (NLP) and can produce human-like texts. Among these models, the GPT (Generative Pre-trained Transformer) series developed by OpenAI is particularly noteworthy. GPT-3.5 and GPT-4 are the two latest versions of this series and both of them show high success in text generation, comprehension and various language tasks (Sallam, 2023; Yastıoğlu, 2023). In this report, the features, performances and application areas of GPT-3.5 and GPT-4 will be discussed.

GPT-3.5 is a language model released in 2022 and has been trained on a large amount of text data. This model is notable for its ability to produce human-like responses. On the other hand, GPT-4 was introduced in 2023 and includes significant improvements over its previous version. GPT-4 was trained on a larger dataset and was capable of performing more complex language tasks (Ali et al., 2023; Yastıoğlu, 2023). In particular, the multimodal input capabilities of GPT-4 are notable for its ability to process different types of data such as text and images (Ali et al., 2023; Gamble et al. 2023).

Several studies show that GPT-4 provides a significant performance improvement compared to GPT-3.5. For example, GPT-4 has achieved higher success rates in medical exams and other academic assessments (Kataoka et al., 2023; Yang et al., 2024). The GPT-4 exhibits higher accuracy rates, especially in responses to complex questions, making it a more effective tool in education and healthcare (Guillen-Grima et al., 2023; Hoppe, 2024; Levine et al., 2023). Furthermore, the ability of GPT-4 to answer image-related questions provides a significant advantage in fields such as medical imaging (Ali et al., 2023; Gamble et al., 2023).

GPT-3.5 and GPT-4 have a wide range of applications from education to health. In education, these models provide students with personalised learning experiences and help teachers to enrich their course content (Sallam, 2023). In healthcare, these models are used in clinical decision support systems, processing medical texts and analysing patient information (Hirosawa et al., 2023; Levine et al., 2023). For example, GPT-4 plays an important role in applications developed for summarising medical guidelines and disease diagnosis processes (Bernstein, 2023; Zhenzhu et al., 2024).

In conclusion, GPT-3.5 and GPT-4 have made significant progress in the field of natural language processing and are effectively used in various application areas. GPT-4 stands out with its higher accuracy rates and multimodal processing capabilities compared to its predecessor. The opportunities offered by these models in areas such as education and health play an important role in the future development of artificial intelligence technologies (Ali et al., 2023; Baktash & Dawodi 2023).

Visual Production and Multimodal Systems

Visual production and multimodal systems have an important place in the fields of education and communication. By bringing together different forms of information and communication, these systems enrich learning processes and improve individuals' meaning-making abilities. Visual production, especially in the digital age, allows individuals to understand and express information more effectively. In this report, the definition of multimodal systems, visual production processes and applications of these systems in education will be emphasised.

Multimodal systems are systems that present information by combining different modes of communication (text, sound, image, etc.). These systems encourage the use of multiple senses in learning and teaching processes and help individuals to understand information more deeply (Lim et al., 2021; Smith et al., 2021). For example, if an educational material contains both text and visual content, students can comprehend this material more effectively. This increases the capacity to address different learning styles of students (Fälth et al., 2022).

Visual production is the process of expressing individuals' thoughts, feelings and knowledge in visual forms. This process allows individuals to develop their creativity and make complex information more understandable. Visual production, especially in education, is used to support students' learning processes. For example, students' use of visual materials when presenting their projects helps them communicate information more effectively (Mitri et al., 2018; Perry, 2020). In addition, multimodal approaches encourage students to produce richer and more meaningful content by combining different modes (Yunus et al., 2022).

The use of multimodal systems in education enriches teaching methods and increases student engagement. By using multimodal approaches, teachers can address students' different learning styles and personalise their learning experiences (Liu et al., 2020; Simanjuntak et al., 2024). For example, in a language classroom, students can learn a language more effectively by using a combination of text, audio and images. Such applications help students develop critical thinking skills and deeper understanding of knowledge (Liu, 2023; Wang, 2022).

However, the effective use of multimodal systems in education requires teachers to have sufficient knowledge and experience on how to integrate these systems. The difficulties teachers face when implementing multimodal pedagogies may limit the effectiveness of these systems (Permatasari et al., 2023). Therefore, it is important that teachers are trained about multimodal systems and supported to use these systems effectively.

In conclusion, visual production and multimodal systems play an important role in education. These systems improve individuals' meaning-making abilities, enrich learning processes and increase participation. In order to use multimodal systems effectively in education, teachers should have knowledge about these systems and have sufficient experience. In the future, multimodal systems are expected to find more place in education and enrich individuals' learning experiences (Crane-Deklerk, 2020; Liang & Yao, 2023).

Generative Artificial Intelligence in Education: Potentials

Student-centred learning stands out as an approach that encourages the active participation of individuals in education and the customisation of learning processes. In this context, GAI applications have a significant potential to enrich student-centred learning environments and enhance students' learning experiences. In this report, the effects and potentials of GAI applications on student-centred learning will be discussed.
GAI is a type of artificial intelligence that can generate new content from existing data. This technology has the capacity to provide learning materials and experiences customised to the individual needs of learners (Ergünen et al., 2023). For example, language models such as ChatGPT provide personalised responses to students, enabling them to actively participate in learning processes (Bozkurt, 2023). Such applications increase learning motivation and make learning processes more effective by providing content according to students' learning styles and interests (Uyar & Doğanay, 2018).

GAI offers several ways to enrich student-centred learning environments. Firstly, this technology allows teachers to diversify their course content and teaching methods. By using GAI applications, teachers can create materials that appeal to different learning styles of students (Elçiçek, 2024). In addition, AI-supported tools help students to manage their own learning processes and make self-evaluation (Tabier & Bakanay, 2023). This contributes to the development of students' independent learning skills.

GAI applications increase interaction among students by supporting collaborative learning environments. Students can develop projects, exchange ideas and conduct group work together through artificial intelligence-based platforms (Gözet, 2023). Such interactions allow students to develop their social skills and think from different perspectives. Moreover, by analysing students' group dynamics, artificial intelligence provides teachers with the opportunity to evaluate students' interactions and participation (Kılıçarslan, 2019).

In conclusion, GAI applications have significant potential to enrich student-centred learning environments and enhance students' learning experiences. By providing individualised learning materials, this technology increases students' motivation and makes learning processes more effective. However, in order to integrate these applications successfully, teachers need to have sufficient knowledge and skills and ethical issues need to be taken

into consideration. In the future, GAI applications are expected to find more place in education and support student-centred learning approaches (Tapan-Broutin, 2023).

Content Development and Automation

Content development and automation in education has an important place in today's digitalised world. GAI applications have the potential to create revolutionary changes in this field. In this report, the role, advantages and potential challenges of GAI in content development and automation processes in education will be discussed.

GAI, as a technology that can generate new content from existing data, significantly transforms content development processes in education. GAI applications in the creation of educational materials reduce the workload of teachers and educators, allowing them to produce faster and more effective content (Özer & Çakmak, 2024). For example, AI-supported tools can automatically generate various types of content such as lecture notes, exam questions and interactive learning materials (Elçiçek, 2024). This allows teachers to focus on more creative and instructive activities.

Furthermore, GAI has the capacity to provide customised content according to student needs. Materials tailored to students' learning styles and interests increase learning motivation and make learning processes more effective (Pekyürek, 2021). For example, an interactive course content created specifically for a student can enable the student to understand better and make the information more permanent.

Automation in education is an important tool to make teaching processes more efficient. By supporting automation processes, GAI helps teachers to use their time more efficiently. For example, AI-based systems can monitor student performance, perform data analysis and optimise teaching strategies (Turhan Türkkan, 2024). Such automation allows teachers to respond more quickly to student needs.

Moreover, AI-supported learning management systems enrich learning experiences by increasing student interaction. These systems support learning processes by providing personalised feedback to students (Buluş, 2024). Tracking students' progress and intervening when necessary allows teachers to guide more effectively.

In conclusion, GAI applications have the potential to significantly transform content development and automation processes in education. This technology has the capacity to provide students with personalised learning experiences while reducing the workload of teachers. However, for the successful integration of these applications, ethical issues need to be taken into account and teachers need to have sufficient knowledge and skills. In the future, GAI applications are expected to find more place in education and support content development processes (Kılınç, 2024).

Feedback and Personalisation

The use of GAI in the process of instructor feedback and personalisation in education has significant potential to

enrich learning experiences and better respond to the individual needs of learners. In this report, the effects, advantages and potential challenges of GAI applications on feedback processes and personalisation in education will be discussed.

GAI has the capacity to transform feedback processes in education. AI-supported systems make learning processes more effective by providing instant feedback to students. For example, chatbots and virtual teachers help students overcome the difficulties they face in the learning process by providing fast and accurate answers to their questions (Yıldız Durak & Onan, 2023). Such applications increase students' motivation to learn and personalise their learning experiences.

Moreover, GAI applications allow teachers to monitor and evaluate student performance. By analysing student data, these systems provide teachers with information on which areas they need to give feedback (Sincar, 2023). This enables teachers to provide more targeted and effective feedback.

By supporting the personalisation process in education, GAI has the capacity to provide content suitable for the individual learning needs of each student. Materials customised according to students' learning styles, interests and performances make learning processes more effective (Tapan-Broutin, 2023). For example, an interactive course content created specifically for a student can enable the student to understand better and make the information more permanent.

In addition, GAI applications provide the opportunity to intervene when necessary by tracking students' progress. By using this data, teachers can determine in which subjects students need more help and provide personalised support accordingly (Buluş, 2024). While such an approach makes students' learning processes more effective, it also reduces the workload of teachers.

In conclusion, GAI applications have the potential to significantly transform the processes of educational feedback and personalisation in education. This technology has the capacity to provide students with personalised learning experiences while reducing the workload of teachers. However, for the successful integration of these applications, ethical issues need to be taken into account and teachers need to have sufficient knowledge and skills. In the future, GAI applications are expected to find more place in education and support feedback processes (Güzey et al., 2023).

Educational Games and Simulations

Educational games and simulations are important tools that make learning processes more interactive and fun. In this context, GAI applications have a great potential for enhancing educational games and simulations. In this section, the role of GAI in educational games and simulations, its advantages and challenges will be discussed.

GAI, as a technology that can generate new content from existing data, is an important tool in the design and development of educational games. GAI has the capacity to automatically generate game scenarios, characters and tasks (Ülker & Çamli, 2023). This allows game developers to produce more content by spending less time.

For example, AI-supported systems can offer customised game experiences according to students' interests and learning styles (Bozkurt, 2023). Such personalised content increases students' motivation and makes learning processes more effective.

Moreover, GAI applications have the ability to dynamically adjust the difficulty levels of educational games. Based on students' performance, the challenges within the game can be increased or decreased, which allows each student to learn at their own pace (Yalçın, 2020). This kind of adaptation makes students' learning experiences more effective, while at the same time reducing learning loss.

Educational simulations enable students to gain practical skills by mimicking real-world scenarios. GAI can help make simulations more realistic and interactive. For example, AI-supported simulations can provide feedback by instantly analysing students' decision-making processes and results (Demirekin, 2023). This situation deepens students' learning processes and enables them to have more meaningful experiences.

In addition, GAI can be used to enrich the content of simulations. The situations that students encounter during simulations can be dynamically generated by artificial intelligence, which enables simulations to offer different experiences each time (Ekrem & Daşikan, 2021). This diversity helps students develop their problem solving skills.

In conclusion, GAI applications have a significant potential for the enhancement of educational games and simulations. By providing personalised learning experiences, this technology increases students' motivation and makes learning processes more effective. However, for the successful integration of these applications, ethical issues need to be taken into account and teachers need to have sufficient knowledge and skills. In the future, GAI applications are expected to find more place in education and support educational games and simulations (Tosun, 2023).

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Chapter 3 - Artificial Intelligence Tools and Competence Development for Educators

Murat Çoban

Introduction

Artificial intelligence (AI) is rapidly spreading as a technology that leads to radical changes in the field of education. While traditional methods in education are changing with student-centered and personalized approaches, AI has become an important part of this transformation (Kanchon et al., 2024). Providing customized learning content in accordance with the individual needs of students, AI enables individualized learning experiences in education. These personalized learning approaches make students' learning processes more efficient, increase their success, and strengthen their motivation to learn (Ayeni et al., 2024).

The role of AI in education not only supports personalised learning but also makes significant contributions to teaching processes. AI-based tools, such as learning analytics, provide data-driven insights to teachers by monitoring student performance and enabling the restructuring of teaching strategies (Susnjak, 2024). These tools enable teachers to identify students' strengths and weaknesses more accurately, helping them to reshape lessons according to student needs (Gedrimiene et al., 2024). These innovative approaches in education enable teachers to develop more dynamic and effective teaching methods by integrating their pedagogical skills with digital technologies (Díaz & Nussbaum, 2024).
In addition, the possibilities offered by AI have brought new forms of education that make learning independent of time and space. For example, virtual assistants and chatbots ensure the continuity of learning by offering guidance to students at all times (Roca et al., 2024). Such technologies allow students to learn at different times and in different environments while easing the workload of teachers (Korda et al., 2024). In this context, AI is transforming not only educational content but also learning environments and students' learning processes.

The implementation of AI in education has also changed the roles of teachers. Student-centered and technology-supported learning models have replaced traditional teaching approaches. This change ends the role of teachers as authorities who only transfer knowledge and move them to a position of facilitating and guiding learning processes. This new role of educators requires new competencies such as digital literacy, data analytics, and technological and pedagogical knowledge (Díaz & Nussbaum, 2024; Gedrimiene et al., 2024; Korda et al., 2024).

For teachers to use AI technologies effectively, it is not enough for them to have only technical knowledge; they are also expected to design more flexible and interactive teaching processes by integrating their pedagogical understanding with technology (Yue et al., 2024).

However, the challenges faced in order to utilize the potential of AI in education cannot be ignored (Ayeni et al., 2024; Díaz & Nussbaum, 2024; Looi, 2024). Rapid integration of technological developments into education systems is one of the most important challenges faced by educators (Nicolas, 2018). Educators need to adopt AI practices, develop their digital skills and adapt their pedagogical roles to technology (Cheng & Wang, 2023). However, some ethical issues need to be resolved in order to make AI responsible in education (Akgun & Greenhow, 2022). Issues such as data privacy, algorithmic biases, and transparency constitute the ethical dimensions of using AI in education (Akgun & Greenhow, 2022; Reiss, 2021; Eden et al., 2024). In this context, it is of great importance for educators to understand not only the technology but also the ethical use of these technologies.

As a result, the role of AI in education is becoming increasingly evident. This transformation in education is reshaping the way teachers and students interact with technology, making the educational ecosystem more flexible, personalized, and efficient. Educators' adaptation to AI and the effective use of these technologies in teaching processes are critical for the future of education. This chapter aims to comprehensively address the potential of AI in education, teachers' adaptation processes to these technologies, and the effects of this transformation on the educational ecosystem.

Use of Artificial Intelligence Tools in Education

Conceptual Framework

Understanding the integration of AI in education requires covering not only the technical dimensions of this technology but also the attitudes of users towards these innovative technologies. At this point, the Technology Acceptance Model (TAM) provides a valuable theoretical framework for understanding the factors influencing the adoption and use of technologies. The basic constructs of TAM include perceived usefulness, perceived ease of use, attitude towards use, and intention to use. Perceived usefulness and perceived ease of use are the primary antecedents of usage attitude and usage intention. Perceived usefulness refers to the degree to which an individual believes that using a particular system will improve job performance, while perceived ease of use refers to the degree to which users feel that using the technology requires minimal physical or mental effort (Davis, 1989). However, the inclusion and configuration of these variables may vary depending on the study design. These differences are usually due to factors such as whether the mediating effect of attitude is examined and whether the study focuses on a specific technology (Şahin & Şahin, 2022).

In this context, educators' attitudes towards AI-based technologies depend on their perceptions of the extent to which these tools improve their teaching processes and how practical their use is (Pokrivcakova, 2024; Wang et al., 2021). For example, AI-supported learning analytics tools offer teachers significant advantages in monitoring students' performance and meeting their individual needs. These benefits increase the likelihood of teachers

adopting the technology, while perceptions of ease of use further accelerate this process (Lakshmi et al., 2024).

The integration of AI into educational technologies not only depends on perceptions of perceived usefulness and ease of use but also influences users' confidence and motivation towards these technologies. For example, if a teacher thinks that an AI-supported learning management system will effectively meet students' needs and positively influence classroom dynamics, they are more likely to adopt it. However, the complex nature of the system or ethical concerns (e.g., data privacy) may negatively affect users' trust in these technologies (Omrani et al., 2022). In this context, the TAM model explains not only users' perceptions of technological innovations but also their behavioral intentions influenced by these perceptions (Davis, 1989; Şahin & Şahin, 2022).

Applications of AI technologies in education provide examples that directly reflect the principles of TAM. For example, AI-based virtual assistants designed for teachers increase perceived usefulness by automating complex tasks and responding quickly to student questions. Similarly, user-friendly interfaces and intuitive designs increase the perceived ease of use of these tools (Li et al., 2024). Such features support teachers' technology adoption, enabling them to use AI effectively in pedagogical processes (Lakshmi et al., 2024).

The TAM model also provides a roadmap to address the challenges that the integration of AI in education may face. In particular, issues such as teachers' lack of knowledge of these technologies or resistance to technology can negatively affect the adoption process (Bhaskar & Rana, 2024). Therefore, educational policies and teacher training programs must aim to increase the perceived usefulness and ease of use of AI-based technologies. Moreover, developing teachers' technological skills and supporting them plays a critical role in this transformation process (Alghamdi & Alhasawi, 2024).

As a result, for the effective use of AI in educational technologies, educators' attitudes and perceptions towards these technologies need to be taken into account. TAM provides a comprehensive theoretical framework to understand and improve the adoption of AI in education. This model supports teachers in integrating technology into their pedagogical processes while enabling students to have more efficient and personalized learning experiences.

Leading Artificial Intelligence Tools for Education

AI tools offer individualized learning experiences in education, providing content and feedback tailored to students' needs (Ayeni et al., 2024; Díaz & Nussbaum, 2024). These tools ease the workload of teachers and enable more informed pedagogical decisions through learning analytics and performance tracking. Moreover, AI-based virtual assistants and content development platforms support learning processes by creating an accessible and continuous support mechanism for students (Kanchon et al., 2024; Korda et al., 2024). The use of AI in education both transforms teaching processes and makes them more inclusive and effective. Below, some AI tools that can be used in education are presented under headings:

Content Production and Management Tools

- ✓ **Canva**: As a visual design tool, Canva allows you to create posters, infographics and social media content. AI speeds up the design process by offering template suggestions and automatic edits. It makes training materials impressive and professional.

  Link: https://www.canva.com

- ✓ **ChatGPT**: It is a text-based AI tool used to create educational material. It contributes to both teachers and students with its functions such as question preparation, summarising and language support. It is suitable for explaining complex topics in understandable language.

  Link: https://chat.openai.com

- ✓ **Kahoot**!: Interactive test and game-based learning platform. It offers individualised learning experiences by analysing performance data with AI support. It ensures that students are motivated and learn by having fun.

  Link: https://kahoot.com

- ✓ **Quizlet**: Allows you to create flashcards and interactive study sets. It provides content enriched with images, sounds and text and has a wide range of uses from language learning to academic studies.

  Link: https://quizlet.com

- ✓ **Synthesia**: Creates educational material by converting text to video. Produces personalised content by providing customisable avatars and scenarios. It helps you to prepare audiovisual materials easily.

  Link: https://www.synthesia.io

- ✓ **Perplexity** AI: It is an AI tool that accelerates information gathering and summarisation processes. It creates simple and instructive content by analysing complex concepts. It offers guidance and information verification functions in research.

  Link: https://www.perplexity.ai

- ✓ **Loom**: Allows you to create screencasts and narrated videos. It is an effective tool for lecture presentations, guidance videos and teamwork. It is easy to use and supports rapid content creation.

  Link: https://www.loom.com

- ✓ **Explain Everything:** It allows you to visualise complex concepts with its digital whiteboard feature. It enriches explanations by providing animation, sound and interactive drawings. Suitable for group work and distance learning.

  Link: https://explaineverything.com

- ✓ **ThingLink:** Allows you to create interactive tags on images and videos. Ideal for producing conceptual maps, multimedia explanations and annotated content. It supports students' visual and auditory learning processes.

  Link: https://www.thinglink.com

- ✓ **H5P**: HTML5-based content creation tool that allows you to create interactive quizzes, presentations and educational materials. Thanks to its user-friendly interface, teachers can easily develop content. It provides integration to distance education platforms.

Link: https://h5p.org

Some tools may charge additional fees to users in order to fully utilize their functionality. Pricing information about the tools can also be accessed by following the pricing guidelines on the relevant web link. There are also tools with more specific features than these. Within the scope of the section, only certain prominent tools are presented.

Student Evaluation and Tracking Systems

There are some AI-supported tools used for the assessment and tracking of students in education. Information about these tools is presented below:

- ✓ **GradeScope**: This AI-supported tool speeds up the grading process for teachers by automatically evaluating written and unwritten answers. It also has features such as rubric-based assessment, peer assessment, and plagiarism detection.

  Link: https://www.gradescope.com

- ✓ **Kahoot**!: This tool increases student engagement through interactive quizzes and game-based learning activities. It allows teachers to assess student achievement by providing real-time feedback and analyses.

  Link: https://kahoot.com

- ✓ **ChatGPT**: It can interact with students to answer questions, summarise text, give feedback, and measure students' understanding. It can also help teachers to create written materials.

  Link: https://chat.openai.com

- ✓ **Fetchy**: supports students' learning by providing them with personalized educational resources. It offers lesson plans and educational material suggestions for teachers, thus facilitating content creation.

  Link: https://www.fetchy.com

- ✓ **Plickers**: It offers teachers who use technology in the classroom in a limited way the opportunity to make instant assessments through QR-coded cards on paper. Students' responses are quickly collected,and feedback is provided.

  Link: https://www.plickers.com

- ✓ **Querium**: Offers personalized educational support to students in STEM (Science, Technology, Engineering, Mathematics) subjects. AI analyses students' knowledge levels and provides tutoring and feedback tailored to each individual.

  Link: https://www.querium.com

- ✓ **Otter.ai:** Converts audio content into written text in real time. This feature enables the repetition of course material for students and the accessibility of lessons for teachers.

  Link: https://otter.ai

- ✓ **DreamBox:** Offers personalized lessons to improve students' mathematical skills. AI adjusts lesson difficulties according to student's skill levels and provides feedback.

  Link: https://www.dreambox.com

- ✓ **Consensus**: It offers structured discussions and consensus-building processes to develop students' group decision-making and critical thinking skills.

  Link: https://www.consensus.app

- ✓ **Plaito**: Provides immediate feedback on grammar, style and clarity to students who are writing. The AI analyses errors in written content and suggests points for correction.

  Link: https://www.plaito.ai

These tools provide AI support to make student assessment and follow-up processes in education more effective and help teachers use their time more efficiently.

Personalized Learning Applications

AI-supported personalized learning applications make learning processes more efficient and interactive by providing educational materials and experiences tailored to the individual needs of learners. Some of the leading tools in this field are presented below:

- ✓ **DreamBox:** Offers personalized mathematics lessons for K-8 students. AI automatically adjusts the course content according to the pace of students' progress, providing material at the appropriate difficulty level for each student.

  Link: https://www.dreambox.com

- ✓ **Squirrel AI:** This platform offers customized lessons based on students' learning speed and levels of understanding. AI analyses students' strengths and weaknesses and creates a personal learning plan.

  Link: https://www.squirrelai.com

- ✓ **Knewton:** Provides adaptive learning solutions for students. By identifying the areas where students fail, AI enables them to focus more on those areas and personalizes the learning process.

  Link: https://www.knewton.com

- ✓ **Smart Sparrow:** Provides students with personalized learning experiences through learning analytics and adaptive learning tools. The system enables students to learn more effectively by adjusting the content according to the needs of each of them.

  Link: https://www.smartsparrow.com

- ✓ **Carnegie Learning:** It is an AI-supported maths learning platform. By providing personalized learning experiences, it helps students develop their mathematical thinking skills.

  Link: https://www.carnegielearning.com

- ✓ **CogBooks:** A platform that offers personalized learning paths. AI enables each student to learn more efficiently on an individual basis by providing course content tailored to the student's learning pace and preferences.

  Link: https://www.cogbooks.com

These tools provide students with a personalized learning experience, with content and feedback tailored to each student's learning style and pace. AI-supported personalized learning can make the learning process more

effective, efficient, and student-centered.

Competence Development of Educators with Artificial Intelligence

Digital Competences for Educators: An Artificial Intelligence Perspective

Digital competence in education refers to teachers' ability to use technology effectively (Amhag et al., 2019). AI plays an important role in developing these competences. Educators' digital competences encompass not only their ability to use technology, but also how to integrate digital tools into educational processes and how to guide students safely and effectively in the digital world (Falloon, 2020). AI enables educators to manage these processes more effectively, individualising teaching methods, analysing student performance and improving teachers' time management (Díaz & Nussbaum, 2024; Susnjak, 2024; Gedrimiene et al., 2024).

AI also contributes to educators' professional development processes (Al-Zyoud, 2020). Teachers can continuously improve their digital skills through AI-based training programmes and mentoring systems (Tammets & Ley, 2023). This development provides opportunities for teachers to use digital tools and make their teaching strategies more effective (Postholm, 2018). Such tools, which increase educators' digital competences, not only improve efficiency in the classroom but also strengthen teachers' professional identities (Al-Zyoud, 2020; Tammets & Ley, 2023).

In this context, developing digital competences in education is critical for teachers to be able to guide students' learning processes more effectively (Kiryakova & Kozhuharova, 2024). AI-supported tools help teachers to increase their digital competences while adding a new dimension to their educational processes (Nguyen, 2024). This development has become a fundamental requirement for both teachers and students to be more successful in the digital age (Tammets & Ley, 2023). It can be argued that investments in increasing the digital competencies of educators are also an important step in the modernisation of education systems.

Artificial Intelligence Supported Teaching Strategies

AI-supported teaching strategies enable student-centred, interactive and personalised learning experiences (Ayeni et al., 2024; Díaz & Nussbaum, 2024). These strategies help teachers to make educational processes more efficient, while providing students with more meaningful learning opportunities (Kanchon et al., 2024; Korda et al., 2024). Strategies such as individualised learning, adaptive learning systems, automatic feedback and assessment, interactive and gamified learning can be shown among AI-supported teaching strategies.

Individualised learning addresses the individual needs of each student by adapting course materials according to students' learning styles and speeds. These systems analyse students' strengths and weaknesses and provide them with tailored content, tests and feedback (Dutta et al., 2024). For example, platforms such as Knewton and Smart Sparrow track student progress and adapt the course with content richness when necessary (Kakish et al., 2022). Adaptive learning systems are systems that assess students' achievement levels in a given subject in real time and modify the course content accordingly (Rane et al., 2024a). This strategy allows students to practice more on subjects they do not understand or have difficulty with (Barbosa et al., 2024). Tools such as DreamBox and McGraw Hill Education's ALEKS create a more effective learning process by providing materials appropriate to each student's learning journey (Ahmad et al., 2025).

Automated feedback and assessment systems can provide immediate feedback to students. Thanks to these systems, the learning process is accelerated and students realise their mistakes earlier (Messer et al., 2024). Tools such as Grammarly and Turnitin assess students' written materials to detect grammatical errors, plagiarism risks and ambiguities. Such tools help teachers to use their time more efficiently. AI-supported interactive and gamified learning strategies are a strategy that increases students' motivation and encourages them to participate more actively in lessons (Onesi-Ozigagun et al., 2024). Tools such as Kahoot! and Quizlet offer students the opportunity to learn in a fun environment. These tools increase students' interest and engagement in learning by providing them with fun tests and games (Wang & Tahir, 2020).

In addition, AI supported with virtual and augmented reality technologies offers students the opportunity to experience real-world environments in a virtual environment (Coban et al., 2022; Gandedkar et al., 2021). zSpace and Google Expeditions visualise complex scientific and mathematical concepts in a way that enables students to better understand them. These tools help students learn in a more interactive way (Dhabliya et al., 2024). These strategies help teachers to adapt their teaching more effectively to the individual needs of students and enable students to be more engaged in their own learning processes (Gandedkar et al., 2021).

Ethics and Data Security Issues

While the rapid development of artificial intelligence systems offers great opportunities in many fields such as education, health and defence, it also raises ethical and security issues. Ethical concerns that arise during the creation and use of these systems threaten values such as justice, equality and privacy. For example, artificial intelligence tools used in education may make biased decisions towards some groups, which may harm equality of opportunity (Farahani & Ghasemi, 2024). Similarly, social biases in the data sets on which algorithms are trained may cause these systems to produce biased results and reinforce existing inequalities (Tejani et al., 2024). Security issues are critical in terms of the impact of artificial intelligence applications on both individual users and systems. In particular, the vulnerability of artificial intelligence systems to cyber-attacks may lead to the manipulation of these systems by malicious people (Hashmi et al., 2024). Artificial intelligence-supported platforms such as learning management systems used in education carry great risks in terms of protecting students' personal data (Rane et al., 2024b; Airaj, 2024). Such vulnerabilities have the potential to both violate the privacy of individuals and create organisational damages.

To overcome these problems, transparency, accountability and regulatory frameworks are of great importance in the design, development and implementation of artificial intelligence systems. In this direction, international collaborations and standards have a critical role to ensure ethical and safety oversight of AI applications. In addition, educators and decision makers should make informed choices by taking into account the ethical and safety dimensions of these technologies and ensure the fair use of systems (Airaj, 2024; Farahani & Ghasemi, 2024; Hashmi et al., 2024; Rane et al., 2024b; Tejani et al., 2024). Shaping the effects of artificial intelligence on society will be possible not only with technical solutions but also with ethical values.

Challenges and Solution Suggestions for the Use of AI in Education

The use of AI in education offers significant advantages such as providing students with personalised learning experiences, reducing teachers' workload and optimising learning processes. However, the widespread use of this

technology brings with it various challenges. Among these challenges, technical, pedagogical and ethical issues stand out (Abulibdeh et al., 2024). In this context, both the identification of these challenges and the development of solutions are critical to ensure the effective and fair use of artificial intelligence technologies in education.

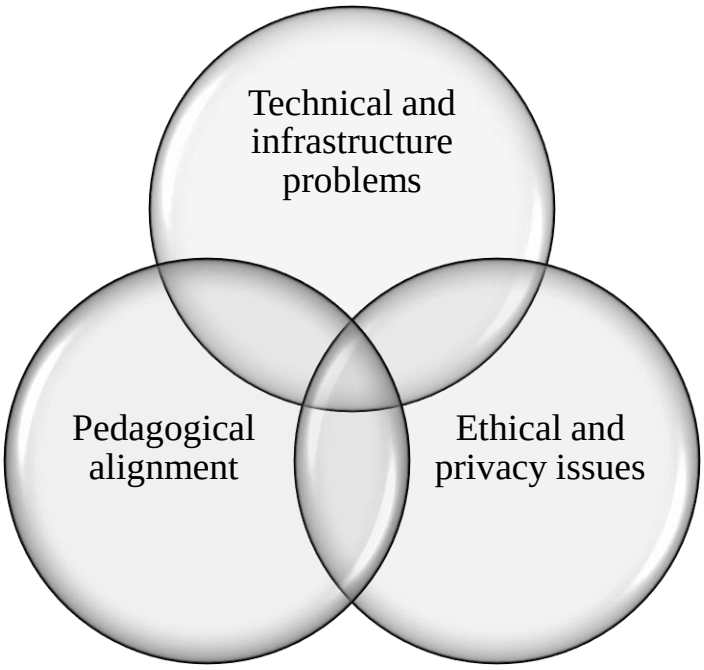

Figure 1. Main challenges for the use of AI in education

Firstly, the lack of the necessary infrastructure for the effective use of AI tools in educational institutions is an important problem. In many schools, basic requirements such as computer hardware, internet access and modern software are insufficient (Hwang et al., 2020). This problem is especially evident in rural areas. In addition, technical know-how is required to integrate and sustain artificial intelligence systems (Kamalov et al., 2023). The solution of this problem requires the creation of comprehensive training programmes for educators and technical staff and the restructuring of educational budgets in this direction.

Secondly, the integration of AI technologies into educational environments requires changes in pedagogical approaches. However, it is observed that teachers have difficulty in adapting to new technologies in this transformation process (Holmes et al., 2019). Educators may have difficulty in learning how to use these tools effectively for pedagogical purposes. In addition, the data provided by these tools may not be used effectively enough to prepare materials customised to the individual needs of students. To overcome this challenge, teachers should be offered professional development programmes to help them understand the pedagogical potential of AI tools (Abulibdeh et al., 2024; Hwang et al., 2020; Kamalov et al., 2023).

Thirdly, the large amount of data collected during the use of AI systems raises serious concerns about students' privacy. In particular, there is a lack of clear rules and regulations on how this data should be stored securely and used only for educational purposes (Airaj, 2024; Farahani & Ghasemi, 2024; Hashmi et al., 2024; Rane et al., 2024b; Tejani et al., 2024). In addition, biased judgements of algorithms may increase the risk of discrimination of certain groups of students. In this context, the solution to ethical problems may be possible through transparency in the design of artificial intelligence tools, fair data usage policies and the implementation of international

standards.

In this context, multidimensional approaches are necessary to ensure the effective use of artificial intelligence technologies in education. Firstly, government support and private sector collaborations can be increased to solve infrastructure problems. Secondly, continuous professional training programmes can be organised for teachers to use artificial intelligence tools pedagogically effectively. Thirdly, ethical rules and data security standards should be clarified at national and international level. Furthermore, awareness should be raised among teachers, students and parents about the ethical use and potential risks of these technologies (Floridi & Cowls, 2022).

In conclusion, realising the full potential of AI technologies in education will be possible not only by solving technical and pedagogical problems but also by prioritising ethical values. With careful planning and a comprehensive implementation process, the use of artificial intelligence in education can benefit all segments of society.

Conclusion

The use of AI tools in education has the potential to transform teaching processes, making learning experiences more effective, personalised and accessible. These tools bring with them a wide range of functions such as analysing student performance, providing materials suitable for individual learning styles and easing the administrative burden of teachers. For example, adaptive learning systems can create a customised learning plan for each student by identifying their individual strengths and weaknesses. This feature enables more effective management of individual differences in the classroom (Ahmad et al., 2025; Barbosa et al., 2024; Rane et al., 2024a).

AI tools offer significant advantages to educators, especially with their data analytics and automation capabilities. With these tools, educators can better understand students' learning tendencies and reshape curriculum design accordingly. In addition, AI-supported tools such as language learning applications and interactive learning platforms can make the learning process seamless by providing educational support to students outside the classroom (Zawacki-Richter et al., 2019). For example, language learning applications such as Duolingo can make language learning both fun and effective by providing content suitable for students' levels (Dualingo, 2024).

In the future, the role of AI tools in education will expand further and they will be able to take on complex teaching tasks. For example, educational robots can allow teachers to get rid of repetitive tasks, while at the same time supporting social learning processes by interacting with students (Luckin et al., 2016). Moreover, the impact of AI on learning analytics will contribute to the development of educational policies not only at the individual student level, but also on a broader scale. These tools can help educators to make strategic decisions based on data and allow them to design more efficient educational systems.

Recommendations

The importance of AI tools in education is not only limited to supporting teaching processes; it also encourages lifelong learning habits by revealing students' individual potentials. However, in order to use these tools effectively, teachers need to develop their digital literacy skills and consider the ethical dimensions of these

technologies. In the future, increasing research on the use of artificial intelligence technologies in education will make these tools more valuable for both teachers and students. Moreover, the sustainability of innovations such as AI in education is critical to adapt to the changing needs of modern societies and to support individuals' lifelong learning processes. This sustainability can be achieved not only through the adoption of innovative approaches, but also through the effective implementation and continuous improvement of these approaches (Fullan, 2007). Integrating innovation into education systems requires students to acquire 21st century skills and teachers to effectively adapt technology to pedagogical processes (Kocak et al., 2021). However, in this process, the cooperation of stakeholders, proper management of resources and a flexible policy framework are important for innovations to remain viable and effective in the long term.

The sustainability of innovative tools such as AI is not only limited to the use of technological tools; it also involves the restructuring of pedagogical strategies and management models. For example, hybrid learning models, supported by digital tools, offer the potential to provide equal opportunities in education. However, the sustainability of these innovations depends on the inclusion of teachers in professional development programmes, the development of students' ability to use technology effectively and the elimination of infrastructure deficiencies (Abendan et al., 2023). It should not be forgotten that the difficulties to be experienced in the dissemination and implementation of innovations are not only related to initial costs, but also to user resistance and rapid change of technology. Therefore, a systematic approach is required to increase the sustainability of innovation in education. Educational leaders, school administrators and policy makers should continuously evaluate the impact of innovative approaches and develop strategies based on the results obtained. For example, data-driven decision-making processes are a critical tool for measuring the effectiveness of innovations and adapting to requirements. In addition, fostering a learning culture in the society and supporting teachers' ability to develop creative solutions are also important for sustainability (Hargreaves & Shirley, 2012).

In conclusion, the sustainability of innovations such as AI in education is a dynamic and complex process and can be made possible not only by the integration of technological tools but also by the joint effort of all stakeholders in education. Accordingly, future education systems should be flexible and inclusive, optimising innovations according to the needs of both individuals and society. The sustainability of AI in education, in this context, appears as a necessity to produce solutions not only to the problems of today but also to the problems of the future.

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Chapter 4- The Design of Instructional Materials with the Aid of Artificial Intelligence

Abdullatif Kaban

Introduction

The recent exponential growth in artificial intelligence (AI) technology has paved the way for innovative applications in the field of education. In particular, generative AI technologies show great promise for the production, diversification, and customization of educational resources. The capacity of generative AI to generate a multitude of material formats, including text, images, audio, and video, provides educators with the potential to more effectively engage with students (Brown et al., 2020; Goodfellow et al., 2014). While it also gives rise to ethical concerns, AI has a profoundly beneficial impact on education, offering avenues such as personalized learning experiences and enhanced teacher engagement (Polat, 2023).

The implementation of generative AI in the field of education has the potential to expedite the process of developing educational materials, thereby reducing time expenditure and facilitating the generation of information tailored to the specific requirements of each student (Tapalova & Zhiyenbayeva, 2022). For instance, the production of materials that are adapted to the distinctive learning preferences of each student in a classroom can enhance the efficacy of instruction (Xia et al., 2022). Nevertheless, as these technologies may have unintended consequences on the learning process, it is essential to address the inappropriate or unethical utilization of these technologies with caution (Bender et al., 2021).

The function of generative AI technologies in the development of authentic course materials will be discussed in this section, along with a number of examples of their use. By analyzing the possible advantages and disadvantages of AI-based methods for designing instructional materials, the goal is to gain a better understanding of the role of these technologies in education. This study serves as a road-map for designing instructional materials using AI, with the goal of providing educators with both theoretical and practical insights.

Generative Artificial Intelligence technologies and their use in education

What is Generative Artificial Intelligence?

A subset of artificial intelligence called generative AI uses data to generate fresh and unique content. This content has multiple uses and can be in various formats, including text, photos, audio, and video (Manel Guettala et al., 2024). Large data sets are typically analyzed using generative AI systems to identify the salient features of fresh data, which are then used to produce content. For example, two neural networks can compete to produce realistic photos and other types of material using generative adversarial networks (GANs) proposed by Goodfellow et al. (2014).

Significant advancements have been made in this technology, particularly in the domains of natural language processing (NLP) and visual processing. Models such as GPT (Generative Pre-trained Transformer) are capable of generating text that is human-like in its quality and style, using large pre-trained language models. Models such as DALL-E are known for their ability to generate visual content (Brown et al., 2020). Generative AI is used in a wide range of fields, including education, health, art and design, and marketing. It is regarded as a complementary tool to human productivity (Liu et al., 2024).

The implementation of generative AI in the field of education offers a multitude of advantages, including the ability to personalize, diversify, and enhance the accessibility of educational materials. For example, educators can employ this technology to develop examination questions tailored to students' specific requirements, design visual aids to simplify complex concepts, or develop audio content to facilitate language learning. As demonstrated by Xia et al. (2022), generative AI tools provide an optimal solution for generating material tailored to individual student needs in adaptive learning platforms.

However, the effective functioning of generative AI systems requires the availability of substantial quantities of data and computational power. This gives rise to a number of ethical and technical considerations. For instance, the accuracy and objectivity of the content generated by the model are of paramount importance in the context of education. Furthermore, the legal responsibilities associated with the content generated by generative AI systems, including matters of copyright, must also be addressed (Bender et al., 2021).

In conclusion, generative AI is a technology with both potential and challenges. While applications of generative AI in education have the capacity to transform learning processes, the ethical, legal, and practical dimensions of these technologies require careful consideration. In this context, it is essential for educators and policymakers to develop guidelines that promote responsible and informed use of generative AI.

Generative Artificial Intelligence Tools for Education

ChatGPT

ChatGPT, developed by OpenAI, represents a fusion of natural language processing (NLP) and generative AI technologies. ChatGPT is capable of generating responses that are human-like in their quality and content in

response to text-based queries or inputs. ChatGPT has a multitude of applications in the field of education, including the creation of text drafts, the enhancement of writing abilities, and the provision of individualized learning guidance for students (Punar Özçelik & Yangın Ekşi, 2024). For instance, it can assist students in generating ideas for composing an essay or help educators swiftly devise lesson plans. Nevertheless, it is imperative to exercise caution when it comes to content accuracy and ethical usage. This tool presents educators with the opportunity to cultivate metacognitive abilities (Hutson & Plate, 2023).

DALL-E

DALL-E is an artificial intelligence tool developed by OpenAI for the generation of visual content. The tool is capable of producing original images and illustrations based on a written description. Its applications in education are numerous, particularly in the design of visual materials. For instance, it can be used to produce special illustrations for textbooks, experimental scenarios, or impressive graphics for historical lessons. Additionally, it serves as a source of inspiration for students, facilitating the expansion of their imaginative capabilities (Marcus et al., 2022).

MidJourney

MidJourney is a notable example of a text-to-visual artificial intelligence model, particularly for its capacity to produce art-based visualizations. This tool is highly effective in visualizing complex or abstract concepts. In an educational context, it can be used to visualize scenes from works of literature, to assist in quality writing activities, or to enable students to critically evaluate media. MidJourney is a tool that can be used to advance the field of media literacy studies (Jaruga-Rozdolska, 2022).

Features of Artificial Intelligence Tools in Educational Materials Design

The aforementioned tools facilitate the expeditious and authentic production of training materials. For example, ChatGPT is capable of generating text-based materials, quiz questions, and interactive scenarios. DALL-E and MidJourney are able to produce immersive and authentic visuals that can be utilized to enhance visual learning. While these tools have immense potential in the field of education, it is crucial for users to ensure the accuracy of the data they input and to critically evaluate the results. However, educators must also be mindful of the ethical, access, and equity-related issues that these tools may raise.

Generative Artificial Intelligence Approaches in Designing Original Course Materials

Text-based Material Production

The use of generative AI tools has the potential to enhance the efficiency of text-based educational material production. In particular, they can alleviate the workload of teachers, enabling them to prepare personalized lecture notes, exam questions, and assignments. For instance, natural language processing models such as

ChatGPT can generate comprehensive lecture notes or texts based on a specified topic. However, it is essential for teachers to assess the accuracy, contextual relevance, and pedagogical value of this content (Fitria, 2021).

Additionally, AI can facilitate the rapid preparation and diversification of exam questions. For instance, it can generate questions at varying levels of cognitive complexity (recall, comprehension, analysis, evaluation) in alignment with Bloom's Taxonomy. This approach enables educators to tailor exams to meet the individual needs of their students. Furthermore, the diversification of questions can be beneficial in promoting academic integrity and reducing cheating rates (Elmourabit et al., 2024).

Assignments and projects are essential for students to demonstrate their learning outcomes in a practical manner. Generative AI can encourage educators to design assignments that are both innovative and original. For instance, ChatGPT can provide scenarios or discussion topics that encompass interdisciplinary contexts. It can also be utilized to offer individualized assignment suggestions that are tailored to specific student profiles.

While the use of AI-generated texts in the educational process offers significant advantages in terms of efficiency, it also presents a number of ethical and pedagogical challenges. In particular, the accuracy, objectivity, and contextual appropriateness of the content are subjects of contention. Furthermore, educators must exercise caution to prevent students from utilizing these materials in a perfunctory, copy-and-paste manner. Rather than viewing generative AI as a mere conduit of information, educators should consider it a guiding tool that fosters critical thinking skills. Instead of preparing assignments themselves, students may present them as their own products by having them produced by artificial intelligence tools. This approach may deprive students of the invaluable learning experience gained during the preparation of the assignment.

Artificial intelligence (AI) tools can be effectively utilized across various academic disciplines. For instance, they can be employed to generate detailed chronological explanations for history courses, sample problem sets for mathematics courses, or analysis questions for literature courses. The flexibility and extensive range of applications of these tools enable educators to save time and students to have more effective learning experiences (İncemen & Öztürk, 2024).

Image-based Material Production

The utilization of visual-based materials represents a significant instrument for the enhancement of the learning process, facilitating greater efficacy and engagement. The advent of generative artificial intelligence is transforming the production of such materials. In particular, tools such as DALL-E, MidJourney, and Stable Diffusion facilitate the rapid and customizable design of educational posters and info-graphics. These technologies empower educators to produce sophisticated visuals without the need for graphic design expertise, thereby enhancing the visual quality of instructional materials (Yang & Zhang, 2024).

Educational posters are an invaluable tool for presenting concepts in a simple and visually appealing manner. Generative AI is an effective method for capturing students' attention and fostering motivation to learn by aligning

poster content with designs tailored to the target audience. Info-graphics generated with AI tools facilitate comprehension of complex information by visually organizing data and information (Lu et al., 2020). This approach has the potential to enhance student achievement, particularly in disciplines such as science and mathematics.

The use of animations in the learning process has been shown to enhance student engagement and facilitate deeper learning through the visual representation of complex processes. Generative AI has the potential to streamline the production of animated content, thereby saving valuable time for educators. For instance, AI integrations in visual production platforms such as Canva enable teachers to develop interactive content with minimal input, as demonstrated by Su and Mokmin (2024).

The use of generative AI in the production of visual-based educational materials also facilitates the development of individualized learning environments. For instance, customized posters or info-graphics can be generated in accordance with students' learning styles. Moreover, optimizing visuals in a specific language or cultural context can enhance accessibility on a global scale.

It is of the utmost importance to ensure that ethical considerations and accuracy are upheld in the production of visual-based materials. It is essential to conduct a thorough examination of the data source and content production process of generative AI tools in order to select the most appropriate ones. The academic accuracy and content relevance of images utilized in educational materials can have a direct impact on learning outcomes.

Production of Audio and Video Based Content

Audio and video materials have become indispensable components of contemporary education. Visualization and audio, particularly in the context of complex subjects, enhance the depth and engagement of the learning process for students. Generative AI tools offer significant convenience to educators by reducing the time and cost associated with the creation of such content. Virtual lectures and narrated videos provide the opportunity to personalize content to align with students' diverse learning styles (Blagoev et al., 2023).

The use of generative AI facilitates the straightforward generation of audio content through the process of natural speech synthesis. For instance, text-to-speech (TTS) technologies are capable of producing texts in a voice of human quality, with the option of different languages and accents. This is especially advantageous for the creation of language learning materials and for addressing accessibility needs. Platforms such as Google's Wavenet technology and ElevenLabs have been shown to significantly reduce the time and effort required for voice-over processes (Fenwick et al., 2024).

Artificial intelligence (AI) can be used to integrate processes such as scripting, adding visuals, voiceovers, and animation in video production. Tools such as Synthesia and Pictory can create video content with only text input. These platforms, which can be used especially for virtual lessons, allow teachers to present their lectures in a professional format. Video content can be made more dynamic by adding interactive elements (Fenwick et al., 2024).

Virtual lessons occupy a significant position within the digitalized domain of education. AI-powered tools facilitate the creation of more engaging lesson content for teachers. For instance, Adobe Podcast AI or Descript assist educators in editing and optimizing audio lecture recordings. Furthermore, these tools provide personalization, enabling the design of lecture content that aligns with student needs (Volarić et al., 2024).

The advent of AI-generated audio and video content has given rise to a number of ethical and quality-related concerns. It is of paramount importance to subject the accuracy, impartiality, and cultural relevance of the content presented to learners to the closest scrutiny. Furthermore, the human-like nature of AI-generated audio and video content calls for the implementation of a control mechanism to mitigate the risk of misinformation.

Practical Application Examples

Generating Lecture Slides with Artificial Intelligence

Lecture slides are an integral component of instructional materials and an efficacious instrument to facilitate learning. Generative AI can assist educators in reducing preparation time while enhancing the quality and impact of their slides. In the context of knowledge-intensive subjects such as history lessons, the use of generative AI tools can streamline the slide preparation process.

Artificial intelligence (AI) tools can be utilized to generate slide templates for history lessons, which are supported by chronological information, key events, and images. To illustrate, ChatGPT is capable of synthesizing historical events and delineating their pivotal elements. Such texts may be enhanced through the use of visualization tools, such as DALL-E or Canva. In the context of a history lesson on the Conquest of Istanbul, AI can provide concise descriptions, images of key figures, and a timeline of relevant events. Furthermore, AI can optimize technical details such as color matching, font selection, and editing during the design process. For instance, Canva's AI-powered design recommendations enable teachers to prepare visually appealing and student-friendly slides. Such tools suggest historical images and icons to place on slides, thereby enhancing their professional appearance.

The incorporation of interactive elements into slides generated by generative AI tools has the potential to enhance student engagement. For instance, in a history lesson, an interactive slide that poses a brief question about a particular historical figure can reinforce knowledge while capturing students' attention. Platforms such as Genially or Pear Deck can be utilized to develop such interactive slides. AI-generated slides markedly reduce the time required for teacher preparation while enhancing the accuracy and visual appeal of the content. Additionally, it is possible to personalize the slides according to students' learning pace and needs, thereby making the learning experience more effective and enjoyable.

It is of the utmost importance to ensure the accuracy of the source material and to comply with the established academic ethical standards when utilising artificial intelligence (AI). In the case of materials prepared with the aid of generative AI, it is imperative to guarantee the accuracy of the content and to cite the sources in an appropriate manner. This is particularly crucial in disciplines such as history, where there is a heightened risk of disseminating misinformation.

Preparing Customized Worksheets for a Distinct Problem-Solving Exercise for Students

Problem-solving activities play a pivotal role in the development of students' fundamental competencies, including critical thinking, analysis, and problem-solving abilities. For such activities to be effective, it is essential that they are designed in accordance with students' levels and interests. Generative AI tools facilitate the generation of personalized worksheets that align with these requirements (Yogi et al., 2024). AI can automatically generate questions that correspond to students' levels, previous achievements, or needs. For instance, OpenAI's ChatGPT model can generate authentic mathematics, science, or grammar questions that are suitable for the subjects or curriculum outlined by educators. These questions can be crafted in accordance with pedagogical frameworks such as Bloom's Taxonomy.

Artificial intelligence (AI) tools afford the opportunity to prepare a unique worksheet for each student. For instance, questions that address the same subject matter but vary in terms of complexity and content can be developed. This provides a flexible learning environment for students with varying learning speeds. Furthermore, the incorporation of explanations or solution hints into questions enhances students' capacity to learn independently. Generative AI has the potential to design worksheets that are not only text-based but also supported by visual elements. For instance, visual generation tools such as DALL-E can rapidly generate visuals associated with a problem, thereby enhancing the engagement of the worksheet. In subjects such as history, geography, or biology, the learning material can be enhanced by the incorporation of maps, graphs, or figures.

Additionally, AI tools can be utilized for the automated assessment of worksheets (Çetin & Aktaş, 2021). This considerably reduces the time required by teachers while providing immediate feedback to students. For instance, an AI system that verifies the accuracy of responses on a mathematics worksheet can offer direct feedback to students and identify areas where they may require further assistance.

Generating Interactive Content for Language Instruction Using an Artificial Intelligence Tool

The incorporation of interactive content is of paramount importance in the field of language education, as it fosters active student engagement and facilitates the acquisition of language skills. These materials transcend the conventional approach to language instruction, enabling learners to cultivate the four fundamental language competencies (listening, speaking, reading, and writing) in a unified manner (Fenuku, 2024). The advent of generative AI tools has opened up new avenues for educators, offering the potential to rapidly and effectively generate content tailored to specific learning objectives. AI tools for language teaching facilitate the personalized generation of text and audio-based content. For instance, ChatGPT is capable of producing dialogues, narratives, or reading passages that align with a specified level. Additionally, ElevenLabs or Google Text-to-Speech technology can develop listening materials by voicing these texts in a natural human voice. This type of material enables students to engage with language in a manner that resembles real-life conversations.

Generative AI tools can be utilized to develop interactive language learning games or exercises for learners. For

instance, an AI tool can construct a personalized vocabulary game comprising words that the learner has previously acquired. Platforms such as Quizlet can provide vocabulary flashcards, quizzes, and mini-games, enhanced with AI-generated content (Sippel, 2022). These tools facilitate an engaging and motivating language learning process.

Artificial intelligence (AI) tools can be employed to generate visual and video content for language teaching. For instance, a tool such as DALL-E can produce visuals that facilitate vocabulary learning, while video production tools such as Synthesia can produce virtual teacher videos on specific topics. Such materials are particularly beneficial for students who are visual learners and who find language learning more tangible when it is presented in a visual format.

Artificial intelligence (AI) plays a significant role in language learning, particularly in the assessment of student performance and the provision of immediate feedback. AI-powered algorithms are utilized by platforms such as Duolingo to analyze student errors and suggest more precise content, thereby enhancing the personalization of the language learning process and facilitating the more expedient resolution of students' deficiencies.

Advantages and Challenges

The application of generative artificial intelligence in the field of education offers the benefit of providing tailored and accessible content, thereby enhancing the efficiency and efficacy of teaching and learning processes. While the majority of students view these tools as a valuable supplementary resource, it is important to acknowledge the potential risks associated with their use. These technologies may pose challenges related to addiction, reduced productivity, and plagiarism, which could conflict with institutional policies (Robles & Ek, 2024). Furthermore, deficiencies such as incorrect answers, low-quality references, and unsafe content production are among the negative aspects of use. It is therefore imperative that generative artificial intelligence be employed in teaching components in a clean and responsible manner. The personnel of generative artificial intelligence in education and their experiences are discussed in detail below.

Advantages

One of the most significant advantages of generative AI tools is the substantial reduction in the time required for teachers to prepare course materials. While traditional methods can necessitate hours of preparation, AI tools can complete these processes in minutes. For instance, teachers can swiftly generate lecture notes, exam questions, or assignment drafts through the use of AI models. This enables teachers to allocate more time to pedagogical planning and individual student support.

Generative AI has the capacity to produce content in a variety of formats and at different levels. Text, visual, audio, or video-based materials can be tailored to align with students' learning styles. For instance, a comprehensive lecture slide with both textual and visual elements can be developed for a history lesson.

Furthermore, AI tools can generate culturally diverse materials, offering students a range of perspectives and fostering a global learning experience.

Artificial intelligence (AI) tools offer significant opportunities to enhance the accessibility of learning materials. Content designed specifically for individuals with disabilities can be readily prepared with the assistance of AI. For instance, text-based materials can be presented in audio format, or visual materials can be accompanied by alternative text. Furthermore, materials can be presented in multiple languages with the aid of automatic translation tools, thereby expanding their accessibility to a broader student population.

Artificial intelligence (AI) facilitates the generation of bespoke educational materials tailored to the specific requirements of individual students. Content can be developed in accordance with students' interests, learning paces, and proficiency levels. As an illustration, AI can generate supplementary exercises concentrating on subject areas in which a student may require additional support. This personalisation enhances the efficacy and satisfaction of the learning process.

Challenges

One of the most significant challenges associated with generative AI tools is the potential for inaccuracy and unreliability in the content they generate. These tools rely on large language models or other AI algorithms to provide answers, which can occasionally result in the dissemination of incorrect information. This can manifest as inaccurate details about historical events or flawed explanations about scientific topics. Such instances warrant careful consideration, as they have the potential to influence students' understanding of the subject matter (Bender et al., 2021).

The ethical implications of AI in education have been a topic of discussion. For instance, the use of AI for homework preparation may raise concerns about academic integrity. Additionally, the lack of clear ethical guidelines on the appropriate use of these tools can cause uncertainty for educators and educational institutions. Furthermore, copyright violations may occur if the content generated is not original (Floridi & Cowls, 2022).

The effective use of generative AI tools requires powerful hardware and an internet connection. However, this may give rise to equality issues for students or teachers who lack access to such technology. In particular, the impact of AI in education may be limited in developing regions. Furthermore, since some tools are complex, teachers may require additional training to use them effectively (Luckin, 2018).

The functionality of AI tools is contingent upon the processing of user data. However, there may be a lack of transparency regarding the collection, storage, and utilization of this data. The safeguarding of students' personal information is of paramount importance, particularly in the context of educational tools designed for children. A deficiency in data security can engender a negative perception of the deployment of AI in education (Zuboff, 2023).

An overreliance on AI tools has the potential to impede the cognitive abilities of educators and learners alike. If

educators entrust the entirety of their course materials to AI, there is a possibility that the human element in the educational process may be diminished. Similarly, students may be at risk of resorting to pre-fabricated solutions without developing the capacity for critical thinking (Selwyn, 2019).

The Future of Generative AI in Education

Emerging Technologies and Potential Innovations

The prospective role of generative AI in education will be further shaped by the advancement of natural language processing (NLP) technologies, which will facilitate the provision of tailored solutions to the needs of students and educators. In particular, conversational AI assistants have the potential to offer students real-time and meaningful guidance by acquiring a deeper contextual understanding (Brown et al., 2020). These technologies can facilitate personalized learning experiences that enhance classroom interactions.

The future may see the widespread use of multimodal AI systems that allow for the simultaneous processing of text, visual, audio, and video-based content. These systems have the potential to generate more holistic educational materials that appeal to students with different learning styles. For instance, an AI could support a physics course with both visual simulations and narrated videos (Mariani & Dwivedi, 2024).

The integration of generative AI with AR and VR technologies can facilitate more immersive learning experiences. For instance, students can engage in experiential learning by "living" historical events in virtual worlds generated by AI or observing biological processes in a three-dimensional environment. Such innovations will expand the scope of experiential learning in education (Gupta & Mohummed, 2023).

The development of artificial intelligence technologies can facilitate the provision of instantaneous feedback to educators by means of a more detailed analysis of students' learning processes. To illustrate, artificial intelligence is capable of detecting individual deficiencies and recommending specific materials to address these deficiencies. This process enhances the precision and efficacy of the learning experience (Luckin, 2018).

In the future, educational platforms supported by artificial intelligence may facilitate more collaborative learning opportunities. For instance, AI can optimize the distribution of tasks among students engaged in group projects, thereby fostering a more balanced and effective working environment. Moreover, AI can analyze group dynamics and provide recommendations to educators aimed at enhancing students' social and academic interactions (Selwyn, 2019).

Transformation of the Roles of Teachers and Students

The integration of generative AI tools into educational processes necessitates a redefinition of traditional teacher roles. Teachers are no longer solely responsible for the transmission of information; they are also guides who effectively utilize AI tools and facilitate learning processes. For instance, teachers can leverage these tools to

provide students with more personalized learning experiences and enable students to learn at their own pace (Luckin, 2018).

In an educational environment that is supported by AI, students assume a more active role in the processes of accessing information and learning. Generative AI tools enable students to explore questions independently, develop projects, and produce sophisticated content. For instance, a student learning a language can engage in real-time communication to practice language using a tool such as ChatGPT, thereby directly influencing their own learning process (Xiao & Zhi, 2023).

The use of AI-supported tools can facilitate the development of collaborative learning environments. In teacher-led projects, students working with AI tools can enhance the efficacy of their individual contributions while engaging in group activities. For instance, the use of DALL·E enables a group of students to design visual materials for a science project and engage in collective reflection on the outcomes (Tan et al., 2023).

The digital literacy skills of both teachers and students have become a fundamental requirement for the effective use of generative AI. While teachers must learn how to integrate AI pedagogically, students must learn to use these tools ethically and effectively. This has led to an increased emphasis on technological literacy in education.

The innovations offered by AI do not entirely supplant the conventional roles of teachers and students in the educational context. Instead, they necessitate a re-evaluation of the relationship between these technologies and pedagogical processes. Teachers must continue to facilitate students' critical thinking skills when utilizing AI tools. Similarly, students must recognize that these tools are merely a resource and that the responsibility for learning ultimately rests with them (Floridi & Cowls, 2022).

The Importance of Original and Ethical Content Production

The potential for generative AI to facilitate the production of original content in the field of education is considerable. These tools facilitate the talents of students and teachers, thereby enabling the development of distinctive and personalized learning materials. However, in the production of original content, it is essential to consider not only the technical skills involved but also the pedagogical suitability of the content and its relevance to educational goals. The ethical issues that arise during the production of AI-supported content represent a significant concern for the future of education. The accuracy and impartiality of information presented in such content can have profound implications, particularly in fields such as history and social sciences. In light of this, it is imperative that teachers and content developers undertake a thorough examination of the content produced by AI.

One of the most significant challenges associated with AI-generated content is the ability to discern whether the material has been appropriated from existing sources. In order to guarantee the originality of the content utilized in an educational context, it is imperative that educators and academic institutions oversee the ethical utilization of sources by AI in the content production process. Furthermore, this can enhance students' dedication to academic

integrity. The production of content by AI has the potential to enhance diversity and inclusivity in education, thereby promoting equality. However, if the content in question is overly focused on a specific language, culture, or social perspective, there is a risk that it may inadvertently reinforce discriminatory attitudes and behaviors among students. It is therefore crucial that AI tools adhere to the standards of inclusiveness in content production. While AI tools offer substantial assistance in the rapid and efficient generation of content, they are unable to entirely supplant the artistic capabilities of humans. It is vital that instructors recognise these tools as supplementary resources and maintain their own pedagogical approaches and contributions, based on their expertise and experience in this process.

Conclusion and Recommendations

This section has elucidated the role and potential of generative artificial intelligence (AI) in education, emphasizing its contributions in numerous domains, including teaching material design and personalized learning processes. The primary messages can be summarized as follows:

- *The Growing Impact of Generative Artificial Intelligence in Education*: Educators can rapidly and effectively develop course materials through the use of text-oriented tools such as ChatGPT, visual production tools such as DALL·E, and other artificial intelligence platforms. This enhances the accessibility and diversity of educational resources.

- *The Significance of Original and Ethical Content Production*: It has been asserted that the successful implementation of artificial intelligence in education hinges on the production of content that is suitable for pedagogical purposes, original, and in compliance with ethical standards. Artificial intelligence-supported content should prioritize both information accuracy and diversity.

- *The Formation of New Roles in Education*: The advent of artificial intelligence is effecting a redefinition of the roles of teachers and students. Whereas teachers are now expected to move beyond the transfer of information to become guides and mentors, students are assuming a more active and independent role in the learning process.

- *Advantages and Challenges*: While the contributions of artificial intelligence to education offer advantages such as saving time and personalization, they also present challenges such as accuracy issues and ethical questions. Therefore, it is essential to plan the use of technology in a conscious and sustainable manner. 5. Sustainable and Responsive Use of Technology: The sustainable and conscious use of artificial intelligence in the future of education depends on teachers and students adopting this technology effectively and ethically.

Recommendations for Educators and Designers

It is recommended that educators and designers develop strategies for the effective use of generative AI tools in the classroom. While these tools offer significant benefits in the development of teaching materials, it is essential to exercise caution regarding their appropriate integration and ethical use. The following recommendations are provided for educators and designers:

- It is incumbent upon educators to define the educational goals to be achieved before utilizing AI tools. The development of content that is compatible with learning objectives enhances the efficacy of education. While the innovative tools offered by AI expand the range of potential teaching materials, it is also essential to ensure that the content aligns with the established teaching objectives.

- It is incumbent upon educators and designers to consider their educational goals when selecting the appropriate AI tools. Each AI tool possesses distinct features and areas of use. For instance, ChatGPT may be more suited for text-oriented content, whereas DALL·E may be preferred for visual materials. Moreover, teachers must develop their digital literacy skills to ensure effective utilization of these tools.

- The utilisation of AI tools in an educational context is not the sole responsibility of teachers. It is also incumbent upon students to interact with these tools and to shape their own learning processes. It is essential that students have a clear understanding of how AI works and are able to use these tools effectively. In this way, students are not merely passive recipients of pre-existing materials, but rather engage in a continuous and independent learning process.

- It is incumbent upon educators to consider the ethical responsibilities associated with the use of AI tools. Key ethical considerations include the security of student data, confidentiality, and the accuracy of content. The content production process of AI should be transparent, and educators should be prepared to address any ethical issues that students may encounter.

- The efficacy of content generated through the use of AI tools must be subject to continuous evaluation and improvement, if necessary. It is incumbent upon educators to conduct regular analyses of student feedback and the effectiveness of the content, with a view to implementing modifications that will enhance the pedagogical value of the tools.

Tips for Sustainable Use of AI

The objective of sustainable use of AI in education is to capitalize on the advantages of the technology while mitigating the challenges it presents. This necessitates the ethical and conscious utilization of AI tools by educators, students, and designers. The following are recommendations for sustainable use of AI in education:

- Educators are bound by a set of ethical guidelines and policy standards when utilizing AI tools. These

encompass the protection of student data privacy, the provision of accurate information, and the production of ethical content. While AI tools are instrumental in the development of educational materials, it is of paramount importance that the content is generated and monitored with pedagogical responsibility.

- It is of the utmost importance for teachers and students alike to cultivate digital literacy skills for the long-term integration of AI into the educational landscape. It is not sufficient for educators to merely utilize AI tools; they must also facilitate student learning on the safe and effective use of these tools. Moreover, students must gain a comprehensive understanding of AI, including its underlying principles, the types of data it requires, and the ways in which this data can be utilized.

- As AI technologies continue to evolve at a rapid pace, it is imperative that educators remain abreast of the latest developments and strive to enhance the efficacy, precision, and user-friendliness of these tools. Incorporating student feedback into the design of AI tools can prove invaluable in optimizing their effectiveness in the educational setting.

- To ensure the sustainable use of AI in education, it is essential to enhance student involvement. Personalized learning experiences facilitate greater student participation in their own learning processes. Consequently, AI-supported content must not only be individualized but also tailored to students' unique needs.

- While AI has the potential to make significant contributions to education, it is important to consider the technological limitations associated with it. These limitations may pertain to situations such as misinformation, cultural biases, or user errors. It is essential for educators to be mindful of these limitations and to recognize that AI should be utilized as a tool, with human intervention and guidance playing a crucial role.

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Chapter 5 - The Role of Artificial Intelligence in Fostering Creativity and Critical Thinking

Turgay Demirel

Introduction

The integration of technology has become a fundamental aspect of teaching and learning by the rapid developments in the era of education. Among the many technological advancements, Artificial Intelligence (AI) emerges as a transformative force, presenting exceptional opportunities to improve educational practices. The capacity of AI to enhance student creativity and foster critical thinking has attracted considerable interest from educators, researchers, and policymakers. Considering the integration of AI in education, it's important to investigate how these technologies can enhance cognitive development, improve learning, and ultimately equip students for the challenges of today's world.

Creativity and critical thinking are increasingly acknowledged as fundamental skills in the 21st century. Because of technological advancements and globalization, society is changing rapidly. This means we need a workforce who are not just skilled but also good at solving problems creatively and thinking critically. Educational systems globally face the challenge of cultivating these competencies within their curricula, yet conventional pedagogical methods frequently struggle to effectively foster creative and critical thinking abilities. This gap presents a chance for AI to assume a crucial part in reshaping educational practices, empowering educators to foster an environment that nurtures creativity and critical thinking.

AI technologies, like intelligent tutoring systems and adaptive learning platforms, have the capability to personalize the educational experience, addressing the varied needs of students. By leveraging data analytics, AI can analyze individual learning styles, preferences, and areas for improvement, enabling educators to customize their instructional approaches accordingly. This personalized approach not only enhances student engagement but also encourages creative exploration, as students are empowered to pursue their interests and ideas within a supportive framework. AI can facilitate collaborative learning experiences where students work together on projects, share ideas, and engage in constructive discussions, fostering creativity and critical inquiry.

AI in education goes beyond simply personalizing learning; it also involves the creation of tools and resources

that foster creative thinking. For instance, AI-driven platforms can give students access to vast repositories of information, enabling them to investigate different viewpoints and create unique solutions to challenging issues. By incorporating AI into educational programs, educators can foster students' critical analysis of the information they encounter, enabling them to evaluate sources and synthesize ideas, ultimately enhancing their analytical capabilities. Furthermore, AI can act as a creative collaborator, supporting students in brainstorming, conceptualization, and project development, ultimately enhancing the learning experience.

However, integrating AI into education presents its own challenges. Addressing concerns about data privacy, ethical implications, and the risk of reinforcing biases is crucial to ensuring that AI becomes a positive force within the classroom environment. Navigating the complexities of AI implementation, educators and policymakers must strive to harness its benefits to support student creativity and critical thinking. Moreover, the professional advancement of educators is essential in order to provide them with the requisite skills and knowledge imperative for the proficient integration of AI technologies within their pedagogical methodologies. Stakeholders must work together to develop a framework that prioritizes the responsible and fair use of AI in education as the educational landscape evolves.

In this context, the current study examines the potential of using artificial intelligence in educational environments in terms of creative and critical thinking. Through a review of current literature and empirical studies, we aim to uncover effective strategies for incorporating AI into educational environments and investigate the effects on cognitive growth and educational results. Through this investigation, we aspire to enhance the current discussion concerning the impact of AI technology in educational contexts and furnish pragmatic recommendations for educators, administrators, and policymakers. The need for innovative approaches to teaching and learning becomes increasingly pressing as we progress in an ever more digital world. By adopting AI as an instrument to enhance student creativity and analytical skills, we can create a more vibrant and adaptable educational environment that equips learners for the obstacles of tomorrow.

In summary, using AI in education offers a great chance to improve student creativity and critical thinking. By tailoring learning experiences, offering access to a wide range of resources, and cultivating collaborative settings, AI can play a vital part in nurturing the competencies essential for thriving in the 21st century. However, careful consideration of ethical implications and professional development for educators is crucial to ensure responsible AI implementation in the classroom. As we initiate this inquiry, we want to highlight how AI can change education and help students develop into creative and critical thinkers in a world that is becoming more complicated.

The Potential of AI in Education

The integration of Artificial Intelligence (AI) in education presents numerous potential benefits, promising to transform traditional educational practices into more personalized, efficient, and inclusive systems. AI technologies can enhance learning by providing personalized educational paths, automating routine tasks, and giving real-time feedback. These advancements not only enhance student engagement and academic performance but also support teachers by alleviating their workload and enabling them to devote more time to personalized student interactions (Chan & Tsi, 2023).

AI technologies have evolved rapidly, leading to transformative applications in various sectors, including education. AI's capability to analyze extensive data, tailor learning experiences, and offer real-time feedback equips it as a powerful tool for improving educational outcomes (Luckin & Holmes, 2016). The application of AI in education includes various tools, such as intelligent tutoring systems and adaptive learning platforms, all designed to foster more interactive and efficient learning spaces (Baker & Inventado, 2014). AI facilitates personalized educational experiences by adapting educational content to align with individual students' needs and learning styles. Intelligent tutoring systems and adaptive learning platforms are examples of AI applications that tailor instruction based on student performance and preferences (Kaur et al., 2024; Zaman, 2024). Machine learning algorithms analyze student data to create personalized learning opportunities, tracking progress and adjusting instruction to address strengths and weaknesses (Alashwal, 2024). Generative Artificial intelligence can transform the educational landscape by fostering student creativity and promoting critical thinking skills. AI-powered personalized learning systems can adapt to individual student needs, offering tailored support and feedback that fosters exploration, problem-solving, and the cultivation of unique perspectives (Balta, 2023; Mello et al., 2023).

The incorporation of AI in educational settings can aid in fostering essential 21st-century competencies, such as collaboration, communication, and digital literacy (S. Murugesan & A. K. Cherukuri, 2023). Students engaging with AI technologies learn to navigate complex information, collaborate with peers, and communicate effectively. These skills are crucial for thriving in our rapidly evolving, interconnected, and technology-driven global landscape. AI technologies play a significant role in fostering computational thinking abilities, essential for solving problems in a technology-driven world. These tools also support students' self-efficacy, increasing their confidence in learning computational concepts (Massaty et al., 2024). AI-driven tools promote inclusivity by providing personalized support to learners with diverse needs, thereby reducing educational inequalities (Faraasyatul'Alam et al., 2024; Farahani & Ghasmi, 2024). AI has the capacity to mitigate disparities in education, especially within under-resourced environments, by facilitating access to sophisticated educational materials and tailored learning opportunities (Panjwani, 2024).

AI applications, such as natural language processing, offer interactive and immersive learning experiences. These tools enhance language learning that enrich the educational environment (Kaur et al., 2024; Pandya, 2024). Generative AI technologies create new educational content, simulate scenarios, and provide training, contributing to a more dynamic and engaging learning experience (Rahman & Singh, 2024). Additionally, AI-based assessment tools can deliver a more comprehensive evaluation of student performance, surpassing traditional testing methods and offering perspectives on the extent of their comprehension and their capacity to utilize knowledge in unfamiliar contexts (Swiecki et al., 2022). AI technologies facilitate improved feedback mechanisms, offering instantaneous and detailed evaluations of student performance. This allows for timely interventions and supports continuous learning (Faraasyatul'Alam et al., 2024; Zaman, 2024). Machine learning in student assessment provides nuanced evaluations and predictive analytics, helping educators identify gaps in knowledge and tailor instructional strategies accordingly (Farahani & Ghasmi, 2024; Pandya, 2024).

AI streamlines administrative tasks, such as grading and scheduling, freeing up educators to focus on teaching and student engagement (Alashwal, 2024). Automation of routine tasks reduces the workload on teachers, allowing them to dedicate more time to personalized student interactions and creative teaching methods (Bobro, 2024). AI-based tools simplify education management by automating everyday tasks, offering real-time analytics, and supporting decisions based on data. This leads to more efficient management of educational institutions and improved resource allocation (Thuy & Tien, 2024).

AI integration in education has important implications for student learning. Research indicate that learning environments augmented by AI have the potential to enhance academic performance, foster greater student engagement, and improve motivation (Luckin & Holmes, 2016). Utilizing AI in educational interventions has demonstrated enhancements in critical thinking, problem-solving, and student engagement, particularly in science education (Selvam, 2024). Utilizing the potential of AI while emphasizing the development of student creativity and analytical skills, teachers can establish a learning atmosphere that enables students to be adaptable, inventive, and intellectually curious. As educational AI progresses, it becomes crucial for researchers, educators, and policymakers to work together in discovering new methods to utilize these technologies effectively for enhancing student achievement and nurturing the upcoming generation of creative and critical thinkers.

Higher Order Thinking Skills

Higher Order Thinking Skills (HOTS) are crucial cognitive processes that extend beyond mere memorization and understanding, empowering individuals to analyze, evaluate, and generate novel ideas or solutions. These skills are crucial for thriving in the 21st century, especially in educational contexts where they are integrated across disciplines to enhance students' critical and creative thinking skills. The development and assessment of HOTS are vital for fostering students' problem-solving skills and preparing them for complex real-world challenges. HOTS encompass cognitive activities such as analyzing, evaluating, and creating, while lower-order thinking skills (LOTS) concentrate on remembering, understanding, and applying information (Rianti et al., 2024). These skills enable learners to anticipate connections between divergent ideas and develop innovative solutions, which is crucial for effective problem-solving and decision-making (Gendenjamts, 2023).

Creative Thinking

Creative thinking encompasses a multifaceted cognitive process characterized by the generation of new, novel, and practical ideas. It is a skill that can be developed through education and practice, and it plays a significant role in problem-solving across various disciplines, including business, technology, science, and the arts. Creative thinking involves approaching problems from diverse perspectives, using knowledge, intuition, and reasoning to generate innovative solutions. This creative process is dynamic, engaging both convergent and divergent thinking, and is supported by the cultivation of specific skills and conditions that foster creativity (Sadowski & Connolly, 1999; Zhanqiang, 2023). Creative thinking often involves lateral thinking, which is the ability to approach problems in unconventional ways, leading to the generation of original ideas by merging different concepts (Moharana, 2013). It is an active process that shifts between converging and diverging thinking, progressing

through phases over time to create a final outcome that is original to the creator (Webster, 2009). When managing disruptive technologies, creative thinking combines innovative, design, and strategic approaches, enabling organizations to address problems from novel perspectives (Dereń & Skonieczny, 2017).

Creative thinking is essential for solving complex problems in fields such as engineering, technology, and business, where it helps in defining problems and implementing solutions (Sadowski & Connolly, 1999). For vocational students, creative thinking is fundamental for applying knowledge in their fields, although many students face challenges in achieving fluency and originality in their thinking (Julizal et al., 2021). In aesthetic education, creative thinking is linked to independent and innovative thinking, which is crucial for cultivating high-quality talents in a rapidly changing society (Xiong, 2024). The ability to think creatively is not innate but can be cultivated through targeted educational strategies and supportive environments. However, fostering creativity often requires balancing structured learning and the freedom to explore and experiment, which can be challenging in traditional educational settings (Lasky & Yoon, 2020).

Critical Thinking

Critical thinking represents an essential cognitive process that requires the active analysis, evaluation, and application of information to form well-informed judgments and decisions. These skills are vital for navigating the complexities of the modern world, as they empower individuals to think autonomously, detect biases, and consider diverse perspectives before drawing conclusions (Halpern, 2001). Critical thinking skills are increasingly acknowledged as fundamental to achieving success in the 21st century. These skills empower individuals to address complex problems, make informed decisions, and adapt effectively to rapidly evolving environments (Dwyer et al., 2014). It employs cognitive skills or strategies that increase the probability of a desirable outcome. These include analysis, synthesis, and evaluation of information through observation, experience, and communication (Halpern, 2001; Papathanasiou et al., 2014). Critical thinking requires metacognitive monitoring, which includes reflecting one's own cognitive processes to enhance and sustain critical thinking abilities (Halpern, 2001). Critical thinking involves careful reasoning and the evaluation of statements, ideas, and theories relative to alternative explanations or solutions. This process empowers individuals to reach independent, competent positions by assessing the weight of available information and evidence (Vincent-Lancrin, 2024). Critical thinking is a crucial learning outcome in education, fostering interdisciplinary approaches and enhancing students' ability to tackle problems from multiple perspectives (Vincent-Lancrin, 2024). Critical thinking is an essential skill for solving problems in everyday life, including educational and occupational settings. It involves identifying problems, finding practical solutions, and making informed decisions based on systematic conclusions and correct arguments (Mulyani, 2022).

AI and the Development of Creative/Critical Thinking Skills

The integration of artificial intelligence (AI) in educational settings has demonstrated potential to enhance both creative and critical thinking skills in education. AI technologies, such as ChatGPT, are being increasingly utilized

to foster these cognitive skills among students and educators (Vasconcelos & Santos, 2023). The cultivation of critical thinking skills is essential for achieving academic success and fostering professional growth, as it encompasses logical reasoning, effective decision-making, and adept problem-solving. Similarly, Creative thinking, which encompasses originality and the generation of novel ideas, is crucial for fostering innovation and adaptability across diverse fields (Zhanqiang, 2023). Artificial Intelligence (AI) has emerged as a powerful tool in supporting both creative and critical thinking across various educational contexts. Integrating AI into learning environments can enhance educators' pedagogical approaches, cultivate essential cognitive skills, and offer personalized learning experiences for students (Zhai et al., 2021).

Cognitive Development and AI

The intersection of AI and cognitive development is an emerging field of research that examines how AI tools can support the cognitive growth of students. Cognitive theories like cognitive developmental theory (Byrnes, 2008) and sociocultural theory of development (Huang, 2021) emphasize the importance of social interaction and problem-solving in learning. AI technologies can facilitate these processes by providing interactive and collaborative learning environments that promote cognitive engagement. AI-powered platforms can create simulated real-world scenarios, enabling students to apply their knowledge in practical contexts. For instance, AI-powered virtual reality and augmented reality applications can create immersive learning environments that challenge students' cognitive abilities (Dede, 2009). These immersive experiences deepen students' comprehension of complex concepts and cultivate their critical thinking and creativity as they navigate and resolve problems within dynamic environments. Additionally, AI can foster cognitive development by offering personalized support that aligns with each student's individual learning requirements. Intelligent tutoring systems can assess students' strengths and weaknesses, offering tailored guidance that promotes cognitive growth (VanLehn, 2011). This personalized learning approach supports students in developing foundational skills while also fostering engagement in higher-order thinking processes.

Fostering Creativity Through AI in Education

Creativity refers to the capacity to produce innovative ideas, concepts, or answers by considering perspectives beyond traditional limits. It involves the innovative combination of existing knowledge in novel ways, expressing oneself in unique forms, and approaching problems with an original mindset (Cropley, 2011). AI can play a crucial role in fostering student creativity by offering tools that encourage creative processes, such as brainstorming, idea generation, and project development. Moreover, AI can help students explore diverse perspectives and approaches, enhancing their creative thinking skills (Lustig, 1995). It is evidenced by a high effect size in meta-analysis research that, AI-based discovery learning models have a significant positive effect on students' creative thinking skills. This suggests that AI can effectively enhance creativity in educational settings (Erizar et al., 2023).

Engaging with AI-enhanced creative tools boosts students' motivation and engagement in learning (Rong et al., 2022). These tools not only stimulate creativity but also encourage collaboration among peers, fostering a community of creative thinkers. Moreover, AI can give tailored feedback on creative tasks, helping students polish

their concepts and boost their creative results (Baker & Inventado, 2014). According to Saritepeci & Yildiz Durak, (2024), AI-supported design-based learning (DBL) activities have shown potential in fostering creative design processes. These activities help students develop creative self-efficacy and reflective thinking skills. AI applications can enhance design thinking by providing inspiration and facilitating creative problem-solving. AI tools like Midjourney and ChatGPT can be integrated into the design thinking process, although educators must balance AI use with human creativity (Poleac, 2024).

Generative AI, like ChatGPT-3, has been found to support divergent thinking in creativity courses, which is key for fostering creative growth. However, careful integration is necessary to avoid potential negative impacts on creative confidence (Habib et al., 2024). Besides, AI-powered tools in early childhood settings can promote creativity through play and imagination. These tools support multimodal creative inquiry, aligning with early childhood pedagogy to enhance creativity and self-expression (Berson et al., 2023). AI-powered learning companions can provide personalized support and feedback, tailoring the learning experience to the unique needs and abilities of each student (Perez-Ortiz et al., 2021). By tailoring the curriculum and educational activities to match personal interests and abilities, AI can assist learners in connecting more profoundly with the content, investigating their unique concepts, and enhancing their problem-solving capabilities.

Furthermore, AI-powered tools can help educators develop more engaging and interactive lesson plans, incorporating multimedia components and simulations that captivate students' attention and foster their imagination (Felix & Webb, 2024). This can create a more engaging and enriching learning environment, where students are inspired to explore innovative approaches and cultivate their creative potential. The successful integration of artificial intelligence in education requires a thoughtful and nuanced approach that prioritizes the nurturing of student creativity and critical thinking. By leveraging AI's capabilities to personalize learning, deliver engaging content, and provide meaningful feedback, educators can create a learning environment that fosters the development of these essential skills (Zhou & Lawless, 2015).

As a result, it is crucial for researchers, educators, and policymakers to work together in discovering new methods to leverage these technologies for enhancing student success and nurturing the upcoming generation of innovative and analytical thinkers. The integration of AI in educational settings has significant potential to foster creativity in students. AI-driven tools can facilitate cognitive development, personalize learning experiences, and foster creative thinking skills.

Enhancing Critical Thinking Through AI in Education

Critical thinking involves analyzing information, evaluating evidence, and making reasoned judgments. It is crucial for academic success and informed citizenship (Facione, 1990). Incorporating AI-powered tools into educational environments holds the potential to support students' critical thinking capabilities by equipping them with resources that encourage inquiry, analysis, and assessment. AI-driven educational technologies can facilitate critical thinking through adaptive learning systems that challenge students to solve complex problems and engage in higher-order thinking (Luckin & Holmes, 2016). Furthermore, AI can help teachers create evaluations that

necessitate critical thinking and problem-solving skills (Lim et al., 2023). By analyzing student responses, AI can provide insights into their thinking patterns and cognitive processes, helping educators tailor their instruction accordingly (Zawacki-Richter et al., 2019). This method of using data for assessment motivates students to think reflectively and assess themselves, which boosts their critical thinking skills.

AI tools can help improve collaborative learning by clarifying goals, bridging perceptual gaps, and promoting deeper understanding, which can enhance critical thinking skills. For instance, in a study involving pre-service teachers in Japan, AI-assisted activities were found to promote students' intellectual autonomy, creativity, and digital literacy which are crucial components of critical thinking (Sako, 2024). AI tools like ChatGPT have demonstrated a capacity to boost students' skills in analyzing and assessing complex scenarios, thus fostering their critical thinking abilities. This is particularly important in both academic and professional settings where logical reasoning is crucial (Harahap, 2024). Furthermore, AI-powered learning platforms can expose students to a diverse range of resources, perspectives, and challenging problems, encouraging them to think critically, synthesize information, and cultivate their own unique viewpoints (García-Martínez et al., 2023).

The use of AI platforms like ChatGPT, Bing Chat, and Bard in chemistry education has shown potential to boost learners' critical thinking, problem-solving, and understanding (P dos Santos, 2023; Vasconcelos & Santos, 2023). These findings underscore the central role of AI in fostering higher-order thinking skills and aligning with constructionist principles of learning. Besides, AI systems in early childhood education can develop critical thinking by encouraging exploration and problem-solving through interactive activities and educational games. These systems adapt to children's strengths and preferences, fostering a critical approach to challenges (Kuchkarova et al., 2024). AI systems can offer students immediate feedback, encouraging them to reflect on their thinking, question their assumptions, and consider different viewpoints (Mello et al., 2023). By engaging in this type of metacognitive exercise, students can develop a deeper understanding of their own learning strategies and become more adept at analyzing information, evaluating evidence, and drawing well-reasoned conclusions.

AI-powered tools can support personalized learning, adaptive assessment, and collaborative problem-solving, which cultivate essential cognitive skills (Felix & Webb, 2024; Grieve et al., 2021; P dos Santos, 2023; Vasconcelos & Santos, 2023). Carefully integrating AI into educational practices empowers educators to harness this technology and transform learning experiences, empowering students to become creative, critical thinkers prepared for the challenges of the 21st century.

In conclusion, the thoughtful incorporation of AI in educational environments holds the potential to substantially boost student creativity and critical thinking abilities. AI-driven tools can facilitate cognitive development, personalize learning experiences, and foster creative and critical thinking skills.

Challenges and Considerations of AI in Education

The integration of Artificial Intelligence into educational and creative processes presents opportunities as well as

challenges for enhancing critical thinking and creativity. AI-powered tools, such as generative models and conversational agents, have the capacity to cultivate intellectual autonomy, creative abilities, and digital literacy. However, their effectiveness is contingent upon proper application, educator support, and careful design of evaluation criteria. The challenges and considerations of using AI to enhance critical thinking and creativity are multifaceted, involving issues of dependency, originality, and the balance between human and machine contributions.

While AI offers significant potential to enhance critical thinking and creativity, it also presents challenges that require careful consideration. Addressing the balance between human and AI contributions, mitigating the risk of over-reliance, and addressing concerns about originality and authorship are crucial factors that require careful consideration. As AI continues to evolve, it is crucial to establish ethical and legal frameworks to guide its integration into education and creative domains, ensuring it supports human expression and intellectual growth.

There is a risk of students becoming overly reliant on AI tools, which can hinder the development of independent creative/critical thinking and diminish the role of personal experience and intuition. Balanced and critical engagement with AI is essential to mitigate this risk (Klochko, 2024). Also, the deployment of AI in education also raises significant concerns about the potential negative impact on essential intellectual and analytical abilities, such as the risk of AI tools being used as shortcuts and diminishing the value of authentic learning experiences (Felix & Webb, 2024).

The use of AI in creative processes raises concerns about plagiarism and the originality of outputs. Critics argue that AI-generated content may be perceived as randomised plagiarism, necessitating stronger regulations and ethical considerations (Jovanovic & Campbell, 2022; Polat, 2023). Additionally, the autonomous nature of AI challenges traditional concepts of intentionality and authorship in creative tasks. A new paradigm is needed to account for the role of AI in co-creative relationships and the perceived value of human intentionality (Feldman, 2017).

A significant concern regarding the integration of AI in education is the ethical implications, particularly pertaining to data privacy and security (Williamson, 2017). As AI systems gather and examine large quantities of student information, it is essential to guarantee that this data is managed in a responsible and transparent manner. Robust data protection measures is crucial to prevent unauthorized access and misuse of sensitive information (Malik, 2024; Pandya, 2024). Transparency and trust are essential, necessitating clear guidelines and parental consent for data collection and utilization (U Zaman, 2024).

AI algorithms may inadvertently reflect biases present in the training data, potentially leading to unequal treatment of certain student groups. Addressing algorithmic bias is critical to prevent reinforcing existing inequalities (Malik, 2024; Pandya, 2024). The digital divide poses a significant challenge, as unequal access to technology can exacerbate educational disparities. Ensuring equal access to AI-driven educational resources is vital for inclusivity (Sytnyk & Podlinyayeva, 2024; Zhunussov, 2024).

Technical constraints, such as software reliability issues and the requirement for robust digital infrastructure, can impede the effective integration of AI in educational environments (Rachovski et al., 2024). Resistance to innovation and skepticism about AI's effectiveness can pose barriers to adoption. Addressing these concerns through educator training and stakeholder engagement is crucial (Bobro, 2024). The financial investment required for implementing AI technologies can be a barrier for many educational institutions. Identifying cost-effective alternatives and securing adequate funding are essential to overcoming these challenges (Bobro, 2024).

Additionally, educators must be adequately trained to integrate AI tools into their teaching practices effectively. Comprehensive professional development programs focused on AI literacy and pedagogical strategies are crucial for empowering educators to effectively leverage AI to enhance student learning outcomes (Luckin & Holmes, 2016). Moreover, it is imperative to sustain a balance between technological integration and interpersonal engagement within the educational environment, given that social and emotional development is essential for the holistic growth of students (Iaosanurak et al., 2016).

The effectiveness of AI tools depends on their ethical and responsible use, as well as the supportive role of educators in guiding students (Rusandi et al., 2023). There is a need for careful design of evaluation criteria and a balance between AI use and authentic learning experiences (Sako, 2024; Volante et al., 2023). Additionally, ethical implications of AI, such as its potential to replace human roles or impact learning outcomes, must be addressed (Poleac, 2024). Moreover, human intelligence and critical thinking should remain central, as they are fundamental skills requiring nurturing from an early age, and should not be overshadowed by AI advancements (Spector & Ma, 2019). As educational AI develops, it's important for researchers, teachers, and policymakers to work together in finding new ways to use these technologies to support student achievement and nurture the next generation of creative and critical thinkers (Ayala-Pazmiño, 2023; Felix & Webb, 2024; Kamalov et al., 2023; Mello et al., 2023).

In conclusion, while AI offers promising potential for bolstering critical and creative thinking abilities, it is crucial to maintain a balance between its use and human oversight, as well as consideration of ethical implications. AI in education should prioritize developing skills and knowledge, ensuring it complements rather than replaces human creativity and critical thinking. The growth of these skills is essential for managing the challenges of today's world and achieving success in both academic and professional domains.

Conclusion

Integrating Artificial Intelligence can transform education by boosting student creativity and critical thinking. As emphasized throughout this paper, the potential of AI to tailor learning experiences, foster collaborative settings, and grant access to diverse resources positions it as a crucial tool in equipping students for the complexities of the 21st century. However, effectively incorporating AI in education necessitates thoughtful consideration of ethical implications, educator training, and maintaining a balance between technological integration and human interaction.

AI tools, including smart tutoring systems and personalized learning platforms, have shown great potential in customizing education to suit each student's requirements. Utilizing AI-based data analytics, these systems can identify students' learning preferences and areas needing improvement, empowering educators to offer tailored support that fosters exploration and problem-solving. This personalized approach not only enhances student engagement but also nurtures an environment conducive to creative and critical inquiry.

Furthermore, AI holds the potential to enhance higher-order thinking skills by providing tools that encourage analysis, evaluation, and synthesis of information. AI's ability to simulate authentic situations and provide immediate feedback helps students develop a more comprehensive understanding of complex topics, enabling them to cultivate their unique perspectives. By integrating AI into the curriculum, educators can facilitate collaborative learning experiences that empower students to engage with their peers, share insights, and collectively tackle challenging problems.

Despite the promising potential of AI, challenges remain. Addressing concerns about data privacy, ethical considerations, and the potential for over-dependence on technology is crucial when integrating AI in educational settings. A thoughtful approach is necessary to ensure responsible implementation. Educators must receive adequate training to leverage AI tools effectively, ensuring the tools complement rather than replace traditional teaching methods. Professional development programs focused on AI literacy and pedagogical strategies are essential for empowering educators to navigate the complexities of AI in the classroom.

Moreover, the balance between AI use and authentic learning experiences is crucial. While AI can enhance creativity and critical thinking, it is imperative to maintain the role of human interaction in education. Social and emotional learning is crucial for student development. Educators should create an environment that balances technological engagement and interpersonal connections.

In conclusion, the integration of AI in education offers great potential to cultivate student creativity and critical thinking abilities. By incorporating AI as a pedagogical tool, educators can foster dynamic and adaptive learning environments that equip students for the complexities of the future. However, this integration requires careful consideration of ethical implications, educator training, and maintaining a balanced educational experience. As we move forward into an increasingly digital world, the collaborative efforts of researchers, educators, and policymakers will be essential in harnessing the full potential of AI to empower the next generation of creative and critical thinkers.

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Chapter 6 - A Paradigm Shift in Measurement and Evaluation Processes: Generative Artificial Intelligence

Hamza Polat, Muhammet Dursun Kaya

Introduction

Measurement and evaluation in education is critical for analyzing learning outcomes, informing instructional decisions, improving educational practices, contributing to research and shaping educational policies. These processes serve as a guide to improve students' learning performance, improve teaching methods and ensure that learning objectives are met. In particular, determining which learning objectives have been successfully completed, which ones have gaps, and which areas need improvement enables the identification and implementation of effective teaching strategies (Wick, 1980; Adom et al., 2020; Nariwal, 2022).

An effective assessment and evaluation process reveals not only individual learning levels but also the effectiveness of teaching methods and the success of educational programs. In this context, analyzing the relationship between learning objectives and actual outcomes sheds light on both the development of current practices and the formulation of future educational policies (Sims, 1944; Wick, 1980). For example, examining goal-outcome alignment may necessitate the revision or improvement of certain teaching methods (Kidman & Chang, 2022; Sjogren, 1970). Moreover, this process provides an important basis for curriculum development and optimization of learning processes by facilitating stakeholders in education to make decisions based on findings (Miller & Sternberg, 1983).

In recent years, the integration of generative artificial intelligence (AI) technologies into educational settings has led to significant changes in assessment and evaluation processes. AI technologies have the potential to improve the accuracy and efficiency of assessment processes, while also providing a more personalized learning experience for students. For example, AI-powered systems can instantly grade students' exams, continuously monitor learning processes through formative assessments, and provide instant feedback to students (González-Calatayud et al., 2021; Luckin, 2017). These features can contribute to positive improvements in students' cognitive learning outcomes.

In addition, AI has the potential to support sensory learning needs. For example, innovative AI-based technologies

such as face recognition can increase students' motivation and enable the design of more adaptive learning environments (Vistorte et al., 2024). Such contextualized learning experiences can play a critical role in preparing students for the future by enhancing their problem-solving and challenge-addressing skills (Gavhane & Pagare, 2024).

However, the integration of AI technologies into assessment and evaluation processes in education brings not only opportunities but also various challenges. In particular, issues of accuracy, privacy and ethical issues raise the need for further research and development in this area. This chapter will look at assessment and evaluation processes in education from the perspective of generative artificial intelligence. The chapter aims to shed light on the paradigm shift caused by artificial intelligence applications in educational processes and to provide guiding tips for researchers and practitioners.

Generative Artificial Intelligence in Education

Generative artificial intelligence (AI) is a class of artificial intelligence that can generate original and creative content using existing data sets. These systems are capable of creating new content in different formats such as text, images, music and even video, not limited to analytical functions. Generative AI usually works with a variety of algorithms such as Generative Adversarial Networks (GANs), diffusion models and large language models (LLMs). These models analyze inputs, learn the logic of content creation, and design unique outputs for specific scenarios (Harshvardhan et al., 2020; Epstein et al., 2023; Goodfellow et al., 2020). This transformation in education and creativity processes makes generative AI stand out with its wide range of applications.

The Role of Generative Artificial Intelligence in Different Fields

Generative AI has had an impact on a wide range of fields, from creative industries to health education. In the art world, for example, this technology allows new aesthetic insights to emerge, going beyond traditional methods. In fields such as visual arts, music and literature, diffusion models synthesize images, while large language models can generate literary texts, poems or technical documents (Epstein et al., 2023). This not only speeds up the workflow of artists, but also allows them to develop entirely new creative approaches.

In software engineering, generative AI tools such as ChatGPT and CoPilot automate the process of writing code, making the software development process faster and more efficient. These tools not only analyze existing code, but also reduce error rates by providing suggestions to improve the functionality of the code (Russo, 2023).

In the healthcare sector, generative AI supports educational processes by creating simulations that enable students to experience complex clinical scenarios. For example, AI-supported virtual patients allow students to both improve their clinical decision-making skills and learn from their mistakes. These processes are integrated with formative and summative assessments, providing a more comprehensive learning experience (Preiksaitis & Rose, 2023).

The Potential of Generative AI in Education

Generative artificial intelligence in education has great potential in designing personalized learning experiences. In particular, the production of materials suitable for individual learning needs and the adaptation of these materials to students increase the efficiency of learning processes. Content tailored to students' individual profiles enables individuals with high self-regulation skills to reach their learning goals faster (Mittal et al., 2024). Moreover, these systems act as an assistant for teachers, automating routine tasks and allowing them to focus more on the teaching process.

In addition to creating educational materials, generative AI is also an important tool in assessment and evaluation processes. In particular, it reduces the workload of teachers with functions such as automatic exam grading, evaluation of written texts and providing individual feedback. At the same time, it provides the opportunity to monitor students' learning performance in real time and analyze this data to make appropriate interventions. This enables more effective monitoring of individual learning pathways and increases students' learning outcomes (Luckin, 2017).

Challenges Faced by Generative Artificial Intelligence

Generative artificial intelligence faces some challenges as well as benefits. Chief among these are ethical issues. The sources of the data sets used to train AI models can affect the fairness and accuracy of the models. In particular, data sets containing bias can reduce the reliability of the results and lead to various ethical debates (Polat, 2023). In social sciences and education, issues such as privacy and data security are also part of these debates (Bail, 2024).

Another challenge is the adoption process of generative AI. Integrating these technologies into existing workflows requires a significant learning curve for users to understand and correctly utilize the technology. There is also a need for strategic planning and pedagogical alignment for effective implementation of the technology (Russo, 2023).

Future Perspectives

Generative AI is expected to become more widely used in the future. However, in this process, existing challenges need to be addressed and interdisciplinary research needs to be encouraged. For example, examining the ethical and legal dimensions of generative AI applications in education could lead to a more transparent and fair use of these technologies.

In the context of education, the pedagogical compatibility of generative AI-supported tools should be increased and the contribution of these technologies to student-centered learning approaches should be examined in more depth. Furthermore, more research should be conducted on how generative AI can be used effectively in

assessment and evaluation processes. In the following section of this chapter, the potential applications of generative AI in assessment and evaluation processes and the effects of these applications on educational processes will be discussed.

Measurement and Evaluation with Generative Artificial Intelligence

Assessment and evaluation is one of the most critical components of teaching processes. These processes provide information on the extent to which students' current learning situations achieve the learning objectives. This information, which is used at the micro scale to monitor students' progress and eliminate missing learning, is very important at the macro scale to make necessary adjustments in curricula. Thus, while monitoring student performance, it can also guide administrators in making decisions about curricula.

The tools commonly used in assessment and evaluation processes are subject to various classifications. In general terms, these tools can be categorized as written, performance-based, observation and feedback-based, technological and psychometric tools. Written instruments are materials such as exams or tests that aim to measure students' level of knowledge and capacity for understanding. Performance-based tools offer the opportunity to observe students' performance through work such as project-based assessment or portfolios. These process-oriented tools are usually related to daily life. Observation and feedback-based tools allow for examining students' behavior through self- and peer-assessment channels. Technological tools include assessment and evaluation materials such as online exams, artificial intelligence systems and e-portfolios developed in accordance with the learning objectives. Finally, psychometric tools consist of scales and tests developed to understand students' cognitive, emotional and social learning states.

Redefining Traditional Evaluation Tools with Generative AI

Generative artificial intelligence technologies have led to a paradigm shift in the field of assessment and evaluation thanks to their content creation and evaluation capabilities. In particular, utilizing generative AI in the preparation and scoring of written assessment tools offers significant advantages in terms of both time and cost. Traditional paper-based assessment tools are written materials that have been used for many years and include quizzes, tests and homework samples to measure students' level of knowledge. Generative AI allows these tools to be diversified. For example, by creating multiple question types for the same learning objectives, problems such as cheating can be avoided.

Table 1. Use of generative AI in paper-based assessment and evaluation process

	Current situation	Generative AI based examples
Paper-based tools	Use of exams, tests, and written assignments	• Creation of measurement and evaluation tools. • Scoring students' responses to these instruments

	• Giving feedback to students

Generative AI systems facilitate the objective assessment of students' written work in areas such as language education. Research has shown that this technology can provide more consistent feedback, reducing teacher workload, especially in crowded classrooms. At the same time, feedback on students' work, such as essays, can be tailored to meet student-specific learning goals. These features suggest that generative AI technologies will be widely used in paper-based assessment and evaluation.

Performance-Based Evaluation and Generative Artificial Intelligence

Performance-based assessment is an approach that examines students' level of achievement of learning objectives within a process framework. However, the application of this approach in large groups of students can often be challenging. Especially in the process of evaluating and observing projects, subjectivity problems may arise due to the human factor. At this point, generative artificial intelligence can offer solutions that optimize project processes. Students can benefit from AI-based guidance systems when determining project topics, clarifying their goals and creating their work schedule. Teachers can improve students' problem-solving skills by generating real-life scenarios with the help of these systems.

Table 2. Use of generative AI for performance-based assessment and evaluation process

	Current situation	Generative AI based examples
Performance-Based Tools	Observe learners performance through performance based tool such as projects, portfolios, and presentations and performance tasks	• Guide students through project planning process • Evaluate learners' works based on certain rubrics • Prepare real-life scenarios for practice

Moreover, generative AI can provide data-based feedback, enabling more systematic monitoring of student performance. AI systems that monitor student progress throughout the project process and make recommendations accordingly provide significant convenience to both teachers and students.

Observational Evaluation and Feedback

The processes of observing and giving or receiving feedback during the teaching process make important contributions in terms of providing individuals with a personalized learning experience and instantly correcting mislearning. This process is not only limited to academic skills, but also allows for the observation of key 21st century skills such as teamwork and leadership. In this context, tools such as various observation checklists, rubrics and video and audio recordings are utilized. Students receive feedback from both teachers and peers, as well as self-assessment, allowing them to gain a deeper understanding of their own learning processes. Although these practices, as one of the innovative assessment methods, play a critical role in helping students develop different skills, they also bring some administrative challenges.

Table 3. Use of generative AI for observation and educational feedback

	Current situation	Generative AI based examples
Observation and Feedback Tools	Tracking learners' progress by using observation forms, peer and self-assessment, rubrics	• Analyzing classroom activities • Getting instant feedback

For example, observing students in crowded classrooms based on specific criteria can increase teachers' workload and lead to feelings of burnout. Moreover, although self-assessment and peer assessment can help students to critically reflect on their own learning, this process can be negatively affected by prejudices among students. Such challenges can be mitigated by the possibilities offered by generative artificial intelligence (AI) technologies. Indeed, as summarized in Table 3, generative AI is expected to facilitate assessment and observation processes.

To give an example, video footage recorded in classrooms equipped with cameras can be analyzed with generative AI technology. These analyses allow meaningful inferences to be made about students' behavior. Moreover, the data obtained from these systems offers the possibility to provide instant feedback to individuals. However, for such analyses to be effective, well-defined criteria and evaluation criteria must first be established. AI systems can offer significant advantages in developing these criteria. For example, by analyzing the patterns of student behavior obtained from classroom records, it may be possible to predict potential problems and develop solutions.

As a result, various behaviors that are directly related or not related to the learning objectives can be identified through observation. In order to make these observations in a healthy way, it is of great importance to evaluate the students individually and to share the results of the observations with them instantly. This process will also support the desired changes in student behavior. Generative artificial intelligence can make the learning experience more effective and efficient by facilitating individualized observation and feedback.

Generative AI as a Technological Tool

In today's world where online teaching activities are becoming increasingly widespread, a large part of the assessment processes are also carried out through online environments. In this context, online exams stand out among the most preferred assessment tools. Online exams usually consist of multiple choice, fill-in-the-blank, matching or open-ended questions. Similar to traditional assessment tools, generative artificial intelligence (AI) systems can offer innovative solutions for online exams. These systems can be used effectively in diversifying question types, automatically preparing questions that are appropriate for learning objectives, and scoring open-ended questions in particular. Thus, they can make significant contributions to the security and effectiveness of online exams.

Table 4. Use of generative AI as technological a tool

	Current situation	Generative AI based examples
Technological	Use of technology for	• Designing AI-based online exams

Tools	measurement and evaluation such as online exams and surveys, AI-powered tools, E-portfolio systems	• Providing adaptive learning paths • Analyzing data for actionable insights

The prediction features of generative AI systems also allow the number of questions in exams to be determined dynamically. For example, the number and type of questions can be customized according to the prior knowledge level of the test takers. This approach can increase engagement by enabling learners to have an exam experience appropriate to their individual knowledge level. At the same time, the difficulty level of the questions can be adjusted according to the learning level of the learners, thus enabling a personalized learning and assessment process. Beyond this, personalized e-portfolios can be created with the help of generative artificial intelligence and learners' online learning behaviors can be tracked in detail. Through these portfolios, students' achievement levels, deficiencies and development needs can be analyzed and important information about the process can be provided. This kind of integration can make assessment processes more personalized, flexible and learner-centered.

Psychometric Tools

Psychometric tests are often used to assess students' characteristics such as attitudes, behaviors, learning styles and motivation. These tests provide valuable information about students' academic achievement as well as their psychological and emotional states. In cases where learning is considered as a whole, it is important to analyze the social, emotional and psychological characteristics of students and develop appropriate strategies. Generative artificial intelligence systems can play a critical role in developing and adapting psychometric tests, analyzing scale data and calculating validity and reliability scores. They can also make predictions about future learning trends by analyzing student behavior and generate solutions based on these predictions.

The natural language processing capabilities of artificial intelligence can contribute to the identification of learning dispositions by analyzing students' responses to open-ended questions. Such analyses can not only understand students' cognitive states, but can also make their learning experiences more positive by providing feedback that is relevant to their psychological well-being. For example, more supportive and motivating feedback can be designed for students with low levels of psychological well-being. Since generative AI can realize such applications quickly and at low cost, it provides a great advantage in terms of reaching large student populations.

Table 5. Use of generative AI as psychometric tools

	Current situation	Generative AI based examples
Psychometric Tools	Measure learners' attitudes, motivations, and certain cognitive abilities by scales and standardized tests	• Developing scale and surveys • Creating adaptable tests • Analyzing data and scoring • Behavior and personality analysis • Continuous monitoring and forecasting

As a result, generative AI systems have great potential not only for measuring and assessing cognitive learning states, but also for detecting and developing solutions for psychological states that are critical in the learning process. Utilizing this potential more effectively requires more academic research on how to adapt artificial intelligence to educational processes. Such studies will contribute to the development of innovative applications that can shape the future of learning and assessment processes.

Future Considerations

The emergence of generative artificial intelligence has necessitated the revision of assessment and evaluation processes in line with current technological developments. In this context, researchers and educators have started to integrate generative artificial intelligence into teaching processes and observe the effects of this integration. Especially in areas such as personalized and adaptive assessment processes, development of new assessment and evaluation tools, dissemination of data-driven decision-making mechanisms and continuous, real-time assessment, generative AI is expected to offer many opportunities in the future. Table 6 summarizes the potential roles of generative AI in future assessment and evaluation processes.

Personalized learning is one of the most popular approaches in education. In this approach, learners are expected to be actively involved in the learning process in line with their individual needs. Learners play an active role in planning the learning process, determining the content, conducting activities and evaluation. Generative AI has the potential to provide both personalized learning opportunities and more effective assessment and evaluation opportunities in these processes. For example, adaptive tests can change the difficulty level and content of questions based on students' prior knowledge. In addition, the feedback mechanism can become more effective with the support of artificial intelligence. For example, in foreign language learning, special content can be presented to students and instant feedback can be provided by analyzing the mistakes made. It is predicted that such applications will become widespread in different disciplines.

Table 6. The role of generative AI in future measurement and evaluation processes

Role	Future Perspectives
Personalized and adaptive assessment	• Adaptive Testing • Comprehensive Feedback
Development of new measurement tools	• Social and Emotional Skills Assessment • Creativity and Critical Thinking Analysis
Data driven decision making	• Performance Forecast • Trend Identification
Continuous and real-time evaluation	• Real Time Monitoring • Gamified Learning

Generative artificial intelligence is expected to create a paradigm shift in assessment and evaluation processes. Beyond traditional methods, an approach where artificial intelligence becomes a part of the assessment process

and offers solutions to improve student performance will come to the fore. In this context, process-oriented assessments aimed at developing students' creativity and critical thinking skills may become widespread. In addition, it will be possible to make predictions about students' emotional states beyond just their cognitive learning outcomes and to produce solutions based on these predictions.

One of the most important uses of artificial intelligence is diagnosis and prediction. In this process, data about specific people or situations are analyzed and predictions are made for the future. Especially in online learning environments, the digital traces left by students can be analyzed to predict their future behavior or classify them according to certain criteria. This approach allows for early intervention on students' academic and emotional states, enabling more efficient management of learning processes. In addition, the challenges faced by students can be identified and solutions can be offered to address these challenges, making educational processes more effective in terms of both cost and time.

One of the biggest criticisms of end-of-process focused assessments is that they ignore students' performance throughout the process. For quality teaching, it is important to continuously monitor students and provide instant feedback on their learning. However, individual differences and crowded classrooms make it difficult to implement such assessment methods. At this point, generative artificial intelligence solutions can come into play and continuously monitor students' learning processes and provide instant feedback to their mistakes. In addition, the learning process can be gamified to develop students' real-life skills.

In conclusion, it is predicted that generative artificial intelligence systems, whose effectiveness has been tested by many researchers today, will be widely used in measurement and evaluation processes in the future. These systems will become task partners by integrating them into assessment processes. In this context, educators, instructional designers and researchers have great duties in terms of how generative artificial intelligence should be adapted to assessment and evaluation processes. It is thought that the experiments and application principles carried out today will guide future assessment and evaluation processes.

Conclusion

The aim of this chapter is to raise awareness among researchers and educators about the use of generative artificial intelligence in assessment and evaluation processes. In this context, the scope of the subject was kept narrow and only the use of generative artificial intelligence in measurement and evaluation processes was focused. When the existing academic studies are examined, it is seen that many studies have been conducted on the use of generative artificial intelligence in these processes. It is understood that these studies especially focus on issues such as evaluating learning processes and giving feedback to students.

In this book chapter, the role of generative artificial intelligence in measurement and assessment is discussed in terms of redefining traditional measurement tools, performance-based measurement and assessment, observation-based measurement and assessment, feedback, generative artificial intelligence as a technological tool and

psychometric tools. Under each heading, examples of how generative artificial intelligence can be used are presented. It is also predicted that in the future, generative artificial intelligence may lead to an important paradigm shift in measurement and evaluation processes. It is thought that generative AI will go beyond being just a tool and become an integral part of assessment and evaluation, especially in personalized learning environments.

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Chapter 7 - Education Policies and Artificial Intelligence: Current Status and Recommendations

Önder Yıldırım

Introduction

Artificial Intelligence in Education: Current Status and Applications

Artificial intelligence (AI) is a machine-based system that can affect real or virtual environments by making predictions, suggestions, or decisions based on goals set by humans. AI appears to operate autonomously, learns about the context, and can adapt its behavior (UNICEF, 2021). In order to mimic human intelligence, it involves learning, reasoning, and self-correction processes. Today, AI is effective not only in industries but also in many areas such as health, agriculture, energy, drive improvement, and software development, and also plays an important role in education. Although AI and adaptive learning technologies have the potential to provide great improvements in education, it should not be forgotten that they cannot be the solution to every problem. Internationally, the role of AI in improving the quality of education is being examined, and research focuses on eight main topics such as information graphics, student modeling, and intelligent guidance systems. The studies aim to increase the potential of AI in education (Shah, 2023, Yu et al., 2021b). Artificial intelligence (AI) in education has a long history in supporting learning processes and has continuously evolved from the first teaching machines in the 1950s to today's personalized learning systems. Technologies such as natural language processing and machine learning, as well as Intelligent Tutoring Systems (ITS) and knowledge bases, have helped both teachers and students optimize their learning processes. AI can provide personalized support by analyzing students' learning data, develop adaptive learning methods, and enable learning anywhere by combining formal and informal learning environments. In addition, AI has a wide impact on education, from the transformation of libraries to lifelong learning, from providing virtual mentor support to teachers to providing global classroom access. The goal of AI in education is to make both teaching processes and student development more efficient and accessible by combining technology with learning sciences to support effective learning (Yu & Lu, 2021; Jia, 2018, Yu, 2018, Woolf et al., 2016). The use of artificial intelligence in education, when looking at the application areas and studies, is generally pedagogically deficient and follows previous technology studies. Especially in studies to be carried out in schools, the absence of pedagogy that will guide the questions of what to study and

how to study can put the future of the studies to be carried out in terms of the field at risk. Because in studies on artificial intelligence, the positive aspects of artificial intelligence are generally praised, and unfortunately, the negative or deficient aspects are mostly not emphasized (Díaz & Nussbaum, 2024). In addition, when looking at the current status of artificial intelligence and the prevalence of studies in different disciplines, the difficulties are also revealed (Crompton & Burke, 2023). Studies based on literature analysis are needed to reveal the types of results and environments in which studies conducted in different disciplines.

Artificial Intelligence in Education Policies: Opportunities and Challenges

Artificial intelligence (AI) in education is providing a significant transformation in education by making teaching and management processes more individualized, effective and data-driven. AI technologies offer innovations in many areas such as creating smart learning environments, providing personalized learning support, assessing students' knowledge and skills, reducing teachers' workload and making decisions based on big data analytics in education management. While students can access personalized learning materials at any time and place thanks to AI, teachers can design learning environments suitable for student needs and evaluate processes. At the same time, educational processes are becoming more efficient with tools such as AI-supported smart classrooms, virtual learning environments, special education tools, automatic scoring and teaching planning. Education administrators can monitor education quality, provide regional equality and integrate ancillary services such as health using AI. This transformation requires new competencies such as data analysis and modeling for teachers and administrators, and offers a strong potential to increase equality, accessibility and quality in education. The opportunities offered by AI make it possible to achieve a more inclusive, fair and effective education system (Yu & Lu, 2021; Chen & Yu, 2015, Wu et al., 2017). With the rapid development of artificial intelligence (AI) technologies, the applications of artificial intelligence (AIEd) in education have increased significantly. AIEd uses AI methods to support teaching, learning and decision-making processes, helping teachers with tasks such as evaluating students' performance, providing feedback, and identifying at-risk students. It is also effective in processes such as providing students with access to learning materials, identifying their strengths and weaknesses, supporting self-regulated learning, and encouraging collaboration among students. AIEd also allows university administrators to monitor dropout rates to help them make program development decisions. Different AI techniques have been successfully used to make learning-teaching environments smarter (Ouyang et all., 2022).
Artificial intelligence (AI) aims to reduce workload and support individual learning by transforming educators' roles, management, and evaluation processes in education. AI enables educators to perform time-consuming tasks, such as lesson preparation, student monitoring, and evaluation, more quickly and effectively. It also helps educators with repetitive tasks, allowing them to focus on generative work. It provides guidance in course design and development processes, content planning, personalized material recommendations, and student deficiencies detection. AI supports the professional development of educators with technologies such as data analytics and machine learning. It also facilitates learning processes in the classroom, provides personalized support to individual students, and increases the quality of education. AI is becoming more effective in education with applications such as personalized education, dialogue systems, intelligent agents, and education for students with special needs. In educational institutions, it contributes to areas such as course programs, exam management, and cybersecurity. AI aims to make educational processes more efficient, and applications that were initially

knowledge-based have now turned into data and logic-based approaches (Arslan 2020: Holmes, 2019, Luckin et al., 2016, Woolf, 2009, Yacef, 2002, Yu et al., 2021c).

The Impact of Artificial Intelligence Technologies on Education Policies

The development of artificial intelligence technology makes learning processes more intelligent and efficient. While students gain knowledge, skills and attitudes through interaction with teachers, peers and teaching materials, artificial intelligence algorithms play an important role in improving learning processes. For example, information recommendation algorithms suggest appropriate resources for students, while information tracking models monitor students' learning status. Natural language processing (NLP) technology answers student questions, while virtual reality (VR) and augmented reality (AR) offer simulated learning environments. Artificial intelligence creates cognitive, information and environmental models to make learning processes more effective. Deep learning and machine learning technologies play a critical role in recommending learning resources and diagnosing processes. In addition, brain science research is used to help students with special needs and provide interventions in learning processes. These processes are supported by technologies such as intelligent tools and robots that enable students to acquire knowledge, share learning resources, collaborate and learn more effectively. Artificial intelligence aims to provide students with better learning experiences and make learning processes more accessible with its applications in education (Yu & Lu, 2021). Artificial intelligence processes data fed by machine learning and performs processes to define and structure patterns and structures. Artificial intelligence-supported systems can be built with machine learning. It is very important that the structure built is smart, adaptable and personalized. In this way, it can be studied how these systems will benefit education. When integrating artificial intelligence into education, we need to know that the system controls everything in every aspect. Because data loss within the system, theft of personal data or ethical problems may cause the results of the education thought to be done correctly to be wrong or erroneous (Alpaydin, 2016, Fox, 2022).

There are three main approaches in the field of artificial intelligence (AI): behaviorism, symbolism, and connectionism. Behaviorism argues that AI mimics human behavior using perception and actions to adapt to environmental changes, and this approach includes methods such as deep learning and biological intelligence algorithms that enable robots to learn and adapt to tasks. Symbolism suggests that AI simulates human reasoning by working on the basis of mathematical logic, and has demonstrated logical reasoning capabilities with systems such as Deep Blue. Connectionism focuses on imitating the functions of the brain by modeling neural networks; deep learning algorithms have demonstrated successful applications in visual recognition, language processing, and strategy games (AlphaGo and AlphaZero). While each approach has its own advantages and limitations, together these methods have advanced AI research and enabled the development of applications that offer practical benefits in daily life (Yu & Lu, 2021; Nilsson, 2010, Xu & Me, 2004).

Innovative Approaches and Learning Analytics

Artificial Intelligence Applications and Tools in Education

In the future, education will experience a major transformation with the rapid development of artificial intelligence (AI) technologies. AI will reshape teaching environments and the functioning of schools, changing the roles of teachers and students. AI technologies will analyze student data and help determine individual learning needs more accurately, so teachers can offer personalized educational content and activities for each student. This will enable the realization of goals such as personalized education, inclusive education, and lifelong learning. In addition, the use of AI in education will bridge the gap between formal and informal learning environments, allowing students to learn in their daily lives. Teachers will focus on interacting with students and guiding their development rather than transferring knowledge. Education will no longer be limited to just presenting information, but will also become a system for the development of students' skills, multiple intelligences, and 21st century competencies. In this process, teachers will be freed from traditional, repetitive tasks and will interact more deeply with students. AI will provide teachers with the opportunity to spend more time on students' social and emotional development. A more holistic approach will begin to be adopted in education, such as focusing on students' spiritual development, developing their social responsibilities, and increasing their happiness. The integration of AI into education will increase teachers' professional knowledge and skills, and will provide them with the opportunity to collaborate with teachers from different disciplines. Future education systems will be designed to support not only academic success but also students' entire development processes. Education will no longer be limited to classroom walls, and learning will become possible anywhere and at any time. Schools will take on a more flexible and open structure with the combination of virtual and physical spaces. As a result, education will become a lifelong process, accessible at all ages and in all places, and in this process, AI will enrich the learning experience by strengthening the interaction between teachers and students (Yu et al., 2021; Yu, 2018, Zhao, 2018).

Human-computer interaction is a field that emerged through the combination of computer science and cognitive psychology, supported by various disciplines such as ergonomics, sociology and linguistics, and aims to examine the interactions between the user and the machine. While traditional models are based on equipment such as keyboards and mice, as technology develops, more natural and effective interactions have been provided with innovative methods such as touch screens, voice commands, motion detection and brain-machine interfaces. Robots and artificial intelligence technologies serve in many areas such as education, security and daily life by using intelligent control systems to achieve goals without human intervention. For example, educational robots provide both information and emotional support to students with information graphics and natural language processing technologies. Virtual reality (VR) and augmented reality (AR) technologies create virtual environments with visuals and simulations, providing both cost savings and safe and effective experiences in areas such as education, vocational training and virtual campus services. However, these technologies require improvements to address challenges such as portability, freedom of interaction, and user experience dizziness (Yu & Lu, 2021; Li & Wang, 2015, Kober et al., 2013, Zhou et al., 2015). Artificial intelligence transforms assessment processes in education, offering the opportunity to assess students' multidimensional characteristics beyond traditional paper-based tests. AI can assess different areas such as academic performance, problem-solving skills,

physical health, and personality development. Technological tools collect data on students' behaviors, interests, and health status, and this data supports student development by providing personalized learning recommendations. Assessments made with AI offer a more comprehensive and individualized approach, reducing the workload of educators and providing personalized materials to students. In addition, AI increases the accuracy of assessment processes by minimizing human errors and biases with intelligent tests and assessment processes. AI also offers teachers the opportunity to quickly provide personalized feedback, but these processes need to be carefully integrated. AI can provide a more consistent evaluation process by providing objectivity in grading, but educators' guidance is still needed (Arslan, 2020, Shah, 2023, Yacef, 2002, Yu and Lu, 2021). In studies conducted with chatbots, especially in language education, artificial intelligence chatbots have been used as a tool to support learners' development. There have been those who define artificial intelligence as a student's partner. These chatbots are generally used as task-based chatbots. The use of artificial intelligence chatbots in students' language education, ensuring fluency, facilitating their learning, and teaching concepts theoretically has brought many advantages (Díaz & Delgado, 2024, Yang et al., 2022).

Artificial Intelligence and the Transformation of the Workforce in Education

Artificial Intelligence (AI) will lead to radical changes in education and the workforce. While AI will eliminate some professions, it will increase the demand for new jobs such as data scientists and software engineers. This change will change the skill requirements in the workforce and create opportunities and challenges for employers and employees. AI can help improve human performance, but it can also raise ethical issues such as privacy, liability, and bias. In addition, governments may implement practices such as universal basic income due to the shrinking workforce. In education, it will be important to teach students how to exist in an AI world. This will not only prepare them for the workforce, but also align with other goals such as democratic participation and living a fulfilling life. Students will need to develop critical thinking skills and evaluate the accuracy of data generated by AI. It will also be important for them to gain the skills to work with AI and design products based on AI systems. AI will create innovative job opportunities and allow people to focus on more generative work. Education should not be limited to technical skills alone, but should also develop students' ability to continuously learn and adapt to evolving technologies (Erikli & Salih, 2022, Shah, 2023).

Conclusion

Artificial intelligence is a machine-based system that can produce suggestions, results or decisions according to the target or purpose determined by the data fed by a human or machine. There is a use of artificial intelligence in many areas in current systems. From the field of education to the field of health, multi-disciplinary uses of artificial intelligence are seen in the literature. In the international field, the role of AI in increasing the quality of education is examined and research focuses on basic topics such as information graphics, student modeling, and intelligent guidance systems. Artificial intelligence has made a rapid entrance in this way. Artificial intelligence subject-based studies are carried out in all areas. However, unfortunately, there are deficiencies in pedagogical terms in most of the studies. The studies conducted follow the methodology and pedagogy of previous technology-based

studies. For this reason, it can bring many risks. Because a lot of information is loaded into artificial intelligence as data. It is not clear where this information will be used, especially in terms of education. It also brings ethical problems. In addition to these. Artificial Intelligence technologies also have positive aspects as they offer innovations in many areas such as creating smart learning environments, providing personalized learning support, evaluating students' knowledge and skills, reducing teachers' workload, and making decisions based on big data analytics in education management. On the other hand, Artificial Intelligence (AI) transforms the roles, management, and evaluation processes of educators in education, thus reducing workload and supporting individual learning. In this way, educators aim to provide students with better learning experiences and make learning processes more accessible with the applications of artificial intelligence in education. It is thought that this section will provide added value to the literature in terms of using artificial intelligence in education, developing policies, and guiding the studies to be conducted.

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Chapter 8 –Transforming Computer Programming Education with Generative Artificial Intelligence

Turgay Demirel

Introduction

Education is undergoing significant changes, especially in programming. Traditional teaching methods are being supplemented or replaced by innovative approaches. The challenges inherent in programming education require a deep understanding of how students acquire knowledge and how instructors can effectively support that learning process. Programming is often perceived as a challenging discipline; novices frequently encounter overwhelming cognitive demands as they grapple with abstract concepts, intricate syntax, and multifaceted problem-solving tasks. Such challenges can cause frustration, lower self-efficiacy, and ultimately, a lack of engagement in the learning process (Kazemitabaar et al., 2023). The pedagogical framework for programming education should incorporate strategies that address the challenges and cultivate essential skills like computational thinking and problem-solving.

Central to effective programming education is recognizing that learning to code goes beyond understanding syntax. It involves fostering a mindset that embraces complexity, encourages exploration, and cultivates resilience to difficulty. Various pedagogical approaches have emerged to address these needs. For example, live-coding sessions allow students to observe expert coders in real time, exposing them to the dynamic and often non-linear thought processes that characterize effective coding practices (Lin et al., 2022). This method contrasts sharply with traditional lecture-based instruction, which often fails to capture the intricacies of programming thought. Collaborative learning environments enhance student engagement and foster a sense of community, which are crucial in the often isolating experience of coding (Magamedova et al., 2022).

Constructivist teaching approaches are central to programming education, underscoring the significance of active learning through problem-solving, project-based assignments, and collaborative activities. These methods encourage students to construct understanding through hands-on experiences and social interactions, following social constructivist principles (Figueiredo et al., 2016). The integration of automated feedback mechanisms, such as those provided by AI tools, can further support this constructivist approach by offering real-time guidance during the debugging process (Gulwani et al., 2018). These tools not only support skill acquisition, but also

promote metacognitive awareness. This allows the student to reflect upon his learning and adapt his strategy accordingly.

Cognitive load theory is also important in programming education, emphasizing the need to manage mental effort in learning complex concepts. Effective instructional strategies should aim to break down intricate ideas into smaller, more manageable components, supplemented by clear explanations and visual aids (Schulte et al., 2010). By reducing cognitive load, educators can help students navigate the complexity of programming more effectively, promoting a more positive learning experience. Recent studies have indicated that tools like GPTutor, which provide code explanations, can significantly alleviate cognitive load, thereby enhancing student learning outcomes (Chen et al., 2023).

Despite the growing recognition of these pedagogical strategies, significant challenges persist in programming education. The abstract nature of programming can lead to low motivation and high dropout rates, particularly among students from diverse educational backgrounds (Mbiada et al., 2022). Experiencing repeated failure, especially in introductory courses, can undermine students' self-efficacy and discourage further study of programming (Qureshi, 2023). Thus, the design of programming curricula must prioritize engaging learning experiences that balance theoretical foundations with practical applications.

The advent of generative AI tools has introduced new dimensions to programming education, offering both opportunities and challenges. These tools can improve student performance through immediate feedback, personalized tutoring, and automated code generation, lowering barriers to entry for beginners (Kazemitabaar et al., 2023). Studies have shown that students who leverage AI tools often report increased confidence and improved learning outcomes (Johnson et al., 2024). However, there are ongoing concerns regarding the overreliance on AI solutions and the potential diminishment of critical thinking abilities (Abdulla et al., 2024). The challenge lies in integrating these tools in a manner that supports, rather than undermines, the development of fundamental programming competencies.

Furthermore, the ethical implications of using AI in programming education should not be ignored. Educators must thoughtfully address concerns about academic integrity, biases in AI-generated materials, and the potential to exacerbate existing disparities in technology access (Denny et al., 2024). As educators navigate these complexities, it becomes imperative to establish best practices that ensure AI tools complement traditional pedagogical methods while fostering a deep understanding of programming concepts.

In conclusion, the pedagogical approaches to programming education are transforming to address the challenges and possibilities presented by both traditional teaching methods and emerging technologies. By adopting a multi-faceted teaching methodology that blends active engagement, collaborative learning experiences, and innovative technologies like generative AI, educators can better equip students with the necessary skills and confidence to succeed in our increasingly digital landscape. As this field continues to evolve, ongoing research and dialogue will be essential to refine instructional strategies and address the ethical considerations that accompany the integration of AI in programming education.

Learning and Teaching Programming with AI

Challenges of Learning and Teaching Programming

Teaching and learning programming present a multitude of challenges that span across different educational levels and contexts. These include the abstract nature of coding, the diversity of learners, and the different skills needed in different coding environments. Here is a summary of the key challenges students have in the learning of programming.

Programming involves complex concepts, syntax, and problem solving that can be overwhelming to beginners (Kazemitabaar et al., 2023; Qureshi, 2023). Programming tasks impose a significant cognitive load on learners, particularly for those with limited prior knowledge tackling complex tasks. Managing this cognitive load is essential to avoid overwhelming students (Kazemitabaar et al., 2023; Qureshi, 2023). Also, novices often struggle with programming logic, syntax, and debugging (Nouri et al., 2020). To build a solid foundation, it is important to address these misconceptions early. Proficiency in programming language constructs alone does not ensure the ability to solve novel programming problems. Developing strong problem-solving capabilities is crucial, as it entails understanding and utilizing algorithms, as well as applying computational thinking principles (Rouhani et al., 2022).

The abstract and conceptual nature of programming can contribute to low student motivation and high dropout rates. The challenge is more pronounced in introductory programming courses, where students from diverse backgrounds struggle with the new and complex concepts (Figueiredo & García-Peñalvo, 2021; Mbiada et al., 2022). Early failures in the learning process can undermine students' confidence and discourage them from continuing to learn programming (Qureshi, 2023). Creating engaging learning experiences is vital for retaining students' interest. The design of programming assignments significantly influences student motivation. Too easy or too hard assignments can decrease motivation and engagement, negatively impacting the learning experience (Kazemitabaar et al., 2023).

While programming education challenges are significant, opportunities for improvement exist. For instance, integrating more practical and engaging teaching methods, such as using technological tools that provide immediate feedback, can enhance the learning experience (Figueiredo & García-Peñalvo, 2021). Introductory programming courses must balance theory and practice for a comprehensive learning experience. This involves designing course materials, developing assignments, and creating feedback opportunities that support active learning (Kazemitabaar et al., 2023; Sarsa et al., 2022).

Pedagogy of Learning and Teaching Programming with AI

The pedagogy for learning and teaching programming blends traditional and innovative methods to address the complexities of programming education. Programming is not easy to learn. Novices can be overwhelmed by the complexity of coding tasks, which can be frustrating and lower their confidence (Kazemitabaar et al., 2023). Programming is more than understanding syntax, it is developing problem-solving and computational thinking skills. The key pedagogical approaches and considerations in programming education are outlined below.

Live-coding, where students observe experts coding in real-time, has been shown to improve both declarative and procedural programming knowledge. This method allows students to experience the dynamic and nonlinear thinking of coding that traditional lecture-based methods often overlook (Lin et al., 2022). Teacher-student interaction is also critical to effective learning. Collaborating helps students develop values and increases their engagement with learning (Magamedova et al., 2022). In addition, teaching programming involves more than just syntax; it requires cultivating computational thinking and problem-solving skills. The development of these programming skills is crucial for students to use their coding knowledge in practical, real-world applications (Kandemir et al., 2021). Additionally, teachers must be aware of students' typical difficulties in learning programming. Utilizing effective instructional approaches, such as breaking down complex concepts and offering practical examples, can help alleviate these challenges (Bosse et al., 2019).

Constructivism emphasizes that learners actively construct their understanding through experience and interaction. In programming education, constructivist approaches offer active learning through problem-solving, project-based learning, and collaborative activities. According to Figueiredo et al. (2016) teaching programming requires a different methodology than other subjects, implying a move away from traditional, passive learning models. In programming, this can be achieved through active learning by solving problems, working on projects, and collaborating. Gulwani et al. (2018)'s work on automated program repair could be seen as supporting constructivist learning by providing feedback that guides students' own debugging process. Ouh et al. (2023)'s evaluation of ChatGPT for coding exercises also aligns with this, as students actively engage with the AI to construct solutions. Pankiewicz & Baker (2023)'s exploration of automated feedback further reinforces the focus on active learning. Kosar et al. (2024)’s study focused on providing novice programmers with hands-on experience using AI tools in a programming course, reflecting a constructivist approach.

Managing the learner's cognitive load when learning programming is critical. In programming, this involves breaking down complex concepts into smaller, manageable chunks, providing clear explanations and examples, and using visual aids to reduce cognitive load. According to Schulte et al. (2010) understanding learning issues such as content, sequence, and learning obstacles is crucial, as it aligns with the principles of cognitive load theory. Kazemitabaar et al. (2023) discusses reducing cognitive load through techniques like worked examples, directly applying this theory. Chen et al. (2023)'s GPTutor tool directly addresses CLT by providing code explanations to reduce cognitive load. Finnie-Ansley et al. (2022)'s study on OpenAI Codex also touches upon CLT, as AI assistance can potentially alleviate cognitive overload for novice programmers. Ozkaya (2023)'s discussion of LLMs in software engineering implicitly touches upon CLT, as these models can potentially reduce cognitive load by automating certain tasks. Kumar et al. (2024)'s investigation of LLMs for feedback generation also relates to CLT, as timely and relevant feedback can help manage cognitive load.

Accoring to social constructivism, learning is enhanced by social interaction. Knowledge construction and skill development can be facilitated through collaborative programming activities, peer feedback, and group projects. Research highlights the social aspect of chatbots that can facilitate the social connection of learning (Adamopoulou & Moussiades, 2020; Karyotaki et al., 2022; H.-Y. Liang et al., 2024). According to 's research on instructor perspectives, there is a concern that AI tools may potentially impede student collaboration (Lau &

Guo, 2023). However, tools like those explored in Qureshi (2023) and Zhang et al. (2024) could be leveraged to foster online discussions and peer feedback, aligning with social constructivist principles. Also, Shoufan (2023)'s exploration of student perceptions of ChatGPT suggests that while AI tools can be helpful, they might also impact social interaction in learning environments. This highlights the need for consideration of the social aspect of the integration of AI tools. Essel et al. (2022)'s study on the impact of a chatbot on student learning touches upon the social aspect, as chatbots can facilitate interaction and support. Haindl & Weinberger (2024)'s investigation of student experiences using ChatGPT in programming further emphasizes the social dimension, as students may use the tool to discuss and collaborate on coding tasks.

Learning through experience and reflection is key in programming. Hands-on experiences, such as internships, real-world projects, and coding activities, allow students to apply their knowledge and cultivate practical programming skills. Firat (2023)'s investigation of university perceptions of AI tools, suggesting a shift towards experiential learning with AI. Bozkurt (2023)'s discussion of AI-powered educational agents further supports this trend. According to a research on OpenAI Codex, AI tools can promote experiential learning by enabling students to more readily experiment with code (Finnie-Ansley et al., 2022). Zhang et al. (2024) 's exploration of AI-generated feedback further supports experiential learning by providing opportunities for reflection and improvement. Kosar et al. (2024)'s study on using ChatGPT in a Java programming course directly reflects experiential learning, as students gain practical experience using AI tools in a real-world coding context.

These theoretical backgroud informs the design of effective programming curricula, instructional strategies, and assessment methods They stress the importance of active learning, problem solving, collaboration, and a focus on developing higher-order thinking skills.

Impact of Generative AI as a Pedagogical Tool in Programming

Possible Positive Impacts of Generative AI on Students' Programming Performance

The impact of generative AI on student performance in programming education presents both opportunities and challenges. Generative AI tools, such as ChatGPT, can be valuable resources for students learning programming, offering explanations, code suggestions, and solutions to programming problems. However, their effectiveness of these tools depends largely on how students use them. While some students may find AI tools useful as additional learning aids, others may encounter adverse effects if they excessively depend on AI-generated solutions without actively engaging in the problem-solving process.

Studies suggest AI tools can improve learning, especially for novice programmers. For instance, research indicates that access to AI code generators can significantly improve task completion rates, code correctness, and reduce the time taken to complete tasks (Kazemitabaar et al., 2023). Furthermore, AI tools can lower the barrier to entry for beginners by simplifying complex concepts and syntax (Kadaruddin, 2023). This can lead to increased student engagement and motivation, as observed in studies where students using AI tools reported reduced stress and greater eagerness to continue learning (Kazemitabaar et al., 2023).

Generative AI tools can enrich students' learning experiences by offering personalized guidance and clarifications. Students who use AI to understand programming concepts and seek clarifications tend to benefit from improved learning outcomes (Lehmann et al., 2024). Studies show that successfully using AI in programming tasks can increase students' confidence in their programming skills. For instance, agriculture students using ChatGPT for microcontroller programming reported increased self-efficacy and positive attitudes towards AI (Johnson et al., 2024). Generative AI can assist novice programmers by offering hints and explanations for error messages, helping them overcome metacognitive challenges and improve their problem-solving skills (Prather, Reeves, et al., 2024).

Possible Negative Impacts of Generative AI on Students' Programming Performance

A significant concern is that students may become excessively dependent on AI tools, using them to complete assignments without grasping the underlying concepts. Over-reliance of AI-generated code can foster academic dishonesty and undermine the development of essential problem-solving and critical thinking skills (Abdulla et al., 2024; Amoozadeh et al., 2024; Dickey et al., 2023). When students have access to generative AI tools, their tendency to explore other traditional educational resources is largely reduced. They tend to rely solely on the AI tool, which does not necessarily guarantee enhanced learning performance (Ooi et al., 2023). Additionally, over-reliance on AI tools could potentially decrease students' active participation in problem-solving and critical thinking activities (Ooi et al., 2023). Certain studies suggest that students who extensively utilize AI tools to generate solutions may experience poorer academic performance compared to those who do not heavily rely on such tools. This is particularly true for students with high learning potential, as reliance on AI can impede their learning process (Wecks et al., 2024). Moreover, students may overestimate their programming abilities due to the ease of obtaining solutions from AI, leading to an illusion of competence This can lead to a lack of preparedness for real-world programming challenges (Prather, Reeves, et al., 2024).

There are concerns about potential biases in AI-generated code and its suitability for novice learners (Denny et al., 2024) . Generative AI might foster misunderstandings of the material and increase cognitive load, especially when dealing with complex queries that require multiple prompts for accurate responses. Generative AI tools like ChatGPT can assist in various programming tasks, including code completion and providing explanations for code. However, output quality may vary depending on training data and prompts used (Ooi et al., 2023; Xue et al., 2024). While generative AI can handle simpler programming tasks effectively, it struggles with more complex queries, which can increase students' cognitive load and require additional effort to obtain correct solutions (Ooi et al., 2023). Moreover, there are ethical and pedagogical concerns about incorporating generative AI into education. Some institutions have banned its use, while others encourage it with appropriate disclosure, reflecting the ongoing debate about its role in education (Xue et al., 2024). Therefore, careful integration of these tools into the curriculum is crucial to maximize their benefits while mitigating potential drawbacks. This includes a focus on pedagogical approaches that encourage active learning, problem solving, and a deep understanding of programming concepts, rather than just relying on the AI to generate code.

In conclusion, generative AI tools present potential to support programming education, but their impact on student performance is multifaceted and influenced by context. Educators and institutions must thoughtfully integrate

these tools into their curricula, seeking to maximize the benefits while mitigating potential drawbacks. The impact of AI tools also depends on how they're integrated into curriculum. Courses that align AI usage with learning goals and provide guidance on ethical use can mitigate potential negative effects (Keuning et al., 2024; Palacios-Alonso et al., 2024). Students with less prior knowledge in programming tend to benefit more from AI tools, as these tools can provide foundational support and guidance (Lehmann et al., 2024). Students' perceptions of AI tools and willingness to use them responsibly are critical to the tools' effectiveness in improving learning outcomes (Lyons et al., 2024).

Teachers' and Students' Views on AI Tools for Programming

Both teachers and students hold diverse perspectives on using AI tools for programming learning. Although they recognize the potential advantages, they also voice concerns about the ethical implications and possible drawbacks. Many teachers recognize AI's potential to personalize learning, provide immediate feedback, and automate tasks like code generation (Lau & Guo, 2023). Some believe AI can help students grasp complex concepts and debug code more efficiently (Kazemitabaar et al., 2023). They consider AI a valuable tool for crafting more immersive and interactive learning environments for students. A primary concern among instructors is the potential for academic dishonesty (Lau & Guo, 2023). Many teachers are concerned about the potential for AI tools to facilitate cheating and compromise academic integrity. They are considering immediate measures to discourage AI-assisted cheating in the short term (Lau & Guo, 2023). There are also concerns about the accuracy and bias of AI-generated code and explanations. Some instructors are apprehensive about the pedagogical implications of integrating AI into their teaching practices (Zastudil et al., 2023). Teachers worry that students may rely too much on AI, which could impede the development of critical thinking and problem-solving skills (Lau & Guo, 2023). There are also worries that students may not fully comprehend the AI-generated code, hindering their ability to write and modify code independently, leading to a superficial understanding of programming concepts (Kazemitabaar et al., 2023; Zviel-Girshin, 2024).

Teachers' long-term strategies regarding AI tools are divided. Some want to ban these tools to focus on teaching programming fundamentals, while others advocate for integrating them into courses to prepare students for future job markets (Lau & Guo, 2023). They advocate for the development of best practices and curriculum adjustments to ensure that AI tools complement rather than replace traditional learning methods (Saari et al., 2024; Zastudil et al., 2023).

Students appreciate AI's ability to provide quick assistance and explanations, particularly for novice programmers (Prather et al., 2023). They find AI tools helpful for generating code snippets, debugging, and understanding complex concepts. Some students have expressed a boost in their confidence and sense of capability when utilizing AI tools for programming activities. In a study involving 264 students, it was found that students' satisfaction with AI tools improved over time, with a significant increase in familiarity and usage (Zviel-Girshin, 2024). Students appreciate the immediate feedback and visualization capabilities provided by AI, which aid in understanding complex programming concepts (Asgari et al., 2024).

Students are generally optimistic about the use of AI tools, although there are concerns about ethical implications, such as cheating and over-reliance on AI for problem-solving (Zviel-Girshin, 2024). Students also acknowledge

the potential for over-reliance and the ethical implications of using AI for assignments (Zastudil et al., 2023). Some worry about developing a false sense of competence and neglecting fundamental programming skills (Fiesler et al., 2021). There are concerns about potential biases in AI-generated code and the potential lack of human interaction in the learning process (Wang et al., 2023). Many students prefer to do their own work on graded assignments and are motivated to understand programming concepts without relying heavily on AI tools (Lau & Guo, 2023).

Overall, both teachers and students see the potential of AI tools in programming education, but stress the need for responsible implementation and ethical considerations. The goal should be to integrate AI in a way that supports, not replaces, traditional teaching methods and fosters a deep understanding of programming concepts.

AI Tools for Learning Programming

Capabilities of Generative AI Tools for Programming

The capabilities of AI tools for programming have significantly evolved, leveraging advanced machine learning models to automate and enhance various aspects of software development. Generative AI tools like GitHub Copilot and OpenAI Codex leverage advanced language models to offer real-time code suggestions, automated error detection, and intelligent code completions. This can enhance productivity and efficiency in programming tasks. However, despite their transformative potential, these tools also present challenges related to accuracy, contextual understanding, and ethical considerations. The specific capabilities and limitations of AI tools in programming are explored below.

Code Generation

AI tools like GitHub Copilot and OpenAI Codex can generate code snippets and provide real-time suggestions, acting as an advanced auto-complete feature. These tools analyze vast code repositories to offer context-aware recommendations, which can significantly reduce the cognitive load on developers (Aarti, 2024). Lau & Guo (2023) describes how AI tools can generate code based on specifications, even handling conversational back-and-forth to refine the user's intent.

Code Completion and Explanation

AI can predict and suggest code completions as you type, speeding up the coding process and reducing errors. J. T. Liang et al. (2024) highlights that developers appreciate AI assistants for reducing keystrokes and recalling syntax. AI tools like Copilot, Ghostwriter, CodeWhisperer, and Tabnine integrate into IDEs to provide contextually relevant code completions, functioning as AI-enhanced autocomplete systems (Lau & Guo, 2023). AI can analyze existing code and provide explanations of its functionality, helping developers understand complex codebases. Also, users can ask AI tools to explain programming concepts and provide code examples, which can help in understanding and verifying the explanations (Lau & Guo, 2023; Mohammadkhani et al., 2022).

Code Transformation and Improvement

AI tools can simplify code by rewriting it using only basic features, making it more accessible for beginners and

reducing the use of advanced language features. AI tools can translate code from one programming language to another. However, the translations are not always perfect (Lau & Guo, 2023). Tools like GPT-4 can refactor existing code to improve its quality based on established metrics, although human validation is necessary to ensure accuracy (Poldrack et al., 2023). These tools can refactor code to improve readability, style, or maintainability. Users can request specific refactoring tasks, such as breaking down a function into smaller helper functions (Lau & Guo, 2023).

Quality Assurance and Debugging

AI tools are equipped to identify and correct bugs, enhancing code reliability. For instance, IntelliDev and other similar tools conduct thorough code reviews and generate tests to improve code quality (Mohan et al., 2024; Zviel-Girshin, 2024). AI tools can assist in debugging through a back-and-forth conversation, where users provide code and output, and the AI suggests edits to help identify and fix bugs (Lau & Guo, 2023). AI tools can act as code reviewers, providing detailed critiques and feedback. Users can prompt the AI to take on specific personas, such as a senior software engineer, to review their code (Lau & Guo, 2023).

Automation and Personalized Support

In education, AI tools can provide personalized feedback and guidance that adapts to individual needs and learning styles. Kazemitabaar et al. (2023) explores the use of AI code generators in supporting novice learners. AI can automate repetitive programming tasks, freeing up developers to focus on more complex and creative work (Denny et al., 2024).

Limitations of AI Tools for Learning Programming

Accuracy and Contextual Understanding

While AI tools can handle easy to medium-level coding problems effectively, they often struggle with more complex tasks that require deeper understanding of programming concepts and contextual awareness. In these cases, human oversight and validation are typically necessary to ensure the accuracy and validity of the AI-generated code (Kuhail et al., 2024; Munoz et al., 2024). AI programming tools have made significant advancements, but they still struggle with highly complex or specialized coding challenges, requiring human oversight and intervention.

Knowledge Base Limitations

AI tools are limited to the knowledge available in their training data, which may not include the latest updates or libraries. They are periodically re-trained, and some tools are augmented to search the web for more recent information. AI-generated code examples may contain harmful biases or offensive stereotypes embedded in variable names or strings, raising ethical concerns (Lau & Guo, 2023).

Ethical and Social Considerations

The integration of AI in coding raises issues related to data privacy, proprietary information protection, and potential job displacement. There is a need for secure AI training methods and ethical usage guidelines to address these concerns (Aarti, 2024; Liu & Li, 2024). Over-reliance on AI tools can lead to a limited understanding of

core programming concepts among novice programmers, potentially hindering their skill development (Zviel-Girshin, 2024).

Mastering Prompt

Novice programmers may have difficulty producing high-quality results when using generative AI tools, as effectively using these tools often requires expertise in creating good prompts. This process, known as prompt engineering, is a crucial skill that enables users to effectively communicate their intent to the AI system and obtain the desired code outputs (Lau & Guo, 2023). Crafting effective prompts involves breaking down programming tasks, using clear language, and repeatedly improving the prompts to get the desired code generation results.

In conclusion, AI programming tools provide substantial productivity and efficiency advantages, but their use necessitates careful consideration of their limitations and ethical ramifications. As these tools continue to evolve, it is crucial to maintain a collaborative environment where human oversight complements AI capabilities, ensuring the development of accurate, reliable, and ethically sound software solutions.

Integrating Generative AI into Programming Courses

The Educational Applications of Generative AI in Programming

Generative AI has a wide range of applications in programming classrooms, transforming how students learn and educators teach. These applications span from code generation and explanation to personalized learning and automated assessment. Here's a breakdown of key applications:

Automated Code Generation and Completion

AI tools can generate code snippets, functions, or even entire programs based on natural language descriptions or specifications. This can be particularly helpful for scaffolding assignments, allowing students to focus on higher-level design and logic rather than syntax (Ooi et al., 2023). Tools like ChatGPT and GitHub Copilot can provide code completions and suggest refactoring options, making it easier for students to write and improve their code efficiently (Ooi et al., 2023). Zastudil et al. (2023) suggests that these tools will play an increasingly significant role in computing education.

Code Explanation and Debugging

AI can analyze existing code and provide explanations of its functionality, helping students understand complex codebases or legacy code. Zastudil et al. (2023) highlights the use of generative AI for generating code explanations. Students can ask AI tools to explain programming concepts and provide code examples, offering alternative explanations and supporting diverse learning styles (Zastudil et al., 2023). Generative AI can explain existing code, helping students understand complex codebases or legacy code (Denny et al., 2024). It can also assist in debugging by identifying potential errors and suggesting fixes. This allows students to focus on solving higher-level problems and understanding code rather than getting stuck on syntax errors. Furthermore, AI can enhance existing error messages, making them more understandable and actionable for novice programmers (Kimmel et al., 2024).

Project Ideation and Rapid Prototyping

Generative AI can help students with brainstorming and ideation, allowing them to explore a wider range of project possibilities. By generating initial prototypes and code for basic functionalities, AI tools can empower students to rapidly test and iterate on their ideas, fostering creativity and exploration (Bull & Kharrufa, 2024). AI tools can quickly generate code for basic functionalities, enabling students to rapidly prototype and test their ideas (Dickey et al., 2023).

Enhancing Learning Materials

Generative AI can create educational materials for programming courses, improving student engagement. These AI-generated materials can save educators time and effort while enhancing the quality of teaching resources (Ho et al., 2024). Instructors can use generative AI to prepare educational materials and facilitate classroom activities, such as active learning modules and games, making the learning experience more engaging for students (Molina et al., 2024; Ooi et al., 2023).

Personalizing Exercises and Feedback

AI can generate personalized programming exercises tailored to individual student needs and learning styles (Logacheva et al., 2024). AI can provide personalized feedback on student code, identifying errors and suggesting improvements, offering a more individualized learning experience. This can be particularly beneficial for novice programmers who need more guidance (Ooi et al., 2023). AI can also personalize assignments based on individual student needs and learning styles (Denny et al., 2024; Hou et al., 2024). AI can analyze student performance data to identify areas where they struggle, and then generate targeted exercises to address those weaknesses. This personalized approach leads to more effective learning and outcomes. Generative AI tools can function as virtual tutors, offering students immediate help and guidance on programming concepts and assignments. This can help students get immediate help outside of classroom hours (Ooi et al., 2023).

Automating Assessment and Tasks

AI can grade programming assignments automatically, freeing up instructors' time and giving students faster feedback. Malik et al. (2019) says generative AI can provide feedback with near human-level accuracy. AI can automate routine programming tasks, like generating code or test cases, letting students focus on harder problems (Malik et al., 2019; Zhang et al., 2024).

Prompt Engineering as a Skill

Instead of directly writing code, students can learn to craft effective prompts for AI code generation tools (Prather, Denny, et al., 2024). This approach focuses on problem decomposition, precise language, and understanding how to communicate effectively with AI. It emphasizes the importance of clearly defining the desired outcome and iteratively refining prompts to achieve the correct code.

While these applications offer significant potential for enhancing programming education, it's crucial to address the ethical considerations and potential challenges associated with using generative AI in the classroom. Educators need to develop strategies to mitigate risks like over-reliance and plagiarism, ensuring that students develop a

deep understanding of core programming concepts while leveraging the power of AI tools effectively (Denny et al., 2024).

Challenges and Considerations of AI on Programming Education

The integration of AI tools into programming education presents several challenges and considerations that educators and institutions must address to ensure effective and ethical learning outcomes. Here's a breakdown of key concerns:

Dependency on AI Tools

Overreliance on AI tools for code generation can hinder students' development of fundamental programming skills. If students rely solely on AI to generate code, they may lack deep understanding of core concepts, problem-solving strategies, and debugging techniques. This over-reliance could lead to difficulties in advanced courses or real-world programming scenarios where AI assistance may not be available or appropriate. The development of robust pedagogical approaches is crucial to mitigate this risk (Denny et al., 2024; Kazemitabaar et al., 2023; Lau & Guo, 2023). Dickey et al. (2023) mentions the concern of over-reliance on these tools, leading to a potential "Junior-Year Wall" where students struggle in advanced courses due to a lack of foundational knowledge and problem-solving skills. Addressing this challenge requires a balanced approach that integrates AI tools strategically while ensuring students develop core programming competencies.

Plagiarism and Academic Integrity

The ease with which AI can generate code raises concerns about plagiarism and academic integrity. Students might submit AI-generated code as their own work, bypassing the learning process. Educators need to adapt assessment methods and develop strategies to detect and address AI-assisted plagiarism. Rethinking assignments and assessments to focus on the application of knowledge can help mitigate this challenge (Kazemitabaar et al., 2023; Mutanga et al., 2024).

Biases and Accuracy of AI-Generated Code

AI models are trained on vast datasets, which may reflect existing biases and inaqquracies in the programming community. So, AI tools can produce inaccurate or suboptimal code, which may include subtle bugs, security vulnerabilities, or stylistic issues that are not aligned with educational goals (Lau & Guo, 2023). Educators need to be aware of these biases and inaqquracies and develop strategies to mitigate their impact on students' learning experiences.

Equity and Access

Access to advanced AI tools may not be equally available to all students, creating equity concerns. The cost of premium AI tools or the need for powerful hardware could disadvantage students from low-income backgrounds, exacerbating existing disparities in access to educational resources. Institutions need to consider strategies to ensure equitable access to AI tools for all students (Gillani et al., 2022). The integration of AI technologies in education often demands substantial technological infrastructure and specialized expertise, which many educational institutions, particularly those in developing countries, may lack. This can hinder the widespread

adoption of AI technologies in programming education (Farooqi et al., 2024).

Adapting Pedagogy and Curriculum

Integrating AI technologies requires a transformation in teaching methods and curriculum development. Educators face the challenge of adapting their curriculum and teaching methods to integrate AI tools effectively while ensuring that students still learn fundamental programming skills (Kazemitabaar et al., 2023; Lau & Guo, 2023). Educators must modify their instructional practices to effectively integrate AI technologies and mitigate the associated concerns. This may entail reimagining assignments, assessments, and learning experiences to emphasize critical thinking, creativity, and collaborative engagement.

Assessment and Evaluation

Traditional assessment methods may need to be revised to prevent AI-assisted cheating and to evaluate student learning more meaningfully. This could include oral exams, video assessments, and other innovative approaches. Additionally, educators may consider incorporating more frequent formative assessments and feedback mechanisms to monitor student progress and provide targeted guidance throughout the learning process (Rahman & Watanobe, 2023).

Prompt Engineering as a Skill

According to Dickey et al. (2023), teaching prompt engineering - the ability to craft effective prompts for AI code generation - should be a valuable skill for programming students. This approach emphasizes problem decomposition, clear language, and understanding how to communicate with AI systems. By developing prompt engineering skills, students can break down programming problems, state their requirements clearly, and use generative AI tools to enhance their workflows. This skill set promotes deeper problem-solving understanding and equips students to collaborate effectively with AI technologies, a crucial competency as software development evolves.

Resistance to Change

Educators may resist incorporating AI into their teaching due to concerns about job loss or reduced human interaction with students. Providing comprehensive training and continuous support for teachers is essential to facilitate a smooth transition and help them maximize the benefits that AI-powered tools can offer in programming education. Overcoming these concerns and empowering educators with the requisite skills and knowledge will be vital for the successful integration of AI technologies in the classroom (Farooqi et al., 2024). By carefully considering these challenges and adapting pedagogical approaches, educators can harness the potential of AI tools to enhance programming education while mitigating the associated risks. A balanced approach that combines AI assistance with the development of fundamental programming skills is crucial for preparing students for success in the evolving landscape of software development.

Conclusion

The field of programming education is undergoing rapid transformation, shaped by the inherent complexities of

the subject and the incorporation of innovative teaching methods, particularly those involving generative AI. This paper has examined various aspects of learning and teaching programming, highlighting the significance of effective pedagogical approaches that address the unique challenges encountered by inexperienced programmers.

Programming entails more than just technical skills; it encompasses critical problem-solving abilities and computational thinking. The pedagogical approaches discussed—such as live coding, constructivism, and social constructivism—underscore the necessity of interactive, collaborative, and experiential learning environments. These methods have been demonstrated to enhance student engagement, promote deeper understanding, and ultimately improve programming competence.

The incorporation of generative AI tools in programming education brings both possibilities and difficulties. These tools can bolster learning through customized feedback, automated code generation, and debugging assistance, but they also raise worries about over-dependence, academic honesty, and the potential diminishment of core programming skills. Educators must navigate these intricacies by striking a balanced approach that integrates AI while guaranteeing students build a robust foundation in programming concepts and problem-solving techniques.

The successful integration of AI in programming education demands a review of assessment techniques, curriculum development, and teaching practices. Educators should emphasize cultivating critical thinking and creativity, equipping students for an increasingly automated and AI-driven workforce. By cultivating an environment that promotes exploration, collaboration, and the responsible use of AI, we can better prepare future programmers to flourish in an ever-evolving technological landscape.

Lastly, the future of programming education calls for a thoughtful blend of innovative teaching methods and generative AI technologies, with the aim of improving student learning outcomes and addressing the inherent complexities of this field.

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Chapter 9 –Artificial Intelligence in STEM and Robotics Education: Innovative Approaches

Önder Yıldırım

Introduction

Scientific and technological developments in the world require that the knowledge and skills necessary for individuals to prepare for the society and the world they live in and to live a suitable life change, and that individuals be trained to acquire this knowledge and skills and to analyze the information they acquire (Atalay et al., 2016). There have been changes in the learning and teaching approaches adopted to provide individuals with knowledge, skills and competencies, and accordingly, radical changes have been made in the curriculum (Türk & Korkmaz, 2023, MEB, 2018).

The rapid change in technology and science has transformed educational approaches by differentiating the needs of individuals and societies. This transformation requires individuals not only to receive and store ready-made information, but also to produce information, make it functional in their lives and to have skills such as critical thinking, empathy and problem solving. It is emphasized that in order to raise individuals with these skills, students should play an active role in the educational process and that teaching processes should be designed accordingly (Türk & Korkmaz, 2023; MEB 2018).

Technology has reshaped our reality, enabling the emergence of concepts such as the information and document sphere within the information society, as well as new categories such as the code society and software society. Software and code have become an inseparable and often unnoticed part of daily life. While this situation creates both functionality and incomprehensibility, artificial intelligence has emerged as an important element of this technological environment. Software is defined as the technological unconscious; artificial intelligence is defined as the artificial unconscious. In order to cope with this complex structure, coding and technological literacy should be emphasized in the education system, and individuals should be enabled to adapt to this new reality in a conscious and knowledgeable manner (Accoto, 2017, Di Stasio & Miotti, 2024, Ferraris, 2021, Panciroli et al., 2023). Generation Z is a term that generally defines the generation born in 2000 and later. This generation consists of individuals who use technology intensively, easily adapt to rapid change, and have a high dependency on digital tools. It has been stated that old curriculums are inadequate in addressing these characteristics of Generation Z. Therefore, it has become a necessity to design teaching processes based on scientific and technological

developments in order to attract the attention of Generation Z and enrich the educational processes (Altuntuğ, 2012, Karabak & Güneş, 2013).

Artificial Intelligence and STEM Education

The integration of artificial intelligence into educational processes is being studied in many countries for purposes such as providing personalized support to students, evaluating student work, and developing learning platforms suitable for individual needs. In this process, it is critical for educators to receive comprehensive training and develop digital skills in order to use artificial intelligence-based tools effectively (Di Stasio & Miotti, 2024).

With the development of data processing and computing technologies, the use of artificial intelligence methods in academic fields has increased. Artificial Intelligence in education has become an interdisciplinary field used to facilitate teaching, learning, and decision-making processes. Artificial Intelligence helps educators in processes such as evaluating student performance, providing feedback, and identifying at-risk students. It also supports student learning processes such as teaching students, providing learning materials, and diagnosing strengths and weaknesses. Artificial intelligence in education helps administrators develop programs by monitoring loss models. Different artificial intelligence techniques have been successfully used to provide smart learning environments (Hwang et al., 2020, Chen et al., 2020; Scruggs et al., 2020, Ouyang et al., 2022). The use of artificial intelligence (AI) technologies in education has offered great opportunities, especially for STEM (science, technology, engineering, mathematics) education. While AI can help teachers with functions such as evaluating student performance, providing feedback, identifying at-risk students, it can also perform tasks such as guiding students' learning processes, providing materials according to their needs, and supporting self-regulated learning. The challenges in STEM education can be overcome by AI creating active, interactive learning environments and predicting students' performance. In addition, AI-supported systems can group students according to their learning preferences and make success predictions. The role of AI in STEM education has led to a major paradigm shift in the transformation of educational methods, and this change will become even more important in the future (Bywater et al., 2019, Holstein et al., 2018; Hung et al., 2017, Ouyang et al., 2022, Smith et al., 2019).

STEM (Science, Technology, Engineering, and Mathematics) education is a movement initiated by the US National Science Foundation in the 1990s to increase student competencies in the fields of science, engineering, and technology (Martín-Páez et al., 2019). This movement soon attracted great attention worldwide, and STEM education began to spread rapidly as a teaching approach that aims to develop students' innovative thinking and problem-solving abilities. In the early years of STEM education, traditional teaching methods such as lectures were generally used, but over time, it shifted to active learning strategies, more participatory methods such as problem-based learning and project-based learning (de Jong, 2019). In this process, studies on students' learning experiences and processes focused more on the development of cognitive, metacognitive, and social skills. In addition, an interdisciplinary approach was adopted in STEM education, and it was emphasized that students should use knowledge from more than one discipline in order to solve real-world problems (Thibaut et al., 2018). The role of technology in education has increased, and STEM education has become more accessible with tools such as learning management systems (LMS), open online courses (MOOCs), intelligent tutoring systems (ITS), and educational games (de Jong, 2019). These tools offer students new learning opportunities such as virtual laboratories and simulations. Learning analytics plays an important role in providing solutions to the challenges

in STEM education by collecting, analyzing, and visualizing student data with the help of these technologies. While the accurate collection and analysis of data allows teachers to develop more effective strategies, learning analytics models based on theoretical foundations also have great potential in the future to provide a deeper understanding in STEM education (Li & Lajoie, 2022). STEM education is an interdisciplinary approach in which science, technology, engineering, and mathematics are taught together. This educational model aims to integrate mathematics and science courses with technology and engineering applications. STEM aims to develop students' problem-solving, creative thinking, and interdisciplinary collaboration skills. Today, it is emphasized that mathematical skills alone are not sufficient and that interdisciplinary thinking methods are effective in solving complex problems (Hangün, 2019, Honey et al., 2014, Sanders, 2009, Wang, 2012). Integration of STEM content includes teaching practices that aim to establish strong connections between different STEM disciplines. While some approaches make multidisciplinary and interdisciplinary distinctions, integrated curricula clearly combine concepts from more than one discipline and give equal attention to each. In order for students to connect interdisciplinary knowledge and skills, it is important to clearly integrate the content. Because students do not make these connections naturally. However, more integration does not always yield better results, and it is emphasized that students need to have sufficient knowledge about each discipline. Integrated STEM education aims to create a more effective learning environment by establishing interdisciplinary connections without negatively affecting students' learning in individual courses (Thibaut et al., 2018; Pearson, 2017).

STEM education aims to enable students to understand and solve complex problems using STEM content knowledge or approaches. This education usually involves active pedagogical approaches such as hypothesizing, experimenting, collecting data, interpreting data, drawing conclusions, and ultimately solving problems by exploring multiple disciplines, where students take active roles. Active learning usually takes place in technology-enriched learning environments, and these environments collect learning data such as students' engineering design processes and in-group interactions. Learning analytics is a developing field that uses learning process data to understand learning in a more comprehensive and real-time manner (Zhu et al., 2022).

Use of Artificial Intelligence in Robotics Coding Education

Artificial intelligence increases efficiency by accelerating teachers' educational content preparation processes. Artificial intelligence education is important for professional development; it offers advantages in lesson planning, vocational training, and student support. The development of local artificial intelligence tools on platforms such as EBA and ÖBA will enable teachers to use technology effectively. In addition, sustainable use of AI in education should be supported through R&D studies and collaboration (MEB, 2024).

Artificial intelligence (AI) technologies offer great potential to improve teachers' classroom management and teaching processes. In particular, AI can support classroom orchestration, improving how teachers organize individual, small group, and classroom-level activities. Although effective classroom orchestration is important for STEM research and collaboration, it can create practical challenges. AI-supported teacher orchestration systems can provide teachers with pedagogical tools and strategies, monitor classroom activities in real time, and facilitate teachers' administrative tasks. This section discusses theoretical possibilities for the design of AI-supported teacher orchestration systems and how these systems can be applied to classroom activities, and poses

open questions for future system designs (Uttamchandani, 2022; Dillenbourg et al., 2018).

Robotics is a multidisciplinary field and has gained an important place in education with the development of artificial intelligence (AI). Intelligent robots in education are designed specifically to meet the psychological needs of children. These robots can interact with children through natural voices, support their learning processes, and offer educational activities. With the combination of artificial intelligence and robotic technologies, children can meet their need to communicate with their peers through robots and cope with emotional problems such as loneliness. In particular, smart robots can provide information to children, answer questions, and engage them in various educational tasks, thus adding a fun touch to the learning process. In addition, smart educational toys are products that include high technology and offer education and entertainment together. These toys create interactive game environments using advanced technologies such as computer technology, sensors, and virtual reality, and allow students to enjoy learning. These types of toys combine traditional toys with digital technology, offering a new experience that allows students to learn by playing games. Smart educational toys reduce students' cognitive load and present information in a more fun and efficient way. In addition, smart robots and toys are equipped with technologies such as facial recognition and speech recognition, and provide appropriate feedback to students by understanding their emotional states, making the educational process more effective. The integration of these technologies in education increases students' intrinsic motivation and enables them to actively participate in the learning process (Yu & Lu, 2021; Li & Zhou, 2016, Huang et al., 2017, Kara & Cagiltay, 2013). The main purpose of robotics in education is to provide students with the opportunity to adapt to new technologies by providing them with general skills such as problem solving and scientific concepts. Robotics in education enables computers to control physical worlds and develops new remote and collaborative applications for teachers and students. With educational strategies based on constructivist theories, it allows students to solve problems in motivating activities with technology. Research in this field has made significant progress in subjects such as cognitive development, collaboration, system evaluation and distance learning (Leroux et al., 1999). Educational robots are among the tools that support learning processes as one of the most concrete examples of technological innovations in education. These robots provide an effective platform for students to develop skills such as problem solving, analysis and creative thinking. Students produce solutions to the problems they encounter using educational robots, test and analyze these solutions. The success of educational robots depends on teachers' adoption of this technology and their ability to guide effectively (Türk & Korkmaz, 2023; Yenilmez & Balbağ, 2016).

Innovative Approaches and Learning Analytics

STEM education aims to provide students with creative thinking and interdisciplinary skills, while artificial intelligence aims to automate problem-solving processes. Artificial intelligence has attracted increasing attention in education in the digital age (Kong et al., 2021). STEM education aims to train creative problem solvers by providing students with problem-solving opportunities by applying multidisciplinary knowledge (Basu et al., 2016; Weintrop et al., 2016). Artificial intelligence literacy is a set of competencies that include effective communication with Artificial Intelligence, critical evaluation, and the ability to use Artificial Intelligence as a problem-solving tool (Kong & Zhang, 2021; Kong, Cheung, & Zhang, 2021; Long & Magerko, 2020; Touretzky et al., 2019).

STEM education is an approach that adopts active learning methods in order to develop interdisciplinary skills and increase students' capacity to produce solutions to complex problems. However, an interdisciplinary approach is generally not adopted in STEM education. The reasons for this include that the curriculum does not support interdisciplinary transition, students' skills in solving such problems are not yet developed, and teachers are not sufficiently prepared to support such processes. Future research should focus on more integrative STEM education to fill these gaps. In addition, current learning analytics applications often only analyze discourse and behavior data and have difficulty providing real-time feedback. Therefore, it is stated that more data sources should be collected to more effectively understand and support students' learning processes with multimodal learning analytics and dynamic guidance systems. Finally, discussions on the fairness of learning analytics models draw attention to how biases can occur in the data collection and model training stages and how these biases can affect equity in education (Zhu et al., 2022; Baker & Hawn, 2021, Ivanitskaya et al., 2002, Spikol et al. (2017).

Inquiry-based learning methods play an important role in STEM education. These methods encourage collaboration among students, increase interest in science, and help them learn scientific processes. Today, significant opportunities and challenges arise in the field of education due to the influence of artificial intelligence and new technologies. Learning analytics is increasingly used to support the development of personalized education. Research in branches such as learning analytics, knowledge graphs, student profiles, and learning behavior analytics increases individualized support in education. However, it is stated that case-based applications are lacking in this field and there is still no clear solution on how to integrate these applications. In addition, big data and learning analytics applications in education accelerate the transformation of educational informatics and provide students with more effective learning opportunities (Xu et al., 2022). Artificial intelligence has a very serious importance in STEM education. This importance is also revealed by the studies. Hiroaki Ogata discussed pencil stroke analysis and group learning support with two case studies on data-based STEM education, and discussed future AI and data-based STEM education directions. Ju-Ling Shih aims to strengthen the interaction between robots, maps, and users by designing a scientific investigation game that allows students to investigate ocean resources with robotic exploration ships. Gautam Biswas aims to analyze student learning behaviors using AI/ML methods and help students learn AI algorithms. Siu Cheung Kong offers a pedagogical design that aims to develop students' AI literacy and produce creative solutions with ethical AI use by adding AI elements to STEM activities. These studies have tried to explain with examples how the integration of STEM and AI in learning environments will be (Kong et al., 2021).

Ethics and Challenges of Artificial Intelligence in Education

In the formation of education policies, the strategic use of artificial intelligence to adapt to the rapidly changing world and improve learning processes emerges as an important requirement. Artificial intelligence has great potential in areas such as determining students' strengths and weaknesses, providing content suitable for learning styles, and guiding teachers. These technologies can save teachers time and provide the opportunity to create differentiated and inclusive educational environments. However, for the effective use of artificial intelligence in education, students and teachers need to understand the basic working logic of these technologies. In addition, there are various risks such as lack of teacher competence, uncontrolled spending of students, data privacy violations, cyberbullying, weakening of social skills, and psychological threats due to the use of artificial

intelligence. In addition, copyright uncertainties in content produced with artificial intelligence necessitate the development of a fair sharing model between content producers and users (MEB, 2024).

While artificial intelligence offers opportunities such as personalized learning in education, reducing teachers' workload and increasing equality, it also creates threats such as success pressure, ethical problems and loss of social skills. The ethical and balanced use of this technology can be possible with approaches that support students' social and emotional development. The effective use of artificial intelligence is of critical importance for shaping future education models while providing equality and accessibility in education (MEB, 2024). It is aimed for students to gain awareness in the cognitive (probability of making mistakes in AI applications) and emotional (importance of human leadership in the ethical use of AI techniques) dimensions of AI literacy. While students create works with AI elements to solve real-world problems, the five big ideas of AI (perception, representation and reasoning, learning, natural interaction and social impact) can be integrated into the curriculum. This design can enrich students' STEM learning experiences from a humanistic perspective (Kong et al., 2021). In STEM education, it is envisioned that tasks that are slightly more difficult than students' abilities can stimulate the learning process. Tasks with the right level of difficulty can increase students' engagement in learning, facilitate task completion, and improve comprehension. AI-supported student-centered environments offer the opportunity to optimize task difficulty by adapting to students' abilities. Instead of preventing student failure, educators should design curricula in a way that students encounter challenges and develop better understanding through effort. This approach can help develop STEM students with 21st-century skills (Nawaz et al., 2022; Kapur, 2016).

Artificial intelligence has gained an important place in education along with STEM. STEM (science, technology, engineering, mathematics) educators emphasize the importance of providing students with AI literacy. Governments in Canada and South Korea have stated that AI ethics should be at the center of the curriculum when planning to invest in AI education for K-12 students. However, since most teachers do not receive training in AI, it is obvious that teachers have a significant impact on this transformation. In a study conducted on science teachers in Singapore, the implementation of a curriculum that includes the integration of AI with science was examined, and teachers discussed the relationship between AI and science and made suggestions for improving the course. In this process, providing systematic support to teachers to provide AI literacy is an important issue (Park et al., 2023).

Artificial Intelligence and STEM Education: Transformative Role in Education

Artificial intelligence systems relieve the burden on teachers in STEM education. STEM education with AI offers students more personalized learning experiences. It also transforms education by making radical changes in the roles of teachers and students (Ouyang et al., 2022). Artificial intelligence technologies relieve teachers from many difficult tasks and allow them to focus on more advanced and complex tasks (Holstein et al., 2019; Hwang et al., 2020; VanLehn, 2011). While automatic assessment methods reduce teachers' workload, automatic translation software accelerates students' language learning processes (Xu & Ouyang, 2021). Artificial intelligence applications can help educators prepare course materials (Razzaq et al., 2009) and provide students with a more efficient educational experience by offering customized learning opportunities. In STEM education, artificial intelligence allows teachers and students to continuously monitor their data related to the process. Thus,

a better understanding of teaching and learning environments is provided (Figaredo, 2020). Systems using artificial intelligence support can be used to predict students' learning performance (Yağci & Çevik, 2019), while wearable technology products can also track students' learning behaviors. Artificial intelligence enables a transformation in the teacher-student relationship in STEM education, enabling a transition from the traditional teaching model to a student-focused learning process. In traditional STEM teaching, teachers take on an important leadership role as people who transfer knowledge to students and manage the process, while in artificial intelligence-supported education, teachers take on a more guiding, collaborative and facilitating role (Xu & Ouyang, 2021).

Conclusion

The use of robotics in STEM and education has reached a different dimension thanks to artificial intelligence. Artificial intelligence will shape both STEM education and the future of robotics in education. Artificial intelligence brings innovations to both fields for educators and students. Educators can use artificial intelligence as an assistant, especially in evaluation and completion. It will make serious contributions, especially in the creation of personalized learning environments. This contribution is significant. In the use of robotics in education, educators use artificial intelligence especially in the creation of code blocks and completion of deficiencies, and will continue to use it as a support robot in the future. In terms of students, they use artificial intelligence as an assistant in the processes of seeing the mistakes they make in both STEM education and robotics, completing their deficiencies, and deciding where to start. It is obvious that artificial intelligence will seriously shape both fields in the future. With the use of artificial intelligence, data security, protection of personal data, ethical situations and socialization in education bring both problems and discussions. This section comprehensively covers the opportunities, challenges, and ethical dimensions of the integration of artificial intelligence into STEM and robotics education. It also provides advice to educators and students on how these technologies can be used effectively in education. This section provides information on innovative teaching methods, learning analytics, and personalized learning applications for educators, researchers, and policy makers. Considering STEM and artificial intelligence together adds depth to the literature, encourages multidisciplinary collaboration, and provides a guiding resource for the development of educational policies. This section, which seeks to explore the potential of artificial intelligence in education, will be an important guide for future educational models.

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Chapter 10 –A New Era in Foreign Language Teaching: Generative Artificial Intelligence

Nurullah Taş, Yunus Aras

Traditional and Modern Approaches in Language Teaching

Traditional and modern approaches to language teaching show significant differences in language learning and teaching processes. While traditional approaches generally focus on language structure and grammar rules, modern approaches emphasise the development of communicative skills and learner-centred learning processes. In this report, the characteristics, advantages and disadvantages of both approaches will be discussed, and the role of artificial intelligence among modern approaches will also be analysed.

Traditional language teaching methods are usually based on techniques such as grammar, translation and memorisation. These methods aim to enable students to learn grammar rules by focusing on the structural features of the language Göçen (2020). However, the biggest disadvantage of this approach is that it is insufficient to develop students' ability to communicate effectively in real life. Research shows that students who learn languages through traditional methods have difficulty in speaking and writing fluently in the target language (Deniz & Çekici, 2023). This situation has led teachers and researchers to question traditional approaches (Ersoy & Ersoy, 2021).

Modern language teaching approaches aim to create a student-centred learning environment. In this context, the communicative approach offers activities and practices to develop students' language skills. Students are encouraged to take an active role in language learning processes and awareness of how language is used in social contexts is increased (Çalışkan, 2021). Modern approaches involve not only learning the rules of language but also the natural use of language. Therefore, students are provided with opportunities to practice their language skills in real-life scenarios (Oruç, 2024).

The role of technology in language teaching is an important component of modern approaches. Technology-assisted language teaching helps students improve their reading, writing, listening and speaking skills (Ersoy & Ersoy, 2021). In particular, computer-assisted language teaching (CATL) and mobile learning applications make students' language learning processes more effective (Akayoğlu, 2017). Artificial intelligence appears as an

important tool in this process. Artificial intelligence-based applications make language learning more efficient by providing customised learning experiences according to the individual needs of students (Ilter, 2018).

Artificial intelligence has the capacity to provide personalised learning experiences in language teaching. For example, language learning applications can analyse students' language skills and provide targeted content in areas where they are weak (Topal & Çifci, 2022). Such applications increase students' motivation and make language learning processes more enjoyable (Bayar, 2024). In addition, AI-supported language teaching reduces the workload of teachers, allowing them to interact with more students one-to-one (Doyumğaç, 2022).

Another important difference between traditional and modern approaches is the assessment methods. In traditional methods, students' achievement is usually measured by written exams, whereas modern approaches focus more on performance assessments. In this context, students are given opportunities to practice their language skills in real-life scenarios and are evaluated based on the data obtained in this process (Urgel, 2023). Such assessment methods better reflect students' language skills.

In conclusion, there are significant differences between traditional and modern approaches to language teaching. While traditional methods focus on language structure, modern approaches emphasise the development of communicative skills and student-centred learning processes. The integration of technology and artificial intelligence increases the effectiveness of modern approaches and makes language learning more accessible. In the future, more technology integration and the use of artificial intelligence in language teaching will help learners improve their language skills.

Evolution of Educational Technologies

The evolution of educational technologies is a critical issue for understanding how educational processes have changed and developed historically. Education has experienced a continuous process of change and transformation throughout human history. This process has progressed in parallel with technological developments and the tools and methods used in education have evolved over time. The evolution of educational technologies has accelerated especially since the mid-20th century and has gained a new dimension with digitalisation. In this report, the evolution of educational technologies, their current status and the role of artificial intelligence in this process will be discussed.

The evolution of educational technologies first started with the emergence of written materials. The invention of writing facilitated the transfer of information and revolutionised education. In the 19th century, with the invention of the printing press, the production of books and other educational materials accelerated, which increased accessibility in education. In this period, education was generally carried out with a teacher-centred approach and students were considered as passive recipients. However, by the mid-20th century, more interactive and student-centred approaches in education began to come to the fore (Çolak Yazıcı & Erkoç, 2023).

Since the mid-20th century, there have been significant developments in the field of educational technologies. In particular, visual media such as television and video started to be used in education, which made learning processes more attractive. In this period, the diversification of technologies used in education led to changes in teaching methods. Methods that encourage active participation of students started to gain more importance in education (Elçiçek, 2024). In addition, the use of computers in education has gained momentum since the 1980s and the first steps of digitalisation in education have been taken.

Today, educational technologies have accelerated the digitalisation process with the widespread use of the Internet. Distance education, online learning platforms and mobile applications have created a new paradigm in education. In this context, digital transformation in education has required the restructuring of teaching methods and learning processes (Demirekin, 2023). Students now have more freedom to access information and develop their skills to manage their own learning processes. This situation enables individualisation and customised learning experiences in education (Yakut Özek & Sincer, 2024).

Artificial intelligence plays an important role in the evolution of educational technologies. Artificial intelligence applications have the capacity to provide personalised learning experiences in education. They make learning processes more effective by providing customised content according to students' learning styles and needs (Yılmaz et al., 2021). For example, AI-supported learning platforms analyse students' strengths and weaknesses and provide them with appropriate learning materials and activities (Özdemir Işık & Kaya, 2024). Such applications increase students' motivation and make learning processes more enjoyable.

Artificial intelligence also reduces the workload of teachers, allowing them to interact with more students one-to-one. Automated assessment systems help teachers to evaluate students' performance more quickly and effectively (Çayak & Erol, 2023). This allows teachers to devote more time to important tasks such as supporting and guiding students. In addition, artificial intelligence contributes to the development of educational policies through data analysis and the use of big data in education (Sincar, 2023).

The evolution of educational technologies also offers important opportunities for equality and accessibility in education. In particular, distance education and online learning platforms provide the opportunity to reach more students by overcoming geographical and economic barriers (Özdemir & Bilgin, 2021). This increases equality of opportunity in education and offers education to a wider audience. However, in this process, issues such as digital literacy and access to technology should also be taken into consideration (Özek & Sincer, 2024).

In conclusion, the evolution of educational technologies reflects a historically significant process of change. Today, the integration of technologies such as digitalisation and artificial intelligence creates new opportunities and challenges in education. This transformation in education requires a restructuring of teaching methods and learning processes and offers students more interactive, flexible and personalised learning experiences. In the future, educational technologies are expected to develop further and the role of artificial intelligence in education is expected to increase.

Definition and Scope of Generative Artificial Intelligence

Generative artificial intelligence (GAI) has become an important research topic in both academic and industrial fields with the acceleration of technological developments in recent years. GAI is a type of artificial intelligence that can generate new content or solutions using algorithms and software designed to develop systems that can exhibit human-like thinking and behaviour. In this context, studies on the definition, scope and application areas of GAI are critical to understanding the potential and effects of this technology.

Artificial intelligence can be defined as systems developed to imitate human intelligence in general. The definition put forward by McCarthy in 1959 has been expanded as the ability of artificial intelligence to achieve its goals (Bobro, 2023). Artificial intelligence aims to create systems capable of solving complex problems by using algorithms that mimic human-like thinking skills (Katsuura et al., 2021). In this context, GAI stands out with its ability to generate new information and content from existing data. For example, GAI systems can generate various types of content such as text, images or music (Belačić, 2024).

Machine learning and deep learning techniques are among the main components of GAI. These techniques enable systems to learn from large data sets and improve themselves over time (Liawrungrueang, 2024). In particular, deep learning algorithms play an important role in analysing and making sense of complex data. In this way, GAI systems can exhibit human-like creativity and problem-solving capabilities (Vaz et al., 2021).

The application areas of GAI are quite wide. It is used in many sectors from education to health, marketing to production. For example, in the field of education, artificial intelligence systems can offer personalised learning experiences by analysing student performance (Begum, 2024). In the health sector, GAI plays an important role in disease diagnosis and treatment processes (Katsuura et al., 2021). In addition, in the field of marketing, GAI undertakes functions such as content creation and campaign optimisation for the target audience (Liu, 2023).
However, in addition to the opportunities brought by GAI, there are also some ethical and security issues. In particular, data privacy and security issues are important factors to be considered in the development of GAI applications (Ijiga, 2024). Ensuring transparency and accountability in the decision-making processes of artificial intelligence systems is critical to increase the reliability of these systems (Jobin & Ienca, 2019). Moreover, the accuracy and reliability of the content produced by GAI should be carefully monitored to prevent the spread of fake news (Gao, 2023).

The future of GAI will be shaped by the development and integration of this technology. In order for artificial intelligence systems to be used in more areas, these systems need to be developed within ethical and legal frameworks (Zubenko et al., 2021). In addition, interdisciplinary research is needed to better understand the effects of GAI on human life. In this context, studies on the ethics of artificial intelligence will provide an important basis for the responsible development of GAI (Salo-Pöntinen, 2021).

In conclusion, GAI has the potential to revolutionise many sectors through the development of systems that exhibit human-like thinking and creation capabilities. However, in order to realise this potential, ethical, security and

legal issues need to be considered. In the future, the wider adoption and integration of GAI will be an important step that will positively impact human life.

The Place of Generative Artificial Intelligence in Education

GAI has created a significant transformation in the field of education in recent years and has radically changed the teaching processes. GAI in education stands out as an effective tool in many areas such as providing personalised learning experiences to students, reducing the workload of teachers and developing educational materials. In this report, the place of GAI in education, its advantages, application areas and challenges will be discussed.

GAI is a type of artificial intelligence that can generate new content and solutions from existing data using techniques such as machine learning and deep learning (Elçiçek, 2024). The use of this technology in education makes teaching methods and learning processes more effective. For example, GAI applications enrich learning experiences by providing students with customised learning materials according to their individual needs (Sincar, 2023). This increases students' motivation and encourages their more active participation in learning processes (Başcillar et al., 2022).

One of the most important advantages of GAI in education is its capacity to reduce the workload of teachers. By automating teachers' lesson planning, assessment and feedback processes, AI-supported systems enable teachers to spend more time on important tasks such as supporting and guiding students (Ülker & Çamli, 2023). In this context, the integration of teachers with artificial intelligence contributes to a more efficient teaching process in education (Özdemir & Bilgin, 2021).

GAI has various application areas in education. For example, virtual teachers and chatbots make learning processes more interactive by providing instant support to students (Ekrem & Daşikan, 2021). In addition, artificial intelligence-based assessment systems can analyse students' performance and provide targeted content in areas where they are weak (Yilmaz et al., 2021). While such applications make students' learning processes more personalised, they also allow teachers to monitor student performance more effectively.

However, the use of GAI in education brings some challenges. Firstly, the reliability and accuracy of artificial intelligence systems directly affect their impact in education. Students' trust in the content produced by artificial intelligence is a critical factor to increase the effectiveness of these systems (Çolak Yazıcı & Erkoç, 2023). In addition, the ethical dimensions of artificial intelligence applications should also be considered. Data privacy and security issues are an important part of the use of artificial intelligence in education (Yılmaz & Yılmaz, 2023). Educational institutions need to take necessary precautions before using such systems.

The future of GAI in education will be shaped by the development and integration of this technology. In order for artificial intelligence systems to be used in more areas, these systems should be developed within ethical and legal

frameworks (Cibaroğlu & Yalçinkaya, 2019). In addition, it is important that teachers receive training on artificial intelligence and have the necessary knowledge and skills to use this technology effectively (Akalin, 2023). Artificial intelligence literacy in education is critical for teachers and students to understand and use this technology (Bayram & Çelik, 2023).

In conclusion, GAI is a technology that has the potential to create a significant transformation in education. It stands out as an effective tool in many areas such as providing personalised learning experiences to students, reducing the workload of teachers and developing educational materials. However, in order to use this technology effectively, a careful approach should be adopted in terms of reliability, ethics and training. In the future, the role of GAI in education is expected to increase further.

Generative Artificial Intelligence Applications in Foreign Language Teaching

GAI applications have become an important tool that transforms educational processes and enriches learning experiences. GAI are systems that can create new content from existing data and have the capacity to provide personalised experiences in language learning. In this report, the place, advantages, application areas and challenges of GAI applications in foreign language teaching will be discussed.

One of the most important advantages of GAI applications in foreign language teaching is its ability to provide learners with customised learning experiences. Artificial intelligence can produce content according to students' individual needs and learning styles, which makes the language learning process more effective (Özkan, 2023). For example, to improve students' vocabulary, AI-supported applications can analyse users' existing knowledge and provide them with appropriate exercises and materials (Demirel & Yalçın, 2021). Such applications increase students' motivation and encourage their more active participation in learning processes (Yağcı & Yıldız, 2023).

GAI has the potential to create interactive and dynamic learning environments in language teaching. For example, AI-based chatbots can help students improve their language skills by interacting with them in natural language (Türker, 2019). Such applications enable students to practice speaking, while at the same time supporting their learning process by providing instant feedback (Çelikkaya & Hayta, 2024). In addition, artificial intelligence can also be used to improve students' writing skills. AI-supported writing assistants can analyse students' written expressions and make suggestions in terms of grammar and style (Gök et al., 2024).

Another important area of GAI applications in foreign language teaching is assessment processes. By analysing students' performance, artificial intelligence can provide targeted content in areas where they are weak (Yağcı & Yıldız, 2023). This allows teachers to monitor student performance more effectively and intervene when necessary. In addition, AI-based assessment systems provide data-driven feedback to teachers by tracking students' progress (Ocak et al., 2021).

The future of GAI applications in foreign language teaching will be shaped by the development and integration

of this technology. In order for artificial intelligence systems to be used in more areas, these systems need to be developed within ethical and legal frameworks (Inal & Cakir, 2021). In addition, it is important that teachers receive training on artificial intelligence and have the necessary knowledge and skills to use this technology effectively (Taşkin et al., 2023).

In conclusion, GAI applications in foreign language teaching are an important tool that transforms educational processes and enriches learning experiences. It offers an effective solution in many areas such as providing students with personalised learning experiences, reducing teachers' workload and improving assessment processes. However, in order to use this technology effectively, a careful approach should be adopted in terms of reliability, ethics and education. In the future, the role of GAI in foreign language teaching is expected to increase further

Exemplary Generative Artificial Intelligence Tools and Applications in Language Education

Grammarly

Grammarly is an AI-powered writing assistant that helps correct grammar, punctuation and spelling errors in written communication. It has been widely used in the field of education, especially in foreign language learning, to contribute to the development of students' writing skills. In this report, the role of Grammarly in foreign language teaching, its advantages, application areas and challenges will be discussed.

Grammarly stands out as an effective tool to improve language learners' written expression. In Puri's study, it is stated that Grammarly helps students in their writing activities by checking grammar, punctuation and spelling errors (Puri, 2023). Students stated that the use of Grammarly contributed to the development of their writing skills. This emphasises the importance of personalised feedback provided by Grammarly in language learning.
Dewi's study examined the impact of Grammarly on EFL learners and found that students found it easy to use, quickly accessible and helpful in checking grammatical errors (Dewi, 2023). Such automatic spelling assessment systems help students to improve their writing skills, while at the same time contributing to their learning of grammar rules.

Among the advantages of Grammarly in foreign language teaching is that students gain more accuracy and fluency in their written expressions. In Sanosi's study, it was emphasised that Grammarly had positive effects on improving students' writing skills (Sanosi, 2022). Students stated that the automatic feedback provided by Grammarly helped them to improve their written work. This situation allows students to have more confidence in their writing process and to understand grammar rules better.

In addition, Dizon and Gayed's research shows that Grammarly plays an important role in increasing vocabulary diversity in students' writing skills (Dizon & Gayed, 2021). AI-supported writing assistants help students expand

their vocabulary and encourage them to use a richer and more diverse language in their written expression.

Grammarly has various application areas in language learning. Students can revise their written assignments and essays using Grammarly and correct grammatical errors. In Fitria's study, it was stated that Grammarly can also be used as an alternative for teachers and can help in the evaluation of students' written work (Fitria, 2021). This makes teachers' written feedback processes more efficient and allows them to better monitor students' progress. Grammarly's mobile applications provide an accessible anytime and anywhere solution to improve students' writing skills. This allows students to instantly review their written work and correct grammar mistakes (Yulianti, 2018). In addition, the detailed feedback provided by Grammarly helps students improve their written expression and contributes to a better understanding of grammar rules.

There are also some difficulties in using Grammarly. Firstly, the limited features offered in the free version may prevent some students from using its full potential (Alam et al., 2023). In addition, the reliability and accuracy of AI-supported systems directly affect their impact in education. Students' trust in AI-generated content is a critical factor to increase the effectiveness of these systems (Wardatin et al., 2022).

In addition, some students stated that the feedback provided by Grammarly is not always accurate and sometimes misleading (Amali, 2024). This may make it difficult for students to develop independent thinking and critical evaluation skills in their written work. Therefore, it is important for teachers to support students' ability to evaluate their own written expression while using tools such as Grammarly.

In conclusion, Grammarly is an effective tool for improving writing skills in foreign language teaching. By providing personalised feedback to students, it helps them improve their written expression, reduces teachers' workload and improves assessment processes. However, the effective use of this technology requires a careful approach to reliability, ethics and training issues. In the future, it is expected that Grammarly's role in foreign language teaching will further increase and find a wider range of applications.

Quillbot

QuillBot is an AI-powered writing assistant that performs functions such as paraphrasing written content, checking grammar and correcting spelling errors. Widely used by students, academic writers and content producers, this tool plays an important role in language learning and the development of writing skills. In this report, the features of QuillBot, its role in foreign language teaching, its advantages, application areas and challenges will be discussed.

QuillBot offers various paraphrase options to make users' texts more fluent and comprehensible. Users can paste their text into QuillBot and rephrase it with different sentence structures and word choices (Rahmani, 2023). This feature is especially important for reducing the risk of plagiarism in academic writing. While QuillBot makes users' texts more original, it also improves the quality of written expressions by making suggestions in terms of

grammar and style (Hasnah, 2024).

Furthermore, QuillBot's grammar check helps users to detect and correct spelling mistakes. This feature helps language learners to learn grammar rules and improve their written expressions (Asmara, 2024). QuillBot helps users to give their written content a more professional look, while at the same time allowing them to improve their language skills.

QuillBot is an important tool in providing personalised learning experiences in foreign language teaching. This artificial intelligence-supported application helps students to improve their writing skills and also contributes to learning grammar rules (Mohammad et al., 2023). Using QuillBot, students can review their written expressions and correct grammar mistakes. This allows students to have more confidence in their writing processes and to better understand grammar rules.

In particular, QuillBot's paraphrasing features help students expand their vocabulary and encourage them to use a richer and more diverse language in their written expressions (Gozali, 2024). Such applications help students to improve their written work and minimise grammatical errors.

Among the advantages of QuillBot in foreign language teaching is that students gain more accuracy and fluency in their written expressions. AI-supported writing assistants help students improve their writing skills, while at the same time making them more effective in written communication. QuillBot plays an important role in increasing vocabulary diversity in students' writing skills. AI-supported systems allow teachers to monitor student performance more effectively and intervene when necessary (Wu & Flanagan, 2023).

QuillBot has various applications in language learning. Students can revise their written assignments and essays using QuillBot and correct grammatical errors. In addition, the detailed feedback provided by QuillBot helps students improve their written expressions and contributes to a better understanding of grammar rules (Cortez, 2024). QuillBot's mobile applications provide an accessible anytime and anywhere solution to improve students' writing skills (Latifah, 2024).

However, there are also some difficulties in using QuillBot. Firstly, the limited features offered in the free version may prevent some students from utilising its full potential (Syahnaz, 2023). Moreover, the reliability and accuracy of AI-supported systems directly affect their impact in education. Students' trust in AI-generated content is a critical factor to increase the effectiveness of these systems (Črček & Patekar, 2023). In addition, some students stated that the feedback provided by QuillBot is not always accurate and sometimes misleading (Jaladara et al., 2023). This may make it difficult for students to develop independent thinking and critical evaluation skills in their written work.

In conclusion, QuillBot is an effective tool for improving writing skills in foreign language teaching. By providing students with personalised feedback, it helps them improve their written expression, reduces teachers' workload and improves assessment processes. However, the effective use of this technology requires a careful approach to

reliability, ethics and training issues. In the future, it is expected that the role of QuillBot in foreign language teaching will further increase and find a wider range of applications.

DeepL

DeepL is a machine translation (MT) service that was launched in 2017 and offers high-quality translations using deep learning technologies. Drawing attention with its user-friendly interface and effective translation algorithms, DeepL has become an important tool in language learning and translation processes. In this report, the features of DeepL, its role in foreign language teaching, its advantages, application areas and challenges will be discussed.

DeepL allows users to translate their texts quickly and accurately. This platform uses neural machine translation (NMT) technology to understand the structural features of the language and produce more fluent translations (Fitria, 2023). DeepL analyses users' texts not only word by word, but also sentence by sentence, and translates them taking into account the context. This feature makes translations more natural and meaningful (Fitria, 2023).

DeepL offers various features that allow users to have more control over the translation process. Users can edit their translation results, switch between different languages and save their texts. Furthermore, DeepL provides vocabulary and expression suggestions to help users better understand their translations (Fitria, 2023). This contributes to language learners to expand their vocabulary and learn grammar rules.

DeepL is used as an important tool in foreign language teaching. Students can review their written assignments and articles using DeepL and correct grammatical errors. In Poláková and Klímová's study, it is emphasised that DeepL helps students improve their writing skills and enriches their vocabulary (Poláková & Klímová, 2023). Such applications help students to improve their written expression and allow them to minimise grammatical errors.

DeepL can also be used to develop listening and speaking skills. By using DeepL, students can listen to texts and practise their pronunciation. This helps students to improve their language skills and also increases their ability to understand and communicate (Fitria, 2023).

Among the advantages of DeepL in foreign language teaching is that users gain more accuracy and fluency in their written expressions. While DeepL helps language learners improve their writing skills, it also enables them to be more effective in written communication (Rescigno & Monti, 2023). Moreover, the detailed feedback provided by DeepL helps students to improve their written expressions and helps them to better understand grammar rules (Benyahia, 2024).

DeepL helps users save time in the translation process. By providing fast and accurate translations, it allows students to complete their written work more efficiently (Fitria, 2023). This allows students to spend more time on language learning processes.

DeepL has various application areas in language learning. Students can revise their written assignments and essays using DeepL and correct grammatical errors. In addition, the detailed feedback provided by DeepL helps students to improve their written expressions and contributes to a better understanding of grammar rules (Brierley, 2023). The mobile applications of DeepL offer an accessible solution to improve students' writing skills anytime and anywhere (Fitria, 2023).

However, there are also some challenges in using DeepL. Firstly, the limited features offered in the free version may prevent some students from using it to its full potential (Colson, 2019). Moreover, the reliability and accuracy of AI-supported systems directly affect their impact in education. Students' trust in AI-generated content is a critical factor to increase the effectiveness of these systems (Gao et al., 2024). In addition, some students stated that the feedback provided by DeepL is not always accurate and sometimes misleading (Fandiño et al., 2019). This may make it difficult for students to develop independent thinking and critical evaluation skills in their written work.

In conclusion, DeepL is an effective tool for improving writing skills in foreign language teaching. By providing students with personalised feedback, it helps them improve their written expression, reduces teachers' workload and improves assessment processes. However, in order to use this technology effectively, a careful approach needs to be adopted in terms of reliability, ethics and training. In the future, it is expected that the role of DeepL in foreign language teaching will further increase and find a wider range of applications.

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Chapter 11 –Personalized Learning Applications in AI-Based Distance Education Systems

Hasan Küçükoğlu

Artificial Intelligence Development in Distance Education

The concept of Education 4.0, which is an extension of the Industry 4.0 concept that developed as a result of the Industrial Revolution, is an approach that emphasizes the role of digital transformation and technology in education. This approach, which advocates that education systems should be digitalized, personalized, and globalized, aims to provide more interactive and efficient learning by integrating technologies into learning processes (Luan et al. 2020).

As a result of the rapid development of digital technologies and the global adoption of technology in education, learning and teaching processes are also changing. AI, which is one of the main components of Industry 4.0 and one of the main elements of this change, is generally defined as attempts to create reflections of human intelligence with the help of computer systems and machine applications, and it has taken on an important role in the field of education by gaining a position beyond making people's lives easier (Bujang et al. 2020).

In this respect, the Education 4.0 concept shaped by AI adopts a more flexible, personalized, and global education approach and provides a structure that offers personalized content and feedback according to students' learning speeds, styles, and achievement levels with advanced technologies. Thus, it is aimed for each student to have a customized educational experience according to their own needs and to make learning processes more efficient (Chen et al. 2022).

The main advantages of AI-supported education management systems developed in line with this goal are shown as follows (Salma, 2023):

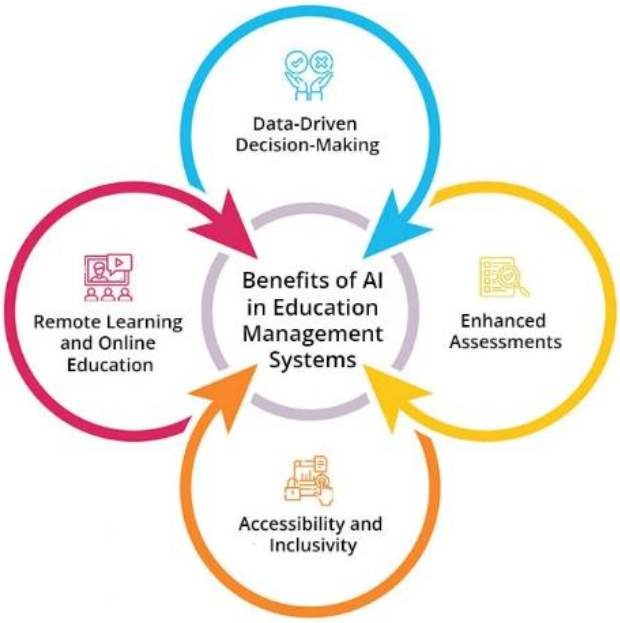

Figure 1. Benefits of AI in Education Management Systems

With the Education 4.0 approach, the most up-to-date education model today, the distance education approach is turning into one of the areas where the effects of AI applications are seen most rapidly. While the first developments on AI experiments in distance education date back to the end of the 20th century, when computer and internet technologies began to be used in education, the effects of AI in distance education became more evident, especially in the 1990s and later, when educational technologies began to develop rapidly (Schiff, 2021). Important turning points and experiments regarding the use of AI in distance education are summarized below:

- **First AI Applications:** AI research first began to be applied in educational technologies in the 1980s. Although the widespread use of AI technologies in distance education was not very possible during this period, early AI-based systems developed to provide personal guidance to students were tried with studies on smart system applications in education. These non-versatile systems were mostly used to analyze student performance and provide appropriate educational materials (Woolf, 2010).

- **The Rise of the Internet in Education and AI Experiments:** With the widespread use of the Internet towards the end of the 1990s, it became possible to switch to distance education. During this period, although AI was generally limited to educational software and programs, the first steps were taken with LMSs and similar platforms that could offer content suggestions according to the individual needs of students. In addition, during this period, some universities and educational platforms providing distance education over the internet started to use simple AI algorithms to analyze student data and provide customized content (Koller, 2013).

- **Early Stages of AI and Distance Education:** In the early 2000s, the use of AI in distance education systems became more widespread. With the use of AI-based systems in student tracking and evaluation processes

on online learning platforms, it became possible to monitor student performance, automatically evaluate exams, and offer personalized learning experiences, and it became possible to recommend customized educational materials according to the individual needs of each student by analyzing the strengths and weaknesses of students (McLoughlin & Lee, 2007).

➢ **Advanced Applications in AI and Distance Education:** The acceleration of the integration of AI and distance education in the 2010s allowed AI applications to find more space, especially in online courses and MOOCs. During this period, the concept of personalized learning became more evident, and students could be offered customized content according to their learning styles. In addition, efforts to provide student support in distance education with tools such as virtual teachers, AI-based chatbots, and voice assistants have accelerated (Haristiani, 2019).

➢ **AI-Supported Distance Education Transformation:** The major transition to distance education worldwide due to the pandemic in 2020 has made the role of AI in distance education even more important, requiring educational platforms to invest in more advanced AI technologies to collect and analyze student data. The development of AI-based systems, such as automatic assessment systems, natural language processing (NLP) technologies, and personal assistants, along with AI algorithms used to provide customized educational content according to the individual needs of students, has led to a major transformation in educational processes (Pinkwart, 2020).

With this transformation process, the prominent developments in making distance education more effective and accessible by offering personalized approaches in education with AI applications are as follows:

- **Computer-Based Learning (CBI):** CBI, which refers to the educational method using computers and digital devices, is the provision of interactive learning materials to students through online courses, software, and applications. With CBI, it is possible to perform many different functions, from creating customized study material for a particular student according to their learning needs to creating customized tests, to evaluating, to warning an instructor about possible learning disabilities, and to answering a student's questions by simulating human speech (Chen et al. 2020).

- **Educational Technologies (EdTech):** EdTech, which means the integration of technology and digital tools into educational processes, is an approach that includes the digitalization of learning materials, online learning platforms, virtual classrooms, mobile learning applications, and more. EdTechs, which aim to provide students with more flexible, accessible, and personalized educational experiences, are frequently used in areas such as LMSs, digital assistants, and automated exam evaluation systems (Bagunaid et al. 2022).

- **AI in Education (AIEd):** Explained as the integration of AI into educational processes, AIEd uses AI technologies to improve students' learning experiences, reduce teachers' workload, and make educational processes more efficient. This concept is used to analyze student data, track processes, provide student-specific feedback, and recommend content for student needs when necessary, aiming to provide personalized education according to students' individual learning speeds, styles, and needs (Dignum, 2021).

- **Data Mining in Education (DME):** DME, which meets the process of extracting meaningful information and patterns from educational data, has great potential to increase the effectiveness of education systems and help produce meaningful insights by understanding students' learning trajectories from large data sets in the education system. DME is also used to increase student achievement, improve teaching methods, and make education policies more efficient (Bhutoria, 2022).

The use of AI technology in education and training processes contributes to the improvement of basic interaction types in distance education by enabling the analysis of users' online learning behaviors, learning needs, and cognitive methods (Güler, 2024).

In this context, the types of interaction in distance education are explained as follows (Abrami et al. 2011):

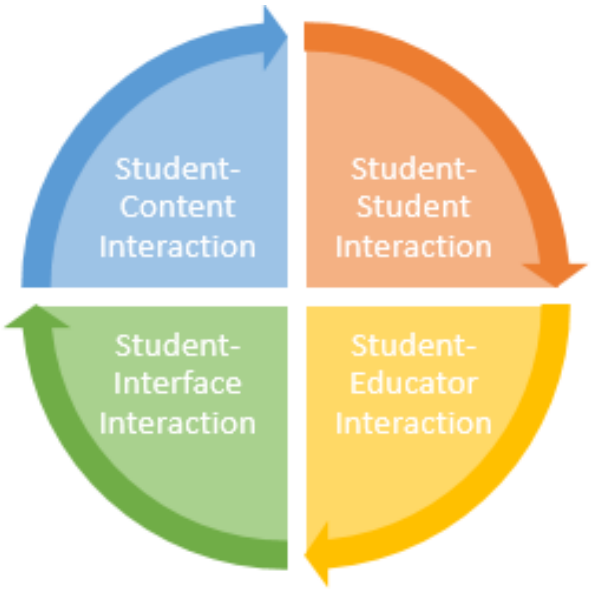

Figure 2. Types of Interaction in Distance Education

- **Student-Content Interaction:** This is the type of interaction that students participating in distance education have with the content in order to create a meaning by associating the subjects they study with their prior knowledge and thus to have a change in their understanding, perspectives, and cognitive structures.

- **Student-Instructor Interaction:** This is the type of interaction that includes processes such as subject transfer, guidance, feedback, progress monitoring and evaluation, and where the interaction can be carried out simultaneously via environments such as telephone or video conference, or at different times via environments

such as correspondence, e-mail, or discussion boards.

- **Student-Student Interaction:** This is the type of interaction where students share information among themselves, participate in discussions, participate in learning activities together, have a social learning experience, develop their collaboration skills, and thus increase their motivation for learning.

- **Student-Interface Interaction:** This is the type of interaction that includes the software and hardware interfaces used so that students can participate in the teaching process as well as access course materials, do their homework, and take exams.

Features of Personalized Learning Tools

Personalized learning is explained as a systematic learning design that adapts a student's learning processes in line with their strengths, preferences, needs, and goals, and as an approach that provides a comprehensive learning experience and skill development (Walkington & Bernacki, 2020). With this type of learning approach, educators are assigned a specific role, such as giving students the opportunity to manage their learning processes, determine and be responsible for implementing educational goals that meet their personal interests and needs, while at the same time providing motivation to learn and improve their academic performance (Atalia et al. 2022).

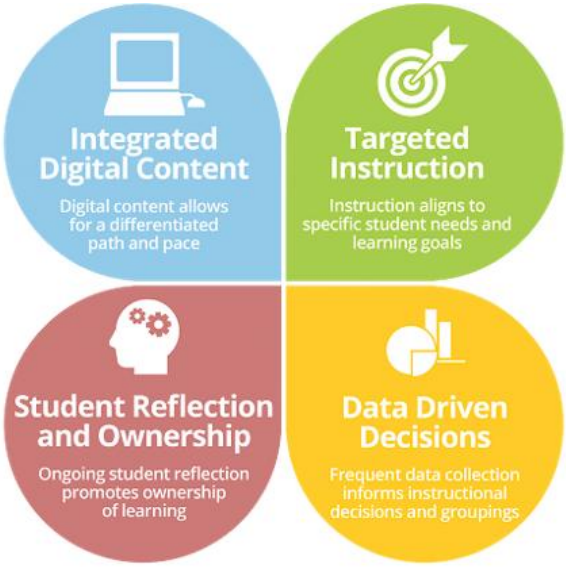

Figure 3. The Core Four Elements of Personalized Learning

Personalized learning tools in AI-based distance education are being developed as technological systems that customize learning experiences to the changing demographic characteristics of students in different age groups, academic levels, and socioeconomic situations and are adapted to the individual needs of the student. These tools, which can be used in different ways such as in NLP, machine learning, speech and facial recognition, video interactions, and holograms, bring learning processes to a more personal, fast, efficient, and high-quality form

while also offering the potential to increase the capacity and effectiveness of learning environments (Cantú-Ortiz et al. 2020).

The main AI-based personalized learning tools are:

- **Adaptive Learning Systems:** ALS is an approach that offers learning experiences customized to students' individual needs and learning styles. With the AI tools used in ALS, students' learning processes are analyzed, and appropriate course content is dynamically adapted, and new materials and applications are presented according to criteria such as students' previous success, participation rates, and interaction percentages. Knewton, DreamBox, and Smart Sparrow can be given as examples of ALS (Chen & Xie, 2020).

- **Intelligent Learning Systems:** ITS are computer-based educational systems that use AI and other advanced technologies, can be adapted to student needs, provide student-specific learning experiences, and can process very complex data streams in real time. The main idea of ITS is that students interact with an adaptable interface that personalizes the learning process depending on their profile and academic achievements. With ITS, it is possible to provide instant feedback and create personalized educational paths for students by measuring students' knowledge levels, strengths, and weaknesses. Carnegie Learning, Sirius, and ALEKS can be given as examples of ITS (Huang et al. 2021).

- **Virtual Assistants:** AI-supported virtual assistants are applications that are actively used to provide 24/7 support, answer questions, provide information about learning materials, and guide students. The main purpose of these systems, which optimize learning processes by providing personalized recommendations to students, is to provide solutions that enable students to reach their optimum academic potential. Google Assistant, Cortana, and Siri can be given as examples of virtual assistants (Wollny et al. 2021).

- **Automatic Assessment and Feedback Systems:** These systems are technologies that instantly evaluate the responses received from students in learning process measurement activities such as homework, exams, projects, and quizzes, provide personalized feedback for each student, and store this information and use it in subsequent evaluations. With automatic assessment and feedback systems, it is possible to identify student errors, provide additional information and resources on topics deemed inadequate, and improve performance with continuous feedback. Turnitin, Grammarly, and Quizlet can be given as examples of automatic assessment and feedback systems (Aberbach et al. 2021).

- **Student Performance Monitoring and Analysis Systems:** Performance monitoring and analysis systems used to track all student interactions and learning processes are used to analyze student data received with AI algorithms for individual process monitoring and personalized recommendations. In these systems, which can dynamically adapt content according to the student's development, the student's interaction with the system is very important. Google Classroom, Blackboard, and Canvas can be given as examples of student performance monitoring and analysis systems (Schumacher et al. 2019).

- **Social and Emotional Learning Support Tools:** These tools, which monitor students' emotional and social learning processes through basic skills and recommend content according to the student's psychological

state, analyze the student's stress level or motivation and offer themes or social learning opportunities that will relax them. Woebot, Replika, and Classcraft can be given as examples of social and emotional learning support tools (Hoffmann et al. 2020).

- **Application of Smart Simulation and Realistic Learning Environment:** Smart simulation systems are technologies that can provide effective solutions in providing a perception of reality in areas that require experimental teaching. In addition to simulating practical applications for students, it is possible to increase the efficiency and quality of distance education application teaching by creating a realistic teaching platform for students with virtual learning environment applications such as AR and VR. VR Lab, Google Expeditions, and Labster can be given as examples of intelligent simulation and realistic learning environment applications (Cebrián et al. 2020).

User Experience Differences

In determining the success of AI applications on distance education platforms, which are generally divided into three main groups as students, educators and administrators, user types and their differentiating features are quite decisive. In AI-based distance education, students experience more personalized, fast, and flexible learning experiences; educators can manage their teaching processes more efficiently and in a data-based manner, and administrators can find better organization, resource usage, and monitoring of student achievements with AI (Aşık et al. 2023).

Accordingly, these solutions, which are customized for each user type, are explained as follows (Ji et al. 2023):

➢ **AI Features for Students**

- **Personalized Learning Plans:** By analyzing the student's learning style and pace, a learning path adapted to their personal needs is presented, allowing each student to follow the most appropriate course content for them.

- **Instant Feedback and Suggestions:** The results of each activity performed by the student on the platform are instantly evaluated by the AI, and customized suggestions are provided on individual development areas.

- **Emotional State Detection and Motivation Support Systems:** The emotional state of the student can be understood from their written expressions, movements, or tone of voice during online learning, and morale-boosting suggestions, calendar reminders, and motivational rewards can be given for this.

- **24/7 Support with Chatbots:** AI-based chatbots that provide instant support can be used to solve students' questions about the course and develop alternative solution suggestions.

- **Learning Goals Tracking:** By tracking the learning goals set by students individually or in study groups, customized content suggestions can be offered to help them achieve their goals.

- **Course Content Adaptations:** Course contents can be dynamically adapted by AI, taking into account the student's previous successes and difficulties, and in-depth content can be produced on topics that are lacking.

➢ **AI Features for Educators**

- **Student Performance Monitoring:** Educators can monitor each student's exam results, assignments, and performance in the course and review each student's development reports and areas that need support.
- **Automatic Content Adaptations:** Depending on the progress of the course and the success of the students, educational content can be automatically changed, and more educational and effective teaching tools and materials can be used.
- **Student Participation Analysis:** By analyzing student participation, interaction frequency, and contributions in the virtual classroom, detailed reports can be provided to the educator about student participation criteria.
- **Automatic Grading and Evaluation:** Students' responses can be evaluated, and information can be provided, thus reducing the time loss of teachers in evaluating exams, quizzes, or assignments.
- **Student Needs Identification:** By analyzing students' learning levels and the topics they have difficulty with, the educator can be informed about which students need more help and the resources that can be used.
- **Virtual Classroom Management:** By helping the educator manage the virtual classroom environment, tasks that increase student participation can be planned, methods to focus their attention and effective group work strategies can be suggested.

➢ **AI Features for Managers**

- **Monitoring School Performance with Data Analytics:** By monitoring the overall performance of the educational environment with data analysis, data such as student achievement levels, teacher performance, and student participation can be reported to the administrator.
- **Success and Performance Evaluation:** Future needs can be predicted and development programs can be prepared based on student achievement data and educator performance evaluations.
- **Optimization of Educational Content and Resources:** By analyzing educational materials and resources, it is possible to determine which content is used more and which subjects have deficiencies.
- **Budget Management and Resource Distribution:** By checking the institution's budget and resource distribution, it is possible to calculate in which areas the budget will be used more effectively and in which departments more investment should be made according to educational needs.
- **Intra-School Interaction and Communication Monitoring:** By monitoring each interaction network and communication in the virtual environment, it is possible to find out which departments or groups are working more efficiently and which areas have difficulties.
- **School Accreditation Process Management:** By monitoring the institution's compliance and requirements in the accreditation process, the compliance status of the institution with educational standards and the areas that need to be developed can be clarified.

As a result, the combination of Education 4.0 and AI technologies is creating a significant transformation in education. This transformation makes educational processes more accessible, personalized, and efficient, while also reshaping teaching methods. In addition to the common goals of providing an effective learning experience, management and teaching process for each user in AI-based distance education solutions, the differences seen in user types make the potential of AI in education and its future application areas more important.

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Chapter 12 –Ethics and Security: Risks of Using AI in Education

Muhammet Dursun Kaya

Introduction

The Growing Role of Artificial Intelligence in Education

As technological transformation in education accelerates, artificial intelligence (AI) has transformed learning and teaching processes with its innovative applications. Generative AI technologies in particular hold promise in many areas such as customizing teaching materials, providing personalized learning experiences according to students' needs, and reducing teachers' workload. For example, language model-based applications such as ChatGPT provide guidance by answering students' text-based questions and accelerate teachers' material preparation processes (Ali et al., 2024; Holmes et al., 2019). However, this rapid development has also brought with it the necessity not to ignore the ethical and security dimensions of AI.

With the expansion of AI use in education, ethical responsibilities in the design and implementation processes of these technologies have begun to be discussed more. For example, the "Ethical Guide to Artificial Intelligence in Education" report published by UNESCO (2021) emphasizes that issues such as biases, data security, privacy, and transparency should be addressed as a priority during the use of AI in education. This report particularly focuses on the potential of AI in education to deepen socioeconomic inequalities. This shows that AI is not only a technical tool, but also a social transformation actor (Floridi & Cowls, 2022).

The increasing role of AI in education also draws attention to the risks that may arise in the event of uncontrolled or irresponsible use of these technologies. Education systems may face data collection practices that violate the privacy of students and teachers, biased decision-making by algorithms, and processes that negatively affect individuals' learning experiences (Selwyn, 2019). In this context, adopting an ethical and security-focused approach is a critical requirement to ensure the sustainable integration of AI in education. Based on this need, this section aims to address the ethical and security risks of AI in education.

Importance of Ethics and Security Issues

The rapid spread of artificial intelligence (AI) applications in education has increased the potential benefits of these technologies, while also raising serious questions in terms of ethics and security. Since education systems often involve students, one of the most vulnerable groups in society, it is of great importance that the technologies used in these systems are designed in line with ethical principles and implemented in accordance with security

standards (UNESCO, 2021). Ethics and security play a critical role not only in protecting the rights of individuals, but also in sustaining trust in AI (Floridi et al., 2018).

Ethical concerns primarily require that AI applications be designed in a bias-free and fair manner. Algorithms used in education risk increasing socioeconomic inequalities, discriminating against certain groups, or standardizing learning experiences (Noble, 2018). Such ethical violations can violate individuals' right to equal access to education and deepen social injustices in the long run. Therefore, it is imperative for AI systems to be fair, transparent and accountable in order to operate in accordance with the basic ethical principles of education (Pedro et al., 2019).

The security dimension, on the other hand, comes to the forefront especially in the areas of data privacy and cybersecurity. AI systems used in education collect and process the personal data of students and teachers. Misuse of this data can harm the privacy of individuals and have serious legal consequences (Selwyn, 2019). In addition, cybersecurity vulnerabilities can disrupt students' learning experiences or lead to larger-scale systemic security problems. In cases where security protocols are inadequate, AI applications in education can become risky and harm all users of the system (Taylor & Rooney, 2016).

The importance given to ethics and security issues in education not only protects the rights and security of individuals, but also ensures the integrity and quality of educational processes. Therefore, ethical and security concerns should be placed at the center of the design when developing AI applications in education. This approach ensures that technological innovations benefit society and that core values in education are preserved.

Ethical Issues

Prejudice and Injustice

As artificial intelligence (AI) systems become widespread in education, the risk of these technologies containing bias and producing unfair results has become increasingly apparent. Since AI algorithms are usually trained based on training data, social biases present in this data can be carried over to AI systems (Noble, 2018). For example, some studies have shown that AI-based student assessment systems can produce results that discriminate against students with low socioeconomic status or ethnic minority groups (Holmes et al., 2019). This can undermine the principle of equality in education and further deepen inequality of opportunity.

Applications of AI in education, especially in individualized learning systems, can exhibit biased behaviors when making predictions based on students' past performance. For example, a low-performing student may be labeled as "failing" by the system, which can limit the student's future educational opportunities (Myers West, 2020). Such biases can have negative consequences, especially for underrepresented groups. Failure to use datasets that increase diversity and inclusivity in the design of AI systems used in education is seen as one of the main reasons for such injustices (Binns, 2018).

From an ethical perspective, transparency and accountability principles need to be adopted to eliminate these bias problems. The transparency of decision-making processes in AI systems is of critical importance for educators

and policy makers (Floridi et al., 2018). In addition, continuous monitoring and evaluation of the results of AI algorithms can contribute to the reduction of biases and injustices. Being aware of the ethical risks in the use of AI in education is a fundamental step towards creating a more inclusive and equitable learning environment.

Privacy and Data Security

Artificial intelligence (AI) applications in education are based on the collection and processing of student data. Data on students' academic performance, behavior, learning habits, and even emotional states form the basis of personalized learning experiences. However, the privacy of this data emerges as a critical ethical issue. Misuse or unauthorized sharing of students' personal information can harm individuals' privacy and create insecurity in the long term (Taylor & Rooney, 2016). Young students, in particular, constitute a vulnerable group in the face of privacy violations, and this further increases the ethical responsibilities of using AI in education (Selwyn, 2019).

Although many educational platforms take measures for data security, such measures may not always be sufficient. In particular, risks such as data being compromised through cyberattacks, students' identities being stolen, and this information being used for malicious purposes are a significant source of concern in the use of AI in education (UNESCO, 2021). Therefore, it is essential to implement security measures such as strong encryption, anonymization, and access control during the collection and storage of student data (Voigt & Von Dem Bussche, 2017).

Although large data sets are needed for AI applications in education to work effectively, the practices of how this data is collected and shared are often controversial. Many educational platforms may collect data without users' consent or share this data with third parties. This becomes an ethical issue due to the lack of transparency in the data collection process and the limited control individuals have over their data (Mendoza, 2022). For example, selling a student's performance data to advertising companies or other commercial organizations is clearly against ethical standards in education.

In addition, data sharing may be subject to different legal regulations at the international level. While the European Union's General Data Protection Regulation (GDPR) protects individuals' rights over personal data, regulations in some countries are more lax (Voigt & Von Dem Bussche, 2017). This could lead to inconsistencies in the data collection and sharing processes of global education platforms and could put students' privacy rights at risk. In order for AI to be used ethically in education, data collection and sharing practices need to be aligned with international standards and users need to be informed about these processes.

Human-Machine Interaction

The rise of artificial intelligence (AI) applications in education may lead to a decrease in teachers' pedagogical functions while reshaping the roles of teachers and students. AI systems may increase efficiency by supporting teachers' assessment and content delivery; however, this may cause teachers to act only as system administrators and lose the human touch. Students may also become passive under the influence of AI, which may negatively affect the development of critical thinking and independent learning skills (Luckin & Holmes, 2016).

AI applications do not sufficiently understand the social, emotional and ethical dimensions of the educational process and risk ignoring these human elements. Teachers' abilities such as empathizing with students and

providing moral support cannot be completely replaced by digital systems. In order for AI to be effective in education, these human elements must be used as a supporting tool and the central role of teachers must be preserved. Moreover, ignoring human elements may deepen inequalities in education. Since AI systems operate based on large data sets containing biases, injustices may arise, such as systems optimized for certain groups not meeting the needs of other groups. Therefore, the effective use of AI in education should be structured in accordance with the principle of justice and equality.

Security Risks

Cyber Security Threats

Artificial intelligence (AI) tools used in education have become a vulnerable target for cybersecurity threats. While these systems provide personalized learning experiences by processing large amounts of personal and institutional data, they also pose an attractive target for malicious actors. Attacks on AI systems can aim to disrupt the operation of systems, especially through phishing attempts or ransomware aimed at obtaining data from students and teachers. Ransomware attacks have the potential to harm the infrastructure of educational institutions in particular. In such attacks, cybercriminals lock down AI systems, making data inaccessible, and demand a ransom to restore access. For example, in 2020, many educational institutions around the world were subjected to such attacks, resulting in serious disruptions in teaching activities (Bergadano & Giacinto, 2023). These threats are not limited to individual data loss, but also jeopardize the sustainability of educational processes.

The data collection and processing processes of AI systems in education bring with them the risk of data misuse. This data includes students' academic performance, behavioral patterns, biometric information, and social interaction data. This information can lead to privacy violations when used for purposes other than education. For example, commercial organizations can use students' data to personalize advertising and marketing campaigns; this poses serious ethical and legal problems (Eze & Shamir, 2024). In addition, if the data falls into the hands of malicious actors, students' digital identities are at risk, which can open the door to fraud or other illegal activities. In cases where educational institutions do not take adequate protection measures against data breaches, a major security gap arises, especially in AI-based systems. In order to prevent such breaches, advanced security measures such as data encryption, authentication, and regular system audits should be implemented.

Some precautions are recommended for educational institutions to take against cybersecurity threats that they are constantly exposed to. The first of these is the use of strengthened encryption methods. Advanced encryption techniques should be used to increase data security for AI-based educational systems (Sangwan et al., 2023). In addition, educational institutions should regularly subject their existing systems to security tests. Regular penetration tests by educational technology providers will help identify pepper security vulnerabilities, especially in remote education environments such as teaching management systems (Illiashenko et al., 2023). Finally, the most important measure to be taken will be the training of users in all roles using the system. Teachers and students should be trained on potential cybersecurity threats and become more conscious users (Preuveneers & Joosen, 2024).

Misleading Content and Propaganda

The easy accessibility of generative artificial intelligence (GENERATIVE AI) tools has made the production of fake content widespread. These tools are used to spread false information by manipulating text, images, and videos. For example, state actors and private groups have used GENERATIVE AI technologies to spread propaganda and manipulate public opinion with fake videos or news. Social media, in particular, paves the way for the rapid spread of these contents. The spread of false information can also undermine public trust in accurate information through the "liar's dividend" effect (Konwar, 2024; Tate Ryan-Mosley, 2023). This effect becomes more devastating in times of crisis and political tension. The use of GENERATIVE AI in educational materials can create challenges in terms of quality control. Materials containing incorrect or incomplete information can negatively affect students' learning processes and reduce the overall quality of education. For example, ensuring the accuracy of course materials produced by AI requires manual control processes. In addition, the lack of clear protocols regarding the reliability of content poses a long-term risk to educational institutions. It is vital to develop transparency and accountability standards for such tools used in education (Zellers et al., 2019).

Addiction and Loss of Control

Over-reliance on artificial intelligence (AI) tools risks changing the nature of learning in educational processes. The increasing reliance on automation, especially in decision-making processes, can limit the pedagogical role of teachers. AI-based systems can weaken the human dimension of education by reducing teachers' sensitivity to student needs. Research shows that the ability of AI to explain its decisions has a limited effect in reducing teachers' dependence on systems. Simpler and more easily understood explanations can alleviate this dependence, but even this may not be effective for complex tasks (Miller, 2023). AI used in education can limit the decision-making capabilities of teachers and administrators, leading to standardization of education. For example, instead of personalized guidance according to students' individual learning paths, algorithms can be encouraged to follow predetermined paths. This can negatively affect creativity and flexibility in teaching processes (Zhai et al., 2024).

As the role of AI in decision-making processes in education grows, the risk of human actors losing control increases. The ability of algorithms to make wrong decisions based on biases can negatively affect student achievement and equal opportunities. Lack of transparency in AI decision-making processes can make it difficult for teachers and administrators to question these systems. As a result, accepting the automated decisions offered by AI tools as they are can hinder critical thinking in educational processes (Alon-Barkat & Busuioc, 2023; Chen et al., 2020). In this context, it is important to ensure balance in the use of AI in education. In order to optimize human-machine collaboration, teachers should be able to understand AI tools and question them when necessary. In addition, integrating these tools into education to support teachers' pedagogical skills is critical to prevent loss of control in decision-making processes.

Strategies to Mitigate Ethical and Security Risks

Designing Transparent and Accountable AI

Transparency and accountability are fundamental principles in the responsible design and implementation of artificial intelligence (AI) systems. The wider understanding of AI systems used in education is not only a technical requirement, but also an ethical imperative. Transparency allows users to understand how these systems work, how decisions are made, and how these decisions affect individuals. For example, explainable AI (XAI)

approaches are being developed to visualize and make understandable the functioning of AI systems (Cheong, 2024).

The advantages of transparent AI in education are multidimensional. Teachers and students can make more informed decisions when they understand the logic of the algorithms. Lack of transparency in AI systems used in education can undermine users' trust in the system due to inadequate communication. For example, when AI algorithms used for teacher evaluation do not explain what their outputs are based on, the fairness of these evaluations can be questioned.

Accountability structures play a critical role in addressing errors or biases arising from AI systems. This should be supported not only by technical transparency, but also by ethical principles and regulatory frameworks. Accountability is made possible by the establishment of clear responsibility mechanisms. These approaches ensure that systems are resistant to misapplication while protecting the rights of users.

Technological innovations offer opportunities for transparency and accountability. However, challenges such as privacy, intellectual property, and algorithmic complexity are encountered during the implementation of these principles. It is recommended that an interdisciplinary approach be adopted to overcome these challenges (Kaminski, 2021). In this context, not only software engineers but also education experts, ethicists, and lawyers should be involved in this process.

As a result, a transparent and accountable AI design not only increases the effectiveness of the technology, but also reduces ethical and security risks in education. AI should be kept under human control and positioned as a tool that strengthens the human elements of education. In this way, a system that is sensitive to the needs of students and teachers can be created.

Data Ethics Rules and Regulations

The use of artificial intelligence (AI) applications in education requires the collection and analysis of large amounts of data. However, this raises concerns about the protection and ethical use of student data in particular. For an ethical and safe AI application, clear rules and regulations for data use are of great importance. This section will discuss existing strategies and recommendations in the context of data ethics rules and regulations.

Many frameworks have been proposed to ensure that the use of AI in education complies with data ethics. For example, the European Commission's Guide for Trustworthy AI emphasizes that applications in the education sector should comply with basic ethical principles such as transparency, traceability and fairness. These principles ensure that student privacy is protected in data collection and processing processes and aim to eliminate bias in algorithms (Hong et al., 2022).

With the widespread use of AI-based systems in education, a large data set is being created on student performance, participation level and behavior. Ensuring transparency in these processes is necessary not only to protect students' rights, but also to increase trust in AI systems. Data collection processes should be carried out with clear information and user consent. In this context, regulations such as the European Union's GDPR have set an important standard by requiring informed consent from data owners (Gujjula & Sanghera, 2023).

New technologies offer innovative solutions to ensure data privacy. Techniques such as federated learning allow data to be analyzed without being collected in a central location. This method protects individual privacy while also enabling effective training of AI models. Federated learning can help prevent data leaks, especially by reducing the risk of student data being collected in central databases (Gujjula & Sanghera, 2023).

It is important for educators and institutions to understand and implement ethical rules in the use of AI and data. For example, regulations such as the European Union's AI Act set mandatory requirements for high-risk AI applications. In addition, comprehensive training and awareness programs are needed for educators to understand and integrate such regulations into their daily practices. This not only ensures compliance with data ethics but also makes it possible to fully utilize the potential of AI (Hong et al., 2022).

Raising Awareness for Educators and Students

Educators and students should be informed about the ethical and safe use of artificial intelligence (AI) technologies. Although the use of AI in education can support students' learning processes, misuse can cause ethical problems. Ethical education teaches these individuals their responsibilities in both technical and social contexts. AI ethics courses, especially in engineering and science fields, develop students' critical thinking skills and help them produce practical solutions to ethical problems (Foltynek et al., 2023).

Educators should understand the potential advantages and risks of AI technologies and transfer this knowledge to their students. To do this, teachers need to be trained on the ethical use of AI. In particular, teaching how to use AI tools correctly can limit the potential of these tools to produce misinformation. In addition, teachers should be encouraged to choose AI tools that comply with ethical principles when creating course materials (Foltynek et al., 2023).

Programs can be developed for students to encourage the ethical use of AI tools. For example, case studies provide students with the opportunity to understand the ethical problems of AI through real-life examples. Such activities allow students to gain not only theoretical knowledge but also the ability to put this knowledge into practice (Foltynek et al., 2023).

Conclusion and Recommendations

The Impact of Ethical and Security Issues on Future Education Models

As artificial intelligence (AI)-supported systems become more prevalent in education, ethical and security issues will have a significant impact on future education models. The bias, injustice, and privacy issues encountered in AI applications used in education processes have the potential to affect not only individual students but also the general structure and philosophy of education (Nguyen et al., 2023). For example, the systemic biases of algorithms can increase inequalities of opportunity in education, which can create serious differences in learning experiences among students. This situation emerges as a threat to social justice in education.

In order for education models to fully benefit from their benefits, such as individualized learning, it is critical to eliminate ethical and security concerns. However, if these issues are not addressed, educational technologies may

conflict with social values while shaping the ways students learn. For example, violation of privacy or constant monitoring of students can negatively affect free thinking and creative learning processes (Turan, 2024). As a result, education systems may become a structure that cannot adequately respond to the needs of both students and teachers.

To minimize the impact of these issues on future education models, comprehensive regulations, standards, and implementation guidelines should be created. These guidelines should include not only technology companies but also educational institutions and policy makers. In order to use AI in education ethically and safely, a culture of collaboration should be developed among all stakeholders. Such an approach can ensure a more effective integration of technological innovations while preserving the core values of education.

Recommendations for Safer AND More Ethical Use of Artificial Intelligence

Safe and ethical use of AI in education requires a multifaceted approach. The first step is to adopt the principles of transparency and accountability in the development processes of AI applications. The fact that the decision-making processes of the algorithms used in education can be explained will increase the trust that users have in the system. In this context, the use of open data and independent audits should be encouraged in algorithm design. In addition, regular monitoring of AI systems and evaluation of their performance allows potential risks to be identified at an early stage.

Strong policies and legal regulations should be implemented for privacy and data security. Comprehensive regulations such as the European Union's General Data Protection Regulation (GDPR) provide an important framework for ensuring data privacy in education (Voigt & Von Dem Bussche, 2017). Educational institutions should review their data management policies to comply with such regulations and ensure that student data is used only for educational purposes. In addition, teachers and students can be made aware of data security, and a more resilient ecosystem can be created in this area.

Finally, an interdisciplinary approach should be adopted in addressing ethical issues. Technology designers, educators, ethicists, and policymakers should come together to ensure that AI systems used in education comply with ethical principles. This collaboration will not only solve current problems, but also allow for a more proactive attitude towards possible future risks. Responsible use of AI in education will maximize the positive impact of technological innovations on education while protecting the rights of individuals and their learning processes.

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Chapter 13 – The Social Impact of Generative Artificial Intelligence in Sport and Recreation: A Comprehensive Analysis of Transformation and Implications

Burak Erdinç Aslan

Introduction

Generative Artificial Intelligence (AI) represents a cutting-edge domain of AI focused on creating new and meaningful content such as images, text, videos, and simulations. This technology has moved beyond traditional predictive and analytical applications, offering transformative possibilities across various industries, including sports and recreation. For example, generative AI enables the development of tailored fitness programs, player performance analysis, and even virtual experiences that enrich fan engagement during live sporting events. Its applications range from tactical decision-making using game simulations to creating immersive VR training environments for athletes (Cossich et al., 2023; Xenonstack, 2024).

In recreation, generative AI is instrumental in gamifying experiences, creating personalized wellness programs, and making recreational activities more accessible to diverse populations. For instance, AI-driven technologies offer adaptive sports solutions for individuals with disabilities, enhancing inclusivity and participation (Xenonstack, 2024)

Motivation for Exploring Social Impacts

The rapid adoption of generative AI in sports and recreation has brought profound social transformations. While the technology offers opportunities such as enhanced training regimens, accessibility improvements, and economic benefits for sports industries, it also raises challenges. Ethical concerns regarding data privacy, algorithmic bias, and unequal access to advanced AI tools necessitate a deeper understanding of its societal implications.

Additionally, the integration of AI into sports and recreation intersects with broader cultural and economic trends. For example, deploying AI in traditionally community-based sports, such as cricket or rugby, could alter participation dynamics, potentially leading to increased reliance on technology over human expertise (Xenonstack, 2024). By examining these social impacts, this study aims to provide insights that can guide the responsible and equitable implementation of generative AI technologies.

Objectives of the Study

The primary objective of this study is to explore and analyze the social implications of generative artificial

intelligence (AI) in the domains of sports and recreation. With the increasing integration of generative AI into these fields, the study aims to understand its transformative impact on society, stakeholders, and cultural dynamics. The objectives are framed to ensure a comprehensive understanding of both the benefits and challenges associated with this emerging technology.

Identify the Applications and Benefits of Generative AI in Sports and Recreation

One of the core objectives is to document how generative AI is applied across various sports and recreational activities. This includes identifying its role in enhancing athlete performance, personalizing fitness programs, and revolutionizing fan engagement through interactive technologies like AI-generated highlights and VR simulations. For instance, in professional sports, AI's ability to simulate player movements and predict outcomes has been pivotal in tactical planning and injury prevention (Cossich et al., 2023; Xenonstack, 2024).

Examine the Social Transformations Induced by AI Technologies

The study seeks to assess how generative AI reshapes participation in sports and recreational activities, particularly focusing on inclusivity, accessibility, and the digital divide. AI's ability to offer tailored experiences for differently-abled individuals, as well as its role in expanding access to underrepresented communities, will be investigated. The study also aims to understand whether these technologies disrupt traditional cultural practices in sports or recreational settings.

Analyze Ethical, Legal, and Social Challenges

A critical objective is to explore the ethical and legal dimensions of generative AI. Issues such as data privacy, algorithmic bias, and unequal access to AI-driven resources will be evaluated to understand their implications on athletes, fans, and recreational users. Moreover, the study will delve into the psychological pressures faced by athletes due to constant performance monitoring and AI-driven performance evaluations (Xenonstack, 2024).

Provide Policy and Practical Recommendations

The final objective is to propose actionable strategies for policymakers, industry leaders, and academic institutions to navigate the challenges posed by generative AI. These recommendations will focus on fostering equity, ensuring data security, and promoting sustainable AI integration practices that benefit all stakeholders in sports and recreation.

Method

Methodology

Research Design: A Qualitative Corpus-Based Analysis

The research design for this study is qualitative and corpus-based, a methodological approach that allows for an in-depth exploration of the social impacts of generative artificial intelligence (AI) in sports and recreation. This approach focuses on gathering, analyzing, and interpreting various forms of data from different sources to form a comprehensive understanding of the phenomenon. The qualitative nature of the study ensures that the social, cultural, and ethical dimensions of AI in sports are explored in a nuanced way. By using a corpus-based methodology, the study allows for a systematic collection of relevant texts that reflect the current and emerging applications of AI in these fields.

Data Sources

The data corpus for this study will be drawn from four primary sources: academic literature, industry reports, case

studies, and expert interviews. Each of these sources provides unique insights into the implementation and implications of generative AI.

Academic Literature:

A review of peer-reviewed journal articles, books, and conference proceedings will form the foundation of the corpus. These academic sources will provide theoretical frameworks, case studies, and empirical research findings that document the evolution and current state of generative AI in sports and recreation. The literature review will focus on understanding the integration of AI into various domains, including performance analysis, fan engagement, and recreational activities (e.g., virtual fitness platforms). It will also examine the ethical concerns surrounding AI use, including privacy, bias, and equity in access to AI tools (Arsturn,2024; Xenonstack, 2024).

Industry Reports:

Industry reports, white papers, and policy briefs from organizations like the International Olympic Committee (IOC), sports management consultancies, and AI technology firms will offer insights into how generative AI is currently being adopted in real-world sports and recreation settings. These sources will help contextualize the findings from academic literature and provide practical insights into how AI technologies are impacting professional sports, amateur recreation, and fan interactions. Industry reports will also address the economic and business implications of AI, such as its role in shaping sports marketing strategies, merchandise sales, and digital engagement (Xenonstack, 2024).

Case Studies:

Case studies will be selected to showcase specific instances of generative AI applications in sports and recreational settings. These case studies could include AI-driven technologies such as virtual reality training systems for athletes, AI-powered coaching platforms, and generative AI used in sports commentary or fan engagement. For example, the case study of AI's role in optimizing player performance in football or analyzing data for tactical decision-making will be examined. Case studies will provide detailed accounts of the operational aspects of these AI tools and highlight the challenges and successes encountered during their implementation (Arsturn, 2024).

Expert Interviews:

Expert interviews will be conducted with key stakeholders involved in the development, implementation, or regulation of generative AI technologies in sports and recreation. These experts will include AI researchers, sports technologists, policy makers, athletes, coaches, and data analysts. The interviews will offer firsthand insights into the real-world applications, limitations, and ethical concerns related to AI adoption in sports and recreation. Interviews will be semi-structured to allow for flexibility in exploring the diverse perspectives of the interviewees. They will also provide insights into the future directions of AI in sports, including emerging trends, innovations, and the societal implications of AI Technologies (Arsturn, 2024; Xenonstack, 2024).

Data Collection and Analysis

Data will be collected systematically across the four sources, ensuring a comprehensive and multi-dimensional approach to understanding the impact of generative AI. The corpus will be analyzed using qualitative content

analysis, which involves coding the data to identify recurring themes, patterns, and insights. This analysis will be iterative, allowing for the continuous refinement of codes and categories as new information emerges. The key themes that will be explored include:

- **Applications of AI**: In sports performance, fan engagement, and recreational activities.
- **Ethical and Social Impacts**: Including privacy concerns, algorithmic bias, and accessibility.
- **Cultural and Societal Shifts**: How AI influences participation, inclusion, and the fan experience.

The study will employ triangulation, combining the different data sources (academic literature, reports, case studies, and interviews) to ensure the validity and reliability of the findings. Triangulation helps cross-verify the information from multiple perspectives, enhancing the robustness of the conclusions drawn from the corpus.

Ethical Considerations

Given the sensitive nature of some of the data involved, particularly in expert interviews and case studies, ethical considerations will be a key part of the research design. Informed consent will be obtained from all interviewees, ensuring that they understand the nature of the study and how their responses will be used. Additionally, confidentiality will be maintained for all personal data, and participants will have the right to withdraw from the study at any time. The research will also adhere to ethical guidelines regarding the use of secondary data, ensuring proper citation and attribution of all sources used in the corpus (Arsturn, 2024; Xenonstack, 2024).

Limitations of the Study

Although the qualitative corpus-based approach provides rich, contextually detailed insights, there are limitations. For instance, the focus on existing literature, reports, and case studies may exclude emerging technologies or applications of generative AI that have yet to be documented extensively. Moreover, the study's reliance on interviews with experts may introduce biases based on the selection of interviewees or their perspectives on the subject matter. These limitations will be acknowledged in the final analysis, and efforts will be made to mitigate them by ensuring a diverse range of sources and perspectives.

Findings

The Application of Generative AI in Sports and Recreation

Generative artificial intelligence (AI) is having a transformative impact on various sectors of sports and recreation, revolutionizing everything from athletic performance analysis to fan engagement. In sports, AI tools like generative design algorithms and predictive analytics are now being used for optimizing player training, tactical simulations, and injury prevention. For instance, generative AI models can simulate different game scenarios, enabling teams to explore various tactical approaches without physically conducting each simulation. These models also help in assessing player potential by analyzing vast datasets, ranging from past performance metrics to biometric data collected during training (Arsturn, 2024; Xenonstack, 2024).

Additionally, in the realm of recreation, AI is transforming how people engage with fitness. Virtual coaches, personalized training plans, and AI-generated workout routines are becoming mainstream through mobile apps and wearables. These platforms use generative AI to create adaptive and individualized fitness plans based on user data, making fitness programs more accessible to people of all skill levels (Arsturn, 2024). Moreover, AI-generated experiences in virtual reality (VR) and augmented reality (AR) have opened up new avenues for recreational activities, offering immersive experiences that cater to diverse interests—from virtual sports to

interactive wellness programs (Xenonstack, 2024)

Ethical and Social Impacts of AI

The integration of generative AI in sports and recreation is not without its ethical and social challenges. One of the primary concerns is the risk of reinforcing biases in AI models. If AI systems are trained on biased datasets—such as those skewed towards male athletes or athletes from wealthier backgrounds—these biases can be perpetuated in performance analytics, recruitment decisions, or fan engagement strategies. For example, AI-driven recruitment platforms may prioritize physical attributes or past performances over a holistic evaluation of an athlete's potential, leading to unequal opportunities for underrepresented groups (Xenonstack, 2024).

Another significant ethical issue is the impact of AI on privacy and data security. The continuous collection and analysis of personal data, including health metrics, performance data, and behavioral patterns, raise concerns about data misuse or breaches. There are also issues surrounding informed consent, as many AI applications in sports and fitness are embedded in apps and platforms that collect extensive personal data without always being transparent about how it is used (Arsturn, 2024; Xenonstack, 2024). As AI continues to play a bigger role in both professional and recreational sports, the importance of establishing clear ethical guidelines and robust privacy protections will grow.

Impact on Participation and Inclusivity

Generative AI has the potential to significantly enhance inclusivity within sports and recreation. AI tools are helping to create more adaptive sports programs, such as those for people with disabilities. For example, AI-powered systems are being used to design customized equipment and personalized coaching, making it easier for athletes with physical challenges to participate in competitive sports (Xenonstack, 2024). Additionally, AI can help broaden access to sports training and education, especially in underprivileged areas, by providing virtual training and educational resources that would otherwise be unavailable due to economic or geographical barriers(Arsturn, 2024).

The use of AI for promoting inclusivity is also evident in fan engagement. AI is enabling sports organizations to offer personalized experiences for fans, tailoring content to individual preferences. Through AI-driven platforms, fans can access personalized highlights, interviews, and interactive content, helping to create a more inclusive and engaging experience regardless of geographic location (Arsturn, 2024; Xenonstack, 2024).

Future Directions

The future of generative AI in sports and recreation is promising, with numerous possibilities on the horizon. One area of potential growth is the increased use of AI for strategic decision-making. As AI models become more sophisticated, teams and athletes could leverage predictive analytics not only to improve performance but also to optimize decision-making in high-pressure scenarios during actual competitions (Arsturn, 2024). Furthermore, AI's role in virtual sports and e-sports is expected to grow, with generative AI creating more realistic, immersive gaming environments that blur the line between physical and virtual sports (Xenonstack, 2024).

Another area to watch is the continued development of AI-powered fan experiences. The increasing integration of AI with immersive technologies such as VR and AR could lead to fully personalized, interactive experiences for fans both in the stadium and at home. This could include virtual attendance at live events, personalized fan interactions with athletes, and AI-generated content tailored to individual interests and viewing habits

(Xenonstack, 2024).

Limitations and Challenges

Despite its vast potential, the widespread adoption of generative AI in sports and recreation faces several limitations. One key challenge is the accessibility of AI technologies, particularly for smaller organizations or recreational facilities with limited budgets. The implementation of AI requires significant investment in both hardware and software, which may be a barrier for many sports teams or recreational centres (Arsturn, 2024). Moreover, there is a need for regulatory frameworks to address the ethical concerns related to AI use, particularly in the areas of fairness, privacy, and bias. Without proper regulations and safeguards, the expansion of AI in sports could lead to unequal outcomes and unintended negative consequences (Xenonstack, 2024).

In conclusion, while generative AI is poised to revolutionize sports and recreation, its successful integration will require addressing ethical challenges, ensuring inclusivity, and fostering a regulatory environment that ensures fair and responsible use. As this technology continues to evolve, the insights gained from this study will serve as a foundation for future research and policy development in the field.

Discussion

The Social and Cultural Impact of Generative AI in Sports and Recreation

Generative AI is reshaping the landscape of sports and recreation in profound ways, with significant social and cultural implications. At its core, generative AI is democratizing access to sports, recreation, and fitness, offering new opportunities for individuals to participate regardless of their physical or geographic limitations. The growing integration of AI-powered platforms for training, fitness, and fan engagement exemplifies how technology can break down barriers and create more personalized, inclusive experiences(Arsturn, 2024; Xenonstack, 2024).

The cultural impact of generative AI is also evident in the way it transforms the sports experience for fans. AI is enhancing fan engagement by personalizing content, including tailored recommendations, real-time interactions with athletes, and immersive, AI-driven fan experiences like virtual and augmented reality applications. These technologies provide fans with a more dynamic and personalized connection to their favourite sports, teams, and players, regardless of location. For instance, fans can engage in virtual reality (VR) games or use augmented reality (AR) apps to view stats and information during live events. This shift towards personalization is also evident in fitness and recreational settings, where AI helps create bespoke workout routines and offers real-time feedback on performance, enriching the experience for users of all levels (Arsturn, 2024).

Ethical Concerns: Privacy, Bias, and Equity

While the benefits of AI in sports and recreation are substantial, ethical concerns also arise, particularly in the realms of privacy, bias, and equity. One of the most pressing concerns is the potential for AI to perpetuate biases present in data. If AI systems are trained on data that lacks diversity—such as biased performance data—this can lead to unfair outcomes in areas like talent scouting, recruitment, or personalized training. For example, AI tools used in recruitment could unintentionally favour athletes from certain regions, genders, or backgrounds, thereby perpetuating existing inequalities in sports. Studies have shown that biases in AI algorithms can skew decision-making processes, reinforcing societal stereotypes rather than promoting inclusivity (Xenonstack, 2024).

Privacy is another significant concern. The extensive data collection required by AI applications in both sports and recreation raises questions about how personal data is stored, shared, and used. Athletes' performance data, along with health and biometric information collected by wearables and AI-driven fitness apps, can be susceptible

to misuse or breaches if not properly managed. While many AI platforms promise to enhance user experience by providing personalized recommendations, they also collect vast amounts of sensitive personal information. This raises ethical questions around data ownership, consent, and the transparency of how data is used (Arsturn, 2024). Moreover, the proliferation of AI technologies could exacerbate existing disparities in access to sports and recreation. While AI holds the potential to increase inclusivity, particularly for individuals with disabilities, it also requires significant infrastructure investment, which may not be available in all regions. Smaller sports organizations or community-based recreational facilities may lack the resources to adopt AI-driven technologies, potentially widening the gap between well-funded and underfunded organizations (Arsturn, 2024).

AI and the Future of Sports: Opportunities and Challenges

Looking ahead, generative AI presents both exciting opportunities and notable challenges for the future of sports and recreation. On the one hand, the growing sophistication of AI models could lead to more accurate performance predictions, refined training techniques, and smarter game strategies. Generative AI can simulate thousands of game scenarios to help teams and athletes optimize their tactics without the need for costly and time-consuming physical practice sessions. This predictive power will enhance not only athletic performance but also strategic decision-making in high-pressure environments (Xenonstack, 2024).

On the other hand, the rapid advancement of AI technology presents challenges related to regulation, accountability, and fairness. For example, as AI begins to play a more prominent role in player evaluations, it becomes crucial to develop regulatory frameworks that ensure AI systems are used ethically and transparently. Sports organizations, especially at the professional level, will need to establish policies that govern the use of AI to avoid exploitation, ensure fairness, and protect the integrity of the sport (Arsturn, 2024). These frameworks will need to address the issue of algorithmic bias, the transparency of AI models, and the ownership and use of data. Without proper oversight, AI could inadvertently reinforce societal inequities or distort competitive fairness.

Moreover, the increased integration of AI in sports media and broadcasting will further change the dynamics between fans and teams. AI-driven content creation can tailor broadcasts, advertisements, and interactions to individual preferences, thereby enhancing fan engagement. However, this shift also raises questions about the role of traditional media outlets and the broader impact on the diversity of voices and narratives in sports. The challenge will be balancing personalization with the need for a diverse range of perspectives and experiences within the sports ecosystem (Xenonstack, 2024).

The Path Forward: Balancing Innovation and Ethics

As AI continues to reshape sports and recreation, it is critical to strike a balance between innovation and ethical responsibility. One path forward is to emphasize transparency in the development and use of AI technologies, ensuring that both consumers and professionals are fully aware of how AI works and what data it collects. Collaboration between AI developers, sports organizations, and policymakers will be essential in creating standards and regulations that protect individuals' privacy and promote fairness. Moreover, ensuring that AI technologies are accessible to a wider range of users—particularly those from underrepresented communities—will be vital to ensuring that the benefits of AI in sports and recreation are distributed equitably (Arsturn, 2024).

In conclusion, while generative AI offers significant opportunities to enhance the sports and recreation industries, its implementation must be carefully managed to mitigate ethical risks. As AI continues to evolve, stakeholders across sports and recreation sectors must work together to ensure that the technologies are used responsibly,

inclusively, and ethically. The findings of this study underline the need for ongoing dialogue and collaboration between technologists, regulators, and industry professionals to ensure that AI remains a force for good in the world of sports and recreation (Xenonstack, 2024)

Conclusion

The integration of generative artificial intelligence (AI) into the realm of sports and recreation has ignited a wave of transformation, influencing not only athletic performance and training but also the broader social and cultural landscape. Through the use of AI-powered tools, sports organizations, fitness enthusiasts, and fans are benefiting from enhanced personalization, immersive experiences, and smarter decision-making. AI-driven advancements are allowing for the optimization of training regimens, improved fan engagement, and data-driven strategies that have redefined how sports are played, followed, and experienced across the globe (Arsturn, 2024; Xenonstack, 2024).

However, as with any disruptive technology, the application of generative AI in these domains presents critical challenges, particularly concerning ethical considerations. Issues related to privacy, data security, algorithmic bias, and equitable access must be addressed to ensure that AI does not inadvertently reinforce existing inequalities or compromise the integrity of sports. For instance, AI's potential to perpetuate biases in player recruitment, fan engagement, or fitness routines necessitates the development of robust ethical frameworks and regulatory measures to maintain fairness and inclusivity (Arsturn, 2024; Xenonstack, 2024).

Moreover, while AI offers significant benefits in terms of performance optimization, personalization, and fan experience, the future of AI in sports and recreation will depend on how well stakeholders can balance innovation with responsible use. Ensuring transparency in AI algorithms, safeguarding user privacy, and promoting equal access to AI-powered tools are paramount to mitigating risks and ensuring the responsible development of AI Technologies(Arsturn, 2024).

In conclusion, generative AI holds immense potential to revolutionize the sports and recreation sectors, but its deployment must be carefully managed. By establishing clear ethical guidelines and fostering inclusive practices, the sports industry can maximize the positive impact of AI while minimizing the risks associated with its use. Going forward, collaboration between AI developers, sports organizations, regulators, and athletes will be crucial in shaping an AI-enhanced future that is equitable, transparent, and inclusive for all (Arsturn, 2024; Xenonstack, 2024).

As the technology continues to evolve, ongoing research and dialogue will be essential to adapt to the changing dynamics of AI in sports, ensuring that its benefits are realized while its challenges are addressed thoughtfully and proactively.

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Chapter 14 –Conclusion and Recommendations: Roadmap for Generative Artificial Intelligence in Education

Murat Çoban

Introduction

Generative artificial intelligence (GAI) applications in education have attracted the attention of researchers with the potential to make teaching processes more efficient and effective. However, the sustainable integration of this technology is not limited to technological solutions; it also requires a comprehensive redesign of educational policies, teaching processes and infrastructure. As presented in Figure 1, increasing the competences of educators, updating the curriculum, strengthening the infrastructure, adopting ethical and safety principles, and supporting research and development processes are among the cornerstones of this transformation (Abulibdeh et al., 2024).

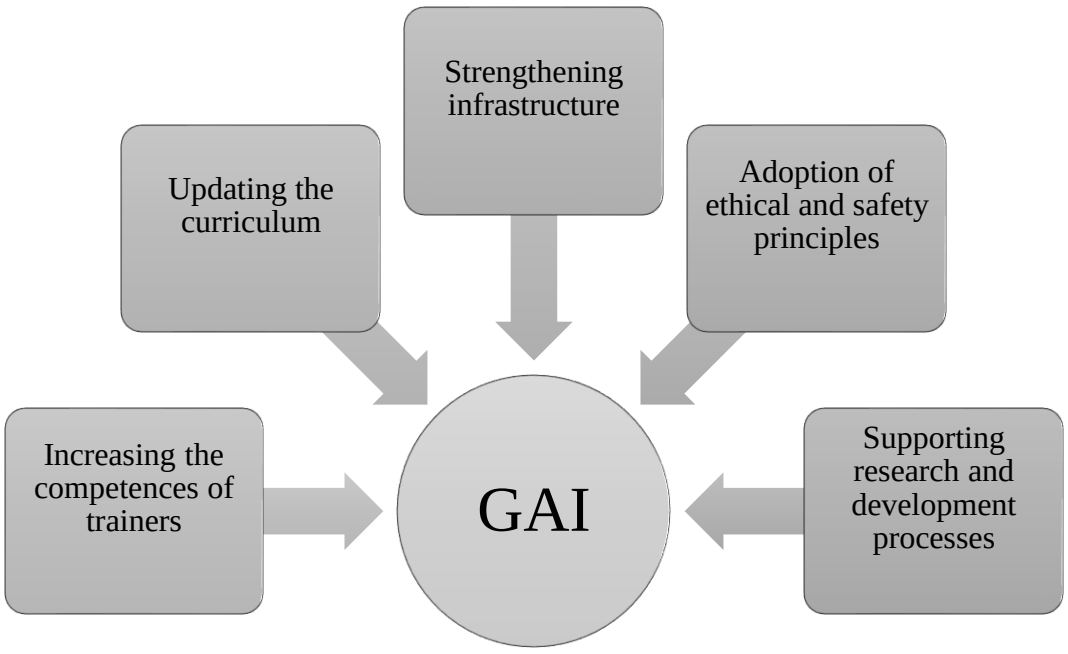

Figure 1. Basic building blocks of the process of developing GAI practices in education

Educators' adaptation to and effective use of the GAI depends on the quality of professional development programmes (Holmes & Miao, 2023). In this context, programmes that include hands-on trainings and case studies

can strengthen teachers' skills towards new technologies. On the other hand, updating the curriculum in accordance with generative AI requires an interdisciplinary approach (Tariq, 2024). In this process, case studies and pilot applications that demonstrate the effects of GAI in different disciplines can play an important role.

Successful implementation of GAI in education systems requires a strong technological infrastructure (Bahroun et al., 2023). It is important to make sustainable investments to strengthen the infrastructure, ensure equality of access, and disseminate technological devices. Furthermore, data security and the establishment of ethical standards are essential to ensure the responsible use of GAI. The privacy of student data, the neutrality of artificial intelligence, and ethical policy development processes should be addressed in this context (Akgun & Greenhow, 2022).

Finally, research and development activities should be encouraged to provide a scientific basis for the effects of AI on education (Chen et al., 2020). Literature-based pedagogical research and multi-stakeholder collaboration models can increase the body of knowledge in this field. The adoption of GAI in education will enable the transformation of not only individuals, but also the social and institutional structure. In this section, some suggestions are given in terms of the usefulness of generative artificial intelligence for educators. The suggestions presented under headings aim to shed light on the future of education systems.

Increasing the Competences of Trainers

In education, GAI is a technology that has the potential to transform both teaching processes and learning experiences. However, in order for this transformation to be achieved, educators need to be able to effectively use and integrate GAI tools into pedagogical practices (Alotaibi, 2024). In this context, increasing the capacity of educators to adapt to technology and developing new competences are critical for education systems to become more efficient and inclusive. GAI competences refer to educators' ability to integrate this technology into learning-teaching processes, develop creative solutions and use it ethically (Nedungadi et al., 2024). These competences are not only limited to technical knowledge but also include skills such as pedagogical understanding, critical thinking and problem solving (Yan et al., 2024). The acquisition of these competences by educators plays an important role in providing students with the skills required by the 21st century (Alotaibi, 2024).

Professional development programmes designed to enable educators to use GAI effectively are one of the basic building blocks of this transformation process (Jurenka et al., 2024). These programmes should be designed according to the needs of educators and include hands-on trainings that combine technology and pedagogy (Yurtseven Avci et al., 2020). For example, workshops and one-to-one mentoring sessions on how to use virtual reality or language model-based tools can be organised. In addition, successful applications for the use of URM in education in different parts of the world attract attention. For example, AI-supported teaching platforms allow teachers to provide individualised feedback (Ayeni et al., 2024). In addition, professional learning communities provide an effective environment for teachers to share their experiences and adapt to new technologies (Trust et al., 2016). Such strategies play a critical role in realising the potential of GAI in the field of education.

Increasing educators' GAI competences is vital not only for the development of individual teachers but also for the development of education systems in general. Designing professional development programmes effectively,

finding solutions to the challenges faced by educators and developing strategies inspired by successful practices will ensure the success of this process (Alotaibi, 2024; Jurenka et al., 2024; Nedungadi et al., 2024; Yurtseven Avci et al., 2020). Because educators may face various difficulties in the process of using tools such as GAI in education. Among these, lack of access to technology, lack of technical knowledge, and time constraints stand out (Hwang & Chen, 2023). To overcome these challenges, educational institutions can create a supportive environment by providing user-friendly tools and offering regular technical support to teachers (Ruiz-Rojas et al., 2023). Furthermore, individualised education programmes and online learning platforms can contribute to addressing these challenges (Yan et al., 2024).

Updating the Curriculum

Education systems are constantly changing and evolving in line with technological advances. The potential of ICTs in education enables students to develop critical skills such as creative thinking, problem solving and technological literacy (Abulibdeh et al., 2024). However, in order to use these technologies effectively, curricula need to be updated, pedagogical approaches need to be re-evaluated and interdisciplinary learning processes need to be encouraged (Alotaibi, 2024).

GAI tools offer students new opportunities in areas such as problem solving, creative writing, data analysis and visual production. The integration of these tools in the curriculum should aim not only for students to learn to use these technologies, but also to understand the mechanisms of their functioning (Chen et al., 2020). For example, language model-based software can be used to improve students' writing skills (Regalia, 2024), while visual production tools can be used in creative projects in art and design courses (Xu & Jiang, 2022). The integration of GAI into education should not be limited to technology-based courses. In different disciplines such as arts, social sciences and sciences, applications that develop students' creativity and critical thinking skills should be encouraged (Bahroun et al., 2023). For example, artificial intelligence tools can be used in history lessons to analyse historical events from different perspectives (Bertram et al., 2021; Liu et al., 2024). In this way, students may have the opportunity to understand both the technology and the relevant discipline in more depth. In this context, instructional strategies need to be redesigned in order to effectively use GAI tools in education (Hwang & Chen, 2023).

Methods such as project-based learning, game-based learning and problem-based learning support the flexibility and creativity offered by GAI (Zheng et al., 2024). For example, students may be asked to develop solutions to environmental problems using an artificial intelligence tool. Such applications encourage not only using technology, but also understanding and critically evaluating it. There are also examples from around the world of successful implementation of the use of GAI tools in the curriculum. For example, some schools have introduced AI-based coding tools in software development courses and enabled students to design their own algorithms (Saari et al., 2024). On the other hand, groups of students who developed creative stories using generative AI in language classes improved their writing skills to a higher level (Lys, 2024). These examples give an idea of how GAI tools can be applied in different disciplines.

In the process of curriculum updates, a number of challenges are often encountered. These challenges include teachers' adaptation to new technologies, infrastructure deficiencies, and different learning levels of students (Nedungadi et al., 2024; Tariq, 2024; Yan et al., 2024; Yurtseven Avci et al., 2020). To overcome these challenges,

teacher training and infrastructure investments should be prioritised (Hwang & Chen, 2024). In addition, the design of GAI tools in an inclusive and accessible manner will ensure that all students benefit equally from these technologies (Jurenka et al., 2024). In this context, the integration of GAI into education should be supported not only by technology but also by pedagogical understanding (Holmes & Miao, 2023). Updating the curriculum will equip students with the skills required by the era and enable a more inclusive, creative and effective approach to education. By utilising the opportunities offered by GAI technologies, educators can ensure that students grow up as individuals who can both use technology and evaluate it in an ethical framework (Bukar et al., 2024; Liu et al., 2023).

Strengthening Infrastructure

In order for GAI to be used effectively in education, a solid technological infrastructure is needed (Ruiz-Rojas et al., 2023). Infrastructure consists not only of technical hardware and software components, but also of systems that enable users to access and use these technologies effectively. Technological infrastructure plays a fundamental role in the integration of digital technologies into educational processes (Timotheou et al., 2023). Therefore, the use of GAI tools in education requires a wide infrastructure ranging from powerful computers that enable data processing to internet access and cloud-based systems (Pedro et al., 2019). Providing this infrastructure will accelerate the digitalisation journey of educational institutions and make learning processes more effective. In terms of hardware, computers with high processing power and data storage units are critical. On the software side, platforms that support artificial intelligence models, systems that provide data security, and user-friendly interfaces are required (Chen et al., 2020). In addition, the transition of educational institutions to cloud-based technologies can increase flexibility while reducing costs (Govea et al., 2023).

Strengthening the technological infrastructure in education should not be limited to schools in big cities, but should also cover rural and disadvantaged areas (Muijs et al., 2004). Ensuring equality of access makes it possible for all students to benefit equally from technological tools (Afzal et al., 2023). For example, distributing portable devices, providing free internet access and using open source software are important steps in creating an inclusive infrastructure.

Infrastructure investments often face problems such as high costs, lack of technical knowledge and sustainability. To solve these problems, public-private partnerships can be encouraged and international funds can be utilised (Koppenjan & Enserink, 2009). In addition, providing technical support to educational institutions and regularly updating the infrastructure can help overcome such problems. In this context, some countries have carried out successful infrastructure projects for the use of GAI in education (Pigola et al., 2021). For example, Singapore has equipped all schools with high-speed internet connection and popularised AI-supported education platforms (Brief, 2024). Similarly, some regions in Europe have strengthened technological infrastructure using cloud-based learning systems (Yathiraju, 2022). Such examples provide an inspiring model for other countries.

As a result, it is essential to strengthen the infrastructure for the effective use of GAI technologies in education. Consideration of factors such as hardware, software and equality of access will enable not only the widespread use of technology but also a more inclusive and sustainable transformation in education.

Ethical and Safety Principles

The use of GAI in education brings various ethical and security issues as well as opportunities (Airaj, 2024; Farahani & Ghasemi, 2024; Hashmi et al., 2024; Rane et al., 2024b; Tejani et al., 2024). The digitalisation of

educational processes, the processing of student data and the incorporation of artificial intelligence algorithms into decision-making processes require special attention to these issues. Adopting ethical and security principles ensures fair and reliable use of GAI technologies in education. In this context, one of the most important ethical issues of GAI use in education is whether the algorithms are unbiased and fair (Farahani & Ghasemi, 2024). Biases in algorithms may negatively affect some student groups and deepen inequalities. To avoid such problems, ethical standards should be applied in algorithm design and artificial intelligence should be supported by human intervention (Tejani et al., 2024). Furthermore, it is important that GAI is only used to support teaching processes and does not mechanise students' learning experiences.

GAI tools collect large amounts of data to analyse student performance and behaviour. This raises serious privacy concerns. Educational institutions should use encryption methods, anonymisation and mechanisms that limit data access to ensure data security (Amo Filvá et al., 2021). At the same time, it is an ethical obligation to inform students and their families about data collection processes and obtain their consent (Mangual Figueroa, 2016). In addition, transparency and accountability are critical in GAI's decision-making processes in education. Students, educators, and parents should understand how AI works and be able to learn the rationale for the decisions made. The transparency of algorithms builds trust as well as allows incorrect or biased decisions to be recognised and corrected.

The use of GAI technologies brings with it various security risks. Cyber-attacks can lead to malicious interception of student data. In addition, incorrect or biased decisions of artificial intelligence systems may negatively affect educational processes. To reduce security risks, strong cyber security infrastructures should be established, regular system updates should be made, and all users should be trained in security awareness (Hashmi et al., 2024). Therefore, educators need to be supported in this regard for the ethical and safe use of GAI. Educational institutions should develop guidelines on how to use GAI tools and ensure that educators act in accordance with these guidelines (Rane et al., 2024b; Airaj, 2024). In addition, it is important to provide ethical trainings on the use of artificial intelligence for students. Because the successful implementation of GAI technologies in education depends on the correct adoption of ethical and security principles. Protection of data privacy, transparency of algorithms and prevention of security risks constitute the basic elements of this process (Airaj, 2024; Farahani & Ghasemi, 2024; Hashmi et al., 2024; Rane et al., 2024b; Tejani et al., 2024). Educators and policy makers should apply these principles to optimise the potential of GAI.

Research and Development

Various research and development activities can be focused on the use of GAI in education. In this context, it is important to conduct research to fully realise the potential of generative artificial intelligence in education (Ahmed et al., 2024). In the research by Bahroun et al. (2023) on the use of GAI in education, a comprehensive analysis of GAI in education was presented, synthesising key data from 207 research articles to identify research gaps and future directions in the field. This study presents through a content analysis examining the transformative impact of GAI in specific educational fields, including medical education and engineering education. In this context, the multifaceted applications of GAI in assessment, personalised learning support and intelligent tutoring systems are highlighted. The study emphasises ethical considerations, interdisciplinary collaboration and responsible

technology use, highlighting the need for transparent GAI models and addressing biases.

Furthermore, a bibliometric analysis of GAI in education is presented and important AI tools, research focus, geographical distribution and interdisciplinary collaboration are also presented. It is revealed that the ChatGPT tool has emerged as a dominant GAI tool and there is a significant and exponential growth of GAI in 2023. Finally, the study also identifies promising research directions such as GAI-supported curriculum design and studies monitoring its long-term impact on learning outcomes. From the results of the study, it can be said that there is a broad consensus on the potential of GAI to reshape education and that researchers, educators and policy makers interested in the intersection of GAI and education will create a deeper connection through GAI.

Intelligent instructional systems are another important area of use of GAI in education. These systems are integrated into educational software and support teaching processes with functions such as automatic feedback, guidance and content creation. This makes it possible to respond faster to the needs of students while alleviating the workload of teachers (Ahmed et al., 2024). Moreover, the role of GAI in interdisciplinary applications is emphasised. Especially in fields such as engineering and medicine, research on how this technology transforms education attracts attention. This transformation has also been examined in the context of sustainability and it has been discussed how GAI can contribute to long-term educational goals (Ahmed et al., 2024).

Conclusion and recommendations

The use of GAI in education is an innovative approach that has the potential to transform learning processes. The contributions of this technology in areas such as personalised learning, intelligent teaching systems and automated assessment increase student achievement and engagement. However, as well as these opportunities, challenges such as ethics, data privacy, equal access and teacher adaptation need to be considered. In order to create an effective roadmap, first of all, training programmes that convey the potential of this technology to teachers and students should be organised, and it should be ensured that GAI is compatible with pedagogical foundations. In addition, the future effects of GAI should be examined in depth in line with sustainability, equal access and ethical principles through interdisciplinary research. Thus, the role of GAI in education can gain a structure that both meets individual learning needs and observes social equality. In this direction, it is critical that policy makers, educators and technology developers work in cooperation.

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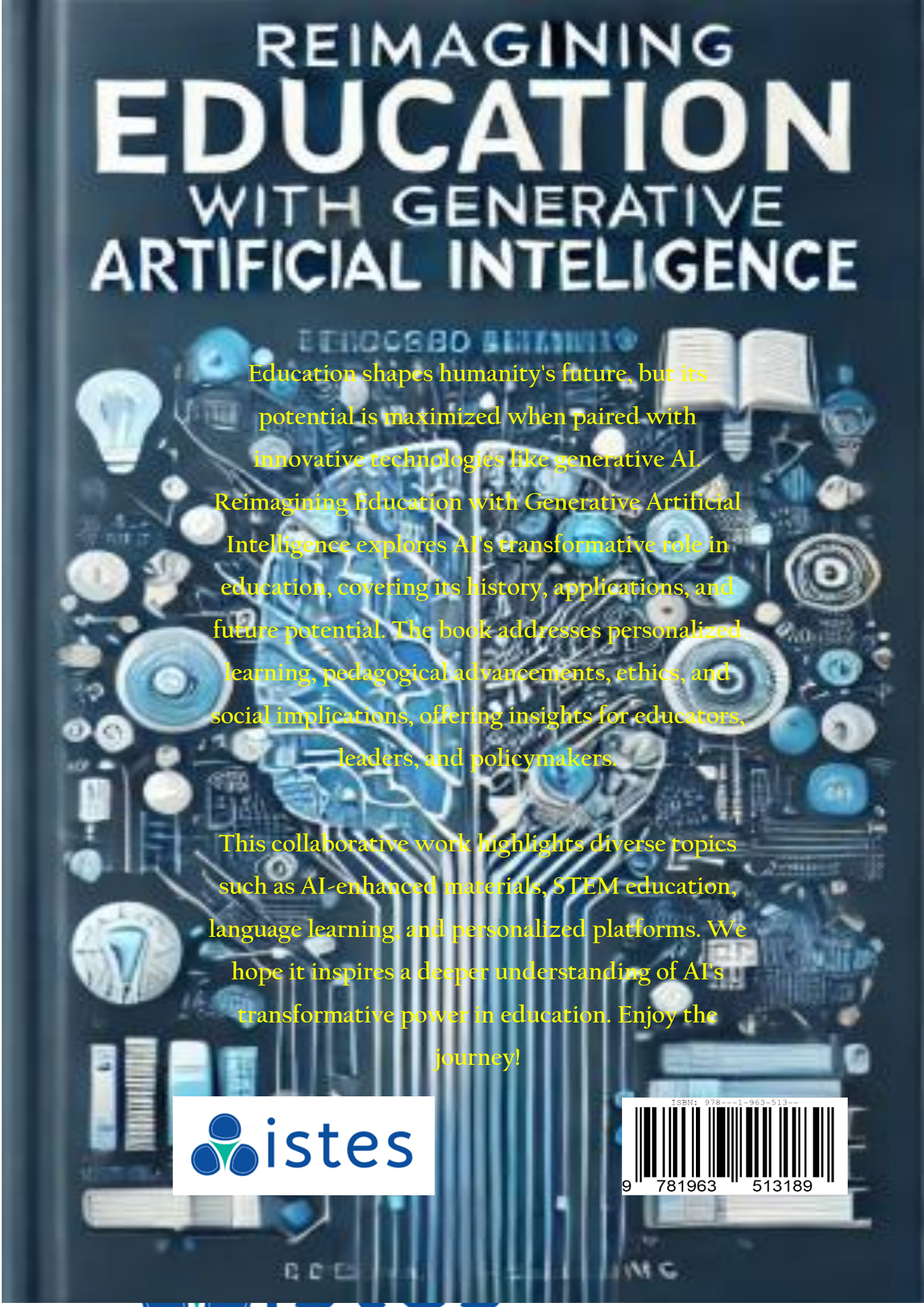
REIMAGINING EDUCATION WITH GENERATIVE ARTIFICIAL INTELIGENCE



Education shapes humanity's future, but its potential is maximized when paired with innovative technologies like generative AI. Reimagining Education with Generative Artificial Intelligence explores AI's transformative role in education, covering its history, applications, and future potential. The book addresses personalized learning, pedagogical advancements, ethics, and social implications, offering insights for educators, leaders, and policymakers.

This collaborative work highlights diverse topics such as AI-enhanced materials, STEM education, language learning, and personalized platforms. We hope it inspires a deeper understanding of AI's transformative power in education. Enjoy the journey!

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