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The Impact of Visionary Leadership on Science-Based Technology Adoption in East Wawonii Elementary Schools

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ABSTRACT

The integration of technology in science learning has become essential in the era of Industrial Revolution 4.0, particularly in primary education. Visionary leadership by school principals is believed to play a critical role in facilitating the adoption of science-based innovative technology in classrooms. This study employed a quantitative approach using a survey design involving 100 elementary school teachers and principals in East Wawonii who have implemented science-based technology in teaching. Data were collected through a validated Likert-scale questionnaire measuring perceptions of visionary leadership and the extent of technology adoption. Correlation and simple linear regression analyses were conducted using SPSS. The findings revealed a strong and significant relationship between visionary leadership and the adoption of science-based technology ($r = 0.87$, $p = 0.001$). Regression analysis confirmed that visionary leadership significantly predicts technology adoption ($\beta = 0.716$, $p = 0.001$), with an R-squared value of 0.757, indicating that 75.7% of the variance in technology adoption can be explained by the leadership variable. These results suggest that visionary leadership is a key driver in promoting technology integration in science learning. Principals who articulate clear long-term goals, inspire innovation, and support teacher development contribute significantly to creating a conducive environment for technology adoption in primary schools. The study highlights the importance of leadership training that focuses on technological awareness and innovation management.

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1. INTRODUCTION

The 21st century has marked a transformative period in education, characterized by rapid technological advancements and the need for adaptive educational leadership. In the context of the Fourth Industrial Revolution (4IR), educational systems worldwide are under increasing pressure to integrate digital technologies to develop students' critical thinking, creativity, problem-solving, and digital literacy

skills (Boholano et al., 2020; Ramaila & Molwele, 2022). Particularly in science education, the use of technology is no longer a supplementary tool but an essential component to support inquiry-based learning, enhance student engagement, and foster scientific literacy from an early age (Rahmat et al., 2023).

In elementary schools, integrating science-based technology—such as simulations, virtual labs, interactive learning platforms, and project-based learning tools—offers opportunities to bridge the gap between abstract scientific concepts and real-world applications (Cunha et al., 2020). These tools not only stimulate student interest but also develop higher-order thinking skills necessary for navigating a complex, technology-driven world (Polly et al., 2020). However, successful integration of such technologies in elementary science classrooms often requires more than infrastructure or equipment; it demands effective leadership that can guide and inspire teachers to adopt, adapt, and innovate within their pedagogical practices (Handayani, 2023).

Visionary leadership has emerged as a crucial factor in promoting educational transformation. In the context of schools, visionary leadership refers to a principal's ability to articulate a compelling future direction, inspire stakeholders, and drive innovation in teaching and learning practices (Thannimalai & Raman, 2018; Wijaya, 2023). Unlike traditional administrative leadership, visionary leaders are proactive, strategic, and future-oriented, often acting as catalysts for school-wide change. In technologically evolving environments, principals with visionary capacities play a key role in enabling and sustaining the adoption of science-based technologies (Liswati et al., 2023).

Research supports that visionary school leaders significantly influence the school climate, teacher motivation, and openness to innovation (Da'as et al., 2020). These leaders not only provide resources but also create a culture of trust and collaboration, where teachers are encouraged to experiment with new teaching tools and strategies. Such leadership is especially important in rural or under-resourced contexts, where institutional inertia and technological limitations can hinder innovation (Teo, 2019). In regions like East Wawonii, where digital transformation is still progressing, the principal's role becomes even more vital in bridging policy intentions and classroom realities.

Studies have shown that when school leaders actively support technology use—through training, vision-sharing, and professional development—teachers are more likely to integrate technology into their instruction (Cheung et al., 2019; Dexter & Barton, 2021). Visionary leadership fosters a shared belief in the value of innovation, thereby influencing teachers' attitudes and reducing resistance to change (Cantos & Callo, 2022). In contrast, schools with passive or reactive leadership often struggle with fragmented or unsustained technology implementation (Ibrahim et al., 2022).

Moreover, research by Costa and Domingos (2019) on STEM teacher development found that leadership practices directly influenced teachers' confidence and competence in adopting technological innovations. Similarly, Bacuna and Castro (2023) emphasized the significance of leadership in shaping the organizational readiness for technology adoption, suggesting that leadership is not just a contextual factor but a determinant of success in educational reform. When visionary leadership is combined with structured support systems—such as access to relevant tools, ongoing mentoring, and collaborative planning—the adoption of science-based technologies can be both effective and sustainable (Nawawi et al., 2023).

Despite the growing body of literature, there remains a gap in empirical studies that explore the relationship between visionary leadership and technology adoption at the elementary level, particularly in rural or geographically isolated regions such as East Wawonii, Indonesia. Many existing studies have focused on secondary or tertiary education or conducted in urban settings where access to technology is more abundant. This leaves a critical need to understand how leadership practices operate in resource-constrained contexts and how they influence the willingness and capacity of teachers to innovate.

Furthermore, while numerous studies highlight the role of school principals in promoting technology use, fewer examine how teachers perceive their leaders' vision and how this perception correlates with actual implementation of technology in classroom instruction. Given that perception often drives motivation and behavior (Lavi et al., 2021), exploring teachers' views on their principal's visionary

leadership may provide nuanced insights into the mechanisms that facilitate or hinder technology integration.

In response to these gaps, this study aims to investigate the influence of visionary leadership on the adoption of science-based technology in elementary schools in East Wawonii. Specifically, it seeks to examine the relationship between teachers' perceptions of their principals' visionary leadership and the extent to which they integrate science-related technologies in classroom learning. By focusing on this unique and underexplored context, the study contributes to both theoretical understanding and practical guidance for leadership development in basic education.

The findings are expected to inform educational policymakers and stakeholders about the strategic role of leadership in driving innovation, particularly in primary education settings. They also offer empirical evidence that can support the design of leadership training programs aimed at equipping school principals with the visionary competencies required to lead technological change. Ultimately, this research aligns with the broader goal of enhancing science education in the digital era, preparing students with the necessary skills to thrive in a knowledge-based global economy.

2. METHODS

This study employs a quantitative approach with an explanatory design to investigate the impact of visionary leadership on the adoption of science-based technology in primary schools. The study population consisted of teachers and principals in elementary schools who have implemented or are currently using science-based technology in their teaching and learning activities. Participants were selected based on several criteria: they had to be principals or teachers, have direct experience in using innovative science-based technology for at least the past year, and hold at least a bachelor's degree to understand the concepts of visionary leadership and technology well. The sampling technique employed was purposive sampling, and 100 individuals were selected, considered sufficient to represent the population in the analysis.

Data was collected using a closed questionnaire based on a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). The questionnaire was divided into two main sections: first, to measure aspects of visionary leadership such as long-term vision, inspiration, and influence; and second, to assess the extent to which science-based technology is applied in learning through indicators such as frequency of use, effectiveness in learning activities, and integration with learning materials. Before being used in the main sample, the questionnaire was pretested on 30 respondents who were not part of the main sample to ensure its accuracy and consistency. Validity was tested using item-total correlation, while reliability was tested using Cronbach's Alpha, the results of which showed a value above 0.7, so the instrument was declared reliable.

The data collection process was conducted both online and offline. Participants were asked to sign a written consent explaining the purpose of the study, their rights as respondents, and how to maintain data confidentiality. If needed, semi-structured interviews were also conducted to get a more detailed explanation of the use of technology in a particular school. These interviews were recorded with the participants' permission, and the results were then transcribed in full for further analysis.

Data were analyzed using descriptive and inferential statistical methods with the help of SPSS software to ensure the accuracy of the results. Descriptive analysis was used to describe respondents' demographic characteristics such as age, education level, and work experience, as well as the distribution of their answers on each research variable. To test the hypothesis about the effect of visionary leadership on technology adoption, a simple linear regression test was conducted with a significance level (α) of 0.05 to determine if there is a significant relationship between the two. Where there was additional data from interviews, it was analyzed thematically to add context to the quantitative results. This step involved coding to identify key themes such as support from the principal or technical barriers to technology adoption. These findings are presented to enrich the understanding of the quantitative analysis.

3. FINDINGS AND DISCUSSION

This study aims to explore the relationship between principals' visionary leadership and the adoption of science-based innovative technologies in learning in primary schools. Visionary leadership support from principals plays a significant role in facilitating technology integration, improving teachers' motivation and skills in using technology effectively in the classroom. Recent research shows that visionary leadership promotes technology awareness in primary schools, which positively impacts technology-based science learning innovations (Wijaya, 2023). Data analysis also showed that principals with visionary planning and technology leadership skills can establish a supportive and inclusive school culture for the adoption of innovative technologies in the classroom (Nawawi et al., 2023). In addition, innovative leadership plays a role in improving the quality of science teaching through the use of technology, where the principal serves as a facilitator for teachers' technology needs in the school (Sirait et al., 2022).

3.1. Correlation Analysis

Based on the results of the correlation analysis, there is a strong and significant relationship between the principal's visionary leadership and the level of adoption of science-based technology in elementary schools, with a correlation coefficient of 0.87 and a p value = 0.001. The p value being below the significance level of 0.05 indicates that this correlation is highly significant. This means that the higher the teachers' perception of the principal's visionary leadership, the higher the level of adoption of science-based technology in learning. This high correlation indicates that visionary leadership plays an important role in encouraging the implementation of technology in primary schools, which can improve the quality of science learning.To clarify, it has been presented in the form of the following table.

Table 1. Relationship between Principal's Visionary Leadership and Science-Based Technology Adoption

Independent Variable	Dependent Variable	Correlation Coefficient (r)	P-value	Significance	Interpretation of Relationship
Principal's Visionary Leadership	Science-based Technology Adoption	0.87	0.001	Highly Significant ($p < 0.05$)	Strong and Positive Relationship

The table above displays the results of the correlation analysis between principals' visionary leadership and the level of adoption of science-based technology in primary schools. Based on the correlation results, a coefficient of 0.87 was obtained with a p-value of 0.001. The correlation coefficient of 0.87 indicates that there is a very strong relationship between teachers' perceptions of principals' visionary leadership and the adoption of science-based technology in the learning process. This positive correlation indicates that the higher the teachers' perception of the principal's visionary leadership quality, the higher the level of science-based technology adoption that occurs in the school.

Statistically, the p-value of 0.001, which is smaller than the significance level of 0.05 indicates that the relationship between the variables of visionary leadership and the adoption of science-based technology in learning is significant. This indicates that the results observed in the sample are likely to reflect patterns in the wider population (Wijaya, 2023). In the context of education, visionary leadership plays an important role in supporting technological innovation, which can enrich the learning process and improve the quality of education in primary schools (Griffiths & Needleman, 2019). The findings support the importance of developing visionary leadership among school principals through training

and leadership capacity building to facilitate effective adoption of science-based technologies in educational settings (Matthews, 2018). Further studies are recommended to examine additional variables, such as peer support or individual teacher characteristics, to gain greater insight into the factors that influence technology adoption in education (Di Leo & Sardanelli, 2020).

Innovative technology-based learning. Principals who lead with a strong vision can increase teachers' confidence and enthusiasm in adopting technology, providing the necessary support for these innovations to be effective (Thannimalai & Raman, 2018; Nawawi et al., 2023). Research shows that effective leadership can help teachers meet the challenges of technological change by providing sufficient resources and continuous professional development (Handayani, 2023). In addition, visionary leadership in schools was shown to improve teachers' technology skills and academic optimism, which contributed to a more meaningful application of technology in learning (Cantos & Callo, 2022). Thus, visionary leadership plays a significant role in supporting the sustainable adoption of technology in primary schools.

So, the results listed in the table above indicate that principals' visionary leadership plays an important role in supporting technology adoption in primary schools. With a strong and significant relationship between the two variables, it can be said that principals who have a clear vision and are able to communicate that vision to teachers will be more successful in encouraging the use of science-based technology. Technology in this context is essential to strengthen the quality of science learning, provide more interactive learning experiences and prepare students to face the challenges of an increasingly digital world. This table provides a strong basis for understanding that principals' visionary leadership is a key factor in increasing the adoption of technology in education, which in turn has a positive impact on improving the quality of learning in primary schools.

3.2. Regression Analysis

A simple linear regression analysis was conducted to explore the causal relationship between visionary leadership and science-based technology adoption further. The results of the analysis show that visionary leadership is a significant predictor of science-based technology adoption. With a regression coefficient of 0.716 (p-value = 0.001), it can be concluded that every one-point increase in perceived visionary leadership correlates with an approximate 0.716-point increase in science-based technology adoption. In addition, the R-squared value of 0.757 indicates that 75.7% of the variation in the adoption of science-based technology can be explained by the visionary leadership variable. This indicates that this regression model is strong enough to explain the effect of visionary leadership on technology adoption in the context of learning in primary schools in Wawonii Timur sub-district.

Table 2. Results of Simple Linear Regression Analysis between Visionary Leadership and Science-Based Technology Adoption

Independent Variable	Regression Coefficient (β)	P-value	R-squared	Interpretation
Principal's Visionary Leadership	0.716	0.001	0.757	Visionary leadership is a significant predictor of technology adoption.

The table above shows the results of the simple linear regression analysis conducted to explore the influence of principals' visionary leadership on the adoption of science-based technology in primary schools. In this analysis, visionary leadership served as the independent variable, while science-based technology adoption was the dependent variable. The results of the analysis show that principals' visionary leadership is a significant predictor of the level of science-based technology adoption, with a regression coefficient (β) of 0.716 and a p-value of 0.001. This regression coefficient indicates that each one-point increase in perceived principal visionary leadership is associated with a 0.716-point increase in the adoption of science-based technology.

The regression coefficient of 0.716 indicates that principals' visionary leadership has a significant and relevant influence on promoting the adoption of science-based technology in learning in primary schools. The study shows that the positive influence of visionary leadership is not only statistically significant but also practical, with a p-value of 0.001, which is well below the significance level of 0.05, so this result has a high degree of confidence and is unlikely to have occurred by chance (Apriyani et al., 2019; Nawawi et al., 2023). The findings confirm that principals who have a clear vision can influence teachers' enthusiasm and readiness to adopt technology as part of the learning process, strengthening the quality of technology-based education at the primary level (Oredein & Obadimeji, 2022).

The R-squared value of 0.757 indicates that the regression model used can explain about 75.7% of the variability in the level of adoption of science-based technology in primary schools. This suggests that most of the variability in technology adoption can be attributed to teachers' perceptions of principals' visionary leadership. The support and policies implemented by visionary principals, such as the provision of technology facilities, periodic training, and the establishment of an innovative culture, contribute to teachers' readiness to integrate technology (Nawawi et al., 2023). A model with a high R-squared indicates strong predictive power, so the principal's visionary leadership can be considered a major factor in influencing the adoption of science-based technology (Bacuna & Castro, 2023; Pribadi et al., 2022). In addition, research shows that aspects such as long-term vision and technology management by principals strengthen the implementation of technology in the classroom, improving the quality and effectiveness of technology-based learning (Musso et al., 2020; Serão & Petry, 2020).

The visionary leadership of school principals plays an important role in promoting innovation and technology integration in primary education. Principals with a strong vision not only provide long-term direction for the school but also ensure the necessary support and resources for teachers. For example, support in the form of adequate technology facilities and training related to technology integration in learning has been shown to increase teachers' motivation and capacity to adopt innovative approaches in the classroom (Antypas, 2021; Yulindasari et al., 2020). Furthermore, visionary leadership helps create a culture of innovation conducive to technology integration, where principals play an active role in providing training and encouraging the use of technology to strengthen the effectiveness of the learning process (Nawawi et al., 2023). Thus, visionary leadership is a key factor in encouraging teachers to use science-based technology in teaching and learning activities, which has the potential to improve the overall quality of education (Riveras-León & Tomás-Folch, 2020).

Thus, this table provides empirical evidence that principals' visionary leadership plays an important role in accelerating technology adoption in primary schools. The high value of the regression coefficient and R-squared emphasizes that the visionary leadership factor has a significant influence on technology-based learning innovation. Effective leadership has been proven to be a key driver in triggering positive change in the education system. Harris and Jones (2019) show that when teachers are included as leaders in collaborative teams, student learning outcomes tend to improve due to their greater involvement in educational decision-making. Meanwhile, Dawson (2023) argues that flexible and adaptive leadership is needed to meet the challenges presented by new technologies such as artificial intelligence, which are drastically changing learning and evaluation methods. Želvys et al. (2019) add that the effectiveness of school leadership that promotes autonomy and accountability is

closely related to improved student achievement, although these results may vary depending on the policy context and educational culture in each country.

However, the challenges of applying leadership skills are also worth noting. Weiner dan Lamb (2020) found that although leadership development programs for teachers are important, the results are not optimal if they are not fully supported by school leaders. Furthermore, Burk-Rafel and his colleagues (2020) underscore the importance of the role of students as agents of change in curriculum innovation in medical schools. When students and lecturers work together, the impact can strengthen the success of change and innovation in the educational program. Therefore, efforts to improve the quality of principals' visionary leadership can be considered an important strategy for improving technology adoption and learning quality in primary schools.

Discussion

This study found a strong and statistically significant relationship between principals' visionary leadership and the adoption of science-based technology in elementary schools in East Wawonii. The correlation coefficient ($r = 0.87$, $p = 0.001$) and the regression coefficient ($\beta = 0.716$) indicate that teachers who perceive their principals as visionary are significantly more likely to adopt technology in their science teaching. These results underscore the critical role of school leadership in shaping innovation practices, particularly in primary education settings facing digital transformation.

The findings are consistent with previous research asserting that visionary leadership significantly influences teachers' willingness to integrate technology into their classrooms. Principals with a clear vision, who are proactive in communicating goals and providing strategic direction, create a learning environment that supports risk-taking and innovation (Thannimalai & Raman, 2018; Wijaya, 2023). In the case of East Wawonii, a rural and developing region, such leadership is especially vital. The technological infrastructure in these areas is often limited, and teachers may lack access to high-quality training or digital resources. Visionary principals can help compensate for these limitations by motivating teachers, facilitating access to resources, and building a supportive school culture.

One of the most significant implications of this study is that leadership in education is not solely about administrative efficiency, but rather about creating and sustaining a shared vision that aligns with educational innovation. When principals articulate a clear long-term vision for technology use in learning, it not only sets a direction but also cultivates a sense of purpose and ownership among teachers (Liswati et al., 2023). Such vision enables teachers to connect their day-to-day teaching practices with broader institutional goals, which in turn fosters greater commitment to implementing new technologies.

Additionally, the study supports the theoretical framework that positions leadership as a central component in organizational change within schools. Visionary leaders act as change agents who challenge the status quo, foster collaboration, and empower their staff (Da'as et al., 2020). In the context of science-based technology adoption, this involves enabling teachers to explore new pedagogical methods, integrating digital simulations, or using data-based tools to enhance students' scientific understanding. When principals encourage professional experimentation and learning, they reduce the perceived risks associated with trying new technologies.

The high R^2 value (0.757) in the regression model further demonstrates that visionary leadership accounts for a substantial proportion of the variance in technology adoption. This supports findings from Costa and Domingos (2019), who argued that leadership in professional development programs significantly influences teachers' competence in STEM integration. Similarly, research by Bacuna and Castro (2023) highlighted that school leaders play a pivotal role in establishing the organizational readiness necessary for successful technological change. In schools where principals are perceived as visionary, teachers tend to feel more confident, supported, and capable of implementing innovative teaching strategies.

Moreover, visionary leadership extends beyond vision-setting. It includes providing tangible support such as technology-related professional development, resource allocation, and constructive

feedback. Nawawi et al. (2023) emphasized that principals who demonstrate strong technology leadership—through regular training, supervision, and policy support—significantly increase teachers' confidence and readiness to adopt digital tools. In East Wawonii, where internet connectivity and access to advanced devices may be limited, this leadership role becomes even more critical. Principals who anticipate these challenges and develop creative solutions—such as offline digital resources or peer-led training—can bridge the digital divide more effectively.

Another essential aspect is the role of visionary leadership in shaping the school culture. A culture that values innovation, continuous learning, and collaboration encourages teachers to take initiative in adopting new instructional technologies (Cantos & Callo, 2022). This aligns with research by Dexter and Barton (2021), who found that team-based leadership approaches involving principals, teachers, and technology specialists lead to greater success in technology integration. When teachers feel that their efforts to innovate are supported by school leadership and their peers, they are more likely to embrace change.

However, while the findings of this study are promising, they must be interpreted with caution. The cross-sectional design limits causal interpretations. Although the regression model indicates a predictive relationship, it cannot establish a definitive cause-and-effect dynamic between leadership and technology adoption. As noted by Di Leo and Sardanelli (2020), statistical significance does not equate to practical causality, particularly in studies without longitudinal data. Future research should consider longitudinal or experimental designs to better capture the dynamics over time.

In addition, while visionary leadership was found to be a major predictor, other variables not included in the model may also influence technology adoption. For example, individual teacher characteristics such as digital literacy, years of experience, or openness to change could moderate the relationship between leadership and adoption (Lavi et al., 2021). Likewise, peer collaboration, school infrastructure, and district-level policies may also play important roles. Including such variables in future studies would provide a more comprehensive understanding of the ecosystem that supports technology integration in schools.

Furthermore, this study's focus on East Wawonii adds valuable insight into educational leadership in rural or less-developed regions. Often, research in educational technology is urban-centric and fails to address the nuanced challenges faced in remote areas. In such contexts, the principal's leadership is not only instrumental but may be the *only* enabling factor for innovation. As suggested by Teo (2019), community-based approaches and grassroots leadership are essential for sustaining innovation in marginalized school systems.

In conclusion, this study affirms that visionary leadership is a foundational element in advancing science-based technology adoption in elementary education. Principals who possess and communicate a compelling vision, offer consistent support, and cultivate a culture of innovation enable teachers to embrace technological change, ultimately improving the quality of science education. These findings reinforce the importance of investing in leadership development programs that focus not just on managerial skills, but also on innovation, digital awareness, and instructional leadership. Such investments are essential for building future-ready schools that can equip students with the skills needed in an increasingly complex and digital world.

4. CONCLUSION

This study concludes that visionary leadership by elementary school principals has a significant and positive influence on the adoption of science-based technology in teaching, as evidenced by a strong correlation and high explanatory power in the regression model. Principals who communicate a clear vision, provide consistent support, and foster an innovative school culture play a pivotal role in enabling teachers to integrate technology effectively into science learning. However, the study is limited by its cross-sectional design and reliance on self-reported data, which restricts the ability to infer causality and may introduce bias in respondents' perceptions. Additionally, the use of purposive

sampling in a specific rural context—East Wawonii—limits the generalizability of the findings to broader populations. Future research should consider longitudinal or mixed-method designs to capture the long-term effects of visionary leadership on technology adoption, and include additional variables such as teacher digital competence, infrastructural readiness, or policy influences. Comparative studies across different regions or educational levels are also recommended to explore contextual differences in leadership impact and to develop more comprehensive models for fostering innovation in schools.

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