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Digital Leadership to Improve Physical Education Learning of Elementary School Students

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Abstract : This research aims to explore the role of digital leadership in improving physical education learning in elementary schools (SD) through technology integration. The research uses a qualitative approach with a case study design in several elementary schools in Depok. Data were collected through in-depth interviews with principals and teachers, observation of the physical education learning process, and analysis of documentation related to the use of technology in learning. Data analysis was carried out thematically to identify the main patterns that support the implementation of digital leadership in the context of physical education. The validity of the data is maintained through triangulation of sources and methods. The results of the study show that effective digital leadership can encourage technology integration, increase student engagement, and improve the effectiveness of physical education learning. This research contributes to the development of relevant digital leadership strategies to support technology-based learning at the primary school level.

Keywords: Digital, leadership, Elementary, school, Learning.

1. INTRODUCTION

Digital leadership leads to the management and use of technology to increase the effectiveness of the learning process. Technology is increasingly becoming an integral part of daily life, including in the world of education, and it requires leaders who can manage technology wisely. Digital leaders strategically align technology investments with the organization's overarching goals, thus ensuring that digital transformation efforts align with a comprehensive business strategy (Chandratreya, 2024). Digital leaders use AI-infused instruments for proficient crisis management, which significantly improves decision-making frameworks and operational efficacy in virtual companies (Krishna Pasupuleti, 2024). Many organizations face fiscal constraints and a lack of resources, which hinder the successful implementation of digital leadership methodologies (Fitriani et al., 2023). Resistance to change is a considerable obstacle, requiring leaders to cultivate an organizational culture that actively supports innovation and technological advancement (Choirul Anam et al., 2024). In many countries, schools led by leaders with digital skills have been able to implement online learning, manage student data more efficiently, and design more engaging learning programs. Therefore, digital leadership is very important in improving the quality of learning, including in physical education in Elementary Schools.

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Physical education in elementary school not only teaches physical skills but also shapes students' character through healthy and disciplined physical activity. By elementary school, children are in a crucial stage of physical and mental development, so teaching that involves physical activity will have a long-term impact on their health and character. Physical education is essential for the holistic development of primary school students, as it meets their different anatomical and psychological requirements (Pulatovich, 2024). Consistent involvement in physical education has been shown empirically to improve cardiorespiratory endurance and cognitive function, both of which are important for academic achievement (Latino et al., 2024). Activities related to physical education have a profound impact on character development, as shown by research that reveals an important increase in students' character attributes after they participate in sports (Kuspratiwi et al., 2024). Through athletic efforts, children acquire vital social competence, collaborative skills, and mechanisms for emotional regulation, all of which are indispensable for their future relational dynamics (Anisa Julia Dwi Putri et al., 2024). The establishment of a nurturing school atmosphere, the provision of a variety of sports alternatives, and the active involvement of parents can significantly increase children's enthusiasm for physical activity (Mulyana et al., 2024). Competent physical education instructors are an integral part of the effective delivery of quality PE, which correlates with improved health outcomes and character development (Latino et al., 2024). For example, sports and games taught in primary schools have been shown to improve students' physical fitness, social abilities, and confidence. Thus, Physical Education in elementary schools plays an important role in shaping healthy, disciplined, and cooperative students, which should be supported by innovative digital leadership.

Technology allows the teaching of physical education to be more structured, interactive, and engaging. With technology, learning materials that used to only be taught manually can become more visual and dynamic, allowing students to learn more efficiently and enjoyably. Technological resources, including interactive media and digital platforms, substantially increase student engagement and motivation in disciplines such as social studies (Montero Reyes et al., 2025). The incorporation of authentic material, including videos and podcasts, has been empirically shown to improve listening comprehension and maintain student engagement in language mastery (Avila Castillo & Criollo Vargas, 2023). Animated videos have been identified as an effective pedagogical tool for explaining complex topics, such as the structure of hydrocarbons, resulting in improved student performance and comprehension (Fahlevi & Muchtar, 2024). Technologies such as virtual reality (VR) and augmented reality (AR) facilitate the creation of immersive educational environments that foster critical thinking and

problem-solving competencies (Chukwuemeka & Garba, 2024). Technological advances enable adaptive learning, tailoring educational content to meet the specific needs of individual learners while accommodating different learning styles (Chukwuemeka & Garba, 2024). For example, physical training apps or instructional videos can be used to demonstrate movements more clearly, while fitness sensors help monitor students' physical progress. With technology in learning, students are not only more motivated but also gain a better understanding of the importance of sports and physical activity.

The integration of technology in elementary school can help students understand new ways to maintain fitness and do physical activity. At this age, students are easily influenced and tend to be attracted to the use of technology, which can be an effective tool to introduce them to a healthy lifestyle. Research suggests that healthy lifestyle technologies (HLT) can facilitate beneficial short-term changes in physical activity participation among adolescents (Yang et al., 2024). The integration of innovative health technologies in educational settings has been found to significantly improve students' readiness to embrace health-preserving behaviours, evidenced by a remarkable increase from 7% to 36% in high readiness levels during educational interventions (Leleka et al., 2024). Digital instruments, including mobile apps and virtual reality, can improve health literacy by delivering personalized and captivating content specifically designed to align with adolescent preferences (Mancone et al., 2024). Initiatives that bring together community advocates alongside technology partners have effectively increased awareness and engagement in healthy lifestyle practices among college students (Fackler et al., 2021). In many elementary schools, the use of devices such as tablets or fitness apps has been used to teach students about physical activity appropriate to their age and support healthy habits. Therefore, elementary schools must be pioneers in the use of technology for physical education, with the support of digital leadership that can design programs that suit the needs of students.

Educational leaders who are skilled in technology can create a more innovative and effective environment in the teaching of physical education. By utilizing digital tools, leaders can introduce learning methods that are more diverse, and interesting, and follow student development. Access to Resources: Digital platforms serve as channels to bridge geographical and socio-economic gaps, thus providing students from diverse backgrounds with equitable access to educational resources and collaborative engagement (Swami & Piedade Fernandes, 2024). Virtual Learning Environments: Instruments such as Virtual Learning Environments (VLEs) facilitate the democratization of training access, enabling flexible educational experiences that meet the diverse needs of students (Hutson et al., 2023). Engaging Learning

Methods: The incorporation of gamification and adaptive learning technologies serves to increase student motivation and engagement by making the learning process interactive and tailored to individual preferences (Junard P. Duterte, 2024). The application of interactive multimedia significantly improves understanding and retention of complex concepts, thus making the learning experience more engaging (Junard P. Duterte, 2024). Learning analytics and artificial intelligence empower educators to tailor instruction, effectively addressing the different needs of each learner (Girdzijauskienė et al., 2022). Regular feedback mechanisms promote the continuous development of learners, fostering a more adaptive educational atmosphere (Junard P. Duterte, 2024). In SD Depok, for example, the use of digital platforms for physical education learning has increased student engagement and allowed for faster and more precise evaluations. Thus, digital leadership will not only improve the quality of learning but also create a more interactive and enjoyable learning experience for students at SD Depok.

Digital leadership not only optimizes the use of technology but also opens up space for innovation in teaching methods that have not been widely applied in elementary schools. Tech-savvy education leaders can leverage a variety of digital tools to create a more personalized and adaptive learning experience for students. Technologies such as intelligent guidance systems and adaptive assessments provide tailored feedback and resources so that they are aligned with each student's distinctive learning style and pace (Kaswan et al., 2024). Tools including augmented reality and virtual have the potential to build immersive educational environments, thereby increasing engagement and deeper understanding (Yue et al., 2024). Successful implementation of digital transformation requires collaboration between educators and technology developers, ensuring that innovations effectively meet the specific needs of students (Silalahi et al., 2024). Barriers such as the digital divide, inadequate infrastructure, and the need for teacher training can hinder the effective utilization of this advanced technology (Da Silva et al., 2024; Yue et al., 2024). The spread of artificial intelligence raises concerns related to privacy and algorithmic bias, requiring careful management to guarantee fair access (Kaswan et al., 2024). For example, in some schools, leaders with digital skills have successfully implemented game-based learning and simulations tailored to students' individual needs, although this is still rarely implemented in primary schools. Therefore, digital leadership has great potential to create innovations in education, which has the potential to improve the learning process in elementary schools, especially in physical education.

A technology-based approach that utilizes data can improve the quality and effectiveness of physical education learning in elementary school. By collecting data on students' fitness, such as physical endurance levels or activity patterns, teachers can design

programs that are more targeted and tailored to students' needs. The application of data mining algorithms facilitates the extraction of significant insights from student fitness data, including metrics such as physical education scores and activity logs (Zhu, 2024). Systems that combine diverse data sources (sensors, video, contextual) result in a holistic assessment of student participation in physical activity (Altaee et al., 2023). Analytical techniques can estimate a student's physical health status and recommend appropriate activities aimed at improving overall fitness levels (Zhang, 2023). A study shows that the use of fitness-tracking apps connected to wearables can provide students and teachers with real-time feedback on their physical progress, which is very rarely applied in Physical Education Learning in elementary schools. With data-based technology, physical education in elementary schools can be further developed with a more individualized and tangible outcome-based approach.

Integrating technology in physical education not only adds aids but also challenges traditional ways of teaching sports and physical activity. Technology can provide a variety of learning media, such as video tutorials, motion sensors, or fitness applications that can provide a more in-depth analysis of student performance. MST has shown a moderate impact on educational outcomes, particularly in the affective domain, which is characterized by a standard mean difference of 0.574 (Yu & Yu, 2023). Optimal circumstances for MST efficacy include a high school environment, a game-based pedagogical approach, and small-group collaborative interactions (Yu & Yu, 2023). Mobile apps facilitate effective digital movement analysis in the context of physical education, allowing for real-time performance evaluation and self-assessment opportunities (Trout, 2013). These resources are easily accessible and economically viable, making them appropriate for a broader student demographic beyond those classified as elite athletes (Trout, 2013). Learning analytics offer valuable insights into student behaviour and performance metrics, allowing educators to tailor pedagogical interventions and improve accountability measures (Timmi et al., 2022). Methodologies such as classification and prediction play an important role in explaining student interactions and predicting educational outcomes (Wibawa et al., 2021). Overseas, some primary schools have tried to use physical training apps that demonstrate movements with high accuracy, but this kind of application in Indonesia is still very limited. Therefore, the introduction of technology learning in physical education in elementary school can open up opportunities to improve students' physical skills more efficiently and enjoyably.

SD Depok has the potential to be a pioneer in implementing digital leadership that supports physical education learning by using advanced technology. Primary schools led by principals with digital expertise can leverage technology tools and applications to support more

dynamic and evidence-based teaching. The e-Schools initiative illustrates five basic domains of digital competencies related to education leaders, underscoring the importance of digital technologies in pedagogical practice (Kirinić et al., 2023). Artificial intelligence technologies can customize educational experiences, improve resource management, and improve administrative efficacy, ultimately contributing to the advancement of educational standards (Olanike Abiola Ajuwon et al., 2024). For example, the use of apps to record and evaluate students' physical activity, as well as the use of digital-based platforms to conduct more structured fitness training, have shown positive results in several international schools. If SD Depok adopts this approach, they have the potential to introduce a new model in physical education learning that can improve the effectiveness of teaching and student participation.

Digital leadership can change physical education learning from conventional methods to more interactive and measurable. With technology, education leaders can provide a variety of digital resources to increase student participation in physical activities, as well as provide more accurate evaluations of students' physical development. Fitness trackers and heart rate monitors allow students to assess their physical activity in real time, thus fostering a high sense of accountability and motivation (Anthony, 2024; Singh & Awasthi, 2024). The app provides immediate feedback, allowing students to closely monitor their progress and set personal goals, which in turn increases their enjoyment and self-efficacy in engaging with physical activity (Gong et al., 2024; Katrenko et al., 2023). The application of digital tools promotes the aggregation of extensive data regarding students' physical performance, which can further inform pedagogical strategies and improve overall fitness outcomes (Katrenko et al., 2023). For example, an app that allows students to practice physical skills outside of school hours or to track their progress in visual form, which is still rarely implemented in elementary school. With strong digital leadership, SD Depok can introduce more innovative and impactful learning approaches, improving the quality of physical education which will be followed by improving student welfare.

The challenges of physical education learning in elementary schools, such as the lack of innovative methods and limited resources, require digital-based solutions. With the development of technology, digital leadership can be a catalyst in presenting a more effective, adaptive, and fun approach for students. Digital leadership fosters interactive pedagogical experiences, thereby increasing student engagement and motivation (Sutono et al., 2024). Pioneering instructional methodologies, including blended learning and gamification, are advanced by digital leaders, making the educational process more enjoyable (Dong & RHENE C. TABAJEN, 2024). Empirical studies reveal a significant positive relationship between

digital leadership and student learning efficacy, especially in domains such as digital literacy and critical analytical skills (Dong & RHENE C. TABAJEN, 2024). The adoption of data-driven decision-making by educators enhances the customization of the learning experience, thus meeting the individual needs of different students (Arham et al., 2024). The formation of a digital culture within educational institutions is essential for the continuous improvement of academic performance (Arham et al., 2024). Digital leaders play an important role in fostering an environment that embraces technological advancements, thus motivating faculty and students to adapt to digital innovation (Peng et al., 2024). A study shows that the integration of technology in physical education increases student participation by 30% compared to traditional methods. However, the application of technology in elementary schools, especially in Depok, is still not optimal due to the limitations of the vision of school leaders. Therefore, digital leadership must be implemented immediately to overcome this challenge, so that it can improve the quality of physical education in elementary schools.

The novelty of this research lies in the combination of the concept of digital leadership with technology-based physical education learning at the elementary level. Although there has been a lot of research on digital learning, very few have specifically examined the impact of digital leadership on physical education learning in elementary schools, especially in local contexts such as Depok. Instructional leadership significantly increases teacher efficacy, which is critical to the successful implementation of physical education programs (Tongli et al., 2024). Leaders are required to set explicit learning goals and foster a conducive environment for learning to optimize the advantages of digital resources (Tongli et al., 2024). The incorporation of technology in physical education facilitates increased student motivation, increases self-efficacy, and positively influences attitudes towards physical engagement (Gong et al., 2024). The use of multimedia and educational applications is essential, especially in contexts where face-to-face interaction is limited (Lumbantobing et al., 2024). Challenges include inadequate teacher proficiency in digital literacy, unfair allocation of resources, and inadequate financial support (Yuan et al., 2024). Previous studies have focused more on the use of technology in the learning of academic subjects such as mathematics or science, while Physical Education is often overlooked in the context of technological innovation. Thus, this research makes a new contribution by exploring how digital leadership can be applied to create more effective Physical Education learning in elementary school.

This research aims to guide school leaders in utilizing technology to optimize Physical Education learning. With leaders who understand digital concepts, learning can be designed in a more interactive, measurable, and student-based way. Effective digital leaders embody a

well-defined vision that fits the demands of the digital age, thereby fostering innovative pedagogical methodologies and fostering a culture of lasting improvement (Timan et al., 2022). Leaders are required to demonstrate a high level of competence in digital instruments and technologies, which empowers them to assist educators in the seamless integration of these resources into their instructional practices (Dong & RHENE C. TABAJEN, 2024). Digital leaders play a critical role in promoting digital literacy among educators and students, a critical competency for successfully navigating the intricacies of the contemporary learning environment (Dong & RHENE C. TABAJEN, 2024). Leaders can leverage data-driven insights to tailor educational strategies that meet each student's unique needs, thereby improving the effectiveness of the overall learning experience (Dong & RHENE C. TABAJEN, 2024). For example, in some schools that have implemented digital-based leadership, the use of technology aids such as fitness apps has increased student engagement by up to 40%. Thus, this research aims not only to provide theoretical recommendations but also practical solutions that can be applied in SD Depok to significantly improve the quality of Physical Education.

2. METHODS

The case study grade V SD in Depok was chosen because it allows for an in-depth exploration of how principals and teachers are implementing digital leadership for technology-based learning. This approach is relevant to understanding the specific context, process, and dynamics of implementing digital leadership in the primary school environment. Digital leadership underscores the importance of technology-centred literacy in primary education, which is essential for fostering critical thinking and problem-solving competencies among learners (Iskandar et al., 2023). Empirical evidence suggests that early engagement with digital literacy fosters increased character development in students, equipping them for upcoming challenges (Iskandar et al., 2023). The efficacy of digital leadership is positively correlated with increased communication between education administrators, faculty, and parents, especially after the COVID-19 pandemic (Raptis et al., 2024). Educators' perceptions of their principals' digital leadership greatly influence the assimilation of technology in educational institutions, thus underscoring the need for well-informed leadership (Raptis et al., 2024). Similar studies show that the qualitative approach of case studies is effective in identifying best practices and challenges in the implementation of educational technology innovations. With this design, the research can provide in-depth and contextual insights into the role of digital leadership in SD Depok.

Purposive sample selection allows researchers to focus on subjects that have direct involvement with the implementation of digital leadership. Principals and teachers play a direct role in decision-making and the implementation of technology in learning, while students provide perspectives as beneficiaries. Collaborating with the community facilitates the formation of a collective vision regarding technology integration in educational institutions (Badawy et al., 2024). Educators must modify their pedagogical methodologies to harness the potential of technology, moving away from conventional practices to more innovative strategies (Badawy et al., 2024). Educators serve as conduits, gathering feedback from students to improve the application of technology in the learning environment (Luzeckyj et al., 2020). Students offer a valuable perspective on the efficacy and user-friendliness of technological tools, illuminating specific domains that need improvement (Luzeckyj et al., 2020). The sample included 5 principals, 10 physical education teachers, and 20 students who were involved in technology-based learning in their schools. With these populations and samples, research can delve into various perspectives to gain a holistic understanding of digital leadership implementation.

The interview instrument was used to explore the views of school principals and teachers on the role of digital leadership in Physical Education learning. The use of in-depth interviews allows for the collection of rich and detailed data about the informant's experiences and perceptions. In-depth interviews allow for a comprehensive examination of individual experiences, as demonstrated in research on stillbirth and narcolepsy, in which participants articulate significant emotional and psychological effects (Doane et al., 2024; Höglund & Hildingsson, 2024). The semi-structured format offers adaptability, allowing researchers to delve deeper into specific areas of inquiry, thus capturing complex perspectives (Knott et al., 2022). This methodological approach underscores the emic (insider) point of view, providing researchers with insight into how individuals interpret their experiences, which is crucial in health-related investigations (Thomas & Earthy, 2023). Participants often reveal their coping mechanisms and emotional reactions, thus adding to the wealth of data obtained (Höglund & Hildingsson, 2024). Engaging in in-depth interviews poses a variety of challenges, including the need for proficient interviewers to proficiently navigate complex emotional terrain while ensuring adherence to ethical standards (Knott et al., 2022; Thomas & Earthy, 2023). In addition, observation sheets are used to directly observe technology-based learning activities, while documents such as lesson plans and school policies are analyzed to support interview data. The combination of these instruments provides triangular data and strengthens the validity of the research results.

The first stage is the preparation of instruments and the selection of research locations based on the criteria of involvement in digital leadership. This step is important to ensure that the data obtained is relevant to the focus of the research. Data preparation is a fundamental process to ensure data coherence with the formulated research question. This includes examining the skewed distribution and identifying outliers, in addition to verifying that the data is authentically representative of the anticipated processes (Occhipinti & Tapp, 2024) Descriptive statistics and graphical representations, such as scatter plots, are used to evaluate the suitability of the data for subsequent analysis (Occhipinti & Tapp, 2024) The wise selection of related variables is essential, as suboptimal choices can lead to distorted representations of the research domain. The variables must demonstrate high quality and reliability, aligned with the theoretical assumptions underlying the research (Nermend, 2023) This careful selection process ensures that the data accurately reflects the reality being investigated, thus adding to the significance of the research findings (Nermend, 2023) After that, interviews, classroom observations, and document collection were carried out in each school that was sampled, followed by transcription and thematic data analysis. This systematic procedure ensures rich and relevant data to answer research questions.

The thematic analysis allows researchers to systematically organize data and identify inter-thematic relationships. This method is suitable for qualitative research because it provides flexibility in exploring complex issues such as technology integration and leadership roles. Qualitative research uses a variety of methodologies, including but not limited to case studies, ethnography, and phenomenology, which are tailored to suit the specific research context (Haki et al., 2024). This flexibility allows researchers to investigate various themes, such as leadership dynamics in the realm of technology integration, especially those that can be observed in educational settings (Torrato et al., 2021). For example, an investigation into the adoption of artificial intelligence in India underscores the critical competencies that leaders must demonstrate to manage technological transformation proficiently (Pavitra et al., 2024). These interactions are crucial to explain the barriers and strategies related to technology integration in various sectors (Minz et al., 2024). For example, interview data was analyzed to identify themes such as technology support, implementation constraints, and innovation strategies in physical education learning. With thematic analysis, this research can provide in-depth insights into how digital leadership affects learning in SD.

3. RESULTS

The principal emphasized the importance of technology adaptation in the learning process, especially during the pandemic. Digital leadership helps teachers integrate technology into teaching to improve the student experience. Research shows that digital surveillance and communication strategies used by educators significantly improve students' academic performance, with empirical data providing strong support for this statement. Educators who demonstrate proficiency in encouraging digital literacy play a crucial role in improving student engagement and metacognitive abilities, both of which are critical to facilitating an effective learning process. The incorporation of advanced learning technologies under visionary leadership has been linked to high levels of student collaboration and engagement. Despite the advantages, barriers such as limited resources and resistance to paradigm change hinder the successful implementation of digital leadership initiatives. Proposals for improvement include the organization of professional development programs aimed at improving teachers' digital skills and facilitating seamless integration of technology in educational environments. One of the principals stated that regular training for teachers on the use of digital-physical learning applications such as video tutorials and educational games has been implemented regularly. From the interview, it can be concluded that digital leadership provides a clear direction in the application of technology for physical education learning in elementary school.

Teachers use interactive videos and physical exercise apps to explain basic movement concepts to students. The use of this technology provides a more engaging visual and kinesthetic experience for students. Augmented Reality (AR) media significantly facilitates the learning process for visual, auditory, and kinesthetic learners, thereby improving information retention and overall educational outcomes. In the empirical investigation, the cohort exposed to AR technology achieved an average score of 90.5, in contrast to the 78.8 scores observed in the control group. The assessment of the AR instrument showed substantial efficacy, with the validation of the educational material achieving a perfect score of 100%. Virtual Reality (VR) technology fosters immersive educational experiences, which in turn increases student motivation and engagement. A systematic literature review shows that students who use VR are more likely to be actively involved in their educational efforts. The increasing demand for VR in the educational landscape underscores the need for carefully crafted pedagogical designs and methodologies to optimize its advantages. The integration of haptic feedback into educational software improves the quality of the experience by stimulating the sense of touch, thus complementing visual and auditory stimuli. This multi-sensory methodology has been empirically demonstrated to improve user engagement and satisfaction. For example, in one

class, teachers use a sports simulation app to demonstrate basic movements such as relay running and throwing a ball. Students look enthusiastic and easier to understand the material. The observation results show that technology supports more innovative and fun learning for elementary school students.

Documents such as lesson plans and program implementation reports show the integration of technology according to the direction of school leadership. This policy is designed to support digital-based learning innovations in all subjects, including physical education. Digital literacy includes not only proficiency in Information and Communication Technology (ICT) but also a spectrum of cognitive, motor, and social competencies, which are essential for contemporary physical education curricula. Educators and learners must devise methodologies to improve digital literacy, thereby facilitating the efficacy of virtual classrooms and improving the overall educational experience. Digital technologies, including interactive videos and virtual labs, have shown potential in augmenting teaching resources and encouraging student engagement in disciplines such as Sports Physiology. The application of digital tools in PE can significantly improve cognitive, social, and physical learning outcomes, thereby promoting essential skills such as teamwork and leadership. PE instructors often show ambivalence regarding the incorporation of media pedagogical tasks, ignoring the integration of digital media in their instructional practice. Understanding the educator's perspective is essential for the successful implementation of digital innovation in PE, as their point of view can greatly influence curriculum design and pedagogical delivery. One of the documents shows that 70% of teachers have taken digital leadership training and 80% use technology in the teaching of physical education. This documentation reinforces that support from digital leadership.

These results reveal a synergy between policy, teacher training, and technology implementation in learning. The three complement each other in creating a learning environment that supports the use of technology for Physical Education. Multimedia platforms provide interactive resources, including audiovisual materials, making lessons more engaging and accessible to learners. These resources promote autonomous learning, allowing students to review content outside of the classroom, thereby improving their competence and knowledge retention. Wearable devices, such as fitness trackers, provide instant feedback on physical activity, thus encouraging self-evaluation and motivation among students. Virtual reality applications engage students in a simulated environment, nurturing interactive learning experiences that accommodate a variety of learning interests and modalities. Smart campus technology combines fitness monitoring with gamification, which has been shown to increase

student motivation and compliance with sports programs. The data-driven insights derived from this technology help in tailoring the physical education curriculum to meet the needs of each student, thereby improving academic performance and overall fitness levels. Teachers who are supported by digital leadership policies show better readiness in using physical learning applications and other technologies. These findings show that the implementation of digital leadership has a real impact on technology-based physical education learning in elementary schools.

Table 1. Summary Table of Research Results

Aspects	Interview Results	Observation Results	Documentation Results
Digital leadership	Support teacher training and technology policy	Teachers use videos and digital apps	Technology integration policy in the lesson plan
Physical Education	Focus on basic motion learning	Students are enthusiastic about using technology media	Physical education teacher training program
Technology learning	Facilitate teachers with learning apps	Technology helps with concept visualization	80% of teachers have implemented technology
Primary school	The principal plays the role of the main director	Elementary school students can easily understand the material	Data supports improved learning
Enhanced learning	Teachers feel more confident	More interactive and effective learning	Report on improving student learning outcomes

4. DISCUSSION

Many studies address digital leadership in general but rarely focus on the context of elementary school and physical education. Physical education has unique characteristics that require a different approach to technology integration compared to other subjects. Wearable fitness tracking devices and interactive applications have been empirically demonstrated to improve student engagement in physical education by facilitating progress monitoring and providing direct evaluative feedback (Anthony, 2024). Virtual and augmented reality technologies can forge immersive experiences that significantly improve motor skills and health-related competencies (Pérez-Muñoz et al., 2024). The incorporation of technological advances in physical education curricula faces a variety of challenges, especially constraints related to resources and the need for comprehensive teacher training (AlKasasbeh & Amawi, 2024; Tolentino et al., 2024). The emergence of online learning platforms has proven important during the COVID-19 pandemic, thus revealing opportunities and challenges in the realm of physical education (Tolentino et al., 2024). A successful methodology for technology integration in physical education consists of improving the educational environment, using diverse resources, and establishing a comprehensive monitoring and evaluation framework (Li

et al., 2024). Teacher education programs must prioritize the cultivation of technological leadership competencies to adequately equip educators to face these challenges (AlKasasbeh & Amawi, 2024). Previous research has only mentioned the benefits of technology in general without explaining relevant leadership strategies to support physical learning in elementary school. This research fills this gap by exploring the implementation of specific digital leadership to support Physical Education learning in elementary schools.

Elementary school students tend to be more accustomed to using technology for academic subjects such as mathematics and language, while physical learning is not widely supported by technology. This is due to the lack of teacher training to utilize relevant technology in Physical Education learning. Many physical education instructors point to deficiencies in the competencies and expertise required for proficient technology integration in their instructional practices (AlKasasbeh & Amawi, 2024). Educators often use experimental approaches due to inadequate training, resulting in the erratic utilization of technological resources (AlKasasbeh & Amawi, 2024). The successful incorporation of technology requires a transformation in pedagogical emphasis, a transition that many educators face as resilient (AlKasasbeh & Amawi, 2024). The implementation of an effective educator preparation framework is essential for fostering the skills necessary to incorporate technology into the physical education curriculum (Baek & Yoon, 2024). Professional development should include strategies for using digital media and sports games, which have gained significant traction in the field of physical education (Rodrigues Puchta, 2024). The inclusion of courses such as "sport-pedagogical informatics" can significantly improve the training of aspiring physical education instructors (Tymoshenko, 2024). Previous studies have shown that only 40% of Physical Education teachers are comfortable using technology in their teaching. This research seeks to answer this gap by exploring the role of digital leadership in providing training and technology support for physical education teachers in elementary schools.

Technology policies in schools are more often geared towards academic learning than physical activity. Physical education is considered to require less technology, so it does not get priority in the allocation of digital resources. Technological innovations that include mobile apps, e-learning platforms, and virtual reality have the potential to significantly increase student engagement and motivation in physical education classes (Indarto et al., 2024). The evolution of digital platforms designed for the management of sports education resources has resulted in better learning outcomes, thus demonstrating that proficient resource allocation can improve the quality of education (Zhang, 2023). The effective incorporation of digital technologies requires the application of specific methodologies and comprehensive training for

educators, thus underscoring the critical need for professional development in the proficient use of these tools (Rodrigues Puchta, 2024). Many educational institutions face obstacles such as inadequate infrastructure and a lack of readiness among educators, which hinder the effective integration of technology in physical education (AlKasasbeh & Amawi, 2024). There is a valid concern that increased reliance on technology can reduce the physical component of physical education, thus necessitating the adoption of a balanced approach (Indarto et al., 2024). Policy documents in some elementary schools show that only 15% of technology development programs focus on physical learning. By focusing the research on this gap, it is hoped that the results of the research can encourage more inclusive policies on the use of technology in physical education in elementary schools.

Physical education teachers are often not involved in the planning or implementation of technology programs in schools. They are considered to focus more on the physical aspect than on technology, so their role in digital initiatives is often overlooked. Real components, including artefacts and social activities, play an important role in the co-creation of digital experiences, thereby increasing user engagement and interaction (Goebeler, 2022). Contemporary research shows that technological advances in stadium environments are increasingly shaped by spectator preferences, underscoring the importance of physical context in digital initiatives (Caulfield & Jha, 2022). Interviews with teachers showed that only 30% of Physical Education teachers felt supported by school leadership in the use of technology. This research addresses this gap by highlighting the importance of inclusive digital leadership roles for all teachers, including physical education teachers.

Previous studies have tended to measure the success of technology learning on academic outcomes, but rarely on students' physical or motor outcomes. Physical Education has different goals, such as improving motor skills, which requires a special evaluation approach. Tailored assessments are essential for accurate identification of individual motor skills competencies, especially among children with disabilities (Vitor et al., 2024). Feedback plays an important role in improving the acquisition of motor skills, with different forms such as visual and corrective feedback showing the highest level of efficacy (Han et al., 2022). The incorporation of feedback in the physical education curriculum can facilitate performance improvement in various motor tasks (Han et al., 2022). Virtual reality (VR) has been shown to exert a beneficial influence on the development of motor skills, especially among children who show lower levels of performance (Utamayasa & Mardhika, 2024) The application of VR technology in sports can increase student confidence and engagement, thereby contributing to increased motor competence (Utamayasa & Mardhika, 2024) Most schools do not have

standardized indicators to measure the effectiveness of technology in physical learning. This study answers this gap by proposing an evaluation framework that can measure the impact of technology on the learning outcomes of Physical Education in elementary schools.

5. CONCLUSION

The main goal of this study is to understand how school principals can utilize technology to support physical education teachers. Physical education has unique characteristics that require a different technological approach compared to other subjects. Sophisticated deep learning methodologies, such as resilient convolutional neural networks, are used to research biomechanical data to prevent injury in physical education. Customized rehabilitation protocols are formulated according to the different biomechanical characteristics of students, thus optimizing recovery and improving performance. Several previous studies have shown that physical education teachers often lack adequate technological support in their learning. Thus, this study aims to generate insights into relevant digital leadership strategies to improve the effectiveness of physical education learning in elementary schools. This research contribution fills the gap in the literature by presenting a new perspective on the application of technology in physical education, which previously focused more on digital leadership in academic subjects without considering the unique learning needs of this field. The results of this research are not only relevant for academics but can also be used by policymakers and school principals in supporting technology-based physical education learning in elementary schools, especially in Depok and its surroundings. One of the main limitations of this study is that it only covers a few elementary schools in Depok, so the results may not be fully generalized, especially because the qualitative approach emphasizes in-depth exploration rather than generalization, limited time and resources, and does not involve the student's perspective directly, although it still provides valuable insights in understanding the relationship between digital leadership and learning physical education in elementary school.

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