

Digital Leadership of School Principals in Enhancing Technology-Based Learning Quality

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Abstract: This research examines the role of school principals' digital leadership in enhancing technology-based learning quality in elementary schools during the Society 5.0 era. The Society 5.0 era demands educational transformation that integrates digital technology with humanistic approaches to create quality learning. School principals, as educational leaders, have a strategic role in directing digital transformation in schools. This research employs a qualitative approach with a case study method in several elementary schools that have implemented technology-based learning. Research findings indicate that principals' digital leadership encompasses five main dimensions: clear digital vision, technology competence, teacher capacity development, change management, and innovation culture building. These findings provide theoretical contributions to educational leadership concept development in the digital era and practical implications for principals' professional development.

Keywords: digital leadership; school principals; learning quality; educational technology; Society 5.0.

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1. Introduction

Background

The Society 5.0 era represents a super-smart society concept introduced by Japan as an evolution from Society 4.0. This concept emphasizes integration between cyber space and physical space to create human-centered society by utilizing technologies such as artificial intelligence, Internet of Things, big data, and robotics. In educational contexts, Society 5.0 demands fundamental transformation in teaching, learning, and managing educational institutions.

Elementary schools as the foundation of national education face significant challenges in adapting to these changes. Technology-based learning is no longer merely an option but an urgent need to prepare generations capable of competing in the twenty-first century. However, technology integration in learning does not automatically improve educational quality without effective leadership.

Digital leadership refers to leaders' ability to utilize digital technology in leading, managing, and developing educational organizations. Unlike traditional leadership, digital leadership demands specific competencies in understanding technology, managing digital change, and creating learning ecosystems adaptive to technological developments.

School principals have crucial roles as change agents in educational digital transformation. They are not only responsible for administrative aspects but must also lead paradigm shifts from conventional to technology-based learning. Principals' leadership in digital contexts demands deep understanding of how technology can improve learning quality, not merely using it as auxiliary tools. This transformation requires clear vision, appropriate strategies, and ability to empower entire school ecosystems in adopting technology meaningfully.

Research on digital leadership in elementary schools remains limited, particularly in Indonesian contexts. Most studies focus on technology leadership in higher education or secondary schools. Yet elementary school characteristics possess unique features, from students' cognitive development, teacher competencies, to available technology infrastructure.

Elementary-age children have different developmental characteristics from adolescents, so technology integration must employ approaches suitable to their developmental stages. Additionally, elementary teachers face particular challenges in integrating technology because

they must teach various subjects with thematic approaches demanding high creativity and adaptability.

Technology infrastructure conditions in elementary schools are also highly diverse, from schools with complete facilities to schools with significant technology access limitations. This gap raises questions about how principals can lead digital transformation in different contexts. Effective digital leadership must accommodate this diversity and find contextual strategies suitable to resources and challenges faced by each school.

The pandemic that occurred several years ago accelerated technology adoption in education. Distance learning forced by situations required all educational stakeholders to adapt to technology within short timeframes. This experience provided valuable lessons about the importance of infrastructure readiness, teachers' digital competencies, and adaptive leadership. However, post-pandemic challenges involve maintaining digital transformation momentum and integrating technology more meaningfully in face-to-face learning, not merely replicating physical classes onto digital platforms.

Problem Formulation

Based on the background outlined, this research formulates several research questions as study focuses. The first question concerns how school principals practice digital leadership in elementary schools during the Society 5.0 era. This question aims to understand how principals execute their leadership roles in digital transformation contexts, including concrete strategies, approaches, and practices in leading change.

The second question addresses what dimensions constitute principals' digital leadership in enhancing technology-based learning quality. This research seeks to identify key elements forming effective digital leadership pillars, from principals' personal competencies, teacher capacity development strategies, to organizational culture building supporting innovation.

The third focus question concerns what challenges and strategies principals face in implementing digital leadership. Digital transformation is neither easy nor linear. Various obstacles exist from infrastructure limitations, resistance to change, to competency gaps. This research seeks to understand these challenges deeply and how effective principals respond and overcome them.

The final question examines how principals' digital leadership impacts technology-based learning quality. This question is crucial because the ultimate goal of all digital transformation efforts is improving learning quality and student outcomes. This research will examine digital leadership impacts not only on technology aspects but also on pedagogical dimensions, student learning outcomes, teacher professionalism, and learning management efficiency.

Research Objectives

This research aims to describe school principals' digital leadership practices in elementary schools during the Society 5.0 era. Comprehensive descriptions of leadership practices will provide real pictures of how digital leadership concepts are operationalized in Indonesian elementary school contexts. This research seeks not only to photograph well-running practices but also understand processes, dynamics, and surrounding contexts.

The second objective is identifying digital leadership dimensions contributing to technology-based learning quality improvement. This identification is important for developing more contextual and applicable digital leadership conceptual frameworks for elementary schools. Identified dimensions can guide other principals in developing their digital leadership.

The third objective is analyzing challenges and implementation strategies of digital leadership in elementary schools. Deep analysis of faced challenges and how principals overcome them will provide valuable lessons about key success factors in digital transformation. Understanding effective strategies can help other schools currently or planning to undertake similar transformations to anticipate obstacles and plan appropriate solutions.

The final objective is evaluating digital leadership impacts on technology-based learning quality. This impact evaluation encompasses various aspects from pedagogical quality, student learning outcomes, teacher competencies, to learning management efficiency. Understanding these impacts is important for validating digital leadership importance and providing empirical evidence about added value generated from digital transformation investments.

2. Preliminaries or Related Work or Literature Review

Society 5.0 Concept in Educational Contexts

Society 5.0 is a future society vision initiated by Japan in the Fifth Basic Plan for Science and Technology in 2016. This concept continues previous industrial revolutions, starting from Society 1.0 as hunting society, Society 2.0 as agrarian society, Society 3.0 as industrial society, Society 4.0 as information society, to Society 5.0 as super-smart society. The fundamental difference between Society 5.0 and previous eras is focus on balance between economic progress and social problem solving through systems integrating cyber and physical spaces optimally.

In educational contexts, Society 5.0 fundamentally changes learning paradigms. Learning no longer centers on teachers as sole knowledge sources but centers on students with teachers as learning facilitators. Technology enables learning personalization adjusted to individual students' needs, interests, and learning speeds.

Digital Leadership in Education

Digital leadership in education represents an evolution from traditional leadership concepts influenced by digital technology developments. This concept is not merely about school principals skilled in using technology but about how educational leaders strategically use technology to achieve learning objectives and develop school organizations.

Sheninger in his 2019 book defines digital leadership as strategic technology use to enhance learning, instruction, and overall school experiences. According to him, digital leadership is not about technology itself but about how technology is used to achieve educational goals.

Digital leadership encompasses several dimensions. The first dimension is digital vision and strategy. Effective principals must formulate clear visions about how technology will be used to improve learning. The second dimension is principals' own technology competence. Principals need not become technology experts but require adequate digital literacy for informed decision-making about technology investments. The third dimension is technology-based learning leadership. Principals must facilitate technology use to improve learning quality, encourage innovative pedagogical practices integrating technology, and conduct monitoring and evaluation of digital learning effectiveness.

Technology-Based Learning Quality

Learning quality refers to process and outcome quality achieving established standards. In technology-based learning contexts, learning quality encompasses several interrelated aspects. The first aspect is pedagogical aspects as quality learning cores. Quality technology-based learning must have content relevance with established learning objectives.

Learning design must be engaging and interactive, utilizing technology potential to create meaningful learning experiences for students. Differentiated learning becomes easier with technology because content and activities can be adjusted to individual students' needs, interests, and ability levels.

Active learning strategy use is also an important indicator of quality technology-based learning. Students are not merely passive information receivers but actively involved in exploration, investigation, collaboration, and creation. Technology provides various tools enabling students to act as researchers, designers, or content creators, not merely information consumers.

3. Proposed Method

Research Approach and Type

This research employs a qualitative approach with case study research type. Qualitative approach selection is based on research objectives to understand digital leadership phenomena deeply and contextually. Qualitative approaches enable researchers to explore digital leadership practice complexity, understand meanings given by actors to their experiences, and capture nuances and dynamics potentially missed by quantitative approaches.

Case studies were chosen as research strategies because they enable researchers to conduct deep investigations of phenomena in real-life contexts, particularly when boundaries

between phenomena and contexts are not clearly defined. Principals' digital leadership cannot be understood separately from school contexts where that leadership is practiced.

This research employs multiple case study designs involving three elementary schools as analysis units. Multiple case study use enables researchers to conduct cross-case analyses that can identify common patterns while understanding contextual differences. Cross-case replication also strengthens research finding credibility compared to single case studies.

Research Location and Time

Research was conducted in three elementary schools in Makassar City selected purposively with certain criteria. The first criterion is schools have implemented technology-based learning for at least two years. This duration is needed so schools have passed initial adoption phases and have sufficient experience integrating technology in learning.

The second criterion is having principals actively leading digital transformation, not merely delegating technology responsibilities to coordinators or certain teachers. The third criterion is showing learning quality improvement indications based on internal school indicators such as student learning outcomes, student engagement, or feedback from teachers and parents.

The three selected schools have diverse characteristics to provide context variation. The first school is a public school in urban areas with complete technology facilities and students from various socio-economic backgrounds. The second school is a private school making technology a differentiation and competitive advantage with significant infrastructure and digital program investments. The third school is a public school in semi-rural areas with infrastructure limitations but having innovative principals in utilizing limited resources.

This characteristic diversity is important for understanding how digital leadership is practiced in different contexts, faced challenges, and developed strategies according to each school's conditions. Research was conducted over six months to provide sufficient time for researchers to build rapport with informants, conduct deep data collection, and understand dynamics occurring in schools.

Data Collection Techniques

The first data collection technique is in-depth interviews conducted semi-structuredly. Interview guides were prepared based on research conceptual frameworks but remained flexible to explore information emerging during interviews. Interviews with principals focused on digital visions and strategies, change leadership experiences, faced challenges, and reflections on their leadership impacts.

Interviews with teachers focused on technology integration experiences, support received from principals, challenges in technology-based learning, and changes they experienced. Interviews were conducted in comfortable places for informants, usually in principals' rooms or teachers' rooms, with durations around forty-five to ninety minutes. Each interview was recorded with informant permission to ensure data accuracy.

The second data collection technique is participatory observation where researchers are present in schools to observe various activities relevant to research focus. Learning observation was conducted using observation protocols encompassing aspects such as technology types used, how teachers integrate technology with pedagogy, student engagement levels, teacher-student interactions, and digital classroom management.

The third data collection technique is documentation study conducted by collecting and analyzing various relevant documents available in schools. Policy and planning document analysis provides understanding about visions, strategies, and programs designed by schools related to learning technology.

The fourth data collection technique is focus group discussions conducted with teachers and students separately. Group discussions with teachers aim to deepen technology-based learning practices, share experiences and challenges, and identify factors supporting or hindering technology integration. Group discussions with students aim to understand their learning experiences with technology, preferences, and improvement suggestions.

Data Analysis Techniques

Data analysis in this research employs thematic analysis which is a method for identifying, analyzing, and reporting patterns or themes in qualitative data. The analysis process begins with transcription and data organization stages. All interview recordings are transcribed verbatim to ensure data accuracy and completeness.

The second stage is coding which is the process of giving labels to relevant data segments. Open coding is conducted by carefully reading data and identifying initial concepts, ideas, or themes emerging from data. Axial coding is conducted to connect categories

emerging from open coding. Selective coding is conducted to integrate and refine categories into main findings answering research questions.

The third stage is theme identification involving code grouping into broader themes. Themes are recurring patterns capturing something important about data in relation to research questions. The fourth stage is interpretation where researchers give meaning to findings by integrating various themes, connecting with relevant theories and literature, and developing coherent descriptive-analytical narratives.

The fifth stage is validation involving member checking where interview transcripts and finding drafts are shared with informants to ensure researcher interpretations align with their intentions and experiences. Peer debriefing is conducted by discussing research processes and findings with research colleagues. Source, method, and theory triangulation are conducted to ensure findings are supported by various types of evidence and perspectives.

4. Results and Discussion

School Research Profile and Context

This research was conducted in three elementary schools in Makassar City with diverse characteristics to provide comprehensive understanding of digital leadership in different contexts. The first school is a public school located in urban areas with approximately 750 students. This school has implemented smart classroom concepts since 2022 with fairly complete technology infrastructure including projectors in every class, computer laboratories, and wireless internet networks covering entire school areas.

The second school is a private school making technology the main differentiation with approximately 450 students. This school has implemented integrated learning management systems, provides tablets for every fourth through sixth grade student, and applies blended learning models. The third school is a public school in semi-rural areas with approximately 320 students. Despite having infrastructure limitations with low computer-to-student ratios and not always stable internet connections, this school has become a digital transformation model with limited resources.

These three schools were deliberately selected to represent diversity of Indonesian elementary school contexts, from schools with complete facilities to schools with resource limitations, from public to private schools, from urban to semi-rural areas. This diversity enables research to identify universal digital leadership principles applicable in various contexts while understanding how contexts shape specific leadership strategies and practices.

School Principals' Digital Leadership Dimensions

From research results in three schools, five main dimensions forming effective school principals' digital leadership in enhancing technology-based learning quality were identified. These dimensions do not stand alone but are interrelated and mutually reinforce each other in creating quality digital learning ecosystems.

Clear and Inspirational Digital Vision

The first dimension is clear and inspirational digital vision. All three principals demonstrate ability to formulate digital visions that are not only clear and measurable but also inspire all school community members. This vision is not merely rhetoric or slogans displayed on walls but translated into concrete planning documents with specific targets and indicators. The first principal states their vision is to make the school a smart school that not only uses technology but integrates it meaningfully in learning, focusing on developing students' abilities to not only be digitally literate but capable of using it to solve problems and create.

Effective digital vision has several important characteristics. First is learning-centered where vision emphasizes technology as a tool to improve learning not as an end itself. Second is realistic yet ambitious where vision considers actual school conditions but encourages continuous improvement. Third is continuous communication where vision is not only delivered once but communicated consistently through various forums. Fourth is participatory where vision is not formulated top-down by principals alone but involves teachers, students, and parents in vision formulation and refinement.

Principals' Technology Competence

The second dimension is principals' technology competence. Research findings show principals need not become technology experts or programmers but need adequate digital literacy for informed decision-making and credible leadership. Technology competence encompasses several levels.

The first level is basic competence encompassing abilities to operate digital devices such as computers, tablets, and smartphones, use productivity applications such as word processors, spreadsheets, presentations, email, and cloud storage, and communicate through digital platforms such as instant messaging and video conferencing applications.

The second level is pedagogical-technology competence encompassing understanding of various available digital learning tools, ability to evaluate technology suitability with learning objectives, and ability to provide constructive feedback on technology-based learning conducted by teachers.

The third level is strategic competence encompassing abilities to analyze educational technology trends and anticipate developments, make appropriate technology investment decisions considering learning needs, sustainability, and total cost of ownership, and manage risks related to data security, privacy, and technology misuse.

Teacher Capacity Development

The third dimension is teacher capacity development which is the most crucial dimension because ultimately digital transformation will be realized through learning practices conducted by teachers in classrooms. Digital leadership is most clearly seen in systematic and continuous efforts by principals to develop teachers' capacities in integrating technology.

Effective professional development programs encompass several components. The first component is structured training conducted gradually from basic to advanced levels. Training is not one-size-fits-all but differentiated based on teachers' initial competence levels. The second component is continuous mentoring involving mentor-mentee systems among teachers, classroom observations and constructive feedback provision, and team teaching for teachers still struggling.

The third component is professional learning community formation where teachers regularly share best practices, discuss challenges, and collaborate in developing content or learning strategies. The fourth component is technical support and resources encompassing availability of responsive help desks or technology coordinators, easily accessible and well-organized digital content repositories, and specific time allocation for teachers to explore new technologies and develop content.

Change Management

The fourth dimension is systematic change management because digital transformation is fundamentally a complex organizational change process facing various resistances. Effective principals understand that digital transformation is not merely technical change but also cultural, mindset, and practice changes requiring structured change management approaches. Digital transformation processes generally go through several phases that need understanding and good management. The first phase is awareness phase where principals conduct socialization about digital transformation urgency, bring teachers and other stakeholders to benchmark to successful schools, and conduct gap identification between current conditions and desired conditions.

The second phase is adoption phase where pilot project implementation begins involving early adopters or most ready and enthusiastic teachers. The third phase is adaptation phase where adjustments are made based on feedback from initial implementation. The fourth phase is transformation phase where technology is already integrated into school culture and becomes a natural part of how schools operate.

Change management success keys encompass several aspects. The first aspect is intensive and transparent communication about transformation objectives, processes, and progress. The second aspect is broad stakeholder participation where teachers, students, parents, and school committees are involved in change processes. The third aspect is empathetic resistance management where principals do not view resistance as enemies but as feedback that improvements are needed in communication and support.

Innovation Culture Building

The fifth dimension is innovation culture building which is the foundation for sustainable digital transformation. Digital leadership is not merely about technology or certain programs but about creating organizational culture supporting innovation, experimentation, and continuous learning.

Innovation culture has several important characteristics. The first characteristic is growth mindset where mistakes are viewed as learning opportunities not failures to be avoided or punished. The second characteristic is strong collaboration where knowledge and resource sharing among teachers becomes norm. The third characteristic is data-based decision-making where using data for evaluation and improvement becomes habit. The fourth characteristic is student voice where students are involved in learning design, student feedback is heard

and seriously followed up, and students are treated as learning co-creators not merely consumers or learning objects.

Digital Leadership Impacts on Learning Quality

School principals' digital leadership practices show significant impacts on various technology-based learning quality aspects. These impacts can be seen from four main dimensions: pedagogical quality improvement, student learning outcome improvement, learning management efficiency, and teacher professionalism improvement.

Pedagogical Quality Improvement

The first dimension is pedagogical quality improvement seen from several indicators. The first indicator is learning becomes more interactive and engaging. Multimedia use such as videos, animations, and simulations increases student involvement in learning. The second indicator is differentiation and learning personalization becoming easier to do. Adaptive learning platforms can adjust content to individual students' learning speeds.

The third indicator is learning becomes more active and collaborative. Collaboration platform use facilitates effective group work even when students are not in the same place. The fourth indicator is twenty-first century skills integration in learning. Critical thinking is developed through digital information analysis activities from various sources.

Student Learning Outcome Improvement

The second dimension is student learning outcome improvement which is the ultimate indicator of learning success. Academic data shows positive trends in all three schools though with different improvement levels. The first school experienced average school exam grade increases of 12 percent in the last two years.

The second school shows students have high digital literacy where 95 percent of sixth grade students can create quality multimedia presentations. National assessment results show scores above national averages. The third school despite resource limitations shows learning outcome increases of 8 percent in one and a half years.

Learning Management Efficiency

The third dimension is learning management efficiency which significantly increases with technology adoption. The first indicator is more efficient learning administration through digitalization of lesson implementation plans and other learning devices. The second indicator is more effective communication with parents through real-time communication platforms. The third indicator is better learning resource management through well-organized digital repositories.

Teacher Professionalism Improvement

The fourth dimension is teacher professionalism improvement which is a long-term impact of effective digital leadership. The first indicator is digital competence improvement where 100 percent of teachers in three schools already use learning management systems. The second indicator is continuous reflection and improvement practices where teachers record learning for self-reflection. The third indicator is networking and collaboration where teacher participation in online communities among fellow teachers increases.

Challenges in Digital Leadership Implementation

Despite showing significant positive impacts, digital leadership implementation faces various challenges that need understanding and overcoming with appropriate strategies. The first challenge relates to infrastructure and resources. Device and connectivity limitations become main obstacles especially in the third school.

The second challenge relates to competencies and mindsets. Digital gaps among teachers are very significant especially between young and senior teachers. Resistance to change also becomes a challenge where some teachers show resistance with various reasons. Overload and burnout also become real challenges where digital transformation adds teacher workloads especially in initial phases.

The third challenge relates to pedagogy where risks of excessive focus on technology and forgetting learning essence become concerns. Digital divide among students also becomes serious pedagogical challenges. Screen time and health also become legitimate pedagogical concerns especially for elementary school age children.

The fourth challenge relates to external factors. Policies and regulations become challenges where frequent curriculum and regulation changes make long-term planning difficult. Parent involvement also varies and becomes external challenges. Technology change speed also becomes external challenges where technology develops very rapidly making it difficult to always update.

Best Practices Digital Leadership Model

Based on cross-case analysis from three schools, several best practices in digital leadership were identified that can become learning for other schools. The first best practice is starting with why or clear objectives. Digital transformation must begin with deep understanding about why transformation is important, not merely what technology will be used or how implementation proceeds.

The second best practice is walk the talk where principals must become role models in technology use. The third best practice is empowerment by empowering teachers as innovators. The fourth best practice is data-informed not data-driven. The fifth best practice is phased implementation.

The sixth best practice is ecosystem approach. Schools cannot conduct digital transformation alone but need supporting ecosystems. The seventh best practice is student-centered. All digital leadership decisions must be based on questions whether this improves student learning and wellbeing.

5. Conclusions

Conclusions

Based on research results and discussion outlined, several important conclusions can be drawn about school principals' digital leadership in enhancing technology-based learning quality in elementary schools during the Society 5.0 era.

The first conclusion is that school principals' digital leadership represents transformational leadership transcending mere technology mastery. Digital leadership is integration between vision, competencies, strategies, and humanistic values to create adaptive, innovative, and student-centered learning ecosystems.

Five identified main digital leadership dimensions namely clear and inspirational digital vision, adequate technology competence, systematic teacher capacity development, effective change management, and innovation culture building are interrelated and mutually reinforce each other.

The second conclusion is that school principals' digital leadership significantly impacts various learning quality aspects. From pedagogical quality perspectives, learning becomes more interactive, differentiation increases, active and collaborative learning is well facilitated, and twenty-first century skills are integrated in learning.

The third conclusion is that digital leadership implementation faces various complex challenges but can be overcome with appropriate strategies. Infrastructure and resource challenges can be overcome with creativity such as utilizing simple technology, bring your own device, and partnerships with external parties.

The fourth conclusion is that the LEAD-TECH model offers comprehensive contextual frameworks for elementary schools with emphasis on child-centered approaches, developmentally appropriate technology, and balanced integration between digital and non-digital learning.

The fifth conclusion is that in the Society 5.0 era, digital leadership must balance between technological advancement and human values. Technology is an enabler, not an end goal. Focus remains on holistic human development encompassing academics, character, and wellbeing.

Recommendations

Based on research findings and conclusions, several recommendations are formulated for various parties involved in education. Recommendations for school principals encompass several important matters. First is starting with clear vision by formulating inspirational and measurable digital visions, consistently communicating to all stakeholders, and translating visions into concrete action plans.

Second is investing in people not just technology by prioritizing teacher capacity development, building learning and innovation cultures, and providing continuous support. Third is leading by example by becoming role models in technology use, showing growth mindsets and openness to learn, and being vulnerable and authentic in leadership.

Recommendations for educational policymakers encompass five main matters. First is standardizing digital leadership competencies by developing clear digital competency standards for school principals. Second is systematic training programs by designing continuous training programs. Third is infrastructure and budget support. Fourth is guidelines and best practices. Fifth is ecosystem enablement.

Recommendations for further research encompass five areas needing further exploration. First is longitudinal studies tracking digital leadership impacts on student learning outcomes long-term. Second is quantitative studies with large-scale surveys. Third is focusing on specific aspects. Fourth is context-specific studies. Fifth is emerging technologies.

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