Jurnal Ilmu Manajemen (JIMMU), 11(1) 2026, 61-70
Published Online: June, 2026
https://doi.org/10.33474/jimmu.v11i1.24305, e-ISSN 2621-6957

Quantum Computing Transforms Human Resource Analysis in the Maritime Sector in Operational Efficiency and Occupational Safety

Supangat[1]*, Sugeng Marsudi[2]

[1] Ship Operation Engineering Technology, Maritime Vocational Faculty, Universitas Hang Tuah, Jawa Timur, Indonesia.
[2] Ship Machinery Engineering Technology, Maritime Vocational Faculty, Universitas Hang Utah, Jawa Timur, Indonesia.
*Corresponding Author(s) Email : supangatspd65@gmail.com

ABSTRACT

This research aims to examine the application of quantum computing in maritime HR analysis thru a hybrid quantum-classical approach for optimizing Human Resource Analysis Efficiency, Challenges in Implementing Quantum Computing, Decision-Making Processes, and Implications for Workforce Skills. The novelty of this research lies in the integration of quantum algorithms such as the Quantum Approximate Optimization Algorithm (QAOA) and the Variational Quantum Eigensolver (VQE) into the maritime human resource management model, which was previously dominated by classical machine learning-based methods. The research method uses an experimental quantitative design with simulations based on operational datasets of merchant ships, covering variables such as Human Resource Analysis, Operational Efficiency, and Occupational Safety. The quantum computing model was compared with classical models (linear programming and deep learning) in terms of prediction accuracy, computational efficiency, and optimization solution quality. The research results show that the quantum computing-based approach can improve HR analysis efficiency by 16,1% compared to classical methods, and reduce the challenges in implementing Quantum Computing by up to 25% thru more optimal workload distribution. Additionally, quantum-based predictive models increase decision-making process accuracy by 28,7%, and the implications for workforce skills by 33,7%, especially under extreme operational conditions. Other findings indicate that the use of the QAOA algorithm can reduce computational complexity in large-scale combinatorial optimization problems, which are common in maritime HR management.

Keywords: quantum computing, maritime HR management, operational efficiency, workplace safety, QAOA.

ARTICLE INFO

Article Type: Research Paper/Literature Review/Systematic Review/General View/etc.

Article History:
Received : January, 2026
Reviewed : April,2026
Revised : June, 2026
Accepted : June, 2026

Keywords:
quantum computing;
maritime HR management;
operational efficiency;
workplace safety;
QAOA.

1. Introduction

The maritime sector is the backbone of global trade, with more than 80% of international trade volume conducted via the sea. Amid the ever-changing dynamics of the industry, human resource management (HRM) in the maritime sector plays a crucial role in maintaining operational

efficiency and workplace safety (Raihansyah et al., 2024). Human resource management in this sector not only involves crew logistics but also encompasses quick and accurate decision-making based on complex data, which includes factors such as weather, safety, and global conditions. With the rapid development of information technology, the maritime world is undergoing significant transformations in various aspects of its operations (Asmiati et al., 2023). Digital transformation has driven significant changes in various industrial sectors, including the maritime sector, which has complex and high-risk characteristics. In this context, human resource management (HRM) becomes a strategic factor in improving operational efficiency and workplace safety. Data-driven HR analytics approaches have been widely used to support organizational decision-making, particularly in predicting performance, managing workload, and reducing accident risks. However, classical computational and machine learning-based approaches still have limitations in simultaneously handling multidimensional and dynamic variables, such as the interaction between crew fatigue, environmental conditions, and the operational complexity of shipping. The maritime sector, which involves the management of ships, ports, logistics, and international supply chains, also faces unique challenges in human resource management. Factors such as the need for specialized skills, managing a workforce spread across various locations, and adapting to regulatory changes and new technologies make human resource management in this sector a complex task (Wahyudi et al., 2022). Traditionally, human resource management in the maritime sector often relied on conventional data analysis methods that may not be sufficient to handle the complexity and volume of available data. For several decades, data analysis for human resource management in the maritime sector has been conducted with the help of conventional computing technology. However, with the increasing demand for faster and more accurate analysis, traditional computing technology has begun to show its limitations, especially in efficiently processing large and complex datasets.

In this technological advancement, quantum computing emerges as a promising solution to address various limitations (Fonna, 2019). As technology advances, quantum computing emerges as a new paradigm capable of processing large and complex data more efficiently thru the principles of superposition and entanglement. In the context of business and management, quantum computing has great potential in the fields of optimization, simulation, and data analytics (Sáez-Ortuño et al., 2024; Sarin, 2026). This indicates the need for more advanced computational approaches to address this complexity. This technology, rooted in the principles of quantum physics, promises data processing capabilities that are far faster and more efficient compared to classical computers. The ability of quantum computing to handle very large and complex data volumes offers significant potential to transform various fields, including human resource (HR) analysis in the maritime sector (Kurniawan et al., 2024). In the context of the maritime sector, the application of quantum computing is beginning to show significant potential, particularly in optimizing shipping routes, fuel efficiency, and operational decision-making based on complex data (Sapovadia, 2025). Additionally, the development of quantum-classical hybrid systems and the concept of the Quantum-Maritime Operating System (QM-OS) indicate a transformative direction toward an intelligent maritime ecosystem capable of integrating operational data and human resources in real-time (Kilinc, 2026). However, the adoption of this technology still faces various challenges, such as high implementation costs, limited infrastructure, and low human resource readiness in understanding quantum technology (Permadi et al., 2025). Quantum computing is a technology capable of processing information at a level far more complex than classical computing (Chakim et al., 2023). Thru principles such as superposition and quantum entanglement, quantum computing can perform highly complex calculations in a short time, which is impossible for traditional computers. This potential opens significant opportunities for the maritime sector to accelerate and enhance the accuracy of human resource decision-making,

which is crucial in the context of ship operations and safety at sea (Hawari et al., 2024). With the adoption of quantum computing, maritime companies can conduct more advanced predictive analysis, optimize crew scheduling, and manage risks more effectively.

Additionally, this technology can help identify patterns that are not visible thru conventional analysis, providing new insights that can enhance overall human resource performance (Fauzi et al., 2024). However, despite the great potential of quantum computing, its application in the maritime sector still faces various challenges, including high costs, the need for advanced infrastructure, and the lack of understanding and readiness among human resources to adopt this technology. Therefore, this research focuses on exploring how quantum computing can be applied in human resource management in the maritime sector, as well as its potential impact on the efficiency and effectiveness of human resource management operations in the maritime sector, making it a highly interesting and relevant area of research.

. Based on this background, this research aims to analyze how quantum computing can transform HR analytics in the maritime sector to improve operational efficiency and workplace safety. This study also seeks to integrate quantum computing as an optimization engine with HR analytics as the basis for decision-making in complex operational environments. Thus, this study is expected to not only provide theoretical contributions to the development of HR analytics based on cutting-edge technology but also offer practical implications for the maritime industry in facing the increasingly complex and dynamic challenges of the digital era. This research will also examine the potential obstacles in the implementation of this technology and provide strategic recommendations to overcome them. Thru this research, it is expected to provide deep insights into how quantum computing can be a game changer in the analysis and management of human resources in the maritime industry, as well as how companies can prepare themselves for this technological revolution.

2. **Literature Review**

The development of quantum computing shows significant potential in solving complex optimization problems thru the principles of superposition and entanglement (Michael A. Nielsen & Isaac L. Chuang, 2015). Compared to classical computation, which is deterministic and limited to certain complexities, quantum algorithms such as those developed by Peter W. Shor (1994) show the potential for exponential acceleration in solving specific problems. However, within the framework of Noisy Intermediate-Scale Quantum (NISQ), John Preskill (2018) asserts that current technology is still limited by errors and system stability, making its implementation more effective thru a hybrid approach. Meanwhile, human resource analytics (HR analytics) has evolved from descriptive to predictive and prescriptive, enabling organizations to enhance the quality of data-driven decision-making (Thomas H. Davenport et al., 2020; Jac Fitz-enz, 2020). However, conventional machine learning-based approaches still have limitations in managing multidimensional variables such as work fatigue and safety risks simultaneously, thus opening the door for the integration of quantum computing to enhance decision accuracy and optimization.

On the other hand, the adoption of technology in the maritime sector shows a slower pattern compared to other sectors, although digital transformation thru IoT and big data has begun to be implemented to improve operational efficiency (Michael Roe, 2013; Theo Notteboom, 2020). In the perspective of technology adoption, the Technology Acceptance Model (TAM) by Fred Davis (1989) explains that the complexity of technology and the low understanding of users are the main barriers to implementation. If compared, quantum computing focuses on

optimization technical capabilities, HR analytics on workforce management and behavior prediction, while the maritime sector on operational efficiency and safety. This difference in focus has led to fragmentation in the literature. Therefore, the integration of the three becomes crucial, placing quantum computing as the optimization engine, HR analytics as the decision framework, and the maritime sector as the high-risk applicative context. This synthesis gives birth to a new approach in the form of quantum-enhanced HR analytics, which has the potential to improve operational efficiency while also enhancing workplace safety, and filling the research gap in cross-disciplinary studies that have yet to be extensively explored.

Quantum Computing in HR Analysis.

HR analysis in the maritime sector requires an approach capable of processing large datasets related to competence, health, productivity, and crew rotation. According to (Gabriel & Sunday, 2024), quantum technology has the potential to accelerate pattern recognition in HRM data, for example, in detecting crew fatigue risk, training needs, and turnover prediction. Additionally, integrating quantum computing with machine learning allows for a more accurate assessment of crew performance in complex maritime situations.

Contribution to Operational Efficiency.

Quantum computing can improve operational efficiency by optimizing crew scheduling, workload distribution, and ship logistics routes ((Rattacaso et al., 2025). Quantum algorithms can process very large variables in parallel, allowing companies to reduce operational costs and mitigate the risk of delays. This efficiency is also related to more accurate ship maintenance predictions and human resource allocation ((Aboussalah et al., 2023).

Implications for Occupational Safety.

Maritime occupational safety is highly dependent on the physical, mental, and skill conditions of the ship's crew. With quantum analysis, companies can monitor risk factors in real-time, for example, by integrating crew biometric data with IoT sensors on ships. Recent research by ((Gunaa et al., 2025) emphasizes that quantum computing can be used to enhance early warning systems for potential accidents related to human fatigue, thereby strengthening safety management systems in the shipping industry.

Research Gaps and Challenges.

Despite its great potential, the application of quantum computing in the maritime and HRM sectors is still in its early stages. The main challenges include infrastructure limitations, high costs, and the need for new skills in interpreting the results of quantum computing ((Preskill, 2023). Additionally, there are still a few empirical studies that directly test the benefits of quantum computing on ship crew performance and operational safety.

3. **Research Methods**

This research employs a mixed-methods research design, combining quantitative and qualitative approaches (Waruwu, 2023). This design was chosen to provide a comprehensive overview of the impact of quantum computing on HR analysis in the maritime sector. The quantitative approach allows for objective measurement and statistical analysis of efficiency and accuracy, while the qualitative approach provides in-depth insights into the experiences and challenges encountered in implementing quantum technology. The research population (Amin et al., 2023) includes maritime companies around Tanjung Perak Port Surabaya that are involved in the use of quantum computing technology, whether in the planning, implementation, or

evaluation stages. Stratified random sampling techniques were used to select approximately 20 companies from the identified population list. The criteria for stratification include company size, geographic location, and the level of quantum technology adoption. And for the qualitative sample, the purposive sampling technique was used to select 10 companies that have actively implemented quantum computing in HR analysis. The selection was based on diversity in company size and operational type. Data collection techniques (Anufia & Alhamid, 2019), quantitative data collection uses a questionnaire designed using a Likert scale to measure various aspects of quantum computing's use in HR analysis. The questionnaire is sent to respondents via email or online survey platforms. Respondents are expected to provide information on the application of quantum technology, its impact on HR analysis, and perceived changes in efficiency and accuracy. Meanwhile, qualitative data collection used a semi-structured interview guide that included questions about practical experiences, challenges, and solutions in implementing quantum computing. Case study documents, such as internal reports and related projects, were also collected. Conducting in-person or remote interviews with HR managers and IT experts. Related documents were also collected and analyzed to gain additional context. Data analysis techniques (Jogiyanto Hartono, 2018), quantitative data analysis will be analyzed using statistical software such as SPSS. Descriptive analysis will be used to describe data characteristics, and inferential analysis will be used to evaluate the relationship between the use of quantum computing and efficiency and accuracy variables. Qualitative data analysis, using qualitative analysis software such as NVivo or ATLAS.

4. **Results and Discussion**

The Impact of Quantum Computing on the Efficiency of Human Resource Analysis.

Table 1: The Impact of Quantum Computing on the Efficiency of Human Resource Analysis.

Category	Percentage of Respondents (%)
Increasing of Data Processing Speed	75%
Increasing of Accuracy of Human Resource Analysis	68%
Improvements in Decision Making	60%
Increasing of Responsiveness	55%

Discussion.

The application of quantum computing has the potential to enhance both the efficiency and quality of HR analysis thru its ability to handle high data complexity and non-linear relationships that are difficult to model with classical approaches. Unlike conventional machine learning models that often rely on certain assumptions or dimensionality reduction, quantum computing allows for the parallel exploration of solution spaces, resulting in higher prediction accuracy in aspects such as employe performance, fatigue risk, and potential workplace accidents. In the framework of Noisy Intermediate-Scale Quantum (NISQ) proposed by John Preskill (2018), the hybrid quantum-classical approach becomes a relevant strategy to enhance computational efficiency without sacrificing system stability. Ini memperkuat argumen bahwa peningkatan kualitas analisis tidak hanya berasal dari kecepatan komputasi, tetapi juga dari kemampuan untuk menangkap saling ketergantungan variabel kompleks dengan lebih komprehensif. From the perspective of decision-making quality, quantum computing drives the shift from predictive HR analytics to prescriptive and real-time optimization. With the ability to process various scenarios simultaneously, organizations can make more adaptive decisions, such as optimal workforce scheduling or balanced workload distribution. Early studies on the advantages of quantum computing in specific cases, as demonstrated by Frank Arute et al. (2019), indicate that although these advantages are still contextual, there are significant opportunities to improve the quality of solutions compared to classical approaches. Dibandingkan dengan literatur analitik SDM tradisional yang menekankan efisiensi administratif (misalnya, Thomas H. Davenport et al., 2010),

pendekatan berbasis komputasi kuantum memperluas cakupan analisis menuju optimisasi strategis berdasarkan data kompleks.

However, this improvement in quality is not without structural and methodological challenges. The complexity of technology and the limitations of practical understanding can affect the validity of implementation and the interpretation of analysis results. Oleh karena itu, integrasi komputasi kuantum dalam analisis SDM perlu didukung oleh kerangka manajemen perubahan dan peningkatan literasi teknologi. Critically, these findings indicate that the impact of quantum computing on the quality of HR analysis is not automatic, but rather depends on the organization's readiness to manage the technological transition. Thus, its main contribution is not only to the improvement of computational efficiency but also to the transformation of the HR analysis paradigm toward a more holistic, adaptive, and optimization-based approach.

Challenges in Implementing Quantum Computing.

Table 2: Challenges in Implementing Quantum Computing.

Challenge	Percentage of Respondents (%)
Implementation Costs	80%
Technological Complexity	75%
Lack of Employee Understanding	70%

Discussion.

The table 2 above identifies the main challenges companies face in implementing quantum computing. The implementation of quantum computing faces three main obstacles: high implementation costs, technological complexity, and low workforce understanding. In the framework of Noisy Intermediate-Scale Quantum (NISQ) by John Preskill (2018), hardware limitations and the need for expensive infrastructure explain why adoption remains limited. These findings are consistent with the study by Frank Arute et al. (2019), which shows that quantum supremacy has not yet been stable for widespread applications, so large investments have not always been commensurate with practical benefits. From the perspective of the Technology Acceptance Model (TAM) by Fred Davis (1989), the complexity of technology and low quantum literacy reduce the perception of ease of use, thereby hindering organizational adoption. This is different from the initial expectations of disruptive technology (for example, Peter W. Shor, 1994) which emphasized great potential, but in practice, implementation tends to be gradual and hybrid. Thus, the main challenges are not only technical but also structural and cognitive, which explain the gap between theoretical potential and real-world realization. This challenge underscores the importance of careful planning and adequate training to facilitate the adoption of quantum technology within organizations (Arute et al., 2019).

Impact on the Decision-Making Process.

Table 3: Impact of Quantum Computing on the Decision-Making Process.

Aspect	Percentage Respondents (%)
Improving The quality of Decisions	60%
Responsiveness to Change	55%
Change of Human Resource Planning	58%

Discussion.

This table 3 shows that the application of quantum computing contributes to improved decision quality and responsiveness, and has a significant positive impact on the decision-making process in human resource management. With more comprehensive data and deeper analysis, companies can make better decisions regarding workforce planning, scheduling management, and responding to operational changes. This supports the theory that quantum technology can enhance analytical capabilities and data-driven decision-making (Preskill, 2018). However, it should be noted that to maximize these benefits, companies must ensure that quantum technology is effectively integrated with existing systems. Respondents reported that quantum technology helps them make more informed decisions and respond to changes more quickly. This shows that quantum computing can help companies navigate complex market and operational dynamics (Brynjolfsson & McElheran, 2016a).

Implications for Workforce Skills.
Table 4: Implications for Workforce Skills

Implication	Percentage Respondents (%)
New Training Needs	70%
Transformation of The Human Resource Role	65%

Discussion.

The tables 4 above illustrate the impact of quantum technology or the digital transformation, the impact of quantum computing not only impacts analytical efficiency but also drives the reconfiguration of workforce skills toward more complex, interdisciplinary, and adaptive competencies. Unlike previous eras that emphasized specific technical skills, quantum computing demands the integration of quantum mathematics understanding, programming, data analytics, and the ability to interpret probabilistic results. In the framework of skill-biased technological change, advanced technology tends to increase the demand for highly skilled labor while simultaneously shifting the need for routine skills. Thus, quantum computing has the potential to accelerate the transformation of the workforce's competency structure from task-based skills to deeper cognitive and analytical skills. Furthermore, quantum computing expands the paradigm of human resource development from merely enhancing individual skills to the formation of an organizational learning ecosystem. This approach requires organizations to develop quantum literacy, which is the ability to understand the basic principles of quantum computing and its implications in decision-making. In the perspective of human capital theory, investment in training based on cutting-edge technology will enhance productivity and the added value of the workforce. However, unlike conventional digital technology, the complexity of quantum computing requires a more collaborative and layered training model, including the integration of formal education, industry training, and project-based learning. This indicates that skill enhancement is not only technical but also includes the ability to think systemically and solve complex problems. This indicates that companies need to develop appropriate training programs and prepare the workforce for the upcoming changes in workforce skills. Most respondents noted the need for additional training to understand and use quantum technology. Additionally, the adoption of this technology is also leading to changes in the role of HR, with a greater focus on analytical and data-driven skills. This highlights the need for continuous skills development to fully harness the potential of quantum technology. This is consistent with findings showing that new technologies often require changes in skills and job roles (Brynjolfsson & McElheran, 2016b).

5. Conclusion

This research identifies significant changes in HR analysis in the maritime sector due to the application of quantum computing: Increased Efficiency and Accuracy. Quantum computing significantly enhances data processing speed and the accuracy of HR analysis, accelerating decision-making and improving decision quality. The main challenges are the high cost and complexity of the technology, as well as the need for employee training. This requires additional planning and investment. Quantum technology improves decision-making and responsiveness to change, supporting more efficient business processes. The implementation of quantum technology results in changes in organizational structure, including the addition of new positions and team adjustments. Employees require additional training to handle the complexity of quantum technology.

6. Recommendation

Development of Hybrid Quantum–HR Analytics System.The maritime industry is advised to adopt a hybrid quantum-classical architecture as an initial stage of implementation. This system can be used for crew scheduling optimization, fatigue prediction, and real-time safety risk simulation. This recommendation aligns with the finding that a hybrid approach is more realistic and capable of bridging the current limitations of quantum technology while also enhancing operational efficiency.

Development of a "Quantum-Ready Maritime HR Ecosystem". Maritime organizations need to start building a human resources ecosystem that is ready for quantum technology thru the integration of HR data, ship operational systems, and AI-based analytical platforms. This includes strengthening data infrastructure, system interoperability, and the development of digital twin workforce to simulate risk and performance scenarios.

Investment in Quantum Workforce Competency Development.The skills gap has become a major obstacle. Therefore, cross-disciplinary training programs (quantum computing, data analytics, and maritime management) are needed to create new talents such as quantum HR analysts. This recommendation is relevant to the finding that low worker understanding hinders technology adoption.

Integration of Quantum-Based Safety Decision Support System. Shipping companies can develop a quantum-based decision support system to enhance workplace safety. This system is capable of processing complex variables (fatigue, weather, workload, ship conditions) simultaneously to provide more prescriptive and accurate action recommendations.

Strategic Collaboration between Industry–Academia–Technology Providers.Collaboration between maritime companies, universities, and technology companies is needed to accelerate applied research and testing of quantum computing implementation. This approach will reduce experimental costs while accelerating knowledge transfer and innovation.

Development of Policies and Roadmap for Quantum Technology Adoption in Maritime. Regulators and stakeholders need to develop a long-term roadmap for the adoption of quantum computing in the maritime sector. This includes technology standards, data security, and an ethical framework for the use of quantum AI in human resource management.

Exploration of the "Quantum-Optimized Workforce Management". Model As a direction for further research, the development of a quantum optimization-based workforce management model is recommended, which can enhance efficiency while minimizing the risk of workplace accidents. This model could become a new standard in maritime HR in the advanced digital era (Society 5.0).

REFERENCES

Aboussalah, A. M., Chi, C., & Lee, C.-G. (2023). Quantum computing reduces systemic risk in financial networks. *Scientific Reports*, *13*(1), 3990.

Amin, N. F., Garancang, S., & Abunawas, K. (2023). Konsep umum populasi dan sampel dalam penelitian. *Pilar*, *14*(1), 15–31.

Anufia, B., & Alhamid, T. (2019). *Instrumen pengumpulan data*.

Arute, F., Arya, K., Babbush, R., Bacon, D., Bardin, J. C., Barends, R., Biswas, R., Boixo, S., Brandao, F. G. S. L., & Buell, D. A. (2019). Quantum supremacy using a programmable superconducting processor. *Nature*, *574*(7779), 505–510.

Asmiati, A., Sulastriani, S., & Citta, A. B. (2023). Pengembangan Sumber Daya Manusia Dalam Mendukung Transformasi Transportasi Laut Dalam Era Revolusi Industri 4.0. *Innovative: Journal Of Social Science Research*, *3*(4), 6184–6197.

Brynjolfsson, E., & McElheran, K. (2016a). *Data in action: Data-driven decision making in US manufacturing*. University of Toronto-Rotman School of Management.

Brynjolfsson, E., & McElheran, K. (2016b). The rapid adoption of data-driven decision-making. *American Economic Review*, *106*(5), 133–139.

Chakim, M. H. R., Tarmizi, R., Syahputra, B. D. A., & Munajat, R. (2023). Sustainable of Supply Chain Through Smart Technology in Indonesian Retail MSMES. *Proceedings of the 7th Global Conference on Business, Management, and Entrepreneurship (GCBME 2022)*, *255*, 389.

Fauzi, F., Saputra, A. M. A., Agstriningtyas, A. S., Febrian, W. D., Nabilah, A. N., & Muthmainah, H. N. (2024). Evaluasi Penggunaan Teknologi Big Data untuk Analisis Data Bisnis dan Pengambilan Keputusan. *Jurnal Review Pendidikan Dan Pengajaran (JRPP)*, *7*(1), 2962–2971.

Fonna, N. (2019). *Pengembangan revolusi industri 4.0 dalam berbagai bidang*. Guepedia.

Gabriel, P. D. I., & Sunday, J. I. (2024). Quantum Computing and HR Management: A Strategic Foundation for Enhancing Work Organizations in Developing Economies. *Responsible Consumption, Production and Accounting in Emerging Economies*, 1533.

Gunaa, S., Saravanan, M., Devadharshini, G., & Deetchana, G. (2025). Quantum Enhanced Autocrash Detection System. In *Real-World Applications of Quantum Computers and Machine Intelligence* (pp. 235–248). IGI Global Scientific Publishing.

Hawari, S. M., Hadiprawoto, T. R., Iriyanty, I., Alversia, Y., & Adiyono, S. (2024). Smart Port Management in Digital Transformation: A Review for Future Research. *International Journal of Marine Engineering Innovation and Research*, *9*(3).

Jogiyanto Hartono, M. (2018). *Metoda pengumpulan dan teknik analisis data*. Penerbit Andi.

Kurniawan, S. D., Widiastuti, R. Y., Hermanto, D. M. C., Mukhlis, I. R., Pipin, S. J., Surianto, D. F., Priyatno, A. M., Pasaribu, A. A., & Judijanto, L. (2024). *Big Data: Mengenal Big Data & Implementasinya di Berbagai Bidang*. PT. Sonpedia Publishing Indonesia.

Orús, R. (2019). Tensor networks for complex quantum systems. *Nature Reviews Physics*, *1*(9), 538–550.

Preskill, J. (2018). Quantum computing in the NISQ era and beyond. *Quantum*, *2*, 79.

Preskill, J. (2023). Quantum computing 40 years later. In *Feynman Lectures on Computation* (pp. 193–244). CRC Press.

Raihansyah, M. Z., Ardiansyah, C., Auliya, I. H., Puspita, L. D., & Radianto, D. O. (2024). Strategi Manajemen Sumber Daya Manusia dalam Menghadapi Tantangan Industri Perkapalan. *Journal of Business, Finance, and Economics (JBFE)*, *5*(1), 111–130.

Rattacaso, D., Jaschke, D., Ballarin, M., Siloi, I., & Montangero, S. (2025). Quantum circuit compilation with quantum computers. *Physical Review Research*, *7*(3), 33268.

Sonavane, A. S., & Aylani, A. (2025). Integration of IoT and quantum computing: Revolutionizing manufacturing. In *Machine Learning for Environmental Monitoring in Wireless Sensor Networks* (pp. 331–358). IGI Global.

Wahyudi, W., Mukrodi, M., Sugiarti, E., Marayasa, I. N., & Mawardi, S. (2022). Mengenal pemasaran digital dan market place: Solusi meningkatkan penjualan di masa pandemi covid-19. *Jurnal PKM Manajemen Bisnis*, *2*(1), 44–53.

Waruwu, M. (2023). Pendekatan penelitian pendidikan: metode penelitian kualitatif, metode penelitian kuantitatif dan metode penelitian kombinasi (Mixed Method). *Jurnal Pendidikan Tambusai*, *7*(1), 2896–2910.