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Philosophy of future: analytical overview of interaction between education, science, and artificial intelligence in the context of contemporary challenges

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Abstract: Currently, artificial intelligence is changing the future landscape of technology and digitalization and transforming the way knowledge is generated and shared in education and science. The aim of the article is to interpret the future through interactions between education, science, and AI and to outline their potential challenges when digital transformations occur. While answering the research questions the mixed-methods approach was applied. For the study both quantitative and qualitative data was collected through descriptive and empirical survey. The empirical survey included computer-assisted web interview to assess the most relevant concepts according to the participants responses. The study involved 42 participants that were selected randomly. The selection criteria concerned educational background, previous experience, representation of diverse perspectives, theories, or approaches within the philosophy, active engagement in educational practice, and wiliness to participate. To analyse the data statistical software NVivo was applied. Approximately 70 recent scientific works were studied to present the problem through multifaceted approach. The findings show the participants' anticipations are related to the cognitive load theory, constructivist theory, and socio-cultural theory. A number of challenges threatening innovative developments arise within the

educational and scientific environments. They include ethical concerns, misinformation, digital divide, unequal infrastructure, lack of regulation, lack of digital skills, resistance to change, technology integration, and limited digital pedagogy. Ethics plays a crucial role in shaping digital transformations in education and science. The category of academic virtue is closely connected to ethical and responsible use of AI. The paradigm of academic virtue includes ethical of knowledge, collaboration, responsibility, honesty, accuracy, adaptability, openness. AI brings automated content creation, language processing opportunities, real-time translation, and enhanced accessibility and, therefore, changes communication in the field of education and science. The research showed that the principles of effective implementation of AI in education and science include philosophical, educational, and ethical dimensions.

Keywords: academic virtue, constructivism, cognitive load theory, digitalization, educational environment, ethics, socio-cultural theory.

Introduction

The idea of societal development is connected with long-term planning and strategic decision-making. Considering future scenarios and anticipating challenges or opportunities, societies develop effective policies and initiatives that promote sustainable growth and address emerging needs of human beings. From a scientific perspective future is defined as a temporal concept that represents the progression of time beyond the present, including both forthcoming outcomes based on the current conditions and uncertainties influenced by various factors such as human decisions, natural processes, and random events (Poli, 2019). Normally, the future is associated with its inherent uncertainty, as it involves the potential for diverse and unpredictable developments that may shape the course of events (Danaher, 2021).

Philosophers, as a rule, explore the nature of the future regarding the questions about its existence, reality, and relationship to the past and present (Orel et al., 2023). Some recent philosophical perspectives view the future as a concrete reality that is going to happen (Todd, 2023), while other findings conceptualize the future as a mere abstraction or construct of human consciousness (Poli, 2019). In the context of social and political philosophy, the future is often related to sustainable development, justice, and collective action oriented to achieve a common goal (Kelz, 2019). The visions of the future shape ideologies, social movements, and utopian narratives about the direction of society. The concept of future is engaged in facilitating interdisciplinary dialogue (Virmajoki, 2022) with various fields, including psychology, sociology, education, and economics, to deepen understanding its main theories and implications. This interdisciplinary approach enriches philosophical studies of the future and its significance for human thought and experience.

According to Kraus, Jones, Kailer, Weinmann, Chaparro-Banegas, & Roig-Tierno (2021), the future is closely connected with technological advancement and digitalization in particular. The findings show that technology and digitalization are key drivers of innovation, building the path of future development (Reis & Melão, 2023). The future is increasingly digital, characterized by the proliferation of digital technologies, data-driven decision-making, and online connectivity. Digitalization enables new modes of collaboration, creativity, and productivity, while also presenting challenges related to privacy, security, and digital divide.

Emerging technologies such as artificial intelligence (AI), blockchain, Internet of Things (IoT), virtual reality (VR), and 5G connectivity are gradually changing the future landscape of technology and digitalization and transforming the way knowledge is generated and shared (Rasa & Laherto, 2022).

Consequently, there is often a logical relationship between education, science and AI, shaping the idea of “present future” (Placek, 2021). Nowadays the “present future” recognizes the creative potential of the present moment considering the expected trajectory of the future (Placek, 2021; Yabe & Yamada, 2023). At the same time, when a wide range of opportunities and challenges related to education, science, and AI in the present are embraced, it is possible to foster innovation and progress in the society. Additionally, investing in research, technology, and education, societies can activate new discoveries and develop creative solutions to complex problems, leading to economic growth, social development, and improved quality of life for communities and individuals.

Research Problem

The question of future is at the heart of all the major challenges facing today’s community. On the one hand, it represents uncertainty, complexity, and potentiality that impacts the present and influences decision-making for future events (Danaher, 2021; Mannucci et al., 2023). On the other hand, many issues are complex and interconnected, involving multiple actors, systems, and variables that interact dynamically (Geels et al., 2023). At the same time, the future presents a number of opportunities for innovation, creativity, and adaptation in addressing these challenges (Kraus et al., 2021). Considering the future as a source of innovation requires openness to change (Bigliardi et al., 2021), implementation of culture of ongoing technological progress (T. Dufva & M. Dufva, 2019), digitalization (). Additionally, the future outlines the responsible use of programs simulating human intelligence such as AI () whose role is increasing every day. And in this sense, the study of interaction between education, science, and AI is of great importance nowadays since it is oriented towards philosophical interpretation of digital transformations and their effect on technological innovation and experimentation in education and science. Moreover, the problems of ethics of AI, academic virtue, and communication in the field of education and science requires detailed analysis on the basis of theoretical and interpretive frameworks and philosophical assumptions.

Research Focus

The philosophical category of future has always been interconnected with a number of concepts in different areas. Education, science, digital technologies are closely related to the future through various philosophical perspectives that form the conceptual approaches to understanding of knowledge, technological progress, and future-oriented professional development (). Definitely, digitalization is transforming education and science by providing new tools, platforms, and opportunities for teaching, learning, research, and positive collaboration. Further digital technologies enable the dissemination of scientific knowledge, improve educational practices, and accelerate the pace of scientific discovery leading to the development of innovations applicable in the future. Therefore, the explanation of the category of future from the philosophical point of view, the description of interactions between education, science, and digitalization will facilitate educational process and make the use of innovative digital tools like AI more responsible.

Research Aim and Research Questions

The aim of the article is to interpret the future through interactions between education, science, and AI and to outline their potential challenges when digital transformations occur. Despite the existing research on digital transformations in education and science, there some gaps remain. Therefore, the article addresses the following questions:

1. What are general approaches to philosophical interpretation of relations between education, science, and AI?

2. What are potential challenges threatening innovative developments and evolution of education, science, and AI?

3. How do problems of ethics and academic virtue affect digital transformations in education and science?

4. How does digitalization, AI in particular, change communication in the sphere of education and science?

Literature Review

AI as a concept of the “present future”

The potential impacts of AI on society are receiving increased attention due to the rapid growth of this technology during Industry 4.0 that is characterized by the integration of digital tools into various industrial processes, leading to the increased automation, data exchange, and smart management (Alenizi et al., 2023). Importantly, in-depth understanding the present state of AI applications and its effects make anticipate and prevent the potential risks that may arise in the future (Jumani et al., 2021). In the “present future”, AI technology is already a significant attribute of societal development, and it also presents the opportunities for innovation and transformation in various spheres (Dwivedi et al., 2023). The findings show that AI-driven technologies are able to improve efficiency, productivity, and decision-making processes (Murugesan et al., 2023). They also lead to advancements in healthcare (Davenport & Kalakota, 2019), environmental monitoring (Zhang et al., 2021), scientific research, education modernization, and social services (Chiu et al., 2023; Xu et al., 2021). The introduction of AI as a philosophical idea come true is essentially a result of human evolution (Poli, 2019). Originally, the human brain serves as a model and inspiration for AI systems, and further AI, being a product of human culture and innovation (Marino et al., 2023), emerges within the context of human society affected historical, political, social, and economic factors. The philosophical perspective of AI involves a broad range of debates concerning the nature of intelligence, its capabilities, societal impact, and moral responsibility.

The philosophical perspective on the nature of intelligence is related to intelligence as problem-solving ability, learning capacity, adaptability, creativity, and consciousness (Palanca-Castan et al., 2021). While human intelligence is characterized by complex cognitive processes, subjective experiences, and emotional awareness, AI typically focuses on tasks such as pattern recognition, optimization, and decision-making based on algorithms and data (Huang & Peissl, 2023). Moreover, intelligence is inseparable from the physical and social context where it operates (Dorotic et al., 2023). Exploring the limitations of AI, it was found that AI systems have made remarkable advancements in many areas but often they lack the specific understanding, creativity, and emotional intelligence exhibited by humans (Müller, 2024). At the same time, AI systems are capable of solving complex problems and reasoning through vast amounts of data using algorithms, heuristics, and logical inference (Xu et al., 2021). The recent findings demonstrate that computational reasoning is closely connected with human cognitive processes (Zhao et al., 2022). Additionally, the questions about the limits of algorithmic problem-solving refer to the ability of AI to generate innovative ideas or solutions and, then, to make rapid and relevant decisions based on recognition patterns, heuristic evaluations, or deep learning mechanisms (Holzinger et al., 2023).

There are three philosophical approaches to interpretation of the connections between technology and society (van de Poel, 2020). The thesis proposing technology as an autonomous force that determines society suggests that technological advancements influence the societal development independently of human intentions or actions. Accordingly, the use of innovative technologies, AI particularly, drives the social changes and leads to unforeseen consequences (Hallström, 2022). The statement that technology is a human construct means that the development and impact of technology

are fundamentally influenced by human intentions, values, and choices. In this perspective, technology is not an autonomous force but rather a product of human creativity, ingenuity, and socio-cultural context (Dwivedi et al., 2023).

The co-evolutionary perspective on technology and society is related to a dynamic relationship where neither technology nor society independently determines the other, but rather they evolve simultaneously and influence each other equally (Sheikh et al., 2023). In this framework, technological innovations emerge within specific socio-cultural contexts, reflecting prevailing values, needs, and aspirations of society, while affecting social practices, institutions, and norms (van de Poel, 2020). Taking this into considerations, AI systems can act autonomously and make morally significant decisions (Laitinen & Sahlgren, 2021). Philosophy helps to outline the ethical principles and values that should guide the design and implementation of AI systems (Ryan & Stahl, 2021), ensuring that they correspond with human values and contribute to the well-being of individuals and society.

From the role of AI and its capabilities, two different types can be distinguished – Strong AI and Weak AI (Müller, 2024). Strong AI, or human-level AI, refers to a hypothetical form of AI that possesses the ability to understand, learn, and reason across a wide range of areas at a level comparable to human intelligence (Butz, 2021). Strong AI demonstrates general cognitive capabilities similar to those of humans, including perception, language understanding, problem-solving, creativity, and self-awareness (Fjelland, 2020). Weak AI, also known as narrow AI, refers to AI-based systems designed for specific tasks or areas. Unlike Strong AI, Weak AI focuses on solving the particular problems within a limited context (Abonamah et al., 2021; Müller, 2024). Figure 1 shows the main characteristics of Strong AI and Weak AI contributing to development of education and science.

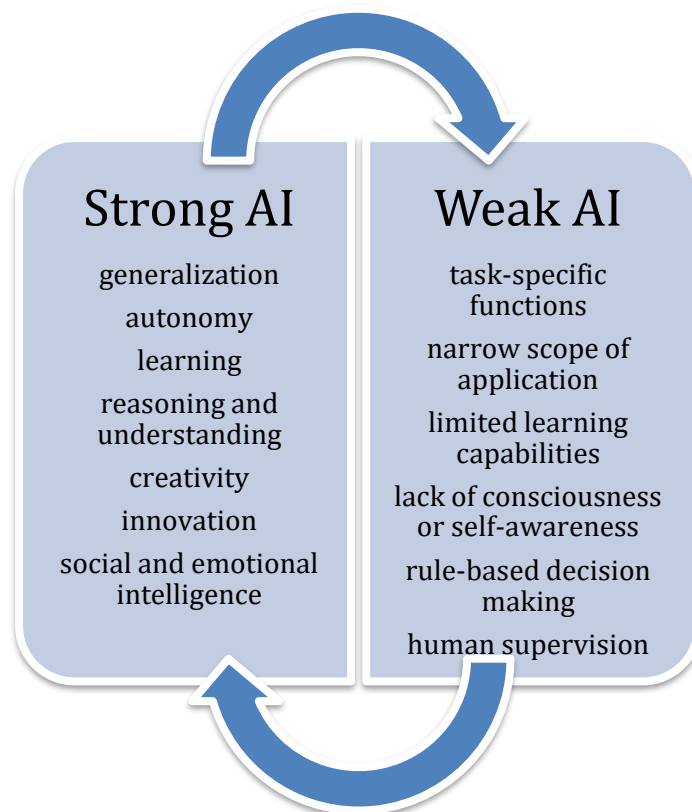


Figure 1. Characteristics of Strong AI and Weak AI contributing to development of education and science

Source: author's own development

AI represents a unique paradigm shift, offering the transformative opportunities to enhance learning methodologies and accelerate scientific discovery. Therefore, it is necessary to build the triangle model to understand interactions between education, science, and AI.

The triangle model to understand interactions between education, science, and AI

Understanding interactions between education, science, and AI involves various perspectives from fields such as cognitive science (Naveed Uddin, 2019), philosophy of mind (Maidaniuk et al., 2022), sociology of technology, and educational theories (Zhang & Aslan, 2021). Theoretical approaches to understanding of interactions between education, science, and AI include constructivist theory, cognitive load theory, and socio-cultural theory (Lea, 2020; Niemi, 2021).

Firstly, it deals with the theory of constructivism that provides a theoretical framework by emphasizing active learning, knowledge construction, and the role of social communication in forming individual understanding (Lea, 2020). In the constructivist view, education is defined as a process of active cognitive process where students actively engage within their educational environment to construct new knowledge (Grubaugh et al., 2023). In the context of AI, constructivist approaches facilitate personalized and interactive learning tailored to individual students' needs and preferences (Mota-Valtierra et al., 2019). Also, AI stimulate the construction of scientific knowledge through observation, reflection, and experimentation.

Secondly, cognitive load theory helps examine the mental efforts required for learning and problem-solving tasks. In education, AI technologies manage cognitive load and adapting instructional materials to students' individual learning needs (Koc-Januchta et al., 2022). By optimizing cognitive load in AI-enhanced learning environments, educators can enhance learning outcomes and support students' cognitive processing. In science the theory presents the scientific concepts and processes minimizing cognitive load (Wu, 2023).

Thirdly, socio-cultural theory emphasizes the role of social interaction and cultural context in individual cognition and learning. Regarding AI, socio-cultural theory highlights the importance of collaborative educational environments, peer interaction, and socio-cultural mediation in fostering learning experiences (Kim & Lee, 2023). AI technologies facilitate collaborative learning since they provide a number of tools for online collaboration, immediate feedback, and knowledge sharing. Additionally, socio-cultural theory fosters scientific inquiry and innovative knowledge construction. The findings state that socio-cultural theory emphasizes the importance of ethical conduct in scientific inquiry and creation of ethical educational environment (Feher & Katona, 2021; Wu, 2023).

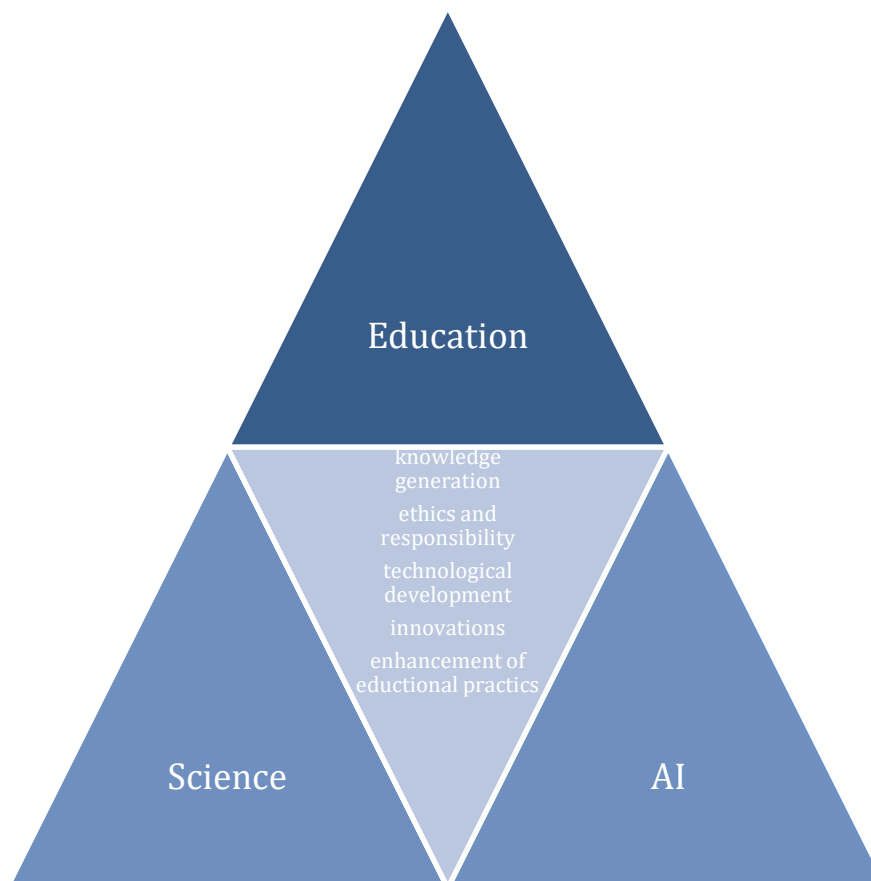


Figure 2. Triangle model showing interactions between education, science, and AI

Source: author's own development

These theoretical frameworks provide the basis for building the triangle model to deeply understand interactions between education, science, and AI (Figure 2). The triangle model is a conceptual framework that reveals the dynamic interactions and interdependencies between education, science, and AI. The education component represents the educational system, formal schooling, informal learning environments, and lifelong learning in particular. Education fostering essential skills among students and introduces the inquiry-based learning approaches that are oriented towards cultivation of curiosity, creativity, and problem-solving (Huang & Peissl, 2023; Zhang & Aslan, 2021). Within the triangle model, education serves as a consumer and producer of knowledge.

The science component represents the process of scientific inquiry, discovery, and knowledge generation. It includes research methodologies, fundamental theories, applied practices, and technology development. Science drives innovation and technological advancement within the educational process as well as the development of AI-based tools (Xu et al., 2023). Within the triangle model, science serves as a source of AI innovations in education and facilitates the implementation of AI-enhanced learning environments.

The AI component deals with the set of technologies, algorithms, and systems that simulate human intelligence and automate cognitive tasks. AI technologies have transformative potential in education, offering personalized learning experiences, adaptive tutoring systems, intelligent educational content, and data-driven decision-making support (Kamalov et al., 2023). Also, AI enhances scientific research maximizing the data analysis and modeling complex phenomena (Khlaif et al., 2023). According to

Keshav Kumar & Narasimham, (2023), the use of innovative technologies, AI and online learning platforms in particular, improves academic achievements significantly. In the triangle model, AI serves as a catalyst for innovation and transformation in both education and science.

Understanding the interactions between education, science, and AI is impossible without exploring the challenges and the development of ethical guidelines to responsible use of AI in education and science.

Exploring the challenges to education, science and the use of AI: ethics, academic virtue, communication

The implementation of AI in education and science presents a number of challenges that need to be addressed to ensure its effective use. One of the primary challenges is ensuring equal access to AI technologies in education and science regardless of their background, socio-economic status, geographic location, or other demographic factors (Goldenthal et al., 2021). Disparities in access to technology can widen the digital divide between the developed and developing communities (Qin et al., 2023). Some findings state that AI applications in education and science often rely on collecting and analyzing large amounts of data resulted in the concerns about data privacy and security (Villegas-Ch & García-Ortiz, 2023).

Belenguer (2022) states that AI and bias refers to the phenomenon where AI-based systems display the biases present in the data leading to unfair or discriminatory outcomes. Bias in AI originates from various sources, including algorithmic design choices and societal biases embedded in the data collection process (Nazer et al., 2023). Also, integrating AI technologies in education and science requires strong digital competencies to effectively use and critically evaluate AI-driven tools (Ng et al., 2023).

At the same time, a great attention is paid towards ethical and responsible use of AI in education and science (Ryan & Stahl, 2021). The use of AI in education and science leads to complex ethical issues that must be addressed. Ethical considerations such as fairness, transparency, accountability, and social justice (Memarian & Doleck, 2023) intersect with the impact of AI-derived technologies on educational practices, scientific research, and societal norms. The findings show that AI-based systems should be designed on the basis of human-centered principles, taking into account the users' needs, preferences, and capabilities. Human-centered approach prioritizes usability, accessibility, and inclusivity (Mhlanga, 2022; Taylor et al., 2023).

Academic virtue refers to a set of values, attitudes, and behaviors that are fundamental to the pursuit of knowledge, intellectual growth, and scholarly excellence within the educational institutions (Berg, 2020). It involves such values as honesty, integrity, curiosity, and innovation (Halbig, 2020). Academic virtue deals with transparency about the capabilities and limitations of AI-based systems, honest representation of research findings, and integrity in data collection, analysis, and interpretation (Hagendorff, 2022). Also, academic virtue accurate testing and verification of AI algorithms, as well as careful consideration of potential biases, limitations, and ethical implications (Hosseini et al., 2023). Promoting innovations, AI technologies offer opportunities for innovative approaches to research or teaching practices. The implementation of AI tools on the principles of academic virtue benefits the academic achievements significantly and contribute to scientific progress.

Additionally, communication in education and science has undergone significant changes due to the integration of AI technologies. AI-powered educational platforms use the communication data

extensively and personalize learning experiences (Kamalov et al., 2023; Win, 2023). Direct communication is affected by language learning applications and translation support tools that facilitate collaboration and overcome language barriers (Huertas-Abril & Palacios-Hidalgo, 2023). Besides, it was found that machine learning algorithms enable researchers to analyze large datasets, identify patterns, and derive meaningful conclusions from complex data (Atkinson, 2023). Visualization techniques, including data visualization and graphical representation, enhance communication of research results fostering understanding and engagement. At the same time, AI-based technologies raise ethical and social considerations related to communication in education and science (Hosseini et al., 2023). Obviously, it is important to ensure transparent, inclusive, and ethically responsible communication practices for increasing teaching and learning outcomes, advance scientific discovery, and establish effective communication models within the educational and scientific environments.

To provide accurate interpretations of the future through interactions between education, science, and AI and to outline their potential challenges when digital transformations occur, it is necessary to conduct empirical study and analyze the research problem on the basis of quantitative analysis.

Research Methodology

General Background

The research devoted to philosophical interpretation of interactions between education, science, and AI, requires the implementation of comprehensive and interdisciplinary methodology to analyse the problem and reveal all of its aspects. While answering the research questions the mixed-methods approach was applied. For the study both quantitative and qualitative data was collected through descriptive and empirical survey. Descriptive survey is an exploratory method and aimed at presenting the current state of the problem within a specific group. Also, it requires an extensive literature review to reveal basic concepts and outline theoretical frameworks of interactions between education, science, and AI. The empirical survey included computer-assisted web interview to assess the most relevant concepts according to the participants responses and to analyze their understandings of main philosophical descriptors of the future through education, science, technological advances, and digitalization.

Sample / Participants / Group

The study involved 42 participants that were selected randomly. This enabled to minimize bias and ensure that the sample is representative of the larger population, increasing the generalizability of the findings. The selection criteria included (1) educational background in the field of philosophy; (2) previous experience in conducting research in the field of philosophy; (3) representation of diverse perspectives, theories, or approaches within the philosophy; (4) active engagement in educational practice, including classroom teaching, curriculum development, or teacher training; (5) wiliness to participate. The researchers ensured that participants understand the purpose of the study, the level of their involvement, and any potential risks or benefits associated with participation in the study. All the participants were informed on the Ethical Guidelines and the data was collected on the principles of informed consent, confidentiality, and voluntary involvement.

Instrument and Procedures

To collect the date the computer-assisted web interview was used. While studying the interactions between education, science, and AI, the method has a number of the advantages combining the traditional survey and the efficiency of online technology. Firstly, the survey questionnaire was designed

according to the research objectives. The questionnaire included closed-ended questions, multiple-choice questions, and rating scales. The interview was conducted through SurveyMonkey and Google Forms. The participants were selected through email invitations and institutional websites according to the criteria established. As the participants responded to the survey questions, their responses were automatically recorded and stored in the online survey database. The computer-assisted web interview revealed the potential limitations such as sample representativeness, response bias, and technological barriers.

Data Analysis

To analyse the data statistical software NVivo was applied. It allowed to import various types of qualitative data, including text documents, audio recordings, videos, and images, and organize it accurately. The coding queries was introduced to quantify and summarize the data, explore patterns and trends across the research problem. Also, NVivo facilitated the thematic analysis to identify the interactions between education, science, and AI on the basis of respondents' answers. The thematic analysis included data familiarization, initial coding of data segments, identifying thematic lusters such as education, science, AI application, AI challenges, ethical use of AI, academic virtue, and communication in the sphere of education and science. Then the identified themes were interpreted in relation to the research questions and objectives. To present the data, the charts, graphs, and table based on the findings were used. Further the survey findings were implemented for elaboration of recommendations of effective use of AI in education and science in the context of the existing challenges.

Research Results

What are general approaches to philosophical interpretation of relations between education, science, and AI?

The findings show that the participants have different anticipations towards theoretical frameworks of interactions between education, science, and AI. Most of them (52 %), consider that cognitive theory is fundamental since it oriented towards minimizing of cognitive efforts of students, help them adapt the educational material, therefore, increase learning outcomes. 31 % of the participants agree that constructivist theory is necessary to implement AI technologies within the educational and scientific environments because it facilitates the construction of new knowledge more accurately. And 17 % of the participants state that socio-cultural is more important, especially when AI tools are applied within the diverse environment and extraction of new knowledge requires considering of cultural approaches. Figure 3 shows the participants' anticipation of theoretical frameworks of interactions between education, science, and AI.

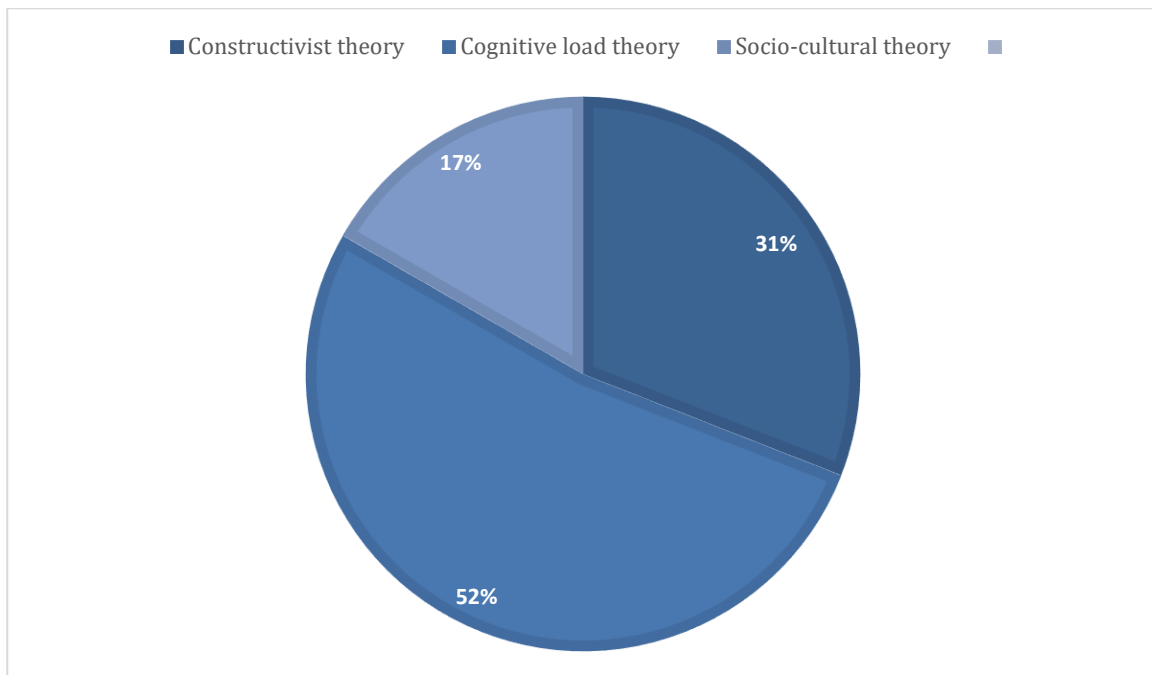


Figure 3. The anticipation of theoretical frameworks of interactions between education, science, and AI

Source: author's own development

To understand the theoretical frameworks deeply, the participants described their qualities regarding education, science and the use of AI. According to constructivist theory, most participants associate it with learning experiences tailored to students' interest, prior knowledge and individual needs (25,1 %); new knowledge constructed through exploration and experimentation (18,5 %); and engagement of students in discussions about ethical implications of AI (16,8%). Therefore, the principles of constructivist theory facilitate creation of active learning environment, implementation of student-centered approach to teaching. At the same time, AI technologies can facilitate collaborative learning experiences by enabling real-time communication, group collaboration, and peer feedback in virtual learning environments.

The analysis of cognitive load theory demonstrates that it requires selection of teaching technologies according to diverse learning styles and preferences (17,1 %); presentation of educational information using multiple modalities (16,7 %); and its organization into smaller portions (15,3 %). All the qualities relate to minimizing the cognitive load since human cognitive system has a limited capacity for processing information. The cognitive load theory emphasizes the importance of managing cognitive load to optimize learning outcomes within the educational process and to enhance the use of AI technologies.

In most responses the socio-cultural theory is associated with learning is situated within authentic contexts and social practices (22,1 %); involvement of individuals in communication to collaborate and construct new knowledge within social contexts (17,5 %); central role of language in mediating learning (16,3 %); and using AI systems to reflect cultural biases, stereotypes, and representations embedded within training data, algorithms, and decision-making processes (14,1 %). Thus, according to socio-cultural theory, education and research are social activities that occur through interaction with others, and AI tools are implemented to facilitate social interaction and collaborative learning by providing

virtual spaces for peer collaboration, group discussions, and mutual problem-solving activities. Table 1 describes theoretical frameworks of interactions between education, science, and AI according to the participants' responses.

Table 1. Description of theoretical frameworks of interactions between education, science, and AI

Theory	Description	Number of participants (%)
Constructivist theory	New knowledge is constructed through exploration and experimentation	18,5
	Learning experiences are tailored to students' interests, prior knowledge, and individual needs	25,1
	Learning activities are situated in real-world contexts or authentic problem-solving situations	12,8
	Assessment methods focus on understanding students' thinking processes, conceptual development, and problem-solving strategies	16,2
	Students are engaged in discussions about ethical implications and societal impacts of AI technologies	16,8
	AI development is based on users' feedback	10,6
	Totally	100
Cognitive load theory	Complex information is organized into smaller portions	15,3
	The information is presented using multiple modalities (visual or auditory)	16,7
	New information is integrated with the existing knowledge	12,2
	Educational materials are designed to optimize cognitive load	14,5
	Teaching technologies are selected according to diverse learning styles and preferences	17,1
	Balancing cognitive effort is important	10,3
	Collaborative learning environment should be established.	13,9
Totally	100	
Socio-cultural theory	Individuals are involved in communication to collaborate and construct new knowledge within social contexts	17,5
	Learning is situated within authentic contexts and social practices	22,1
	Learning is influenced by sociocultural factors such as social norms, values, beliefs, and historical contexts	11,6
	Language plays a central role in mediating learning	16,3
	Knowledge is co-constructed through social interactions, collaborative dialogue, and negotiation	12,2
	AI systems may reflect cultural biases, stereotypes, and representations embedded within training data, algorithms, and decision-making processes	14,1
	AI technologies empower communities by providing tools for collective problem-solving and knowledge sharing	6,2
Totally	100	

Source: author's own development

What are potential challenges threatening innovative developments and evolution of education, science, and AI?

The findings show that a number of challenges threatening innovative developments and evolution of education, science, and the use of AI within the educational and scientific environments. Most of the survey participants (58,9 %) stated that ethical concerns require careful consideration of ethical principles and values while implementing AI-derived technologies in education and science. 56,7 % of respondents admitted that data privacy and security, including unauthorized access to personal information, pose significant challenges to the responsible use of AI and digital technologies in education and scientific research. Also, 34,5 % of individuals worry about proliferation of misinformation, fake data, and pseudoscience and think these things undermine scientific literacy and critical thinking skills, posing challenges to the dissemination of accurate information and evidence-based knowledge.

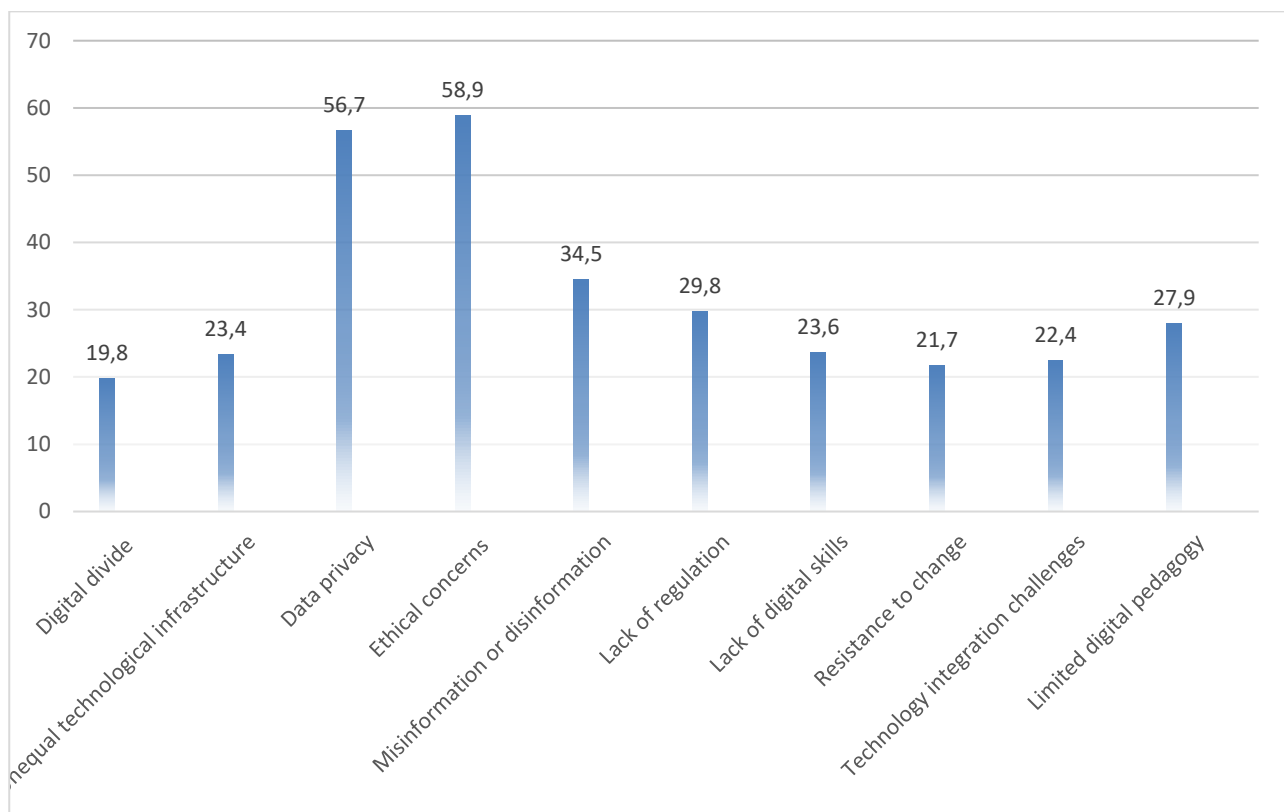


Figure 4. *Challenges threatening innovative developments and evolution of education, science, and AI*

Source: author's own development

Other challenges include digital divide (19,8 %), unequal digital infrastructure (23,4 %), lack of legal regulation on using AI in education and science research (29,8 %), lack of digital skills among the students and the instructors (23,6 %), resistance to change (21,7 %), technology integration challenges (22,4 %), limited digital pedagogy (27,9 %). Since the most of respondents showed that ethical concerns are important when AI technologies are integrated in education in science, it is necessary to investigate their development and use in details.

How do problems of ethics and academic virtue affect digital transformations in education and science?

Ethics play a crucial role in shaping digital transformations in education and science. According to the respondents the ethical issues affecting digital transformations in education and science include ethical decision making (23,9 %), scientific integrity (31,2 %), learner's autonomy (12,3 %), inclusion (28,5), equal access (28,5 %), fairness (34,5 %), transparency (19,7 %), algorithmic bias (24,3 %), and data privacy (63,4 %). Figure 5 shows the problems of ethics affecting digital transformations in education and science.

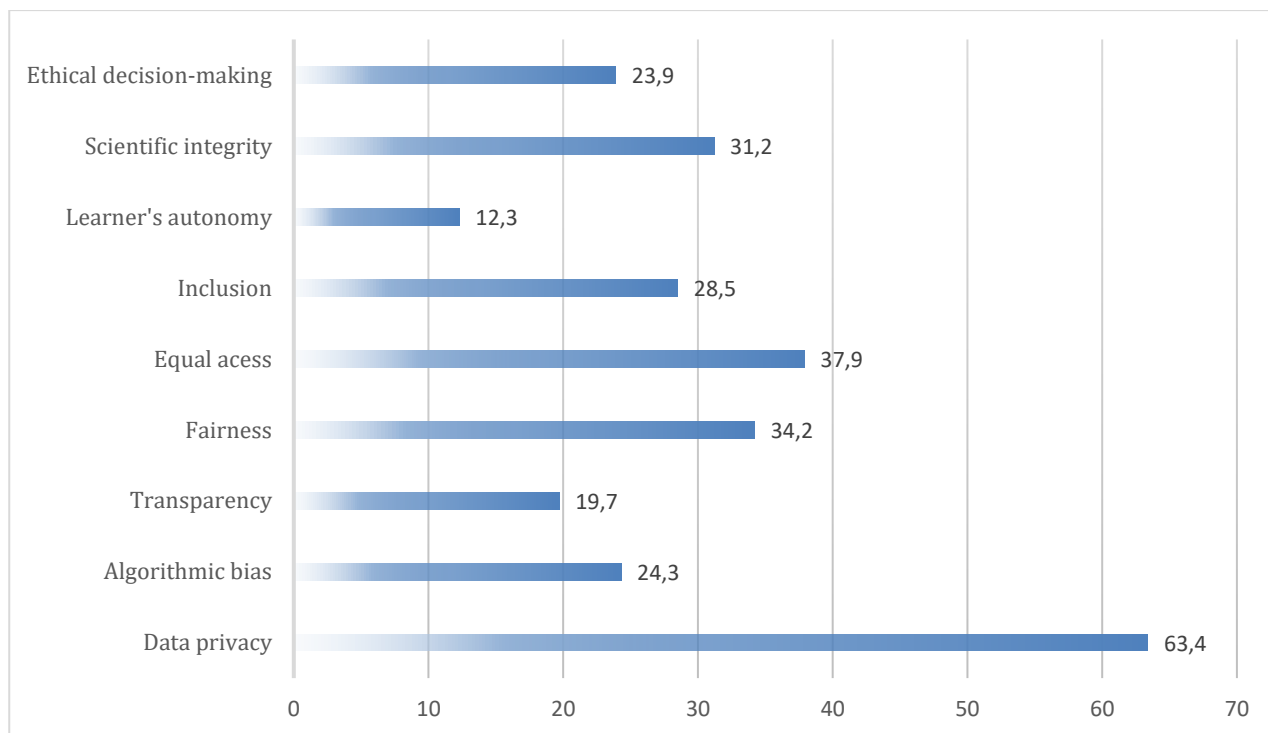


Figure 5. Problems of ethics affecting digital transformations in education and science

Source: author's own development

Firstly, ethical considerations are related to data privacy, confidentiality, and security because they impact the data collection, storage, and use of personal information on digital educational platforms. To ensure data protection means to organize the educational process effectively and to conduct the scientific research according to the Ethical Guidelines. Also, ethical considerations are associated with accessibility and elimination of digital divide. Promoting equal access to the educational materials, platforms, or AI tools will benefit both students and instructors, and make the educational process positive. Therefore, ethics serves as a guiding framework to promote digital transformations in education and science. Also, ethics contributes to the advancement of knowledge and societal development on the principles of responsibility, honesty, and respect.

The category of academic virtue is closely connected to the ethical and responsible use of AI in education and science. The findings show that paradigm of academic virtue include seven conceptual domains: ethical of knowledge, collaboration, responsibility, honesty, accuracy, adaptability, openness. it was revealed the ethical use of knowledge concerns avoiding plagiarism and ethical use of digital tools. Collaboration is related to international and academic interactions. Responsibility is often associated

with accurate decision-making and self-control as responsibility for own decision while conducting research. Honesty domain includes professional honesty and honest use of Internet. At the same time, accuracy deals with carrying out the testing, verification of data, and its further dissemination. Adaptability is related to resilience of the students and instructors, and openness includes respect to the academic community, openness in presenting own results, etc. Figure 6 presents the paradigm of academic virtue in education and science in the context of using AI.

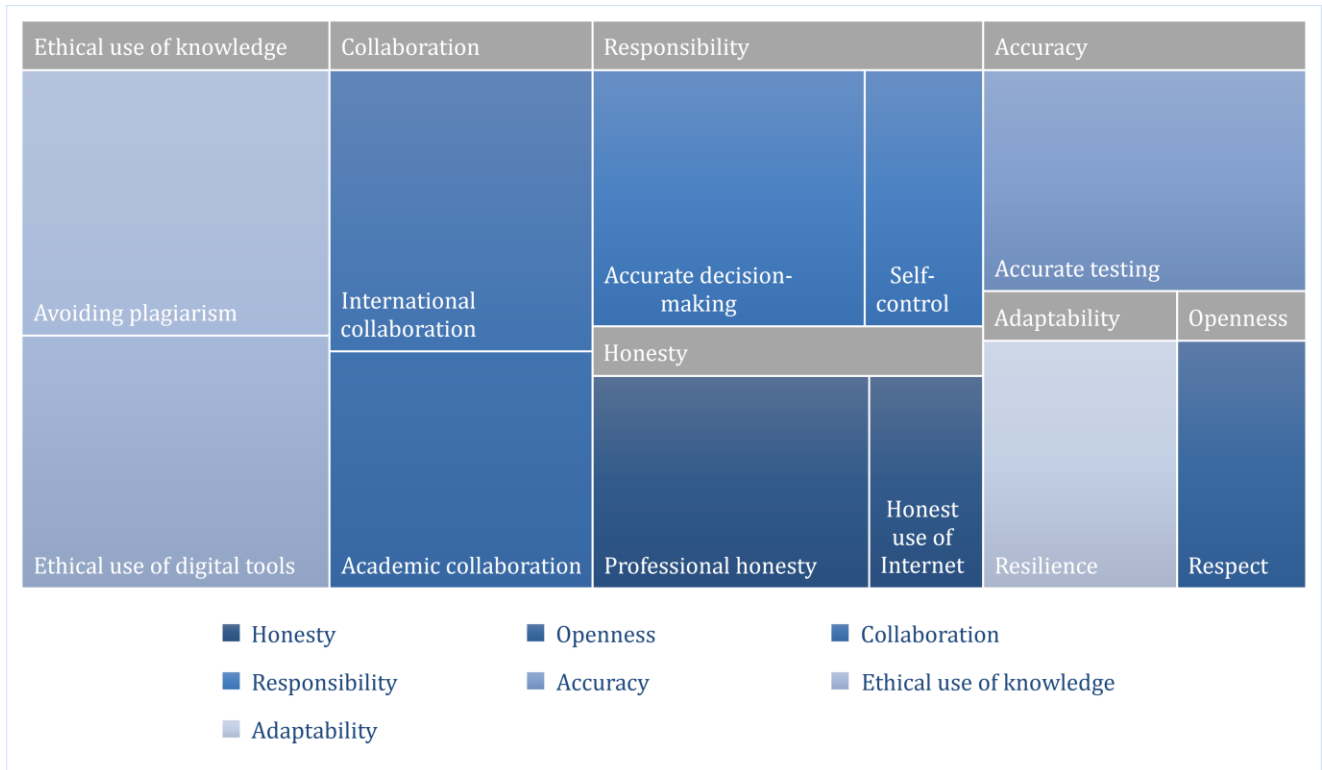


Figure 6. Paradigm of academic virtue in education and science in the context of using AI

Source: author's own development

How does digitalization, AI in particular, change communication in the sphere of education and science?

AI changes communication in the sphere of education and science as well. The findings show that digitalization brings automated content creation (67,8 %), language processing opportunities (53,2 %), real-time translation (46,7 %), and enhanced accessibility through elimination of geographical barriers (46,5 %). Naturally, digital platforms and AI-driven technologies facilitate remote communication and collaboration, enabling educators, researchers, and students to connect regardless of geographical location. Moreover, AI-powered educational tools and virtual assistants offer real-time assistance and support to learners. It was found that AI technologies automate content creation processes, including text generation, data visualization, and multimedia production.

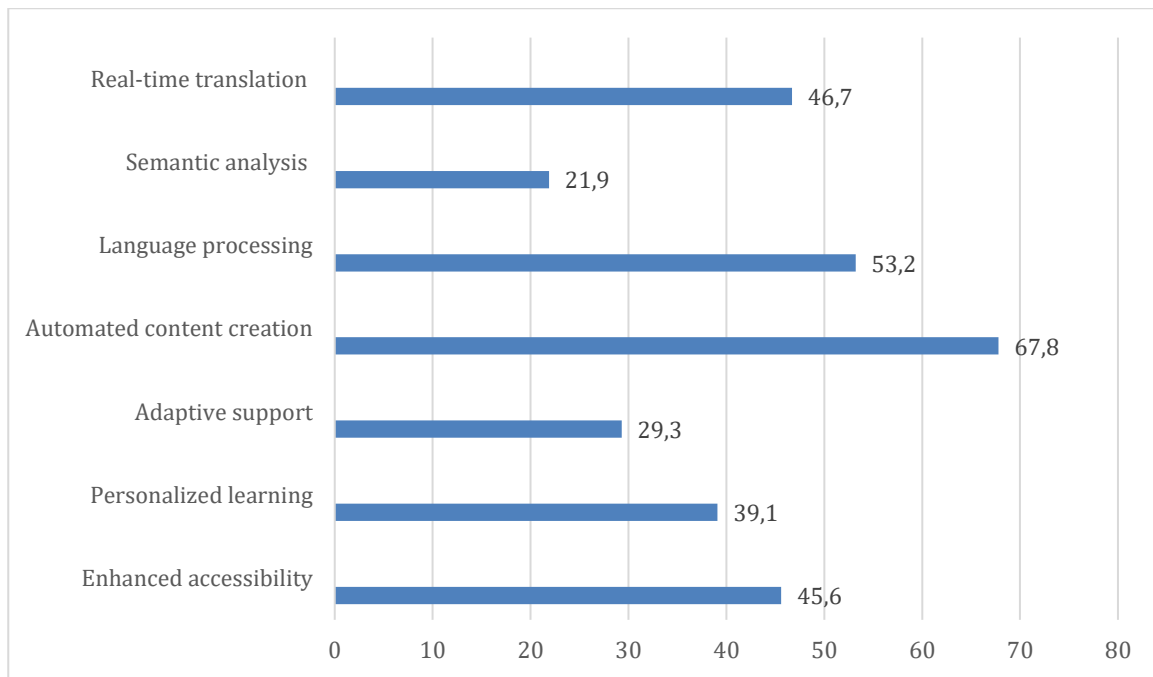


Figure 7. Changes in communication under impact of digitalization

Source: author's own development

Therefore, the analysis of theoretical frameworks of interactions between education, science and the use of AI, description of the challenges threatening innovative developments and evolution of education, science, and AI, including problems of ethics and academic virtues, and the changes in communications under the impact of digitalization requires elaboration of principles of effective implementation of AI in education and science that can be applicable in future.

Discussion

The research devoted to the philosophical interpretation of interactions between education, science, and AI showed that innovative technologies bring significant changes in educational and scientific environments and enhance the efficiency of all the essential processes. It was found that these interactions are explained from the point of view of constructivist (Grubaugh et al., 2023), cognitive load (Koć-Januchta et al., 2022), and socio-cultural (Niemi, 2021) theories. At the same time, according to the survey respondents, cognitive theory load is fundamental since it oriented towards minimizing of cognitive efforts of students, help them adapt the educational material, therefore, increase learning outcomes. Constructivist theory is responsible for implementation of AI technologies within the educational and scientific environments because it facilitates the construction of new knowledge more accurately. Since AI tools are used within the diverse environment, socio-cultural theory facilitates the building of algorithms to apply AI tools. The analysis of potential challenges threatening innovative developments and evolution of education, science, and AI proved that respondents face certain difficulties related to ethical concerns, data privacy and security, misinformation, digital divide, unequal digital infrastructure, lack of legal regulation on using AI in education and science research, lack of digital skills among the students and the instructors, resistance to change, technology integration challenges, limited digital pedagogy. Despite a number of challenges taking place within the educational

and scientific environments, the most of survey participants showed that ethics is an important factor when AI technologies are introduced.

The different aspects of ethical and responsible use of AI in education and science are presented in the works of Ryan & Stahl (2021), Memarian & Doleck (2023), and Mhlanga (2022). For example, Memarian & Doleck (2023) state that ethical considerations intersect with the impact of AI-derived technologies on educational practices, scientific research, and societal norms. And Taylor, O'Dell & Murphy (2023) pay attention towards incorporation of human-centered principles such as usability, accessibility, and inclusivity into the system of AI ethics. Considering the survey results, it is worth mentioning that AI ethics shares the principles of responsibility, honesty, and respect and, therefore, contributes to the advancement of knowledge and societal development. Academic virtue is closely connected to the ethical and responsible use of AI in education and science. Since it is related to ethical use of knowledge, responsibility, and accuracy, the findings demonstrated that the problems of ethics and academic virtue affect digital transformations in education and science, the practices aim to balance innovation and societal impact.

The research devoted to philosophical interpretation of interactions between education, science, and AI enabled to develop the principles of effective implementation of AI in education and science. Firstly, they include philosophical principles (Taylor et al., 2023; van de Poel, 2020). Also, educational (Chiu et al., 2023; Zhang & Aslan, 2021) and ethical dimensions (Berg, 2020) are differentiated. The philosophical principles oriented towards effective implementation of AI in education and science concern a range of perspectives that provide the ethical, epistemological, and social aspects of integrating AI technologies (Nyholm & R  ther, 2023; Orel et al., 2023). They are important for fostering responsible use of technology within the educational and scientific environments. Considering these principles, instructors and researchers can critically examine the ethical implications, philosophical assumptions, and social qualities of AI-driven practices, ensuring that AI technologies correspond with moral decision-making and promote such values as honesty, responsibility, and fairness. Also, philosophy helps understand complex ethical issues, challenge biases and inequalities typical for AI-based systems. Moreover, the philosophical principles explain fundamental concepts used to foster the transformative approaches that prioritize diversity, equity, and justice in the context of using AI. It was found that implementation of AI in education and science at the philosophical dimension includes a number of principles. First of all, it is knowledge-based principle (Lea, 2020) and principle of managing cognitive load (Wu, 2023). Others include: principle of ethical decision-making (Hosseini et al., 2023; Memarian & Doleck, 2023) and student-centered principle (Win, 2023).

According to the respondents' responses, the knowledge-based principle means that AI tools focus on specific domains or problem areas and use various mechanisms to derive new knowledge. Also, the survey participants admitted the importance of facilitation of sustainable collaboration between humans and machines. Considering the principle of managing cognitive load, the study showed that it is associated with AI adaptation to student's cognitive capabilities, task complexity, and current workload; personalization of student's experience by tailoring the content to individual preferences, learning styles, and contextual factors. Moreover, it was found that AI tools are able to automate routine tasks and provide assistance in performing complex tasks. The principle of ethical decision-making is focused on transparent and fair implementation of AI tools, and protection of personal data. Additionally, the student-centered principle is oriented towards tailoring of learning experiences to the individual needs, preferences, and abilities of each student. In this context, students are encouraged to make autonomous decisions and AI-enabled educational platforms offer flexible learning pathways. The student-centered principle builds a theoretical framework for the creation the inclusive educational environment through AI tools.

The educational principles of AI implementation deal with the application of pedagogical interventions like active learning, differentiation of learning, evidence-based practice, interdisciplinary integration, and lifelong improvement (Kamalov et al., 2023; Nyholm & R  ther, 2023; Rasa & Laherto, 2022). Since these principles are fundamental guidelines to design, implement, and evaluate the educational process, they are oriented towards creation of effective educational environment. In the context of using AI the educational principles emphasize the importance of correspondence of innovative technologies with educational objectives, tailoring learning experiences to students' individual needs. The respondents testify that the educational dimension includes five principles: principle of lifelong learning, differentiated principle, principle of active learning, evidence-based principle, and principle of interdisciplinary integration. Lifelong learning is usually connected to the possibility of AI-powered learning platforms to personalize learning experiences and provide continuous assessment. Besides AI should be responsible of developing not only specific knowledge but also essential competencies that are relevant across different areas. The survey participants agreed with the theoretical findings that AI-driven technologies create individual learning paths for each student based on their strengths, weaknesses, interests, and learning styles, and therefore, these tools are able to adapt instructional content and provide personalized feedback and assessment. The introduction of active learning principle means that AI-powered platforms facilitate collaborative problem-solving activities and offers various learning activities such as simulations or gamification that enhance students' engagement. According to respondents, the evidence-based practice enables AI systems to automate analysis processes and process vast amounts of data to make a decision. Moreover, to be evident, AI algorithms should be oriented towards the generation of scientific concepts and valuable information. Further, interdisciplinary integration is provided through diverse expertise, data from multiple sources, different research methods and techniques.

Ethical considerations are fundamental for effective AI implementation, ensuring that AI technologies are developed and used in a responsible and moral manner (Memarian & Doleck, 2023). In education, AI systems prioritize data privacy and data security is essential to maintain trust and compliance with privacy regulations. In science, ethical considerations include promoting academic virtue and establishment of positive communication (Hosseini et al., 2023). Moreover, ethical AI implementation in both education and science requires ongoing reflection, evaluation, and improvement of AI technologies to make them transparent, fair, human-centered, and proactive. The answers of survey participants correspond with theoretical findings completely and they denote that the ethical dimension include data privacy, academic virtue, and positive communication in the sphere of education and science. Data privacy is characterized by the following: AI systems provide only restricted entry; AI systems collect and process the minimum amount of sensitive data; individuals should provide informed consent before their data is collected, processed, or used. At the same time, academic virtue, being a set of values, attitudes, and behaviors that are fundamental to the pursuit of knowledge, intellectual growth, and scholarly excellence, suggests that digital technologies should be used responsibly and testing should be conducted accurately. Also, following academic virtues the participants of the educational process should avoid plagiarism and self-plagiarism, respect intellectual property, and develop the educational materials using honest and objective information.

Thus, the implementation of AI requires the development of specific measures to build positive educational and scientific environments through philosophical, education, and ethical dimensions. The analysis of philosophical interpretation of interactions between education, science, and AI helped to draw the requirements to effective implementation of AI and counteracting the existing challenges when integrating AI-based technologies. At the same time, if implemented positively, AI-based technologies are oriented towards creation of more targeted applications and, consequently, leads to the substantial

increases in the future uses of AI technologies strengthening the interactions between education, science, and AI.

Conclusions and Implications

The future is closely connected with technological advancement and digitalization in particular. Currently, AI is gradually changing the future landscape of education and science. Also, it transforms the way knowledge is generated and shared. Consequently, there is often a logical relationship between education, science and AI, shaping the idea of “present future”. In the “present future”, AI technology is already a significant attribute of societal development, and it presents the opportunities for innovation and transformation in various spheres as well. The philosophical perspective of AI involves a broad range of debates concerning the nature of intelligence, its capabilities, societal impact, and moral responsibility. It was found that there are three philosophical approaches to interpretation of the connections between technology and society: (1) technology as an autonomous force that determines society; (2) technology is a human construct means; and (3) the development and impact of technology are fundamentally influenced by human intentions, values, and choices. Theoretically, the interactions between education, science, and AI are understood through constructivist, cognitive load, and socio-cultural theories. Constructivism provides a framework by emphasizing active learning, knowledge construction, and the role of social communication in forming individual understanding. In the context of AI, the constructivist approaches facilitate personalized and interactive learning tailored to individual students’ needs. The cognitive load theory helps examine the mental efforts required for learning and problem-solving tasks. The socio-cultural theory emphasizes the role of social interaction and cultural context in individual cognition and learning. These theories provide the basis for building the triangle model to reveal the dynamic interactions and interdependencies between education, science, and AI.

The implementation of AI in education and science presents a number of challenges that are to ensure its effective use. The special attention was paid towards ethical and responsible use of AI in education and science. Ethical considerations such as fairness, transparency, accountability, and social justice intersect with the impact of AI-derived technologies on educational practices, scientific research, and societal norms. Academic virtue refers to a set of values, attitudes, and behaviors that are fundamental to the pursuit of knowledge, intellectual growth, and scholarly excellence within the educational institutions. It was found that academic virtue concerns the transparency about the capabilities and limitations of AI-based systems, honest representation of research findings, integrity in data collection, analysis, and interpretation. Additionally, communication in education and science has undergone the significant changes due to the integration of AI technologies. AI-powered educational platforms use the communication data extensively and personalize learning experiences. And it was found that direct communication is affected by language learning applications and translation support tools that facilitate collaboration and overcome language barriers.

The results will be applicable for the advancement of knowledge in the philosophical fields oriented towards responsive use of AI-based technologies in education and science. The findings can be used for further elaboration of the ethical guidelines of using AI tools through educational interventions and while conducting scientific research. Since the future of AI holds tremendous promise and potential for transforming various aspects of society, the findings will be useful for philosophers, futurists, sociologists, educators, economists, and computer science in particular.

Suggestions for Future Research

Being a boosting technology, AI may have the specific long-term effects that may vary depending on the its use, purposes, and sphere involved. Obviously, AI implementation has the potential to transform industries and labor markets. Also, AI systems affect innovations spread, enhancement of productivity, improve education and professional skills development. In future the use of AI-driven technologies will only increase. But a small amount of scientific works are devoted to long-term impact of AI because it requires a comprehensive and interdisciplinary approach to address the complexity and uncertainty of future outcomes. Obviously, further investigations must concern the long-term impact of AI technologies on learning outcomes, academic achievements, and professional skills development across different educational levels. The researchers should focus on identifying effective AI-driven interventions and instructional strategies that enhance student's engagement and implement responsible use of AI tools. Since many philosophical questions are complex, interdisciplinary integration allows philosophers to draw objective and accurate conclusions as well as apply mixed methodologies for comprehensive analysis of the research problems. Integrating perspectives from other disciplines enriches philosophical inquiry by providing alternative viewpoints, methods, and conceptual frameworks. Moreover, interdisciplinary integration in philosophy enhances its practical relevance. Therefore, in future the special attention must be paid towards philosophical interpretation of improvements of interdisciplinary integration between computer science, education, psychology, sociology, and other relevant disciplines to address complex challenges and opportunities at the intersection of AI, education, and science.

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Conflict of Interest

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References

- Abonamah, A. A., Tariq, M. U., & Shilbayeh, S. (2021). On the Commoditization of Artificial Intelligence. *Frontiers in psychology, 12*, 696346. <https://doi.org/10.3389/fpsyg.2021.696346>
- Alenizi, F. A., Abbasi, S., Mohammed, A. H., & Rahmani, A. M. (2023). The artificial intelligence technologies in Industry 4.0: A taxonomy, approaches, and future directions. *Computers & Industrial Engineering, 185*, 109662. <https://doi.org/10.1016/j.cie.2023.109662>
- Atkinson, C. F. (2023). Cheap, Quick, and Rigorous: Artificial Intelligence and the Systematic Literature Review. *Social Science Computer Review*. <https://doi.org/10.1177/08944393231196281>

- Belenguer, L. (2022). AI bias: exploring discriminatory algorithmic decision-making models and the application of possible machine-centric solutions adapted from the pharmaceutical industry. *AI and ethics*, 2(4), 771–787. <https://doi.org/10.1007/s43681-022-00138-8>
- Berg, H. (2020). Virtue Ethics and Integration in Evidence-Based Practice in Psychology. *Frontiers in psychology*, 11, 258. <https://doi.org/10.3389/fpsyg.2020.00258>
- Bigliardi, B., Ferraro, G., Filippelli, S., & Galati, F. (2021). The past, present and future of open innovation. *European Journal of Innovation Management*, 24(4), 1130-1161. <https://doi.org/10.1108/EJIM-10-2019-0296>
- Butz, M. V. (2021). Towards Strong AI. *KI – Künstliche Intelligenz*, 35, 91–101. <https://doi.org/10.1007/s13218-021-00705-x>
- Chiu, T. K. F., Xia, Q., Zhou, X., Chai, C. S., & Cheng, M. (2023). Systematic literature review on opportunities, challenges, and future research recommendations of artificial intelligence in education. *Computers and Education: Artificial Intelligence*, 4, 100118. <https://doi.org/10.1016/j.caeai.2022.100118>
- Danaher, J. (2021). Axiological futurism: The systematic study of the future of values. *Futures*, 132, 102780. <https://doi.org/10.1016/j.futures.2021.102780>
- Davenport, T., & Kalakota, R. (2019). The potential for artificial intelligence in healthcare. *Future healthcare journal*, 6(2), 94–98. <https://doi.org/10.7861/futurehosp.6-2-94>
- Dorotic, M., Stagno, E., & Warlop, L. (2023). AI on the street: Context-dependent responses to artificial intelligence. *International Journal of Research in Marketing*. <https://doi.org/10.1016/j.ijresmar.2023.08.010>
- Dufva, T., & Dufva, M. (2019). Grasping the future of the digital society. *Futures*, 107, 17-28. <https://doi.org/10.1016/j.futures.2018.11.001>
- Dwivedi, Y. K., Sharma, A., Rana, N. P., Giannakis, M., Goel, P., & Dutot, V. (2023). Evolution of artificial intelligence research in Technological Forecasting and Social Change: Research topics, trends, and future directions. *Technological Forecasting and Social Change*, 192, 122579. <https://doi.org/10.1016/j.techfore.2023.122579>
- Feher, K., & Katona, A. I. (2021). Fifteen shadows of socio-cultural AI: A systematic review and future perspectives. *Futures*, 132, 102817. <https://doi.org/10.1016/j.futures.2021.102817>
- Fjelland, R. (2020). Why general artificial intelligence will not be realized. *Humanities and social sciences communications*, 7, 10. <https://doi.org/10.1057/s41599-020-0494-4>
- Geels, F. W., Kern, F., & Clark, W. C. (2023). Sustainability transitions in consumption-production systems. *Proceedings of the National Academy of Sciences*, 120, 47. <https://doi.org/10.1073/pnas.2310070120>
- Goldenthal, E., Park, J., Liu, S. X., Mieczkowski, H., & Hancock, J. T. (2021). Not All AI are Equal: Exploring the Accessibility of AI-Mediated Communication Technology. *Computers in Human Behavior*, 125, 106975. <https://doi.org/10.1016/j.chb.2021.106975>

- Grubaugh, S., Levitt, G., & Deever, D. (2023). Harnessing AI to Power Constructivist Learning: An Evolution in Educational Methodologies. *EIKI Journal of Effective Teaching Methods*, 1(3). <https://doi.org/10.59652/jetm.v1i3.43>
- Hagendorff, T. (2022). A Virtue-Based Framework to Support Putting AI Ethics into Practice. *Philosophy & Technology*, 35, 55. <https://doi.org/10.1007/s13347-022-00553-z>
- Halbig, C. (2020). Virtue vs. virtue ethics. *Zeitschrift für Ethik und Moralphilosophie*, 3, 301–313. <https://doi.org/10.1007/s42048-020-00078-0>
- Hallström, J. (2022). Embodying the past, designing the future: technological determinism reconsidered in technology education. *International Journal of Technology and Design Education*, 32, 17–31. <https://doi.org/10.1007/s10798-020-09600-2>
- Holzinger, A., Saranti, A., Angerschmid, A., Finzel, B., Schmid, U., & Mueller, H. (2023). Toward human-level concept learning: Pattern benchmarking for AI algorithms. *Patterns*, 4(8), 100788. <https://doi.org/10.1016/j.patter.2023.100788>
- Hosseini, M., Resnik, D. B., & Holmes, K. (2023). The ethics of disclosing the use of artificial intelligence tools in writing scholarly manuscripts. *Research Ethics*, 19(4), 449-465. <https://doi.org/10.1177/17470161231180449>
- Huang, L., & Peissl, W. (2023). Artificial Intelligence – A New Knowledge and Decision-Making Paradigm? In: Hennen, L., Hahn, J., Ladikas, M., Lindner, R., Peissl, W., van Est, R. (eds) *Technology Assessment in a Globalized World*. Springer, Cham. https://doi.org/10.1007/978-3-031-10617-0_9
- Huertas-Abril, C. A., & Palacios-Hidalgo, F. J. (2023). New Possibilities of Artificial Intelligence-Assisted Language Learning (AIALL): Comparing Visions from the East and the West. *Education Sciences*, 13(12), 1234. <https://doi.org/10.3390/educsci13121234>
- Jumani, A., Laghari, A., Narwani, K., & David, S. (2021) Examining the Present and Future Integrated Role of Artificial Intelligence in the Business: A Survey Study on Corporate Sector. *Journal of Computer and Communications*, 9, 80-90. <https://doi.org/10.4236/jcc.2021.91008>
- Kamalov, F., Santandreu Calonge, D., & Gurrib, I. (2023). New Era of Artificial Intelligence in Education: Towards a Sustainable Multifaceted Revolution. *Sustainability*, 15(16), 12451. <https://doi.org/10.3390/su151612451>
- Kelz, R. (2019). Thinking about future/democracy: towards a political theory of futurity. *Sustainability Science*, 14, 905–913. <https://doi.org/10.1007/s11625-019-00697-6>
- Keshav Kumar, K. & Narasimham, N. V. S. L. (2023). The empirical analysis in determining the critical determinants of using technology in utilising online learning platforms for improving academic achievements using Anova analysis. *EIKI Journal of Effective Teaching Methods*, 1(2). <https://doi.org/10.59652/jetm.v1i2.10>
- Khlaif, Z. N., Mousa, A., Hattab, M. K., Itmazi, J., Hassan, A. A., Sanmugam, M., & Ayyoub, A. (2023). The Potential and Concerns of Using AI in Scientific Research: ChatGPT Performance Evaluation. *JMIR Medical Education*, 9, e47049. <https://doi.org/10.2196/47049>
- Kim, S. W., & Lee, Y. (2023). Investigation into the Influence of Socio-Cultural Factors on Attitudes toward Artificial Intelligence. *Education and Information Technologies*. <https://doi.org/10.1007/s10639-023-12172-y>

- Koć-Januchta, M. M., Schönborn, K. J., Roehrig, C., Chaudhri, V. K., Tibell, L. A. E., & Heller, H. C. (2022). "Connecting concepts helps put main ideas together": cognitive load and usability in learning biology with an AI-enriched textbook. *International Journal of Educational Technology in Higher Education*, 19, 11. <https://doi.org/10.1186/s41239-021-00317-3>
- Kraus, S., Jones, P., Kailer, N., Weinmann, A., Chaparro-Banegas, N., & Roig-Tierno, N. (2021). Digital Transformation: An Overview of the Current State of the Art of Research. *SAGE Open*, 11(3). <https://doi.org/10.1177/21582440211047576>
- Laitinen, A., & Sahlgren, O. (2021). AI Systems and Respect for Human Autonomy. *Frontiers in artificial intelligence*, 4, 705164. <https://doi.org/10.3389/frai.2021.705164>
- Lea, G. R. (2020). Constructivism and its risks in artificial intelligence. *Prometheus*, 36(4), 322-346. <https://doi.org/10.13169/prometheus.36.4.0322>
- Maidaniuk, I., Tsoi, T., Hoian, I., Doichyk, M., Patlaichuk, O., & Stupak, O. (2022). The Problem of Artificial Intelligence in Contemporary Philosophy. *BRAIN. Broad Research in Artificial Intelligence and Neuroscience*, 13(4), 436-449. <https://doi.org/10.18662/brain/13.4/397>
- Mannucci, S., Kwakkel, J. H., Morganti, M., & Ferrero, M. (2023). Exploring potential futures: Evaluating the influence of deep uncertainties in urban planning through scenario planning: A case study in Rome, Italy. *Futures*, 154, 103265. <https://doi.org/10.1016/j.futures.2023.103265>.
- Marino, D., Gil Lafuente, J., & Tebala, D. (2023). Innovations and development of artificial intelligence in Europe: some empirical evidences. *European Journal of Management and Business Economics*, 32(5), 620-636. <https://doi.org/10.1108/EJMBE-03-2023-0085>
- Memarian, B., & Doleck, T. (2023). Fairness, Accountability, Transparency, and Ethics (FATE) in Artificial Intelligence (AI) and higher education: A systematic review. *Computers and Education: Artificial Intelligence*, 5, 100152. <https://doi.org/10.1016/j.caeai.2023.100152>
- Mhlanga, D. (2022). Human-Centered Artificial Intelligence: The Superlative Approach to Achieve Sustainable Development Goals in the Fourth Industrial Revolution. *Sustainability*, 14(13), 7804. <https://doi.org/10.3390/su14137804>
- Mota-Valtierra, G., Rodríguez-Reséndiz, J., & Herrera-Ruiz, G. (2019). Constructivism-Based Methodology for Teaching Artificial Intelligence Topics Focused on Sustainable Development. *Sustainability*, 11(17), 4642. <https://doi.org/10.3390/su11174642>
- Müller, V. C. (2024). Philosophy of AI: A structured overview. In N. A. Smuha (ed.), *Cambridge handbook on the law, ethics and policy of Artificial Intelligence* (pp.1-25). Cambridge: Cambridge University Press. <https://philarchive.org/archive/MLLPOA>
- Murugesan, U., Subramanian, P., Srivastava, S., & Dwivedi, A. (2023). A study of Artificial Intelligence impacts on Human Resource Digitalization in Industry 4.0. *Decision Analytics Journal*, 7, 100249. <https://doi.org/10.1016/j.dajour.2023.100249>
- Naveed Uddin, M. (2019), Cognitive science and artificial intelligence: simulating the human mind and its complexity. *Cognitive Computation and Systems*, 1, 113-116. <https://doi.org/10.1049/ccs.2019.0022>

- Nazer, L. H., Zatarah, R., Waldrip, S., Ke, J. X. C., Moukheiber, M., Khanna, A. K., ... Mathur, P. (2023) Bias in artificial intelligence algorithms and recommendations for mitigation. *PLOS Digit Health*, 2(6), e0000278. <https://doi.org/10.1371/journal.pdig.0000278>
- Ng, D.T.K., Leung, J.K.L., Su, J., Wui Ng, R. C. W., & Chu, S. K. C. (2023). Teachers' AI digital competencies and twenty-first century skills in the post-pandemic world. *Educational technology research and development*, 71, 137–161. <https://doi.org/10.1007/s11423-023-10203-6>
- Niemi, H. (2021). AI in learning: Preparing grounds for future learning. *Journal of Pacific Rim Psychology*, 15. <https://doi.org/10.1177/18344909211038105>
- Nyholm, S., & Rüter, M. (2023). Meaning in Life in AI Ethics – Some Trends and Perspectives. *Philosophy & Technology*, 36, 20. <https://doi.org/10.1007/s13347-023-00620-z>
- Orel, Y., Khodykina, Y., & Chernova, T. (2023). Philosophy of the Future in the Context of Scientific and Pedagogical Workers Training and Artificial Intelligence Application. *Futurity Philosophy*, 2(1), 44–62. <https://doi.org/10.57125/FP.2023.03.30.04>
- Palanca-Castan, N., Sánchez Tajadura, B., & Cofré, R. (2021). Towards an interdisciplinary framework about intelligence. *Heliyon*, 7(2), e06268. <https://doi.org/10.1016/j.heliyon.2021.e06268>
- Placek, T. (2021). Past, present and future modally introduced. *Synthese*, 198, 3603–3624. <https://doi.org/10.1007/s11229-019-02302-w>
- Poli, R. (2019). Anticipation and the Philosophy of the Future. In: Poli, R. (eds) *Handbook of Anticipation*. Springer, Cham. https://doi.org/10.1007/978-3-319-91554-8_10
- Qin, Y., Xu, Z., Wang, X., & Skare, M. (2023). Artificial Intelligence and Economic Development: An Evolutionary Investigation and Systematic Review. *Journal of the Knowledge Economy*. <https://doi.org/10.1007/s13132-023-01183-2>
- Rasa, T., & Laherto, A. (2022). Young people's technological images of the future: implications for science and technology education. *European Journal of Futures Research*, 10, 4. <https://doi.org/10.1186/s40309-022-00190-x>
- Reis, J., & Melão, N. (2023). Digital transformation: A meta-review and guidelines for future research. *Heliyon*, 9(1), e12834. <https://doi.org/10.1016/j.heliyon.2023.e12834>
- Ryan, M., & Stahl, B. C. (2021). Artificial intelligence ethics guidelines for developers and users: clarifying their content and normative implications. *Journal of Information, Communication and Ethics in Society*, 19(1), 61-86. <https://doi.org/10.1108/JICES-12-2019-0138>
- Sheikh, H., Prins, C., Schrijvers, E. (2023). AI as a System Technology. In: *Mission AI. Research for Policy*. Springer, Cham. https://doi.org/10.1007/978-3-031-21448-6_4
- Taylor, R. R., O'Dell, B., & Murphy, J. W. (2023). Human-centric AI: philosophical and community-centric considerations. *AI & Society*. <https://doi.org/10.1007/s00146-023-01694-1>
- Todd, P. (2023). Critical Notice: The Modal Future: A Theory of Future-Directed Thought and Talk. *The Philosophical Quarterly*, pqad087. <https://doi.org/10.1093/pq/pqad087>

- van de Poel, I. (2020). Three philosophical perspectives on the relation between technology and society, and how they affect the current debate about artificial intelligence. *Human Affairs*, 30(4), 499-511. <https://doi.org/10.1515/humaff-2020-0042>
- Villegas-Ch, W., & García-Ortiz, J. (2023). Toward a Comprehensive Framework for Ensuring Security and Privacy in Artificial Intelligence. *Electronics*, 12(18), 3786. <https://doi.org/10.3390/electronics12183786>
- Virmajoki, V. (2022). Limits of conceivability in the study of the future. Lessons from philosophy of science. *Futures*, 142, 102993. <https://doi.org/10.1016/j.futures.2022.102993>
- Win, Y. W. (2023). The Challenges in Tertiary Level Study in Professional Communication Among University Graduates Through Online Education. *EIKI Journal of Effective Teaching Methods*, 1(3). <https://doi.org/10.59652/jetm.v1i3.44>
- Wu, Y. (2023). Integrating Generative AI in Education: How ChatGPT Brings Challenges for Future Learning and Teaching. *Journal of Advanced Research in Education*, 6-10. <https://doi.org/10.56397/JARE.2023.07.02>
- Xu, Y., Liu, X., Cao, X., Huang, C., Liu, E., Qian, S., ... Zhang, J. (2021). Artificial intelligence: A powerful paradigm for scientific research. *Innovation (Cambridge (Mass.))*, 2(4), 100179. <https://doi.org/10.1016/j.xinn.2021.100179>
- Yabe, Y., & Yamada, S. (2023). A pilot study of how the past, present, and future are represented in three-dimensional space. *Frontiers in psychology*, 14, 1071917. <https://doi.org/10.3389/fpsyg.2023.1071917>
- Zhang, K., & Aslan, A. B. (2021). AI technologies for education: Recent research & future directions. *Computers and Education: Artificial Intelligence*, 2, 100025. <https://doi.org/10.1016/j.caeai.2021.100025>
- Zhang, X., Shu, K., Rajkumar, S., & Sivakumar, V. (2021). Research on deep integration of application of artificial intelligence in environmental monitoring system and real economy. *Environmental Impact Assessment Review*, 86, 106499. <https://doi.org/10.1016/j.eiar.2020.106499>
- Zhao, J., Wu, M., Zhou, L., Wang, X., & Jia, J. (2022). Cognitive psychology-based artificial intelligence review. *Frontiers in neuroscience*, 16, 1024316. <https://doi.org/10.3389/fnins.2022.1024316>