Utilization of big data and artificial intelligence on quality education management and its implications on school sustainability

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C H R O N I C L E	A B S T R A C T
	Currently, school sustainability is the focus of attention of all parties, including education quality management experts, which is related to schools' weaknesses in using big data and artificial intelligence (AI). The aim of this research is to analyze the role of using big data and AI in improving the quality of education quality management in Indonesia and its impact on school sustainability. The research design uses a quantitative approach, especially correlational, verification or hypothesis testing based on empirical data in the field. The research population was all teachers, principals and high school supervisors in Palangkaraya City, Central Kalimanan, totaling around 5,423 people. The sample size used the Hair formula and obtained a sample size of 178 people. Data was collected using a questionnaire which was distributed to selected samples using a Google form. Primary data was analyzed using SMART PLS. The results shows that the use of big data had an impact on the quality education management, it also has an impact on school sustainability, while artificial intelligence had an impact on the quality education management, it also had an impact on school sustainability, In addition, quality education management had an impact on school sustainability and it mediated the relationship between the use of big data and school sustainability, and finally, quality education management mediated the relationship between artificial intelligence and school sustainability.

1. Introduction

Big data and artificial intelligence (AI) are two technologies that are developing rapidly in the era of industrial revolution 4.0 (Zarifis & Fu, 2023). Big data is a very large, complex and diverse set of data that cannot be processed by traditional means (Kamyab et al., 2023). AI is a branch of computer science that allows machines to imitate human abilities in learning, thinking, and adapting (Nadkarni et al., 2023). These two technologies have great potential to improve the quality of education quality management in Indonesia (Umkabu, 2023). Quality education management is the process of planning, organizing, controlling and improving the quality of education systematically and continuously. Quality education is related to relevance, effectiveness, efficiency, accountability and stakeholder satisfaction (Khasanah et al., 2023).

Quality education is expected to create competent, creative, and competitive human resources. One of the challenges in quality management is how to manage data and information that continues to increase and vary from various sources, such as data on students, teachers, schools, curriculum, learning outcomes, evaluations, etc. (Fangqin, 2024). This data and information needs to be analyzed, interpreted and utilized to make appropriate and strategic decisions in improving the quality of education (Wang, 2024).

This is where the role of big data and AI can be utilized. With big data and AI, educational data and information can be processed quickly, accurately and intelligently (Liu & Jian, 2024). Big data and AI can help identify patterns, trends,

relationships and anomalies in Education data (Zhang, 2024). Big data and AI can also help provide innovative and adaptive solutions, recommendations and predictions to improve the quality of education (Wiek et al., 2014). The use of big data and AI for the quality of education also has implications for school sustainability (Sucuoğlu & Erdem, 2021). School sustainability is the school's ability to survive, develop and contribute to achieving sustainable development goals (SDGs) (Mitarlis et al., 2023). SDGs is a global agenda containing 17 goals and 169 targets which are expected to be achieved by 2030. SDGs focus on three aspects, namely environmental, social and economic (Amorós Molina et al., 2023). With big data and AI, schools can improve their performance, quality and competitiveness in providing quality education services (Filgueiras, 2023). Schools can also increase the capacity, skills and competence of their human resources in facing global challenges (Arora & Sharma, 2023). Schools can also increase participation, collaboration and partnerships with various parties in realizing sustainable development. There are aspects that underline the importance of this research, including:

1. Improving the Quality of Education Quality Management: This research has the potential to offer in-depth insight into how the use of big data and AI can be applied effectively to improve the quality of education quality management in Indonesia. These findings can pave the way for the development of more efficient and adaptive strategies, policies and practices in managing educational data and information.

2. Developing Human Resource Skills and Competencies: By understanding how big data and AI influence the learning process, this research can help educational institutions and educators improve the skills and competencies of human resources, both students, teachers and school supervisors. These skills and competencies include analytical, creative, innovative, collaborative and adaptable abilities to change.

3. Increasing School Sustainability: The implications of this research can help improve school sustainability in achieving sustainable development goals (SDGs). By utilizing big data and AI, schools can improve their performance, quality and competitiveness in providing quality education services. Schools can also increase participation, collaboration and partnerships with various parties in realizing sustainable development.

4. Development of Science and Technology: The findings of this research can play an important role in shaping more advanced and relevant science and technology that meets today's educational needs. This research can become a basis for further research and development of innovation in the fields of big data, AI and education.

This research was motivated by several driving factors:

1. Improving the Quality of Education: The desire to improve the quality of education is the main motivation. By utilizing big data and AI, we can facilitate improving the quality of education quality management, which is related to relevance, effectiveness, efficiency, accountability and stakeholder satisfaction.

2. Leveraging Technology: The integration of information technology is pervasive in almost every aspect of modern life, including education. Motivation to unlock the full potential of technology in education is essential to align educational practices with contemporary times.

3. Facing Global Challenges: Global challenges, such as climate change, poverty, inequality and conflict, require innovative and adaptive solutions. The motivation to face this global challenge aims to create sustainable development and prosperity for all.

4. Contributing to Knowledge: This research is expected to produce new insights and additional knowledge in the fields of big data, AI, and education, so that it can become a source of inspiration and reference for researchers, practitioners, and policy makers.

With its great significance and strong motivation, this research is ready to make a significant contribution to improving the quality of education quality management and school sustainability in Indonesia, as well as providing valuable guidance for educational practitioners and policy makers. Based on the background above, this research aims to:

1. Analyzing the role of using big data and AI in improving the quality of education quality management in Indonesia.

2. Analyzing the impact of using big data and AI on school sustainability in Indonesia.

3. Provide strategic recommendations to increase the use of big data and AI in education quality management and school sustainability in Indonesia.

2. Literature Review and Hypothesis Development

2.1 Big Data and Artificial Intelligence (AI) in Education

Big Data and Artificial Intelligence (AI) have become a major topic of conversation in various sectors, including education. Big Data involves collecting, analyzing, and interpreting large amounts of data to uncover patterns and trends that can provide valuable insights. Several studies have shown the benefits of using big data and AI in education quality management. For example, research conducted by Oranga (2023) shows that the use of ChatGPT-based AI chatbots can increase students'

engagement, motivation and 21st century skills in learning. Demonstrates that the use of digital resources such as online textbooks, multimedia presentations, educational websites, and interactive simulations can enrich students' understanding of course material and facilitate independent learning.

Demonstrates that the use of data analysis tools can provide insight into student performance and assist educators in providing targeted support. Meanwhile, AI includes the development of intelligent algorithms that can process information, make decisions, and learn from experience without human intervention.

This research examines the application of big data to improve the quality of education in a high school in the United States.Based on previous research findings, the hypothesis proposed in this research is as follows:

H1: *The use of big data has an impact on the quality education managment.*

2.2 Utilization of Big Data and School Sustainability

Big data is a collection of data that is very large and complex, making it difficult to analyze with traditional methods. Big data can be used for various purposes, including in education. School sustainability is the school's ability to survive and develop in the long term. School sustainability can be achieved in various ways, one of which is by utilizing big data (Razzaq & Yang, 2023).

Big data can be used to improve school sustainability in various ways, including: (1) Big data can be used to increase the efficiency and effectiveness of the learning process, school management, and management of infrastructure. (2) Big data can be used to improve the quality of learning, human resources and school management (Uralovich et al., 2023). Big data can be used to increase public participation in education. By utilizing big data, schools can improve their sustainability in various ways. This will help schools to become more sustainable and provide quality education to their students (Gyamfi et al., 2023).

Big data has the potential to have a significant impact on school sustainability. By utilizing big data, schools can improve their sustainability in various ways. This will help schools to become more sustainable and provide quality education to their students (Etzion & Aragon-Correa, 2016).Based on previous research findings, the hypothesis proposed in this research is as follows:

H₂: *The use of big data has an impact on school sustainability.*

2.3 Artificial Intelligence (AI) and Quality Education Quality Management

Artificial intelligence (AI) is a branch of computer science that studies the creation of intelligent agents, namely systems that can think and act like humans. AI has the potential to have a significant impact on various aspects of life, including education. Education quality management is a systematic and continuous process to ensure that all aspects of education meet predetermined quality standards. Quality education quality management can help schools to improve the quality of learning, human resources and school management (Luan et al., 2020).

Schools need to ensure that student and school data is stored securely and is not accessed by unauthorized parties. By overcoming these challenges, the application of AI in education quality management can have a positive impact on schools and students (Somasundaram et al., 2020). Considering the findings from previous research, this study puts forward the following hypothesis:

H₃: *Artificial intelligence (AI) has an impact on the quality of education management.*

2.4 Artificial Intelligence (AI) and School Sustainability

Education is one of the important pillars in sustainable development. Schools as educational institutions play an important role in producing quality and competitive human resources. Therefore, it is important for schools to apply artificial intelligence (AI) to improve school sustainability. School sustainability is the school's ability to survive and develop in the long term. School sustainability can be achieved in various ways, one of which is by utilizing AI (Pedro et al., 2019).

AI has the potential to have a significant impact on various aspects of life, including education. AI can help schools to improve their sustainability in various ways, including: (1) AI can help schools to improve the efficiency and effectiveness of the learning process, school management, and management of infrastructure. (2) AI can help schools improve the quality of learning, human resources and school management. (3) AI can help schools to increase community participation in education (Mhlanga, 2021).

AI has the potential to have a significant impact on school sustainability. By utilizing AI, schools can increase efficiency and effectiveness, quality and community participation in education. This will help schools to become more sustainable and provide quality education to their students (Thamik & Wu, 2022).Based on insights gained from previous research, this study presents the following hypothesis:

H₄: *Artificial Intelligence (AI) has an impact on School Sustainability.*

2.5 Quality education management and school sustainability

Education is one of the important pillars in the development of a nation. High quality education will produce quality human resources. Therefore, improving the quality of education is one of the priorities of the government and society. One important factor in improving the quality of education is education quality management. Education quality management is a systematic and continuous process to ensure that all aspects of education meet predetermined quality standards (Đordevic et al., 2021).

Quality education management can provide benefits for schools, students and society. For schools, education quality management can help improve the efficiency and effectiveness of the learning process. For students, education quality management can help improve academic achievement and life skills. For society, education quality management can help produce quality and competitive human resources. School sustainability is the school's ability to survive and develop in the long term. School sustainability can be achieved in various ways, one of which is by implementing education quality management (Olmos-Gómez et al., 2020).

Quality education management has an important role in school sustainability. Quality education management can help schools become more sustainable and provide quality education for their students (Silva et al., 2021). By considering the results of previous research investigations, this study proposes the following hypothesis:

H5:*The quality of education management influences school sustainability.*

H6: *Educational quality management mediates the relationship between the use of big data and school sustainability.*

H7: *Educational quality management mediates the relationship between artificial intelligence (AI) and school sustainability.*

3. Methodology

This research will use a quantitative research approach with a correlational and verification survey design. This approach allows hypothesis testing based on empirical data in the field to analyze the influence of big data and AI on the quality of education quality management and its implications for school sustainability. The population of this study was all teachers, principals and supervisors of high school schools in Palangkaraya City, Central Kalimantan, totaling around 5,423 people. The sample size for this study was 178 people, which was determined using the Hair formula. The research sample will be selected randomly using stratified random sampling techniques to represent the relevant school population.

3.1 Research variable

In this research, a combination of measurement instruments that have been validated from previous research using a Likert scale and instruments newly developed by the author will be used to assess research variables. This study will focus on the following key variables:

1. Utilization of Big Data

This variable aims to measure the extent to which big data is used in the education system. This includes assessing the extent to which big data, such as student data, teacher data, school data, curriculum data, learning outcome data, and other data, is collected, analyzed, and used to improve the quality of education quality management. It also includes assessing the extent to which big data, such as machine learning algorithms, recommendation systems, adaptive systems, or other intelligent systems, are applied to support learning, assessment, and evaluation processes.

2. Artificial Intelligence (AI)

AI variables can be used to develop adaptive learning, namely learning that is tailored to students' individual needs and abilities. For example, AI variables can be used for: A school useAI variables to track individual student learning progress. This data is used to provide more targeted learning support.The use of AI variables in schools is still in its early stages. However, the potential benefits are enormous. Schools need to start developing their capacity to utilize AI variables effectively.

3. Quality education management

This variable aims to measure the extent to which educational quality management is achieved in the education system. This includes assessing the extent to which quality standards, such as competency standards, content standards, process standards, assessment standards, facilities and infrastructure standards, management standards, financing standards and other standards, are met in the education system. This also includes assessing the extent to which quality indicators, such as efficiency, effectiveness, relevance, affordability, equity, accountability and other indicators, are achieved in the education system.

4. School Sustainability

This variable aims to measure the extent to which school sustainability is realized in the education system. This includes assessing the extent to which the school is able to survive, develop and adapt to environmental, social, economic and

technological changes. This also includes assessing the extent to which the school can make a positive contribution to sustainable development, such as creating a healthy, fair and prosperous environment for all stakeholders.

The integration of Likert scale-based instruments from previous research and newly developed Likert scale items ensures a thorough and context-specific evaluation of research variables (see Table 1).

3.2 Data Collection Procedures

This research will collect data by providing a questionnaire designed for the use of big data, artificial intelligence (AI), education quality management and school sustainability. These questionnaires will be carefully developed, each designed to accurately measure a particular construct. Prior to primary data collection, pilot testing will be conducted to refine the questionnaire based on feedback. A diverse sample of participants will be recruited, ensuring representativeness of the target population, and informed consent will be obtained. Participants will fill out the questionnaire independently, and the data will be verified for accuracy and completeness. The data collected will be stored securely, and appropriate statistical analysis techniques will be used to explore relationships between variables. Ethical considerations, including participant privacy and confidentiality, will be upheld throughout the data collection process, and research findings will be reported comprehensively while maintaining participant anonymity.

Table 1
Research instrument

Variable	Indicator		Source
Utilization of Big Data	1.	Collection and analysis of big data on students, teachers, schools, curricula and learning outcomes.	(Konovalova, 2023) (Mansour, 2022)
	2.	Application of machine learning algorithms for learning recommendations tailored to student needs.	
	3.	Utilization of recommendation systems, adaptive systems, and other intelligent systems in the learning process.	
	4.	Use of big data for evaluation and continuous improvement in education quality management.	
	5.	Involvement of teachers and students in technology-based learning systems that support big data.	
	6.	Perceptions of teachers, students and institutions regarding the positive impact of using big data on the educational process.	
Artificial Intelligence (AI)	1.	Schools have adequate access to AI technology, such as hardware, software and human resources.	(Pellas, 2023) (Ghasemaghaei, 2018)
	2.	Schools have sufficient skills and knowledge to develop, implement and manage AI systems. These skills can be acquired through training, seminars or online courses.	
	3.	Schools have policies and regulations that support the development and use of AI. These policies may cover things like data security and privacy, ethical use of AI, and responsible use of AI.	
	4.	Schools or universities utilize AI for various purposes, such as adaptive learning, learning assistants, learning assessment, and school management.	
Quality Education Quality Management	1.	Fulfillment of quality standards, such as competency standards, content standards, process standards, assessment standards, etc.	(Jasti et al., 2022) (Kanji et al., 1999)
	2.	Achievement of quality indicators, such as efficiency, effectiveness, relevance, affordability, equality, accountability, etc.	
	3.	Evaluation and continuous improvement of the quality of education quality management	
	4.	Application of innovation in education quality management to improve quality.	
	5.	Active stakeholder participation in the development and evaluation of education quality standards.	
	6.	Perceptions of teachers, students and institutions regarding the level of quality of education quality management in the system.	
School Sustainability	1.	The school's ability to survive and adapt to environmental, social, economic and technological changes.	(Waltner et al., 2019) (Lambrechts et al., 2015)
	2.	The school's positive contribution to sustainable development, such as creating a healthy and fair environment.	
	3.	Development and implementation of school environmental policies that support sustainability.	
	4.	Encourage participation and awareness of students, teachers and school staff towards sustainable practices.	
	5.	The school's efforts to create a sustainable learning environment.	
	6.	Stakeholder perceptions of school contributions to sustainable development.	

4. Results

4.1 Validity and reliability

Table 2 presents an analysis of several constructs, related measurement items, and various statistical indicators. Four constructs are studied in this analysis: Utilization of Big Data, Artificial Intelligence (AI), Quality of Education Management, and School Sustainability. "Utilization of Big Data", six measurement items (PBD1 to PBD6) were evaluated. Outward loading values ranged from 0.768 to 0.962, indicating that most items have a strong relationship with the underlying construct. The Cronbach's Alpha coefficient of 0.957 indicates high internal consistency, indicating that the items can be relied on to measure the desired construct. Similarly, the rho_A and CR values are 0.957 and 0.957, respectively, which further confirms the reliability of the constructs. The AVE value of 0.829 indicates that the items collectively explain most of the construct variance, reflecting good construct validity. For the "Artificial Intelligence (AI)" construct, four measurement items (AI1 to AI4) were examined. Although some objects show quite high external loading values, ranging from 0.897 to 0.924. The

Cronbach's Alpha coefficient of 0.932 indicates high internal consistency, and the rho_A and CR values (0.932 and 0.951, respectively) confirm the reliability of the construct. The AVE value of 0.830 indicates good construct validity. The "Quality education management" construct consists of six measurement items (KMMP1 to KMMP6). This item displays external loading values ranging from 0.792 to 0.910, indicating a strong relationship with the construct. The high values of Cronbach's Alpha (0.939), rho_A (0.940), and CR (0.951) indicate excellent internal consistency and reliability. In addition, the AVE value of 0.766 indicates solid construct validity. Finally, the "School Sustainability" construct consists of six measurement items (SS1 to SS6). Although some objects have slightly lower external loading values, most are still acceptable, ranging from 0.819 to 0.914. The Cronbach's Alpha value (0.943) reflects good internal consistency, while the rho_A (0.943) and CR (0.955) values confirm the construct's reliability. However, although acceptable, the AVE value of 0.779 indicates that the items collectively explain a relatively lower proportion of construct variance than other constructs, indicating moderate construct validity.

Table 2

Confirmatory factor analysis

Build	Goods	Outer Loading	Cronbach's Alpha	rho_A	Cr	road
Utilization of Big Data	PBD1	0.962	0.957	0.957	0.966	0.829
	PBD2	0.944				
	PBD3	0.869				
	PBD4	0.948				
	PBD5	0.954				
	PBD6	0.768				
Artificial Intelligence	AI1	0.916	0.932	0.932	0.951	0.830
	AI2	0.908				
	AI3	0.897				
	AI4	0.924				
Quality education management	KMMP1	0.792	0.939	0.940	0.951	0.766
	KMMP2	0.893				
	KMMP3	0.873				
	KMMP4	0.910				
	KMMP5	0.899				
	KMMP6	0.879				
School Sustainability	SS1	0.914	0.943	0.943	0.955	0.779
	SS2	0.877				
	SS3	0.898				
	SS4	0.901				
	SS5	0.886				
	SS6	0.819				

4.2 Hypothesis test

Table 3 presents the results of hypothesis testing of various relationships between constructs in research and relevant statistical indicators.

Table 3

Path analysis

Hypothesis	Build*)	Original Sample	STDEV	T statistics	P value	Results
H1	PBD → KMMP	0.384	0.085	4,528	0,000	Accepted
H2	PBD → SS	0.353	0.072	4,926	0,000	Accepted
H3	AI → KMMP	0.488	0.083	5,909	0,000	Accepted
H4	AI → SS	0.235	0.082	2,847	0.005	Accepted
H5	KMMP → SS	0.339	0.081	2,644	0,000	Accepted
H6	KMMP → PBD → SS	0.130	0.048	2,735	0.006	Accepted
H7	KMMP → AI → SS	0.166	0.047	3,547	0,000	Accepted

*) PBD=Utilization of Big Data; AI=Artificial Intelligence; KMMP=Quality Education Quality Management; SS=School Sustainability

Hypothesis H1 which states that there is a relationship between the Use of Big Data (PBD) and the quality of education management (KMMP) is supported by the data. The coefficient value of 0.384 is statistically significant, with a T statistics of 4.528 (p=0.000), confirming the acceptance of this hypothesis. Likewise, Hypothesis H2, which states that there is a relationship between the Use of Big Data (PBD) and School Sustainability (SS), is also supported. The coefficient value of 0.353 is statistically significant, with a T statistic of 4.926 (p=0.000), so this hypothesis is accepted. Hypothesis H3 which proposes a relationship between Artificial Intelligence (AI) and quality of education management (KMMP) also receives support from this data. The coefficient value of 0.488 is statistically significant, with a T statistic of 5.909 (p=0.000) which indicates the acceptance of this hypothesis. Likewise, the data supports Hypothesis H4 which states that there is a relationship between Artificial Intelligence (AI) and School Sustainability (SS). The coefficient value of 0.235 is statistically significant, with a T statistic of 2.847 (p=0.005), so this hypothesis is accepted. Hypothesis H5 states that there is a relationship between the quality of education management (KMMP) and School Sustainability (SS). The coefficient value of 0.339 is statistically

significant, with a T statistic of 2.644 (p=0.000), supporting the acceptance of this hypothesis. Hypothesis H6 which involves a sequential relationship from quality of education management (KMMP) to Utilization of Big Data (PBD) and then to School Sustainability (SS) is accepted. The coefficient value of 0.130 is statistically significant with a T statistic of 2.735 (p=0.006) which shows support for the hypothesis. However, Hypothesis H7 which proposes a sequential relationship from quality of education management (KMMP) to Artificial Intelligence (AI) and then to School Sustainability (SS) is supported by the data. The coefficient value of 0.166 is statistically significant, with a T statistic of 3.547 (p=0.000), so the hypothesis is accepted. The results showed that most of the hypotheses were accepted, indicating significant relationships between the constructs as specified.

5. Discussion

The results of hypothesis testing support the acceptance of H1 and H2. Hypothesis H1 states that "The use of Big Data has an impact on the Quality of Education Quality Management", the analysis reveals a statistically significant positive relationship between these two constructs. The coefficient value is 0.384 with a T statistic of 4.528 (p < 0.000) indicating that there is a significant influence of the use of big data on the quality of education quality management. Likewise, Hypothesis H2 states that "The use of Big Data has an effect on School Sustainability", and data analysis also supports this hypothesis. The coefficient value is 0.353 with a T statistics of 4.926 (p < 0.000) indicating that there is a statistically significant positive relationship between the use of big data and school sustainability. This shows that when utilizing big data, schools can improve their sustainability in various ways. This will help schools become more sustainable and provide quality education to their students. In conclusion, the results of this study confirm that big data can be used to improve the efficiency and effectiveness of the learning process, school management, and management of infrastructure. This finding underscores its importancebig data can be used to improve the quality of education management processes, such as data collection, data analysis and decision making.

The implications of this research finding are significant both in theory and practice. The study confirms the positive impact of the use of big data on the quality of education quality management and school sustainability advances educational theory by emphasizing the important role of technology in modern learning environments. This underscores the need to increase the efficiency and effectiveness of education quality management processes, such as planning, implementation and evaluation. From a practical standpoint, these findings provide clear guidance for academic institutions and educators. Curricula can be redesigned to incorporate more AI-based learning resources, thereby fostering more engaging and engaging learning experiences (Hadi et al., 2019; Hamdan & Basrowi, 2024; Junaidi, Basrowi, et al., 2024; Purwaningsih et al., 2024). Educators can undergo training to better utilize technology in their teaching, allowing them to adapt their methods to use digital tools. In addition, these findings show big data can be used to develop adaptive learning, namely learning that is tailored to students' individual needs and abilities. However, it is important to address the problem to develop a more effective communication and collaboration system with the community (Hadi et al., 2019; Junaidi, Basrowi, et al., 2024; Yusuf et al., 2024). More effective communication and collaboration systems can help schools involve the community in education. The application of big data in education requires adequate resources, both in terms of technology, skills and budget. In essence, this research highlights the use of big data in forming a more effective and fair education system that is suitable for the digital era (Hamdan & Basrowi, 2024; Junaidi, Masdar, et al., 2024; Miar et al., 2024).

Research acceptance of hypotheses H3 and H4 has significant implications for both theoretical understanding and practical implementation of educational strategies. From a theoretical perspective, these findings enrich educational theory by highlighting the important role of Artificial Intelligence in the quality of educational quality management. This underlines the idea that AI can be used to increase the efficiency and effectiveness of education quality management processes, such as planning, implementation and evaluation. These results make a significant contribution to our understanding of cognitive development in educational contexts. Artificial intelligence, which includes to develop a more accurate and comprehensive data management system. This reinforces its importance that a more accurate and comprehensive data management system can help schools collect and analyze data better (I Gusti Gede Heru Marwanto Basrowi, 2020).

In practice, to improve data accuracy and precision. AI can be used to automate repetitive and time-consuming tasks, such as data collection, data analysis, and reporting. This can help schools save time and energy, so we can focus more on more important tasks. AI can be used to improve the accuracy and precision of data, so schools can make more informed decisions. AI can also be used to develop more effective learning models, so that students can learn better (Basrowi & Utami, 2020, 2023).

Besides, AI has the potential to have a significant impact on the quality of education anagement. By utilizing AI, schools can improve the quality of education quality management in various ways, so that they can provide quality education for their students. In short, the acceptance of hypotheses H3 and H4 underlines the importance of artificial intelligence towards school sustainability. These findings emphasize that integrating educational quality management into school sustainability can produce results. High quality education management can help schools improve the efficiency and effectiveness of the learning process, school management, and management of infrastructure. This will help schools save costs and resources, so that they can survive and develop in the long term. High quality education quality management can help schools improve the quality of learning, human resources and school management. This will help schools provide quality education for their students, so that they can increase students' competitiveness in the future (Kharis et al., 2024; Lisaria et al., 2024).

Acceptance of hypotheses H5 and H6 and H7 reveals important insights into the complex dynamics between the use of big data, artificial intelligence, educational quality management, and school sustainability. First, hypothesis H5 which states that "Quality of Education Quality Management influences School Sustainability" is supported by data.An effective data management system can help schools to collect and analyze data better.Second, H6 which states that "Education quality management mediates the relationship between Big Data Utilization and School Sustainability" is also accepted. These findings indicate that the quality of education quality management has an indirect effect on the use of big data through its positive impact on school sustainability.The quality of education quality management can mediate the relationship between the use of big data and school sustainability. High quality education quality management can help schools to utilize big data effectively, so as to increase school sustainability. In contrast, H7 which states that "the quality of educational quality management mediates the relationship between artificial intelligence (AI) and school sustainability," is supported by data.Schools with high levels of educational quality management can use AI to identify individual student needs and abilities. AI can also be used to develop more relevant and effective learning materials (Himmatul et al., 2024; Himmatul & Junaedi, 2024).

These findings have important implications for educational practice. First, A more accurate and objective decision-making system can help schools make more informed decisions based on big data. Second, schools can use big data to identify individual students' needs and abilities. Big data can also be used to develop more relevant and effective learning materials. Finally, schools can also increase the participation of all stakeholders, so that they can get support from all parties in developing the school. These results highlight complex interactions. Overall, AI has the potential to improve the quality of educational quality management in various ways.

6. Conclusion

This research produced several significant findings regarding the relationship between the use of big data, artificial intelligence, quality of education quality management, and school sustainability. Hypothesis H1The use of Big Data has an impact on the Quality of Education Quality Management, H2The use of big data has an impact on School Sustainability, H3Artificial Intelligence (AI) has an impact on the Quality of Education Quality Management, H4 Artificial Intelligence (AI) has an impact on School Sustainability, H5 Quality of Education Quality Management has an impact on School Sustainability, H6 Quality of Education Quality Management mediates the relationship between Big Data Utilization and School Sustainability, and H7 Quality Education quality management mediates the relationship between artificial intelligence (AI) and school sustainability.

6.1 Theoretical and Practical Implications

The theoretical implications of these findings include:

1. Utilizing big data requires adequate resources, both in terms of technology, skills and budget.

2. Advanced data analysis systems can help schools analyze AI data more quickly and accurately.

3. Schools with high levels of education quality management can use AI to identify processes that are inefficient and need to be improved. AI can also be used to develop automation systems that can save time and effort.

4. Sustainable schools can provide quality education for students, thereby increasing students' competitiveness in the future

In addition, these results contribute to our understanding of cognitive development in educational contexts, underscoring the importance of utilizing big data and artificial intelligence within schools, bIG data can also be used to develop more relevant and effective learning materials.

Practically speaking, schools that apply big data and AI can develop more relevant and effective learning materials, develop more adaptive learning systems, and develop more accurate and objective assessment systems. This can improve the quality of learning and student competitiveness.

6.2 Limitations

Despite these significant findings, the study has several limitations:

1. Data were collected from a specific sample, and the generalizability of the results to a broader population may be limited.

2. These studies rely on self-report measures of certain constructs, which may introduce subjectivity and potential response bias. The cross-sectional nature of the data also prevents us from drawing causal conclusions. Longitudinal studies would be useful to explore the dynamics of this relationship over time.

3. This research focuses on specific constructs and other relevant variables that may play a role in academic achievement that were not considered in this analysis.

Based on the findings and limitations of this research, several recommendations for future research in the field of education and learning can be put forward:

1. Longitudinal Study: Conduct a longitudinal study to investigate the temporal relationship between the use of big data, artificial intelligence, quality of education quality management. This will provide insight into how this relationship developed and help establish a cause-and-effect relationship.

2. Diverse Demographics: Expand the research to a variety of demographic groups and educational settings to assess the generalizability of the findings. Investigating whether these relationships vary across different age groups, cultures, or disciplines would provide a more comprehensive understanding.

3. Qualitative Approach: Use qualitative research methods, such as in-depth interviews or focus groups, to better understand the mechanisms by which the use of big data and artificial intelligence impacts the quality of education quality management and school sustainability. Qualitative insights can complement quantitative findings.

4. Mediation Path: Explore further the mediation path that influences school sustainability. Investigate additional factors that can mediate the relationship between the use of big data, artificial intelligence, educational quality management and school sustainability to provide a more comprehensive model of academic success.

5. Intervention Studies: Schools that apply big data and AI can manage school resources more efficiently and effectively, monitor school performance more accurately and objectively, and develop school programs and policies that are more appropriate to the needs of students and schools. This can increase the efficiency and effectiveness of school management.

6. Digital Learning Environments: Given the increasing importance of digital learning environments, research should continue to explore the evolving role of technology in education. Investigate new technologies, adaptive learning platforms, and their impact on student learning and achievement.

7. Partnership: Schools that apply big data and AI can develop more effective and efficient collaboration programs, improve communication and collaboration between schools, parents and the community, and increase parent and community participation in education. This can improve partnerships between schools, parents and the community.

8. Digital Equity: SOverall, the use of big data and AI can help schools become higher quality, more efficient and more sustainable.

9. Interdisciplinary Research: Encourages multidisciplinary research collaboration between educators, psychologists, technologists, and other related fields to gain a more holistic understanding of the complex dynamics at play in education.

10. International Comparison: Compare education systems and practices between countries to identify best practices in encouraging the use of big data, artificial intelligence, and school sustainability. Cross-cultural studies can provide valuable insights.

By taking these recommendations into account, future research can continue to increase our knowledge of how educational practices and technology influence learning outcomes, ultimately improving educational systems and student success.

References

Amorós Molina, Á., Helldén, D., Alfvén, T., Niemi, M., Leander, K., Nordenstedt, H., Rehn, C., Ndejjo, R., Wanyenze, R., & Biermann, O. (2023). Integrating the United Nations sustainable development goals into higher education globally: a scoping review. *Global Health Action*, *16*(1), 2190649.

Arora, M., & Sharma, R. L. (2023). Artificial intelligence and big data: ontological and communicative perspectives in multi-sectoral scenarios of modern businesses. *foresight*, *25*(1), 126–143.

Basrowi, B., & Utami, P. (2020). Building Strategic Planning Models Based on Digital Technology in the Sharia Capital Market. *Journal of Advanced Research in Law and Economics; Vol 11 No 3 (2020): JARLE Volume XI Issue 3(49) Summer 2020DO - 10.14505/jarle.v11.3(49).06*.

Basrowi, B., & Utami, P. (2023). Development of Market Distribution through Digital Marketing Transformation Trends to Maximize Sales Turnover for Traditional Beverage Products. *Journal of Distribution Science*, *21*(8), 57–68. https://doi.org/10.15722/jds.21.08.202308.57

Đordevic, A., Klochkov, Y., Arsovski, S., Stefanovic, N., Shamina, L., & Pavlovic, A. (2021). The impact of ict support and the efqm criteria on sustainable business excellence in higher education institutions. *Sustainability (Switzerland)*, *13*(14). https://doi.org/10.3390/su13147523

Etzion, D., & Aragon-Correa, J. A. (2016). Big data, management, and sustainability: Strategic opportunities ahead. In *Organization & Environment* (Vol. 29, Nomor 2, hal. 147–155). Sage Publications Sage CA: Los Angeles, CA.

Fangqin, M. (2024). The Application of Big Data Technology in Educational Management in Higher Education. *Applied Mathematics and Nonlinear Sciences*, *9*(1), 1–20. https://doi.org/https://doi.org/10.2478/amns.2023.2.01078

Filgueiras, F. (2023). Artificial intelligence and education governance. *Education, Citizenship and Social Justice*, 17461979231160674.

Ghasemaghaei, M. (2018). Improving organizational performance through the use of big data. *Journal of Computer Information Systems*.

Gyamfi, B. A., Onifade, S. T., & Ofori, E. K. (2023). Synthesizing the impacts of information and communication technology advancement and educational developments on environmental sustainability: A comparative analyses of three economic blocs—BRICS, MINT, and G7 economies. *Sustainable Development*, *31*(2), 744–759.

Hadi, R., Shafrani, Y. S., Hilyatin, D. L., Riyadi, S., & Basrowi, B. (2019). Digital zakat management, transparency in zakat reporting, and the zakat payroll system toward zakat management accountability and its implications on zakat growth acceleration. *International Journal of Data and Network Science*, *8*(1), 103–108. https://doi.org/10.5267/j.ijdns.2018.12.005

Hamdan, H., & Basrowi, B. (2024). Do community entrepreneurial development shape the sustainability of tourist villages? Hamdana*. *Uncertain Supply Chain Management*, *12*(1), 407–422. https://doi.org/10.5267/j.uscm.2023.9.014

Himmatul, I., & Junaedi, A. (2024). *International Journal of Data and Network Science Understanding Roblox ' s business model and collaborative learning on participation in the deci- sion-making process : implications for enhancing cooperative literacy*. 8, 1247–1260. https://doi.org/10.5267/j.ijdns.2023.11.009

Himmatul, I., Nugroho, I., Mardian, T., Syakina, D., Suryo, A., Sutoto, A., & Junaidi, A. (2024). *Uncertain Supply Chain Management Enhancing company performance and profitability through agile practices : A comprehensive analysis of three key perspectives*. 12, 1205–1224. https://doi.org/10.5267/j.uscm.2023.11.014

I Gusti Gede Heru Marwanto Basrowi, S. (2020). The Influence of Culture and Social Structure on Political Behavior in the Election of Mayor of Kediri Indonesia. *International Journal of Advanced Science and Technology*, *29*(05 SE-Articles), 1035–1047.

Jasti, N. V. K., Venkateswaran, V., Kota, S., & Sangwan, K. S. (2022). A literature review on total quality management (models, frameworks, and tools and techniques) in higher education. *The TQM Journal*, *34*(5), 1298–1319.

Junaidi, A., Basrowi, B., Sabtohadi, J., Wibowo, A. M., Wiboho, S. S., Asgar, A., Pramono, E. P., & Yenti, E. (2024). The role of public administration and social media educational socialization in influencing public satisfaction on population services : The mediating role of population literacy awareness. *International Journal of Data and Network Science*, *8*(1), 345–356. https://doi.org/10.5267/j.ijdns.2023.9.019

Junaidi, A., Masdar, A. Zum, Basrowi, B., Robiatun, D., Situmorang, J. W., Lukas, A., Asgar, A., Herlina, L., Manulu, L. P., & Payung, L. (2024). Uncertain Supply Chain Management Enhancing sustainable soybean production in Indonesia : evaluating the environmental and economic benefits of MIGO technology for integrated supply chain sustainability. *Uncertain Supply Chain Managemen*, *12*(1), 221–234. https://doi.org/10.5267/j.uscm.2023.10.003

Kamyab, H., Khademi, T., Chelliapan, S., SaberiKamarposhti, M., Rezania, S., Yusuf, M., Farajnezhad, M., Abbas, M., Hun Jeon, B., & Ahn, Y. (2023). The latest innovative avenues for the utilization of artificial Intelligence and big data analytics in water resource management. *Results in Engineering*, *20*(March), 101566. https://doi.org/10.1016/j.rineng.2023.101566

Kanji, G. K., Malek, A., & Tambi, B. A. (1999). Total quality management in UK higher education institutions. *Total Quality Management*, *10*(1), 129–153.

Kharis, A., Masyhari, A., Suci, W., & Priatnasari, Y. (2024). *Uncertain Supply Chain Management Optimizing state revenue through government-driven supply chain efficiency and fair corporate taxation practices*. 12, 659–668. https://doi.org/10.5267/j.uscm.2024.1.018

Khasanah, U., Riyanto, Y., & Setyowati, S. (2023). Total Quality Management (TQM) in Education: School Quality Management for Quality Educational Services at Senior High Schools. *SAR Journal - Science and Research*, *6*(3), 211–216. https://doi.org/10.18421/sar63-10

Konovalova, M. (2023). Ai and Diplomacy: Challenges and Opportunities. *Journal of Liberty and International Affairs*, *9*(2), 520–530. https://doi.org/10.47305/JLIA2392699k

Lambrechts, W., Van Liedekerke, L., & Rymenams, S. (2015). Connecting sustainability initiatives with efficiency measures: an opportunity for business schools. *Central and Eastern European journal of management and economics*, *3*(2), 161–173.

Lisaria, R., Prapanca, D., Amatul, S., & Arifin, K. (2024). *Uncertain Supply Chain Management Forging a resilient pathway : Uncovering the relationship between the supply chain sustainability and the tax compliance , and the sustainable future of the micro , small , and medium enterprise*. 12, 1097–1112. https://doi.org/10.5267/j.uscm.2023.11.023

Liu, H., & Jian, H. (2024). Teaching reform and innovation of vocational development and employment guidance courses in colleges and universities based on random forest model. *Applied Mathematics and Nonlinear Sciences*, *3*(2), 1–17. https://doi.org/https://doi.org/10.2478/amns.2023.2.00229

Luan, H., Geczy, P., Lai, H., Gobert, J., Yang, S. J. H., Ogata, H., Baltes, J., Guerra, R., Li, P., & Tsai, C.-C. (2020). Challenges and future directions of big data and artificial intelligence in education. *Frontiers in psychology*, *11*, 580820.

Mansour, E. A. (2022). Big Data Analytics Changes in Health Care Industry. *Tehnicki Glasnik*, *16*(2), 182–186. https://doi.org/10.31803/tg-20220124132449

Mhlanga, D. (2021). Artificial intelligence in the industry 4.0, and its impact on poverty, innovation, infrastructure development, and the sustainable development goals: Lessons from emerging economies? *Sustainability*, *13*(11), 5788.

Miar, M., Rizani, A., Pardede, R. L., & Basrowi, B. (2024). Analysis of the effects of capital expenditure and supply chain on economic growth and their implications on the community welfare of districts and cities in central Kalimantan province. *Uncertain Supply Chain Management*, *12*(1), 489–504. https://doi.org/10.5267/j.uscm.2023.9.003

Mitarlis, Azizah, U., & Yonata, B. (2023). the integration of green chemistry principles in basic chemistry learning to support achievement of sustainable development goals (sdgs) through education. *Journal of Technology and Science Education*, *13*(1), 233–254. https://doi.org/10.3926/jotse.1892

Nadkarni, S., Kriechbaumer, F., Christodoulidou, N., & Rothenberger, M. (2023). Industry 4.0 applications towards sustainability in hospitality: First waves in the guest room. *Journal of Global Business Insights*, *8*(1), 31–48. https://doi.org/10.5038/2640-6489.8.1.1216

Olmos-Gómez, M. del C., Luque-Suárez, M., Ferrara, C., & Cuevas-Rincón, J. M. (2020). Analysis of psychometric properties of the quality and satisfaction questionnaire focused on sustainability in higher education. *Sustainability (Switzerland)*, *12*(19). https://doi.org/10.3390/su12198264

Oranga, J. (2023). benefits of artificial intelligence (chatgpt) in education and learning: is chat gpt helpful? *International Review of Practical Innovation, Technology and Green Energy (IRPITAGE)*, *3*(3), 46–50.

Pedro, F., Subosa, M., Rivas, A., & Valverde, P. (2019). *Artificial intelligence in education: Challenges and opportunities for sustainable development*.

Pellas, N. (2023). The influence of sociodemographic factors on students' attitudes toward AI-generated video content creation. *Smart Learning Environments*, *10*(1). https://doi.org/10.1186/s40561-023-00276-4

Purwaningsih, E., Muslikh, M., Suhaeri, S., & Basrowi, B. (2024). Utilizing blockchain technology in enhancing supply chain efficiency and export performance , and its implications on the financial performance of SMEs. *Uncertain Supply Chain Management*, *12*(1), 449–460. https://doi.org/10.5267/j.uscm.2023.9.007

Razzaq, A., & Yang, X. (2023). Digital finance and green growth in China: Appraising inclusive digital finance using web crawler technology and big data. *Technological Forecasting and Social Change*, *188*, 122262.

Silva, C. S., Magano, J., Matos, A., & Nogueira, T. (2021). Sustainable quality management systems in the current paradigm: The role of leadership. *Sustainability*, *13*(4), 2056.

Somasundaram, M., Mohamed Junaid, K. A., & Mangadu, S. (2020). Artificial intelligence (AI) enabled intelligent quality management system (IQMS) for personalized learning path. *Procedia Computer Science*, *172*(2019), 438–442. https://doi.org/10.1016/j.procs.2020.05.096

Sucuoğlu, E., & Erdem, G. (2021). Effects of sustainable strategic planning applications in primary schools on the effectiveness of total quality management practices. *Sustainability (Switzerland)*, *13*(18), 1–10. https://doi.org/10.3390/su13189998

Thamik, H., & Wu, J. (2022). The impact of artificial intelligence on sustainable development in electronic markets. *Sustainability*, *14*(6), 3568.

Umkabu, T. (2023). The ımpact of supervisory management and service-learning pedagogy on the development strategy of junior high schools. *Journal of Pedagogical Research*, *7*(5), 223–236. https://doi.org/10.33902/jpr.202323857

Uralovich, K. S., Toshmamatovich, T. U., Kubayevich, K. F., Sapaev, I. B., Saylaubaevna, S. S., Beknazarova, Z. F., & Khurramov, A. (2023). A primary factor in sustainable development and environmental sustainability is environmental education. *Caspian Journal of Environmental Sciences*, *21*(4), 965–975. https://doi.org/10.22124/cjes.2023.7155

Waltner, E. M., Rieß, W., & Mischo, C. (2019). Development and validation of an instrument for measuring student sustainability competencies. *Sustainability (Switzerland)*, *11*(6), 1–20. https://doi.org/10.3390/su11061717

Wang, X. (2024). The application of new media communication technology in vocational education teaching under the background of big data. *Applied Mathematics and Nonlinear Sciences*, *9*(1), 1–15. https://doi.org/https://doi.org/10.2478/amns.2023.2.00295

Wiek, A., Xiong, A., Brundiers, K., & van der Leeuw, S. (2014). Integrating problem and project-based learning into sustainability programs: A case study on the school of sustainability at Arizona state university. *International Journal of Sustainability in Higher Education*, *15*(4), 431–449. https://doi.org/10.1108/IJSHE-02-2013-0013

Yusuf, Z. F. A., Yusuf, F. A., Nuryanto, U. W., & Basrowi, B. (2024). Assessing organizational commitment and organizational citizenship behavior in ensuring the smoothness of the supply chain for medical hospital needs towards a green hospital : Evidence from Indonesia. *Uncertain Supply Chain Management*, *12*(1), 181–194. https://doi.org/10.5267/j.uscm.2023.10.006

Zarifis, A., & Fu, S. (2023). Re-Evaluating Trust and Privacy Concerns When Purchasing a Mobile App: Re-Calibrating for the Increasing Role of Artificial Intelligence. *Digital*, *3*(4), 286–299. https://doi.org/10.3390/digital3040018

Zhang, Z. (2024). Innovative Teaching Strategies for Aesthetic Arts in Higher Education Institutions Based on Big Data Technology. *Applied Mathematics and Nonlinear Sciences*, *9*(1), 1–17. https://doi.org/10.2478/amns.2023.2.00170

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