



Academic Supervision of Mathematics Teachers to Enhance Digital Literacy: A Case Study at SMP Negeri 2 Nibong, North Aceh Regency

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ABSTRACT

The purpose of this study is to: (1) analyze academic supervision carried out by school principals in improving the digital literacy of mathematics teachers, (2) analyze the digital literacy competence of mathematics teachers in SMP Negeri 2 Nibong North Aceh Regency. Using a qualitative case study approach, data were collected through in-depth interviews, classroom observations, and documentation of the principal and three mathematics teachers. The data were analyzed by methods of reduction, display and conclusion drawing. The results recommend that the joint planning of academic supervision through a clinical approach was more effective, the focus of supervision changed from administrative compliance to mentoring teachers in the integration of mathematical software. Teachers' digital literacy improved greatly, particularly in designing digital learning experiences, selecting adaptive visual media, and conducting online platform-based assessments. High motivation of teachers and sufficient facilities were important supporting factors. Limited availability of principals and differences in initial digital competence of teachers (digital gap) were identified as barriers. Regular and systematic academic supervision, considering a dialogical/clinical approach, was effective in improving the digital literacy of mathematics teachers. These findings point to the need to redefine the role of the supervisor from an administrative overseer to a mentor and technology facilitator, with implications for the practice of school leadership development for digital-era education.

1. Introduction

Education is an integral part of human life, a means of facilitating positive change (Ilhan et al., 2024). Education is expected to be used to develop potential abilities into practical competencies needed for improving quality of life. Education, therefore, is a continuous process which has no limits of space and time. This is affirmed in Indonesia's Law No. 20 of 2003 on the National Education System, Chapter II, Article 3, which stipulates that national education functions to develop capabilities and shape the character and civilization of a dignified nation in the effort to educate the nation's life, with the aim of developing learners' potential to become individuals who are faithful and devoted to God Almighty, possess noble character, are healthy, knowledgeable, capable, creative, independent, and become democratic and responsible citizens (Nurdin, 2015).

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In the current digital age, the delivery and quality assurance of educational services are still advancing(Rasdiana et al., 2024). The integration of technology within learning environments is an ongoing process of innovation. However, digitalization in education has not yet resulted in a complete change and, in some respects, has increased the digital divide(Komarudin et al., 2024). Therefore, educational providers, especially teachers, need to acquire technological literacy quickly and efficiently in order to keep up with these developments(Salimi et al., 2025).

Education is a collective responsibility of all stakeholders, parents, schools and society. Cooperation among these three parties is necessary, schools and teachers in particular being directly responsible for children's education in the formal learning environment(Alhashem et al., 2022). Thus, improving the quality of teachers is very important to improve the quality of education outcomes at the school level and the overall progress and quality of education in Indonesia(Munawar & Siraj, 2026). Teachers are crucial to the success of instruction in the teaching and learning processes, since they are the ones who make decisions about classroom policy, including how curricula will be implemented in practice(Khadijah et al., 2025). Thus, a qualified and professional teacher is vital to manage the classroom learning activities to meet the educational expectations and optimize the student learning outcomes(Khairani et al., 2025).

academic supervision in the widest meaning of the word as the backbone of education, a principle which is true for most education systems in the world(Sugiar et al., 2024). systematic supervision helps improve the quality of teacher leadership, fosters mutual respect among teachers, helps teachers to diagnose instructional difficulties, and improves the individual competence of teachers(Usman et al., 2023). conceptualises academic supervision as a principal-led support that develops leadership of teachers and staff in the pursuit of educational goals and is reflected in the provision of guidance, encouragement and opportunities for the development of teaching expertise and skills(Kreber & Wealer, 2023). Academic supervision is a direct involvement of principals and teachers in educational activities, which presupposes their joint responsibility for learning outcomes(Bakokonyane & Pansiri, 2024).

There are three major functions of academic supervision. The first is to help and guide teachers by direction, information and training to improve their teaching skills and competencies(Yolviansyah & Hermanto, 2023). The second is to support teachers to identify and solve instructional problems(Dwikurnaningsih & Paais, 2022). The third is to evaluate the implementation of the curriculum in relation to available facilities and infrastructure. Supervision is essentially an art of cooperation which is used in the teaching and learning process for optimal outcomes in education.

The UNESCO Declaration states that every human being has the inalienable right to lifelong learning, to enable full and effective participation in the information society. To this end, the Indonesian Ministry of Education and Culture initiated the School Literacy Movement (Gerakan Literasi Sekolah/GLS) in 2015 to create schools as lifelong literacy centres for all members of the school community(Cahyani et al., 2025). Digital literacy is one of the literacy competencies teachers are expected to develop and implement for students and as such requires intentional and ongoing development(Aulia & Tasrif, 2025). Moreover, the Law of the Republic of Indonesia No. 14 of 2005 places this competency in the context of the pedagogic capacity of teachers to manage the learning of students effectively(JANTHAPASSA et al., 2024). UNESCO defines digital literacy in terms of the basic educational activities of reading, writing and mathematics(Tinmaz et al., 2023). Digital literacy is not only the ability to operate information, communication and technology devices, but also covers social competences, learning capacity and critical, creative and inspirational thinking dispositions, which are the core digital competences to be possessed by individuals(Villar-Onrubia et al., 2022). In this context, digital literacy is functional to enhance the cognitive capacity of Indonesia's human

resources, ensuring that digital skills extend beyond basic operation of devices to more substantive and transformative competencies.

From the above discussion, it can be concluded that one of the main competencies that teachers should have in this era is literacy, namely competencies that are oriented to technological and information capabilities or more popularly called digital literacy. In the twenty-first century and beyond, teachers will be challenged to keep pace with the rapid development of information and communication technologies. Classroom teaching and management in this era, then, must be in line with prevailing technological standards. Digital literacy is the knowledge and skills to use digital media, communication tools and networks to find, evaluate, use and create information and to apply it in a healthy, wise, intelligent, accurate, appropriate and legally compliant manner to support communication and interaction in daily life. An alternative definition of digital literacy as the ability to use and interact critically with information, technology and digital media to assess, produce and communicate according to one's needs (Tomczyk, 2025).

This challenge is particularly evident among the math teachers at SMP Negeri 2 Nibong, North Aceh Regency. Preliminary observations show that digital literacy competencies are still uneven, and academic supervision by the school principal has not been optimally directed towards strengthening teachers' technological capacity in mathematics instruction. Considering that principal-led academic supervision plays a strategic role in supporting the professional development of teachers, it is important to study the implementation of this supervision in practice and its contribution to improving the digital literacy of mathematics teachers at the school. Thus, the objectives of this study are: (1) to analyze the academic supervision carried out by the school principal in improving the digital literacy of mathematics teachers; (2) to analyze the digital literacy competence of mathematics teachers at SMP Negeri 2 Nibong, North Aceh Regency.

2. Methodology

2.1 Research Approach and Design

In this research, descriptive method with qualitative approach was used. As the main focus of the inquiry is a characteristic phenomenon of actor behavior, especially the school principal and mathematics teachers in the implementation of teacher resource development plans at SMP Negeri 2 Nibong, it was appropriate to use qualitative method to get the lived experiences of research subjects and interpret them using qualitative procedures that have been used in the study (Gioia, 2021).

This method aims at creating a comprehensive and detailed description of specific events and phenomena occurring in specific characteristic objects and subjects. Implementation of a case study method involves collecting in-depth information and presenting it in the narrative form to provide a comprehensive depiction of the phenomenon under investigation (LÖSCH et al., 2023).

Thus, this research is descriptive research that aims to describe facts and characteristics of a particular field systematically and accurately. This study highlights the descriptive nature of data (Stanley, 2023). In describing the phenomenon as it is and not on the explanatory power, hypothesis testing, prediction or implications. Therefore, this research aims to describe "Academic Supervision of the School Principal in Enhancing Mathematics Teachers' Digital Literacy at SMP Negeri 2 Nibong, North Aceh Regency" as long as the phenomenon is still open for systematic study.

2.2 Research Setting and Period

Choosing the research setting and time frame is an important part of qualitative research because the research setting should be relevant to the problem the research is attempting to address. The setting and schedule of this research are as follows.

This research was conducted in SMP Negeri 2 Nibong . The choice of this school as a research site was based on the following considerations: (a) the school has experienced a massive decline in student enrolment for the last few years, which raises concerns of declining community interest and trust, and (b) the school is a relevant context for exploring how twenty-first century teaching competencies are being developed among its staff. The data collection was conducted from December 2023 to March 2024.

2.3 Research Subjects

a. Subject

The object of research is the thing, person or entity that provides the data to the variables and central issues under investigation. Research subjects have an important role because they are the main source of data about the variables studied (Arikunto, 2016). The subject of the research in this study is SMP Negeri 2 Nibong, so that the field data is still in accordance with the research problem and does not deviate from the original objectives of the study.

b. Informants

The informants of this study were selected by a purposive sampling technique. Purposive sampling is a sampling technique with data sources determined by specific considerations, for example, people who are considered to be the most knowledgeable about the phenomenon under study so that they can provide a clear understanding of the object or social situation being studied (Sugiyono, 2016, p. 368).

The main sources of information were competent and relevant informants, while the research site as an element of the larger social situation included the conditions of the circumstances and environment of the research problem. The informants in this study were the school principal and three mathematics teachers at SMP Negeri 2 Nibong. They were selected based on the criteria of their direct involvement and knowledge of the academic supervision process and its role in improving the digital literacy skills of mathematics teachers.

2.5 Instrumentation and Data Collection

The research analyzes the Academic Supervision of the School Principal in Improving the Digital Literacy of Mathematics Teachers at SMP Negeri 2 Nibong, with the research subject being the teachers and school staff. Therefore, the identification of informants is an important part of this research. Informants are grouped into two, initial informant (informan pangkal) and key informants (informan pokok).

The first informant is a person who is believed to be able to provide general information related to the research topic and to find other people who can be used as key informants who are able to provide more in-depth and detailed information. The data collection techniques are the most strategic step in research because the prime goal of any study is data collection. If researchers do not know the good way to collect data, then they will not get data that meets the quality standards. Therefore, the data collection of this research was conducted in the following stages in order to get an in-depth understanding of the school principal's academic supervision in improving the digital literacy of mathematics teachers of SMP Negeri 2 Nibong, North Aceh Regency, which are:

a. Method of Observation

According to(Roulston & Choi, 2017), all scientific research is based on observation. Because the researcher can only work based on data, which is the factual evidence obtained through direct

observation of reality. The researcher in this method used a non-participatory observation technique where the researcher did not participate in the activities being studied but only observed and examined them to understand and seek answers or to gather evidence related to the academic supervision practices implemented by the school principal.

2.6 Data Validity Testing Techniques

Data validity testing was undertaken through a number of techniques which are outlined below to account scientifically for data obtained through qualitative research.

a. Increasing Persistence

The increasing persistence means careful and continuous observation during research process. This method allows the researcher to accurately and systematically record the certainty and order of events. The increase in persistence also increases the credibility of the data as the researcher can re-verify whether the data identified earlier are correct or wrong. The researcher can also describe the phenomena observed with accurate and systematic through this process. To support this process, the researcher extensively read relevant reference books, previous research findings and documents related to the phenomena under investigation. Such engagement, in turn, sharpens and broadens the researcher's understanding, thereby allowing for more accurate verification of the credibility of the data obtained.

b. Triangulation

Triangulation is a technique for testing the credibility of in-depth cross-checking of data obtained from various sources, methods and time periods. The data obtained from interviews with the school principal and the three mathematics teachers were triangulated with data from sources, documentary evidence and other corroborating evidence. Data collection techniques were performed by triangulation of data by cross checking the data obtained from the same informant with different methods, namely interview, observation, and documentation. Any conflicting results were resolved through further discussion with the relevant or additional data sources to find the most accurate information. To ensure data validity and credibility, interviews were conducted in the morning when informants were usually more attentive and less preoccupied with the day's worries, and by cross-checking the interview and observation data collected at different times, repeating data collection when inconsistencies were found until consistent results were achieved, and comparing the results with those obtained by other researchers.

2.6 Data Analysis

In qualitative research, data analysis is carried out during the data collection process and after the completion of data collection within a specified period. At the time of the interviews, the researcher analyzed the answers of the informants simultaneously. If the analyzed answers were not satisfactory enough, the researcher continued with the probing questions until credible data were acquired. This process was iterative and continued iteratively until data saturation was reached. Data analysis activities included three components: data condensation, data display, and conclusion drawing/verification (Miles & Huberman, 1994).

3. Results

3.1 Theoretical and Practical Implications

The success of academic supervision in enhancing teachers' digital literacy at this school can be attributed to the principal's capacity to transform the supervision paradigm from inspection, which identifies deficiencies, to facilitation, characterized by continuous mentorship. The implementation of e-supervision approaches alongside a coaching methodology demonstrated efficacy in surmounting psychological obstacles across generations of instructors. Supervision served as a conduit for adaptation for senior educators and a platform for innovation for junior educators. The existence of a peer tutoring program reinforces the idea that enhancements in digital literacy cannot be achieved through unilateral instruction but require a collaborative ecosystem inside the educational setting. However, infrastructure limitations and instructor workload provide significant obstacles. The essential element for equitable and just digital change in education is proactive and inclusive principal leadership.

Additionally, these findings indicate a practical necessity for policy adjustment at the District Education Office and School Management levels. Principals may no longer depend solely on a singular, inflexible supervising tool. The results of this study demonstrate the necessity for new operational guidelines that ethically govern the administrative preparation processes of educators, alongside training programs that equip school supervisors with digital competencies that are equal to or exceed those of the teachers they oversee. This supervisory paradigm risks diminishing its actual efficacy in the field without an augmented supervisory capacity.

3.2 Contribution to the Body of Knowledge

In brief, these findings have been effectively integrated into the current knowledge base on educational management and instructional technology, reinforcing the conceptual link between school leadership theory and digital innovation adoption theory, two domains that have often been studied independently.

These findings enhance the notion of Instructional Leadership for twenty-first-century educational administration. Classical literature (Hallinger et al., 2025) has defined the principal's primary duty as matching courses and overseeing student progress through conventional supervision. This study introduces a novel aspect to this field of knowledge: digital instructional leadership. This research posits that contemporary instructional leadership encompasses not only the principal's role in ensuring teacher adherence to established curricula but also the principal's capacity to cultivate a digital ecosystem and promote digital agency among educators.

These findings align with Everett Rogers' Diffusion of Innovations hypothesis. Rogers asserts that change agents capable of interpersonally conveying new ideas are essential for the adoption of innovation within an organization. This study addresses a practical gap in the theory by redefining the principal as an Internal Change Agent who operates tactically within the school environment through differentiated supervision, rather than as a formal overseer. This study presents an asymmetric intervention model (basic, intermediate, and advanced levels) that operationalizes Rogers' diffusion theory within educational settings. Teachers categorized as "laggards" in technology adoption are not marginalized through punitive oversight, but rather supported through an andragogical approach, while "innovators" are afforded the latitude to autonomously pursue their knowledge exploration.

The integrating of these findings into the Technological Pedagogical Content Knowledge (TPACK) paradigm by (Mishra et al., 2022) offers a novel and more dynamic perspective. Nonetheless, TPACK has predominantly been seen as an intrinsic ability that educators must cultivate independently through training for the past two decades. This study contests the prevailing notion by illustrating

that TPACK is not a static construct but an adaptable competency, which can be significantly improved with a systematic external intervention, specifically clinical academic supervision. Consequently, the research is not merely a validation or replication of pre-existing knowledge, but rather a natural progression that enhances and integrates classical ideas of educational management within the framework of their applicability to the reality of the digital era.

5. Conclusions

The study's findings indicated that academic supervision at SMP Negeri 2 Nibong has successfully transitioned from traditional inspection-based methods to a humanistic, needs-coaching approach, augmented by e-supervision. This transformation commenced with a needs assessment to identify the digital divide among teachers, resulting in a reduction of technostress for senior educators and fostering increased innovation among younger teachers. This modification resulted in quantifiable advancements in the three dimensions of digital literacy: digital skills (autonomous development of interactive educational media and task organization in the digital realm), digital culture and ethics (professional cyber-communication and adherence to copyright), and digital safety (enhanced awareness of student data protection via cloud storage utilization). Peer tutoring and inclusive budgeting policies that enhanced access to multimedia and Wi-Fi, especially for honorary (non-permanent) teachers, addressed the primary obstacles of generational disparities, time constraints, and insufficient personal devices. These findings theoretically enhance existing instructional leadership theory by emphasizing that the efficacy of twenty-first-century supervision relies not on bureaucratic control, but on supervisors' empathetic ability to bridge generational digital divides, reconceptualizing technostress as a consequence of inflexible supervisory practices rather than teachers' cognitive deficiencies. These findings further expand digital literacy theory by demonstrating that technological capabilities, ethical responsibility, and data safety form an interrelated ecosystem rather than discrete competences. The findings suggest that schools need not rely on costly external training. The mobilization of internal social capital via peer tutoring between junior and senior teachers, along with the reallocation of operational funding for a shared digital infrastructure, can facilitate organic, low-pressure competency transfer and enhance digital equity, particularly for honorary instructors. In light of these findings, the study advocates for school principals to establish formal incentives or administrative relief for teachers acting as peer tutors and to devise flexible, phased supervision schedules that balance managerial and instructional responsibilities; for senior teachers to maintain their motivation for learning and fully leverage peer support; and for junior teachers to persist in enhancing their digital competencies, particularly in utilizing artificial intelligence for efficient task assessment, while reinforcing their mentoring obligations to colleagues.

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