The Role of Morality and Ethics in Utilizing Artificial Intelligence for Technology and Vocational Education in the Digital Era of Industry 4.0

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Abstract: The digital era in the industrial revolution 4.0 has brought significant changes in various aspects of life, including education. With the presence of increasingly sophisticated digital technology and the widespread use of Artificial Intelligence (AI), the education system is currently faced with new challenges to adapt to the times. However, the emergence of AI also has a negative impact on education, especially in the context of Technology and Vocational Education, namely increasing plagiarism, excessive dependence, lack of skill development, and weakening of culture, norms, and interactions between students and lecturers. This study aims to analyze the moral and ethical role in the use of AI in Technology and Vocational Education. The literature review research method is used in this study with a qualitative approach. Secondary data collection was carried out with the help of Google Scholar web technology and the bibliometric processing application VOSViewer. The data analysis technique applies the Miles & Hubberman model which consists of: data collection, data reduction, data presentation, and conclusion drawn. The results of the study show that morals and ethics play a central role in the utilization of artificial intelligence (AI) in Technology and Vocational Education in the digital era of the Industrial Revolution 4.0. The study also recommends strategic steps to ensure the use of AI in Technology and Vocational Education remains ethical and effective.

Keywords: Moral, Ethic, Artificial Intelligence, Technology and Vocational Education, Philosophy of Science

1. INTRODUCTION

The Industrial Revolution 4.0 has brought significant changes in various aspects of life, including education. With the presence of increasingly sophisticated digital technology and the widespread use of Artificial Intelligence (AI), the education system is currently faced with new challenges to adapt to the times. On the one hand, the use of artificial intelligence (AI) in education, according to Rochmawati, et al (2023), has a positive impact, including: (1) Personalization of learning; (2) Adaptive teaching; (3) Data analysis for decision-making; (4) Virtual assistant for teachers; (5) Global access through online platforms and; (6) Improvement of critical and creative thinking skills. Vocational education and artificial intelligence (AI) are interconnected and have great potential to increase the effectiveness and relevance of vocational education in today's

digital era (Yahya, et al., 2023). However, the emergence of AI also has a negative impact on education, especially in the context of Technology and Vocational Education (PTK), namely increasing plagiarism, excessive dependence, lack of skill development, and weakening culture, norms, and interactions between students and lecturers (Lukman, et al., 2023; Seo, et al., 2021).

Technology and Vocational Education, which aims to prepare students with technical skills and practical expertise to meet the needs of the world of work, is now in a position that is quite threatened. Uncontrolled implementation of AI can replace human skills in various vocational fields (Pakpahan, 2021). Furthermore, the integration of AI in PTK is often carried out without considering moral and ethical aspects, so it has the potential to cause new problems, such as the misuse of technology, the loss of humanism in education, and injustice in access and application of technology. Meanwhile, students from vocational schools are required to have a good work culture. In building a work culture, students are not only motivated to be productive, but also taught to prioritize ethical and moral values (Sutjipto, 2019).

Until now, there has not been a comprehensive framework related to moral and ethical rules in the use of AI in the field of Technology and Vocational Education. In this case, moral and ethical guidance is very important to ensure that the use of AI can support educational goals, not threaten the essence of PTK itself. Previous research has discussed the implementation of AI in education and its impact on the world of work, but not many have specifically explored the role of morality and ethics in the use of AI for PTK in this digital era. Therefore, this research is relevant to fill this gap.

Unlike previous research that tends to focus on the technical aspects of the application of AI in education, this study emphasizes the importance of building a moral and ethical framework as a foundation for utilizing AI in PTK. This study also examines the impact of using AI holistically, both positively and negatively, and offers a strategic approach to mitigate emerging risks. The purpose of this research is to analyze the moral and ethical role of AI in the use of AI in Technology and Vocational Education in the digital era of the Industrial Revolution 4.0.

2. LITERATURE REVIEW

1. Morality and Ethic

Moral was originally known as mores, which in Latin means habits, ways of life, and traditions where mores can also be interpreted by the manner and attitude shown (Alia, et al., 2020). Morality is a standard used to judge a person's good or bad, both as an individual, a member of society, and as a citizen (Febriyanti, & Dewi, 2021). The term moral has a strong connection with habits, traditions, and lifestyles, especially when it is judged in the context of good or bad, as well as right or wrong (Prasetyaningrum, et al., 2022). Morality is related to the extent of the rights of individuals or organizations to access information, as well as what are their obligations in maintaining, using, and disseminating information (Shobirin & Ali, 2019. It can be concluded that morality is a standard of behavior related to habits, traditions, and the rights and obligations of individuals or organizations in judging the good, bad or right or wrong of an action in their personal, social, and informational lives.

In language, ethics is a science that discusses human deeds or behavior, as well as determining what is good and what is bad, while in general, ethics refers to the rules, norms, or guidelines used by individuals in acting and behaving (Jamil, 2022). Ethics is an assessment of the good and bad of human behavior which includes social values (Nilava & Fauzi, 2020). According to Badroen in Wahyuningsih (2022), ethics is a system of individual or group behavior that is formed from a system of values or norms that come from natural phenomena in the society. Ethics is an idea or ideal regarding the desire for goodness in human deeds and behavior (Tardjono, 2021). It can be concluded that ethics is a human act to determine good and bad, including social values, norms, guidelines in action, and ideas about moral goodness formed by societal values.

2. Artificial Intelligence in Digital Era of Industry 4.0

Industry 4.0, as the fourth industrial revolution, integrates advanced technologies such as artificial intelligence (AI), robotics, *the Internet of Things* (IoT), and *blockchain* into manufacturing processes, creating interconnected intelligent systems (Kiciński & Chaja, 2021). IoT, as a key component, refers to a network of devices that collect and share data to improve operational efficiency, enable predictive maintenance, and support automated decision-making (Gubbi, et al. 2013). AI technology analyzes large amounts

of IoT data to provide predictive analytics and process optimization, while robotics enables the automation of complex tasks with greater precision and efficiency (Kiciński & Chaja, 2021). In addition, blockchain integration improves transparency, traceability, and security in the supply chain and supports secure collaboration through centralized and trusted data logging (Bodkhe, et al. 2020).
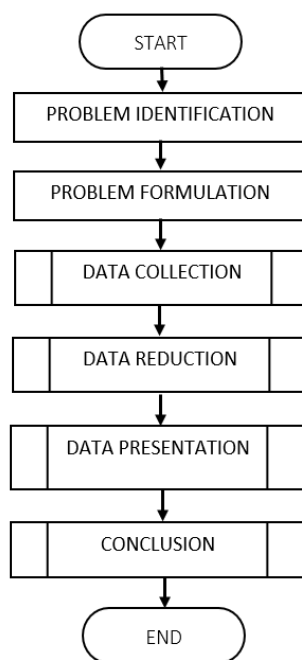
Artificial intelligence (AI) is a key element in the transformation of Industry 4.0. AI enables machines to mimic human intelligence in learning, reasoning, and problem-solving, paving the way for predictive analytics and automated decision-making (Kiciński & Chaja, 2021). With advanced algorithms, AI can process IoT data at scale to optimize manufacturing processes, improve efficiency, and minimize errors. The technology also allows for greater flexibility and adaptability in the face of changing markets and operational needs, making it a critical solution for maximizing productivity and innovation in the Industry 4.0 ecosystem (Kiciński & Chaja, 2021).

3. Technology and Vocational Education

Vocational technology education is an integration between technology and vocational education that has a different focus, but is combined to increase its effectiveness (Suhaedin, et al., 2023). Technology education is a learning process that teaches natural phenomena and facts and allows students to apply this knowledge through the use of technology (Pahira, et al., 2023). Meanwhile, vocational education is a form of education that emphasizes the mastery of practical skills and technical knowledge needed to enter the world of work in a specific field (Yahya, et al., 2023). Vocational school is a form of formal education at the secondary level which is a form of continuing education from junior high school/MTs or equivalent, with the main focus being to equip students to be ready to work in certain fields according to the intended work group (Hadi, 2021). In this case, it shows that vocational education is a formal education level that can start from Vocational High School (SMK), Diploma/Vocational, S2, and S3. Thus, it can be concluded that Vocational technology education is an integration between technology education, which focuses on the application of science through technology, and vocational education, which emphasizes the mastery of practical and technical skills for the world of work, so it is designed to prepare students at various levels of formal education, ranging from secondary to vocational colleges.

3. METHODS

This research will use a qualitative approach. This approach was chosen because it allows researchers to delve deeply and thoroughly into the phenomenon being studied (Sugiyono, 2022), in this case regarding the moral and ethical role of AI in the use of AI in Technology and Vocational Education learning in the digital era of the industrial revolution 4.0. The research method used is literature review. Secondary data in this study was obtained through a search for metadata of international journal research articles through Google Scholar, with a focus on the research results in 2019 – 2024. The search results will be reduced and analyzed bibliometrically using the VOSViewer application. The data analysis technique in this study applies the Miles & Hubberman model with steps of data collection, data reduction, data presentation, and conclusion drawn.

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Figure 1. Design of Research Procedure

4. RESULTS

The literature review in this study begins with the collection of a database of research articles from international journals through Google Scholar. The search is focused on using the keywords "AI in Technology and Vocational Education", "Morals

and AI", "Ethics and AI". Google Scholar presents dozens of research articles with these keywords. Then the database was sorted with the criteria of the last 5 years of publication, namely 2019-2024. From the results of the sorting, they were sorted in accordance with the focus of the research so that 15 main research articles were obtained that will be analyzed in this study with details in the following Table 1.

Table 1. Research Article Details

| Year	Journal	Research Title	Focus	Researcher	Research Method
2020	Institute of Electrical and Electronics Engineers (IEEE Access)	Artificial Intelligence in Education: A Review	AI	Chen, et al.	Qualitative (Literature Review)
2020	Journal Frontiers in Psychology	Challenges and Future Directions of Big Data and Artificial Intelligence in Education	AI	Luan, et al.	Qualitative (Literature Review)
2021	Springer: AI and Ethics	Emerging Challenges in AI and the Need for AI Ethics Education	AI	Borenstein & Howard	Qualitative (Literature Review)
2021	Journal of Physics: Conference Series	Application of Artificial Intelligence in Modern Vocational Education Technology	AI	Wu	Qualitative (Literature Review)
2021	Journal EAI (European Alliance for Innovation)	Perceptions and Prospective Analysis of Artificial Intelligence and its impact on Human Resources in the Indonesian Industry 4.0	Ethic & Moral	Purwaamijaya, et al.	Qualitative (Comprehensive Interview and Exploration)
2022	International Journal of Information Management	Ethical Framework for Artificial Intelligence and Digital Technologies	Ethic	Ashok, et al.	Quantitative (Systematic Literature Review)
2022	Journal Academy of Management Learning & Education	Morality In The Age of Artificially Intelligent Algorithms	Moral	Moser, et al.	Qualitative (Literature Review)
2023	Journal Educational Technology Quarterly	Digitalization of Vocational Education Under Crisis Conditions	AI	Kovalchuk, et al.	Qualitative (Literature Review)
2023	Springer: Education and Information Technology	Ethical Principles for Artificial Intelligence in Education	Ethic	Nguyen, et al.	Qualitative (Documentation)

Year	Journal	Research Title	Focus	Researcher	Research Method
2023	COMUNICAR: Media Education Research Journal	Reflections on the Ethics, Potential, and Challenges of Artificial Intelligence in the Framework of Quality Education (SDG4)	Ethic	Vivar & Penalvo	Qualitative (Literature Review)
2023	Informing Science: The International Journal of an Emerging Transdiscipline	The Impact of Artificial Intelligence on Workers' Skills: Upskilling and Reskilling in Organisations	AI	Morandini, et al.	Qualitative (Narrative Review)
2023	JOVES: Journal of Vocational Education Studies	The Role of AI In Vocational Education: A Systematic Literature Review	AI	Rosyadi, et al.	Quantitative (Systematic Literature Review)
2024	The Kenya Journal of Technical and Vocational Education and Training	The Impact of Artificial Intelligence on the Future of Technical and Vocational Education and Training (TVET) in Bungoma County: A Stakeholder Analysis	AI	Lumuli & Opicho	Quantitative Descriptive
2024	JAIEM: Journal of Asian Islamic Educational Management	Ethics of AI Integration in Higher Education: Exploring Moral Dimensions	Moral	Sain, et al.	Mix Method (Case Study)
2024	International Journal of New Developments in Education	Research on Artificial Intelligence Enabling Changes in College Students' Moral and Ethical Education	Ethic & Moral	Yawen	Qualitative (Literature Review)

The fifteen articles were then bibliometric reduced using the VOSviewer application. The results of bibliometric data processing in the application display Network Visualization, Overlay Visualization, and Density Visualization. Network Visualization presents the results of the analysis of research keyword network trends. As a result, the keyword that often appears is "Artificial Intelligence", while the keyword that rarely appears is "Human Resource". Overlay Visualization presents the results of the analysis of research trends in the year. The results show that more research on the 3 search keywords above will be carried out in 2022-2023. Density Visualization presents the results of analysis of density trends or research trends. The results show that research on the 3 search keywords above is more likely or more often to be carried out with a focus

on "Modern Vocational Education" and rarely "Human Perspective". The results of bibliometric data reduction and analysis using VOSViewer in this study can be seen in the following Figure 2.
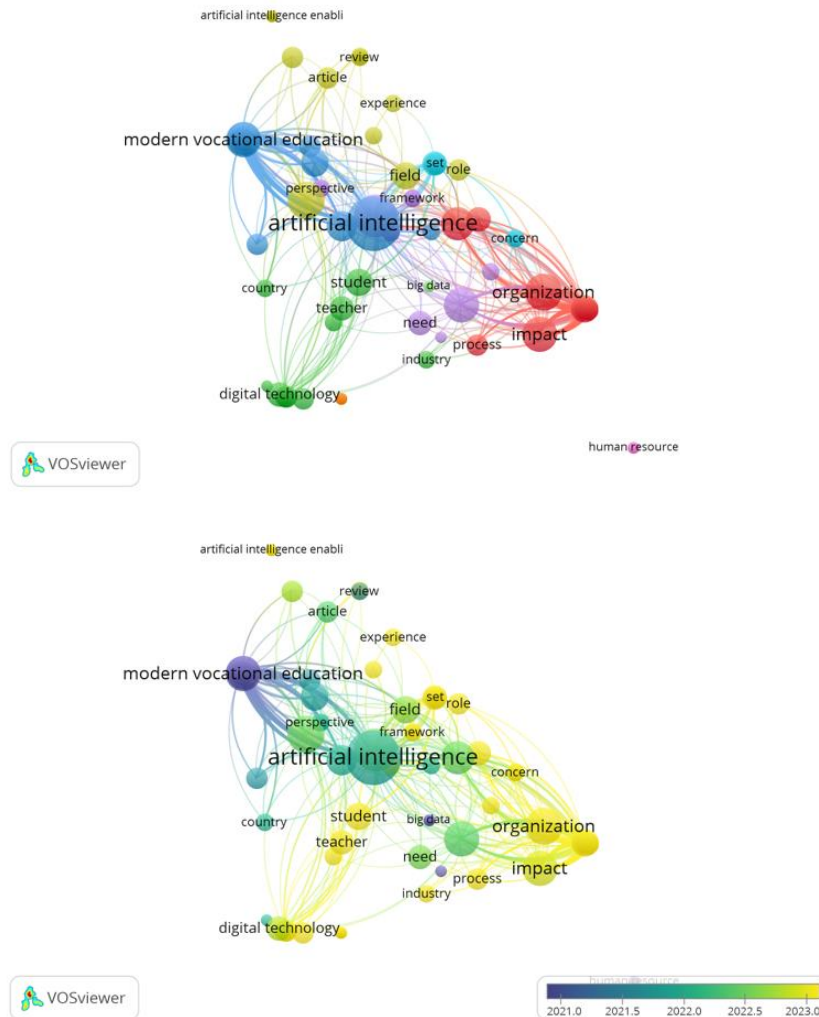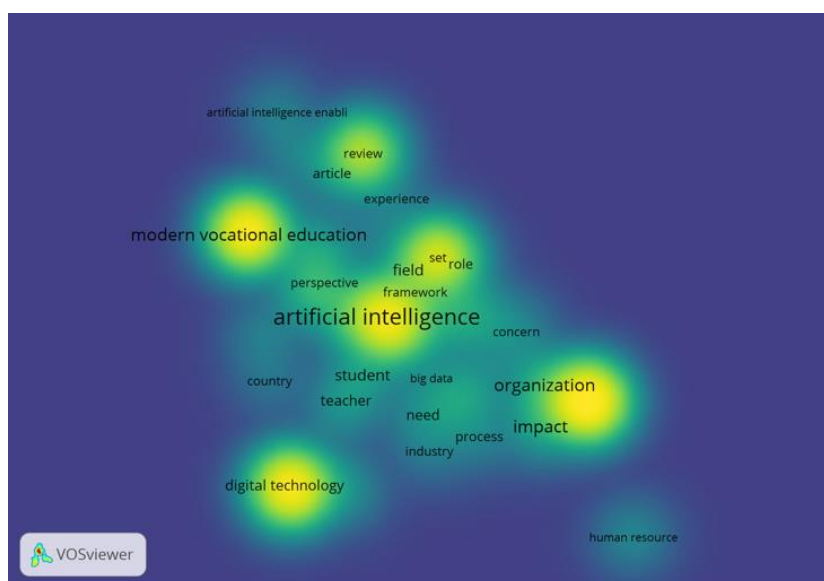
Figure 2. Result of Bibliometric Data Reduction and Analysis Using VOSViewer

5. DISCUSSION

1. The Impact of Artificial Intelligence in Digital Era of Industry 4.0

The application of artificial intelligence (AI) in technical and vocational education and training (TVET) has great potential to revolutionize the vocational education system. AI enables more adaptive learning through personalizing material according to individual needs, while accelerating the technical training process with advanced technology-based simulations. In the world of education, AI has made administrative tasks easier, such as reviewing student work results, assigning grades, and providing feedback automatically (Rosyadi, et al., 2023). Web-based platforms and AI-based computer programs also allow for more efficient and structured teaching. Even so, the existence of AI also has a negative impact such as a lack of practical experience for students because the dominance of technology-based learning and teachers' perceptions of the effectiveness of AI are still diverse, so an integrated approach is needed to optimize the use of AI (Chen, et al., 2022).

The positive impact of AI in learning has been proven by many studies. This technology helps create teaching methods that are more innovative, effective, and relevant to the demands of the industrial era 4.0. In the context of human resource (HR) management, AI-based applications enable more accurate analysis, prediction, and diagnosis to support strategic decision-making (Purwamijaaya, et al., 2021). In this case,

AI can predict training needs, diagnose performance issues, and design the right solutions to improve work efficiency. However, this over-reliance on technology also risks ignoring humanistic elements in the world of work, such as creativity and empathy, which are still unique strengths of humans compared to machines.

In addition, the ability of AI to replace tasks previously performed by humans is increasing (Morandini, et al., 2023). This creates new dilemmas, especially in the fields of education and employment. On the one hand, AI-powered automation improves operational efficiency, but on the other hand, a high reliance on technology can underestimate the role of humans, both as educators and workers (Luan, et al., 2020). The massive use of big data and the integration of AI-based technology often make humans simply complement the process that should remain centered on interpersonal relationships. Therefore, in utilizing AI, it needs to be balanced with strategies to maintain ethical values, empathy, and practical experience, so that technology can truly become a supporting tool that empowers humans in the digital era of industry 4.0.

2. The Role of Morality in Utilizing Artificial Intelligence in Digital Era of Industry 4.0

Artificial Intelligence (AI) has had a major impact on learning in Technology and Vocational Education (PTK), such as enabling personalization of learning, improving the efficiency of the teaching process, and analyzing student performance in real-time (Wu, 2021). However, behind these benefits, the use of AI also has a negative impact, especially in moral aspects. For example, excessive use of AI can reduce students' independence of thinking, increase the risk of privacy violations, and create dependence on technology without understanding the underlying moral values (Nguyen et al., 2023). To address this problem, the utilization of AI in Technology and Vocational Education must be done with a responsible approach. AI should not only be focused on technical efficiency, but should also be designed and used to support the formation of students' moral character, such as reinforcing the values of honesty, responsibility, and integrity through thoughtful and moral-based arrangements (Borenstein & Howard, 2021).

Morality plays an important role as a guide in the use of AI in Technology and Vocational Education, ensuring that this technology is not only a learning tool but also a means of forming a complete personality of students. In this digital era, the existence of
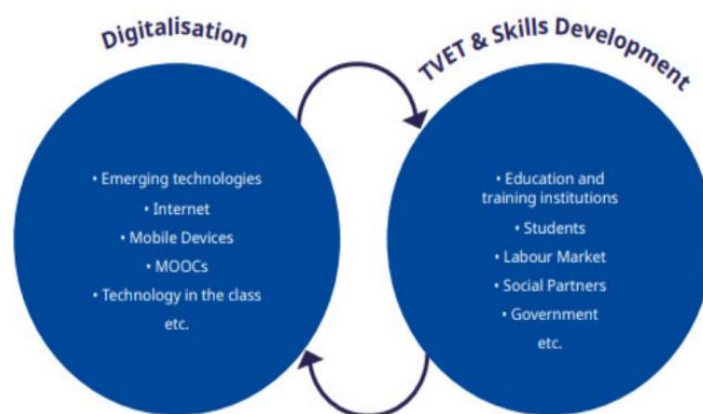
AI and Technology and Vocational Education reinforce each other. AI technology can help modernize teaching methods in Technology and Vocational Education, while moral-based education in Technology and Vocational Education can ensure that students use AI wisely and responsibly (Yawen, 2024). Eliminating AI from Technology and Vocational Education is unrealistic, given its potential to support personalized learning and improve students' technical skills. Instead, moral values must be strengthened in the use of AI so that students not only understand technology but are also able to use it with good morals in both professional and personal contexts (Sain et al., 2024).

A concrete step that can be taken to limit and regulate the use of AI in learning in Technology and Vocational Education is to develop specific moral guidelines for the use of this technology. The guidelines should include principles such as data privacy, algorithmic transparency, and limiting reliance on technology (Nguyen et al., 2023). In addition, educator training in Technology and Vocational Education also needs to be focused on integrating moral values in AI-based teaching, such as providing moral decision-making simulations in a technology-based environment (Yawen, 2024). This approach will ensure that learning in Technology and Vocational Education not only produces graduates who are technically skilled, but also have a high moral awareness in facing the challenges of the Industry 4.0 era. Thus, morality is not only a barrier, but also a key guide in the use of AI to support sustainable and more ethical education.

3. The Role of Ethic in Utilizing Artificial Intelligence in Digital Era of Industry 4.0

The use of artificial intelligence (AI) in technology and vocational education has great potential to revolutionize learning, but it is important to ensure that its application remains ethical. Ethics acts as a counterweight so that the use of AI not only focuses on efficiency, but also upholds human values, such as justice, transparency, and responsibility. Ethical violations in the use of AI in technology and vocational education have become a concern, including algorithms that inadvertently reinforce biases, lack of transparency in AI-based decision-making, and over-reliance that risks reducing students' critical thinking skills (Ashok et al., 2022). In addition, the digital competency gap between teachers and students also increases the risk of inequality in learning (Kovalchuk et al., 2023). This condition confirms that while AI has many advantages, its implementation requires strong ethical guidance to prevent adverse negative impacts.

While these ethical challenges are real, removing AI from the tech and vocational education ecosystem is not a wise solution. In contrast, technology and vocational education and AI reinforce each other. AI supports vocational education by creating adaptive learning environments, presenting personalized content, and providing simulations of complex industrial processes (Lumuli & Opicho, 2024). On the other hand, technology and vocational education is the foundation for the development of a workforce that is skilled in designing, managing, and utilizing AI for modern industrial needs (Kovalchuk et al., 2023). Studies show that this combination is able to enhance a student-centered competency-based approach, resulting in graduates who are better prepared to face the challenges of the digital industry (Vivar & Penalvo, 2023). However, to achieve this synergy, joint efforts are needed in closing infrastructure gaps, improving educator competence, and strengthening government policy support (Lumuli & Opicho, 2024).

Figure 3. Illustration of Digital Technology Connections Mutually Reinforcing with Technology and Vocational Education

(Source: Grech & Camilleri, 2017)

In order for the use of AI in technology and vocational education to remain on an ethical track, concrete steps are needed. First, it is important to design an ethics training program for educators to ensure a deep understanding of the responsible use of AI, including the prevention of algorithmic bias and the management of transparency (Ashok et al., 2022). Second, an AI literacy plan is needed to strengthen digital skills for both educators and students, accompanied by an ethics observatory that encourages cross-sector discussions and formulates the best guidelines (Vivar & Penalvo, 2023). Third,

cooperation between stakeholders, namely governments, industry, and educational institutions, must be strengthened to provide resources and infrastructure that support the ethical application of AI (Kovalchuk et al., 2023). Finally, it is recommended to prepare a standard code of ethics for the use of AI in technology and vocational education, which serves as a clear operational guideline, so that AI can be used for innovation without violating dignified educational principles, such as the code of ethics for plagiarism.

6. CONCLUSION

The results of this study show that morals and ethics play a central role in the use of artificial intelligence (AI) in Technology and Vocational Education in the digital era of the Industrial Revolution 4.0. A bibliometric analysis of 15 research articles reveals that research trends on AI in Technology and Vocational Education tend to focus on the development of modern vocational education, but often ignore humanist perspectives, such as justice and morality. While AI has been shown to improve learning efficiency through personalized materials and technology-based simulations, its use also presents a number of ethical challenges, including algorithmic bias, privacy violations, and dependency that can reduce student independence. For this reason, the application of AI in Technology and Vocational Education not only requires cutting-edge technology, but also an ethical-based approach to ensure that the use of AI does not violate human values.

The study also recommends strategic steps to ensure the use of AI in Technology and Vocational Education remains ethical and effective. Among them is the preparation of code of ethics guidelines that include the principles of algorithm transparency, data privacy protection, and bias prevention. In addition, it is necessary to develop an AI literacy program for educators and students to improve digital skills while building an understanding of the responsible application of AI. Cross-sector cooperation between governments, industry, and educational institutions is also important to provide adequate supporting infrastructure. With this step, AI is not only a tool that improves learning efficiency, but also a means of character building that upholds moral and ethical values, creating graduates who are ready to face challenges in the digital era with high integrity.

LIMITATION

The results of this study emphasize the importance of maintaining moral and ethical standards in the application of *Artificial Intelligence* (AI) in technology and vocational education (PTK) in the midst of the rapid digital development of the Industry 4.0 era. The use of AI in accordance with educational values and ethical principles is essential to prevent abuse and ensure the integrity of the learning process is maintained. However, this study has limitations because it only uses a bibliometric approach, which relies on previous literature analysis without directly involving stakeholders in the PTK ecosystem. Although the bibliometric method provides a comprehensive overview of previous research trends, this approach cannot deeply capture the perspectives of those directly affected by the implementation of AI, such as vocational school students, teachers, vice principals for curriculum, learning technology experts, vocational education experts, and PTK students. Therefore, it is recommended that further research be conducted with an empirical approach to explore the perceptions of these key stakeholders. In addition, further research can be focused on developing practical guidelines that include moral and ethical aspects in the use of AI in PTK, so that its use not only improves learning outcomes but also remains aligned with essential educational values in the digital era.

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