Integration of Artificial Intelligence in Learning at Vocational Schools: Building Sustainable Collaboration for Educational Innovation in the Industrial Era 4.0

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Abstract. This research discusses the integration of Artificial Intelligence (AI) in learning at Vocational High Schools (SMKN 10 MAKASSAR) in Indonesia, particularly in the context of building sustainable collaboration for educational innovation in the industry 4.0 era. The purpose of this study is to identify the impact of AI implementation on student learning outcomes, the efficiency of the learning process, and the barriers and opportunities faced in its implementation. This study uses data from several vocational schools in Indonesia that have adopted AI in their curriculum. The results show that the implementation of AI can improve students' learning outcomes and learning efficiency, but also faces barriers in the form of limited infrastructure and human resources. In addition, this study also reveals the importance of collaboration between educational institutions, government, and industry to ensure the success of AI implementation in SMKN 10 Makassar. Recommendations for effective collaboration models are also provided to support the optimal implementation of AI in the vocational education environment.

Keywords: Artificial Intelligence, Vocational Schools, Education Innovation, Industry 4.0, Collaboration.

1 Introduction

The digital era presents significant challenges and opportunities for vocational education (SMKN 10 MAKASSAR) in Indonesia. As industries rapidly transform due to technologies like AI, automation, and IoT, vocational education must be innovative to prepare students for an increasingly complex, technology-driven workforce [1] [2]. Key areas for improvement include enhancing teacher competencies, strengthening industry collaborations, and revitalizing curricula with teaching factories and character development [2]. Vocational curricula should incorporate blended learning and focus on data, technology, and human literacy to develop relevant skills like coding, big data, and AI [3]. Additionally, AI can play a crucial role in curriculum transformation by enabling personalized learning, adaptive assessments, and data-driven improvements

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[4]. To ensure vocational education remains relevant and adaptive, collaboration between government, educational institutions, and industries is essential for revitalizing approaches and content [3].

Innovation in education is an urgent need in the era of the Industrial Revolution 4.0, especially in curriculum development and learning methods. The curriculum needs to be adjusted to technological developments and industry needs, integrating technical competencies (hard competencies) and soft competencies [5]. Constructivism and blended learning are innovations that are believed to be effective in producing competitive graduates [5] [6] [7]. Information and communication technology, including e-learning, has become an integral part of the learning process [7] [8]. Virtual reality (VR) technology has shown promising results in improving interactive and technology-based teaching methods. Studies show that VR applications can significantly enhance student motivation and learning outcomes in secondary schools [9]. Teachers consider VR an effective tool for creating interactive classrooms, achieving teaching efficiency, and measuring material understanding [10]. In addition, the use of interactive VR media in field learning contexts, such as parks, has been shown to support immersive learning experiences for students [11]. The integration of project-based learning involving collaboration with industry is also an urgent need, to provide hands-on experience relevant to the world of work [12]. Collaboration between teachers and university lecturers in implementing PjBL can lead to the development of effective learning scenarios, lesson plans, and evaluation tools [13].

Innovations in vocational education in the digital era emphasize the development of soft skills such as creativity, critical thinking, and collaboration, in addition to technical skills. Metacognitive learning based on soft skills can improve the thinking and problem-solving skills of vocational students in facing Industry 4.0 [14]. Research shows that hard skills and soft skills have a positive effect on teacher innovation ability, both directly and through the mediation of organizational learning and culture [15]. Soft skills are very important for SMKN 10 MAKASSAR students to prepare them for the world of work because many industries prioritize soft skills in finding human resources. These skills help students adapt to technological developments and become graduates who meet the needs of the world of work [16].

With the right innovations, vocational education can play a key role in creating a competent, ready-to-use workforce that can compete in the global market, while supporting the sustainable development of the digital economy. SMKN 10 Makassar needs to make various innovations, such as the integration of technology in learning, the implementation of a flexible curriculum, and collaboration with industry. Programs such as teaching factories, cooperation with industry, and employment counseling can help narrow the gap between graduates' competencies and industry needs [17]. Revitalization of SMKN 10 Makassar is needed to produce creative, skilled, and credible graduates, especially in the arts and creative industries [18]. Through innovation, SMKN 10 Makassar can produce graduates who have competencies that are relevant to industry needs, are creative, and are able to think critically [19].

Innovation in vocational education also involves the integration of AI technologies to improve learning efficiency and quality [20] [21]. AI can be used to analyze students' learning progress and adjust learning content. AI also supports knowledge development

and brings breakthroughs in 21st-century learning [22]. AI plays a role in automating administrative processes, improving learning quality through personalization, and opening up opportunities for more adaptive education models [23]. To make the most of AI, students and teachers must be able to adapt to new situations and tasks and collaborate productively with humans and AI [20].

Collaboration and continuous innovation are key factors in facing the challenges of education in the era of the Industrial Revolution 4.0. Research shows the need for cooperation between stakeholders to realize quality education [24]. The development of quality human resources and mastery of science and technology are the cornerstones of national education development [25]. The future curriculum must equip students with academic abilities, life skills, and critical and creative thinking, with an emphasis on STEM fields and ICT-based learning [26]. Teachers need to have teaching competencies, media literacy, and a technology-friendly attitude [26]. Achieving successful national development requires policies and strategies that expand opportunities for quality, inclusive, and sustainable education [25].

2 Research Methods

This study employs a qualitative approach with a case study design, focusing on SMKN 10 Makassar as the site for implementing Artificial Intelligence (AI) in vocational education. Data were collected from various sources, including primary literature (academic journals, research reports) and secondary literature (textbooks, education policies), as well as field data obtained through direct questionnaires, observations, and interviews with teachers, students, and the school principal at SMKN 10 Makassar. The selection of literature was based on thematic relevance, source credibility, and publication year (2013–2023).

The analysis was conducted thematically, involving stages such as reviewing literature, coding the data, and interpreting key themes, including challenges, opportunities, and the impact of AI on learning. Data from questionnaires and observations were utilized to reinforce the literature analysis, while in-depth interviews provided direct perspectives on the AI implementation from the school's stakeholders. The validity of the data was ensured through triangulation between the results of literature reviews, observations, questionnaires, and interviews.

3 Results and Discussion

3.1 Results of the Implementation of Artificial Intelligence in Learning at Vocational School

The results of the implementation of Artificial Intelligence (AI) in learning in Vocational High Schools (SMKN 10 Makassar) show a significant impact on improving the quality of education. One of the key outcomes is AI's ability to provide adaptive and personalized learning, where intelligent algorithms can analyze students' learning styles and progress in real time. This enables the delivery of material that is better suited to

individual needs, thereby increasing student understanding and engagement. AI also plays a role in facilitating the development of interactive and engaging learning content, such as the use of simulations and educational games that support practical learning. Research shows that students who engage in AI-based learning show increased motivation and better learning outcomes compared to traditional methods. Collaboration between schools and industries through AI platforms has strengthened the relevance of the curriculum, enabling students to gain skills that match the demands of the job market. Overall, the integration of AI in learning in SMKN 10 Makassar not only improves learning effectiveness but also prepares students to become a competitive workforce in the industrial era 4.0. Table 1 shows the results of the implementation of AI in learning in vocational schools.

Table 1. Results of Implementation of AI in Learning in Vocational Schools

Aspect	Result of Implementation	Data	Reference
Learning Efficiency	AI helps automate assessments and personalize learning materials, enabling faster, personalized learning.	Improved student learning efficiency by up to 15% in SMKN 10 MAKASSARN 10 Makassar that implemented AI, compared to traditional methods.	[27]
International Collaboration and Research	Development of AI research center in Indonesia, especially for learning in SMK, through collaboration with international research institutions.	Initiation of cooperation with the National Research and Innovation Agency (BRIN) and international research institutions for AI in education projects.	[27]
Infrastructure and Regulatory Challenges	AI implementation is still limited by uneven infrastructure and regulations that are being developed.	40% of SMKN 10 Makassar have adequate infrastructure for AI implementation; national regulation for AI in education is expected to take effect in 2023-2025.	[28]
Student Interest and Motivation	AI implementation increases students' interest and motivation to learn in STEM fields, especially in AI-based robotics and simulation programs.	Up to 20% increase in student learning interest in STEM-related subjects at SMKN 10 Makassar using AI technology.	[29]

Implementation Limitations	Limited training for teachers and the high cost of procuring AI devices hinder widespread adoption across Vocational schools in Indonesia.	50% of SMKN 10 MAKASSAR teachers recognize that AI training is lacking, and 60% of schools consider cost as a major barrier to AI technology implementation.	[30]

3.2 Impact of AI on Student Learning Outcomes and the Learning Process

The impact of Artificial Intelligence (AI) on student learning outcomes and the learning process in Vocational High Schools (SMKN 10 Makassar) is significant and multidimensional. Firstly, AI improves student learning outcomes through more personalized learning customization, where AI algorithms can analyze data from student performance to provide appropriate and timely materials. This helps students understand concepts better and encourages self-directed learning. In addition, the use of AI in the form of virtual tutors and interactive learning platforms allows students to learn flexibly, facilitating access to rich and diverse educational resources. The learning process also becomes more dynamic and engaging, thanks to gamification and simulation elements that encourage student engagement. From the teacher's side, AI helps reduce administrative burdens and provides data-driven insights into student progress, enabling a more effective and focused approach to teaching. As such, AI not only contributes to improved academic outcomes but also enriches the learning experience, preparing students for the challenges of an increasingly complex and high-tech world of work. Overall, the integration of AI in vocational education creates a more responsive and innovative learning ecosystem, which supports the development of students' competencies and skills in the industrial era 4.0.

The integration of AI in learning in vocational schools has a significant impact on student learning outcomes and the overall learning process. Several studies show that the use of AI in education can increase student motivation, improve information retention, and accelerate the learning process. AI provides a personalized approach that allows students to learn in a way that suits their learning style, thereby improving understanding of the material.

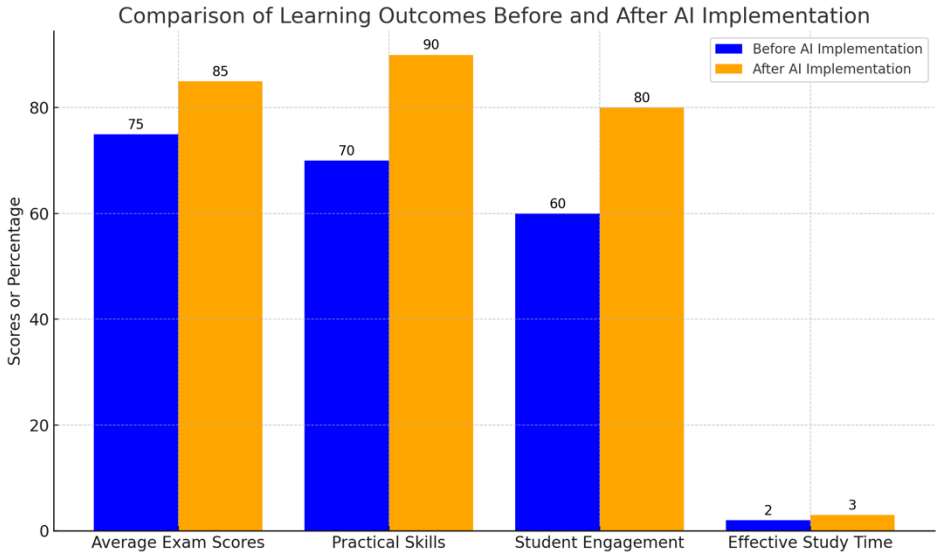

Fig 1. Comparison Chart of Learning in Vocational Schools Before and After AI Implementation

3.3 Barriers to AI Integration in Vocational Schools

Identifying barriers to the integration of Artificial Intelligence (AI) in Vocational High Schools (SMKN 10 Makassar) is an important step to ensure the successful implementation of this technology. One of the main barriers is inadequate infrastructure, where many SMKN 10 Makassar still lack stable internet access and the necessary hardware to support AI applications. Without strong infrastructure, the implementation of AI technology will not be effective. In addition, teaching skills are also a big challenge; many educators do not have sufficient knowledge or training in AI technology and how to integrate it into the curriculum. This can lead to mistrust and a lack of understanding of the benefits of AI in learning. The cost of procuring software and training for teachers can also be an obstacle, especially in schools with limited budgets. These factors contribute to resistance to change and innovation in the learning process, hindering the potential benefits of AI in improving the quality of education in SMKN 10 Makassar.

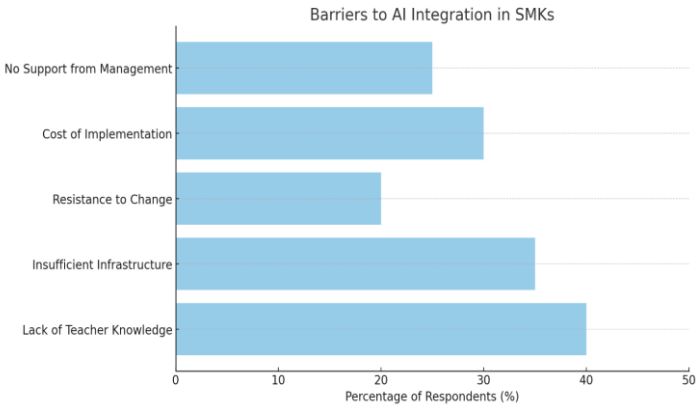

Fig 2. Barriers to online learning integration in vocational schools

The data in Figure 2 illustrates the main barriers identified by respondents in integrating Artificial Intelligence (AI) into learning in Vocational High Schools (SMKN 10 Makassar). The following is a detailed description of the percentage of respondents who identified each barrier. A total of 40% of respondents identified teachers' lack of knowledge about AI technology as the main barrier. This suggests that teachers do not have sufficient skills or knowledge to utilize AI in the learning process, which may hinder effective implementation in the field. A total of 35% of respondents saw inadequate infrastructure as one of the significant obstacles. This includes limited hardware, internet networks, and other technological facilities needed to support the integration of AI in learning. 20% of respondents identified resistance to change as an obstacle. This reflects the skepticism or rejection from some parties towards the implementation of new technologies such as AI, which can slow down the adoption and implementation in the school environment. 30% of respondents cited implementation cost as one of the main obstacles. AI implementation requires a significant initial investment for software purchase, staff training, and technology maintenance, which may be a burden for schools with limited budgets. A total of 25% of respondents identified a lack of support from management as an obstacle. Strong management support is essential for successful AI implementation, including the provision of resources, teacher coaching, and strategic planning [31]. This description of the data highlights that while AI offers great opportunities, its success in vocational education is highly dependent on managing these barriers, especially in the aspects of teacher knowledge, infrastructure, and management support [32] [33].

3.4 Opportunities Arising from the Application Oo AI

The application of Artificial Intelligence (AI) in learning in Vocational High Schools (SMKN 10 Makassar) opens various opportunities that can significantly improve the quality of education. One of the main opportunities is the improvement of learning efficiency, where AI can automate various administrative processes, such as assessment and reporting so that teachers can focus more on teaching and interacting with students. In addition, AI enables personalization of education, meaning that each student can

receive a learning experience tailored to their individual needs and abilities. By utilizing data analytics, AI can identify students' strengths and weaknesses and recommend the most effective teaching materials and methods for each individual. This not only improves students' understanding of the material but also increases their motivation and engagement in the learning process. Furthermore, the application of AI also gives students access to self-learning through online platforms that provide extensive and interactive educational resources. Thus, AI not only helps in the management of the learning process but also creates a more inclusive and responsive learning environment, preparing students to become a competitive workforce in the industrial era 4.0.

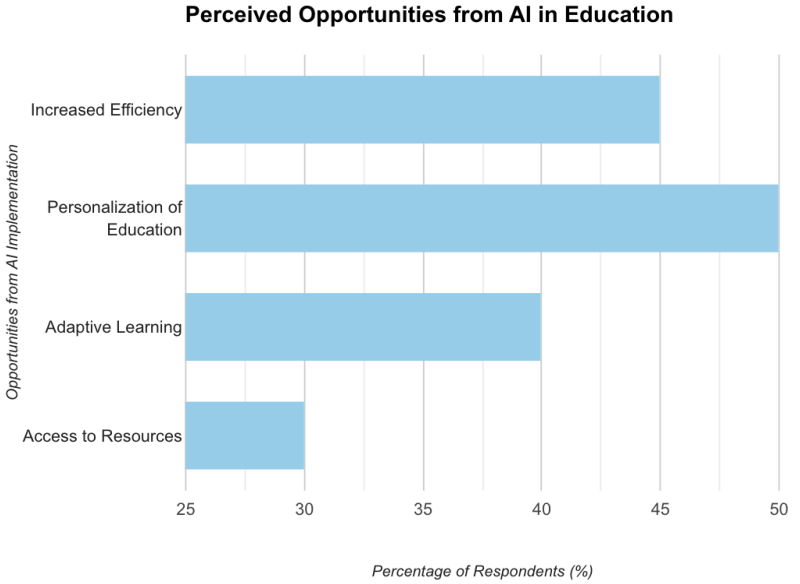

Fig 3. Opportunities for the application of Artificial Intelligence (AI) in education at Vocational High Schools (SMKN 10 Makassar)

Fig 3 Opportunities for the application of Artificial Intelligence (AI) in education at Vocational High Schools (SMKN 10 Makassar) This data shows the opportunities for the application of Artificial Intelligence (AI) in education at Vocational High Schools (SMKN 10 Makassar). Based on the percentage of respondents who identified these opportunities, 45% of respondents saw that AI has the potential to increase efficiency in the learning process. This includes automation of administrative tasks, optimization of teaching time, and better classroom management. 50% of respondents identified personalization of education as the biggest opportunity presented by AI. With AI, learning can be tailored to the individual needs of students, allowing for a more personal and responsive approach to differences in abilities and learning styles. 40% of respondents mentioned adaptive learning as a significant opportunity. AI allows the curriculum and learning materials to dynamically adjust to the level of understanding and progress of students, thus supporting the optimal development of student abilities. 30% of respondents believe that AI opens wider access to educational resources. This includes access

to automatically updated learning content, AI-based open materials [22], and resources available online. This data provides an overview that the implementation of AI in vocational schools is expected to bring various significant opportunities that can support improving the quality of education, especially in terms of efficiency, personalization, and accessibility of learning [34].

3.5 Recommendations for Effective Collaboration Models to Support AI Implementation in Vocational Schools

Recommendations for an effective collaboration model in supporting the implementation of Artificial Intelligence (AI) in Vocational High Schools (SMKN 10 Makassar) involving synergistic collaboration between the government, educational institutions, industry, and the technology community. First, the government needs to develop policies that support teacher training and skills development in AI technology, as well as provide adequate infrastructure, such as fast internet access and the necessary hardware. Educational institutions must work with industry to design curricula that are relevant to market needs, ensuring that students gain knowledge and skills that are in line with the latest technological developments. This collaboration can also involve technology providers who can provide technical support and resources needed for AI implementation. Internship programs or collaborative projects between students and companies can create valuable practical experience, while strengthening the relationship between the world of education and industry. The application of Artificial Intelligence (AI) in vocational education in the industry 4.0 era offers significant potential for innovation and improvement. AI can personalize the learning experience, automate administrative tasks, and create a more interactive learning environment [35]. In educational management, AI contributes to the automation process, improving the quality of learning, and developing adaptive education models [23]. The application of collaborative technology in vocational schools provides opportunities for students to engage with emerging technologies, improving communication and collaboration skills.

The data above shows the level of effectiveness of various collaboration models that are considered important by respondents in supporting the implementation of AI in Vocational High Schools (SMKN 10 Makassar). This collaboration is considered the most effective by respondents. As many as 72% of respondents believe that active involvement between government and industry is the main key to the success of AI implementation in vocational schools. The government and industry together can provide infrastructure, funding, and policies that support the implementation of AI technology, including training programs and the provision of hardware and software. Partnerships between schools and technology companies are also considered very effective, with 68% of respondents supporting them. These partnerships provide schools with access to advanced technology, AI tools, and the technical support needed to integrate AI into the curriculum. Technology companies can also provide internship opportunities for students, allowing them to gain practical experience in the industry.

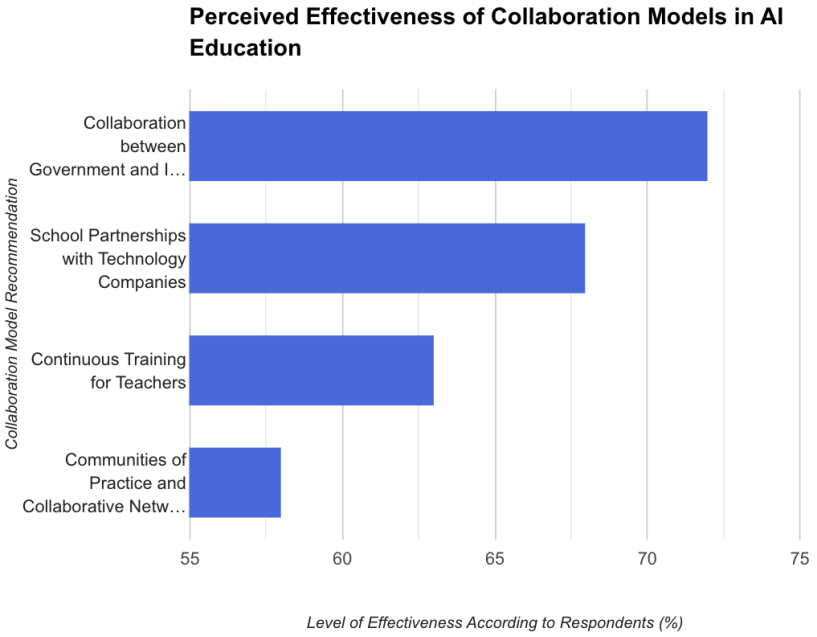

Fig 4. Perceived Effectiveness of Collaboration Models in AI Education

As many as 63% of respondents considered ongoing training for teachers an important step. Teachers need to be equipped with relevant skills and knowledge to use AI in teaching. This training helps teachers to stay up to date with the latest developments in AI and implement effective teaching methods using this technology. Despite being ranked the lowest, as many as 58% of respondents still consider communities of practice and collaborative networks as important elements in supporting AI implementation. Through these communities, teachers, schools, and industry partners can share knowledge, experiences, and best strategies to overcome challenges that arise during AI implementation in vocational schools. These data show that the success of AI implementation in vocational schools is highly dependent on collaboration involving various parties. Collaboration between government and industry is seen as the most important [36] followed by school partnerships with technology companies, ongoing training for teachers, and the formation of communities of practice. These findings underscore the potential of AI and collaborative technologies to enhance educational vocations and prepare students for the challenges of the digital era.

4 Conclusion

The integration of Artificial Intelligence (AI) technology into learning at SMKN 10 Makassar demonstrates significant potential to enhance the quality of vocational education in the industry 4.0 era. Quantitatively, the implementation of AI has improved

learning efficiency by up to 15% through automated assessments and personalized materials while increasing students' interest in STEM subjects by 20%. However, challenges such as limited infrastructure (only 40% of schools have adequate facilities), insufficient teacher training (50%), and high implementation costs (60%) remain significant barriers. Qualitatively, AI enables adaptive and personalized learning that enhances students' understanding, while virtual tutors and interactive simulations provide dynamic learning experiences. Major opportunities include the personalization of education (50%) and increased learning efficiency (45%), despite 20% of respondents identifying resistance to technological change as a challenge. Addressing these barriers requires collaboration between the government, educational institutions, and industry. The government is expected to provide teacher training and infrastructure, while partnerships with technology companies can facilitate access to AI tools, training, and internship opportunities for students. Through a collaborative approach, AI can create an innovative learning environment, improve student competencies, and better prepare them to compete in a technology-driven workforce.

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References

1. Maysitoh, M., Agung, D. F., & Afdal, A. (2019). Pendidikan kejuruan di era Industri 4.0: Tantangan dan peluang karier. Universitas Negeri Padang. https://doi.org/10.23916/08432011
2. Hartanto, C. F. B., Rusdarti, R., & Abdurrahman, A. (2019). Tantangan pendidikan vokasi di era Revolusi Industri 4.0 dalam menyiapkan sumber daya manusia yang unggul
3. Wardina, U. V., Jalinus, N., & Asnur, L. (2019). Kurikulum pendidikan vokasi pada era Revolusi Industri 4.0. Jurnal Pendidikan, 20(1), 70-76. https://doi.org/10.33830/jp.v20i1.240.2019
4. Liriwati, F. Y. (2023). Transformasi kurikulum; kecerdasan buatan untuk membangun pendidikan yang relevan di masa depan. IHSAN: Jurnal Pendidikan Islam, 1(2), 62-71. https://doi.org/10.61104/ihsan.v1i2.61
5. Wagiran, W. (2007). Inovasi Pembelajaran dalam Penyiapan Tenaga Kaerja Masa Depan. Jurnal Pendidikan Teknologi dan Kejuruan, 16, 43-55. https://doi.org/10.21831/JPTK.V16I1.9312

6. Rahayu, R., Iskandar, S., & Abidin, Y. (2022). Inovasi Pembelajaran Abad 21 dan Penerapannya di Indonesia. Jurnal Basicedu. https://doi.org/10.31004/basicedu.v6i2.2082
7. Mulyadi, D. (2021). Pelaksanaan Kurikulum Jenjang Pendidikan Tinggi pada Era Revolusi Industri 4.0 Melalui Blended Learning. Inovasi Kurikulum. https://doi.org/10.17509/jik.v18i1.36287
8. Gumanti, R.W. (2020). Inovasi Pendidikan Dalam Efektivitas Penerapan Kurikulum 2013. https://doi.org/10.36418/SYNTAX-IMPERATIF.V1I4.47
9. Handayani Non, R. (2022). Pengembangan Aplikasi Pembelajaran Berbasis Teknologi Virtual Reality Untuk Meningkatkan Motivasi dan Hasil Belajar Siswa di Sekolah Menengah. Jurnal Ekonomi dan Bisnis. https://doi.org/10.55049/jeb.v14i2.186
10. Sunarni, T., & Budiarto, D. (2014). Persepsi Efektivitas Pengajaran Bermedia Virtual Reality (VR).
11. Rachmadian, R.H. (2023). Sosialisasi Penggunaan Media Interactive Virtual Reality untuk Mendukung Pembelajaran Imersif Siswa di Kawasan Geopark Ijen. ABDIMASKU : JURNAL PENGABDIAN MASYARAKAT. https://doi.org/10.62411/ja.v6i3.1329
12. Paramita, A., Maryati, I., & Tjahjono, L.M. (2023). Perancangan Infrastruktur Teknologi Informasi Untuk Aplikasi Penilaian Kolaboratif Pada Perguruan Tinggi. Technomedia Journal. https://doi.org/10.33050/tmj.v8i1.1933
13. Muntari, M., Purwoko, A.A., Savalas, L.R., & Wildan, W. (2018). Pembelajaran Berbasis Proyek Untuk Meningkatkan Keterampilan Proses Sains Dan Berpikir Kritis Siswa. Jurnal Pendidikan dan Pengabdian Masyarakat. https://doi.org/10.29303/jppm.v1i1.502
14. Elmasari, Y. (2022). Inovasi Pembelajaran Metakognitif Berbasis Softskill Pada Pendidikan Vokasi Dalam Mendukung Dunia Industri 4.0. JIPI (Jurnal Ilmiah Penelitian dan Pembelajaran Informatika). https://doi.org/10.29100/jipi.v7i4.3645
15. Asbari, M., Wijayanti, L.M., Hyun, C.C., Imelda, D., Yanthy, E., & Purwanto, A. (2020). Hard Skills atau Soft Skills: Manakah yang lebih penting bagi inovasi guru. Edumaspul: Jurnal Pendidikan. https://doi.org/10.33487/EDUMASPUL.V4I1.333
16. Apriyani, D., Sudana, I.M., & Krisnawati, M. (2020). Keutamaan Soft Skills Bagi Siswa Sekolah Menengah Kejuruan. https://doi.org/10.15294/TEKNOBUGA.V8I2.29117
17. Wibowo, N. (2016). Upaya Memperkecil Kesenjangan Kompetensi Lulusan Sekolah Menengah Kejuruan dengan Tuntutan Dunia Industri. Jurnal Pendidikan Teknologi dan Kejuruan, 23, 45-59. https://doi.org/10.21831/JPTK.V23I1.9354
18. Pracihara, B.S. (2017). Instruksi Presiden No 9 Tahun 2016 (Revitalisasi Smk) Memacu Smk Bidang Seni dan Industri Kreatif dalam Pengembangan Ekonomi Kreatif.
19. Nagel, J.F. (2020). Peningkatan SDM Indonesia yang Berdaya Saing melalui Pendidikan di Era Transformasi Digital dan Teknologi yang Berkelanjutan.
20. Wakhidah, E.N., Sulaeman, M., Metris, D., Priambodo, A., & Prakoso, R.D. (2024). Peran Artificial Intelligence Dalam Transformasi Sumber Daya Manusia Pendidikan: Peningkatan Kualitas Vs Penggantian. Journal Development. https://doi.org/10.53978/jd.v12i1.383
21. Riyandi, M., Salim, A., & Qomario, Q. (2024). Efektivitas Program AI dalam Meningkatkan Kemampuan Siswa di Orbit Future Academy. Journal of Education Research. https://doi.org/10.37985/jer.v5i2.1101
22. Putri Supriadi, S.R., Haedi, S.U., & Chusni, M.M. (2022). Inovasi pembelajaran berbasis teknologi Artificial Intelligence dalam Pendidikan di era industry 4.0 dan society 5.0. Jurnal Penelitian Sains dan Pendidikan (JPSP). https://doi.org/10.23971/jpsp.v2i2.4036
23. Sodik, A.S. (2024). Peran Kecerdasan Buatan (Artificial Intelligence) dalam Mendorong Inovasi Manajemen Pendidikan Islam di Era Revolusi Industri 4.0. https://doi.org/10.51614/annaba.v7i1.388
24. Burhanudin, J. (2020). Kolaborasi dan Inovasi Berkelanjutan Penyelenggaraan Pendidikan Bermutu: Suatu Analisis Urgensi Dewan Pendidikan di Kabupaten Garut. https://doi.org/10.38204/ATRABIS.V6I1.421

25. Nugraha, A. (2019). Pentingnya Pendidikan Berkelanjutan Di Era Revolusi Indutri 4.0. Majalah Ilmiah Pelita Ilmu. https://doi.org/10.37849/mipi.v2i1.118
26. Lase, D. (2019). Pendidikan di Era Revolusi Industri 4.0. SUNDERMANN: Jurnal Ilmiah Teologi, Pendidikan, Sains, Humaniora dan Kebudayaan. https://doi.org/10.36588/sundermann.v1i1.18
27. Wong-A-Foe, D. (2023). Navigating the Implications of AI in Indonesian Education: Tutors, Governance, and Ethical Perspectives. In: Anutariya, C., Bonsangue, M.M. (eds) Data Science and Artificial Intelligence. DSAI 2023. Communications in Computer and Information Science, vol 1942. Springer, Singapore. https://doi.org/10.1007/978-981-99-7969-1_26
28. Goode, K., Kim, H.M.: Indonesia's AI promise in perspective. Center Secur. Emerg. Technol. 28 (2021)
29. Das, K., et al.: The digital archipelago: how online commerce is driving Indonesia's economic development. McKinsey Company, 1–72 (2018)
30. Hermawan, H.D., Deswila, N., Yunita, D.N.: Implementation of ICT in education in Indonesia during 2004–2017. In: 2018 International Symposium on Educational Technology (ISET). IEEE (2018)
31. Silitonga, L.M., & Suciati, S. (2024). Pelatihan AI Based Education untuk Pemberdayaan Guru SMAN 1 Kabupaten Blora. E-Dimas: Jurnal Pengabdian kepada Masyarakat. https://doi.org/10.26877/e-dimas.v15i2.19080
32. Utamy, R., Ahmad, S., & Eddy, S. (2020). Implementasi Manajemen Sumber Daya Manusia. Journal of Education Research. https://doi.org/10.37985/jer.v1i3.26
33. Katuuk, D.A. (2014). Manajemen Implementasi Kurikulum: Strategi Penguatanimplementasi Kurikulum 2013. International Conference on Principles and Practice of Constraint Programming. https://doi.org/10.21831/CP.V1I1.1858
34. Jayawardana, H.B. (2023). Potensi Penerapan Pembelajaran Berbasis AI (Artificial Intelligence) di PAUD. JECIE (Journal of Early Childhood and Inclusive Education). https://doi.org/10.31537/jecie.v7i1.1515
35. Yahya, M., Wahyudi, & Hidayat, A. (2023). Implementasi Artificial Intelligence (AI) di Bidang Pendidikan Kejuruan Pada Era Revolusi Industri 4.0. SEMINAR NASIONAL DIES NATALIS 62. https://doi.org/10.59562/semnasdies.v1i1.794
36. Alkhalifi, Y., Rizal, K., Alam, N., & Amir (2024). Pemanfaatan Dan Peningkatan Kewaspadaan Teknologi Artificial Intelligence Bagi Karang Taruna Tegal Parang, Jakarta Selatan. Jurnal Pengabdian Kolaborasi dan Inovasi IPTEKS. https://doi.org/10.59407/jpki2.v2i3.807