Journal of Innovative and Creativity
Journal Homepage: https://joecy.org/index.php/joecy
e-mail: journaljoecy@gmail.com

Faculty of Education
University of Pahlawan Tuanku Tambusai
ISSN 2775-771X (Online)
ISSN 2962-570X (Printed)
5 (3) 2025, Page: 32638-32646

Efektivitas Senam Otak (*Brain Gym*) Terhadap *Generalized Anxiety Disorder* Pada Usia Lanjut Di Kabupaten Deli Serdang

Effectiveness of Brain Gym Exercises on Generalized Anxiety Disorder among Older Adults in Deli Serdang Regency

Milna Chairunnisa[1], Miskah Afriani[2] , Rahmawati Tarigan[3]
[1,2,3] Institut Kesehatan Helvetia, Medan, Indonesia

Published: November , 2025

ABSTRACT

Lanjut usia (Lansia) bukan suatu penyakit, namun merupakan tahap lanjut dari suatu proses kehidupan yang ditandai dengan penurunan kemampuan tubuh untuk beradaptasi dengan stress lingkungan. Penelitian ini bertujuan untuk menganalisis efektivitas senam otak (*Brain Gym*) dalam menurunkan tingkat kecemasan pada individu yang memasuki usia lanjut (pra-lansia dan lansia awal) di Kabupaten Deli Serdang, dengan mempertimbangkan aspek psikologis dan fisiologis yang mendasari kecemasan pada masa transisi menuju usia lanjut berdasarkan teori kecemasan geriatrik. Dalam konteks lansia, Senam otak menawarkan intervensi yang aman, non-invasif, murah, dan dapat dilakukan secara mandiri atau berkelompok. Beberapa penelitian menunjukkan bahwa latihan *Senam Otak* secara rutin mampu menurunkan gejala kecemasan, meningkatkan kualitas tidur, dan memperbaiki kesejahteraan psikologis pada populasi usia lanjut. Penelitian ini menggunakan pendekatan kuantitatif dengan desain penelitian pretest postest control group. Populasi dalam penelitian ini dilakukan di dua Desa Perdamean dan Tanjung Mowara B Kabupaten Deli Serdang sebanyak 48 orang. Sampel dipilih dengan menggunakan total sampling yaitu 48 orang. Dimana sampel sebanyak 48 orang ialah sampel yang mengikuti sekolah lansia yang ada di Desa. Adapun alat tes yang digunakan dalam mengukur kecemasan lansia yaitu menggunakan *Hamilton Rating Scale for Anxiety (HRS-A).* Berdasarkan pengukuran menggunakan alat tes tersebut dan dilakukan analisis uji normalitas yang menghasilkan data distribusi normal.
Hasil yang didapat dalam penelitian ini menemukan bahwa adanya perbedaan signifikan antara kelompok eksperimen dan kelompok kontrol, dimana berdasarkan nilai yang diperoleh setelah data dianalisis, sehingga dinyatakan ada pengaruh melakukan senam otak (*Brain gym*) terhadap *Generalized Anxiety Disorder* pada usia lanjut.

Kata Kunci : Senam orang (*Brain gym*), *Generalized Anxiety Disorder (GAD),* Lanjut Usia

ABSTRACT

Elderly (older adults) is not a disease, but rather a later stage in the life process characterized by a decline in the body's ability to adapt to environmental stress. This study aims to analyze the effectiveness of Brain Gym exercises in reducing anxiety levels among individuals entering older adulthood (pre-elderly and early elderly) in Deli Serdang Regency, considering the psychological and physiological aspects underlying anxiety during the transition into older age, based on geriatric anxiety theory. In the context of older adults, Brain Gym offers a safe, non-invasive, low-cost intervention that can be performed either independently or in groups. Several studies have shown that regular Brain Gym practice can reduce anxiety symptoms, improve sleep quality, and enhance psychological well-being among older populations.This study employed a quantitative approach with a pretest-posttest control group design. The population was drawn from two villages—Perdamean and Tanjung Morawa B—in Deli Serdang Regency, comprising a total of 48 participants. All 48 individuals who attended the local elderly education programs (elderly schools) in these villages were included as respondents, selected through total sampling. The Hamilton Rating Scale for Anxiety (HRS-A) was used to assess anxiety levels among participants. Normality testing of the collected data indicated a normal distribution. The results revealed a statistically significant difference between the experimental and control groups. Based on the analyzed data, it was concluded that Brain Gym exercises have a significant effect on reducing symptoms of Generalized Anxiety Disorder (GAD) among older adults.

Keywords: *Brain Gym, Generalized Anxiety Disorder (GAD), Older Adults*

© The Author(s). 2021 Open Access This article is licensed under a Creative Commons Atibution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. To view a copy of this licence, visit http://creativecommons.org/licenses/by/4.0

INTRODUCTION

The development of digital technology in the last decade has experienced significant acceleration, particularly with the advent of artificial intelligence (AI), which has impacted nearly every aspect of life, including education. This digital transformation requires educational institutions to adapt rapidly, particularly in the process of mentoring and supervising academic teachers. Teachers no longer simply need to master pedagogical and professional competencies; they also need advanced digital literacy, including AI literacy, to be able to optimally utilize technology in learning. According to Andi (2020:5), the integration of technology in teacher development allows for competency improvement through a more structured, flexible, and sustainable process.

collaborative coaching process that integrates digital platforms, AI tools, learning data analysis, and technology-based mentoring. The implementation of technology-based academic supervision not only increases the effectiveness of supervision but can also accelerate teachers' adaptation to educational innovations. application such as AI lesson planners, automated assessment tools, learning analytics dashboards, and virtual coaching become part from practice modern supervision .

However, in reality, not all teachers are ready to face these changes. Various obstacles remain, such as limited digital competency, limited school facilities and infrastructure, and low motivation to learn new technologies. Technology-based supervision offers a solution to bridge this gap. Through coaching programs utilizing digital tools, teachers can receive more personalized, regular, and well-documented guidance. Therefore, this research is crucial for comprehensively examining technology-based academic supervision strategies to improve teachers' AI literacy.

RESEARCH METHODS

This study uses a descriptive qualitative approach to describe the phenomena, experiences, challenges, and implementation of technology-based academic supervision in improving teachers' AI literacy. Descriptive qualitative research allows researchers to gain in-depth information about supervisory practices and the perceptions of teachers, supervisors, and principals regarding the use of technology in professional development. According to Creswell (2018:32), qualitative research focuses on understanding the meanings participants attach to a particular social issue or phenomenon.

The research subjects consisted of teachers, principals, and supervisors involved in the technology-based supervision process. Data collection techniques used semi-structured interviews, direct observation, and documentation in the form of supervision recordings, digital coaching reports, and the use of AI platforms in learning. Data validity was tested through source and method triangulation. Data analysis was conducted using the stages of data reduction, data presentation, categorization of findings, and drawing conclusions.

RESEARCH RESULTS AND DISCUSSION

1. Implementation of Technology-Based Academic Supervision

Based on the research findings, technology-based academic supervision is implemented through several mechanisms: the use of a Learning Management System (LMS), cloud-based supervision applications, digital communication platforms, and AI tools to help analyze teacher performance. Supervision is conducted both online and offline, including the use of video conferencing features for teaching observations, analysis of learning recordings, and the provision of data-based feedback.

The implementation of technology-based academic supervision in this study demonstrates a significant paradigm shift in the teacher professional development process. Supervision, which was previously conducted primarily through conventional methods, has now shifted to a process that utilizes digital technology as the primary instrument. The use of a Learning Management System (LMS) serves not only as a tool for distributing materials but also as a means of monitoring teacher performance in real time. Through the LMS, supervisors can view teacher activities such as the level of activity in the digital classroom, assignment patterns, the effectiveness of classroom management, and teacher-student interactions. The supervision process becomes more objective because every activity is automatically recorded and documented, minimizing the assessment bias that typically occurs in manual supervision.

Furthermore, the use of cloud-based supervision applications makes the guidance process more flexible, less reliant on physical meetings, and can be conducted at any time. Supervisors can provide

supervision notes, feedback, and competency improvement recommendations through a digital platform directly accessible to teachers. The presence of AI tools such as AI feedback generators further accelerates the feedback process because they can automatically analyze learning aspects, such as the quality of material delivery, the use of active learning strategies, and curriculum coherence. These findings indicate that technology integration not only increases efficiency but also improves the quality of guidance because all data is documented and can be analyzed over the long term.

Teaching observations via video conference are also an important part of the technology-based supervision process. Teachers can be recorded while teaching, and these recordings can then be analyzed together with the supervisor to identify strengths and weaknesses in the learning process. Supervisors and teachers can reflect together using the time stamp feature, allowing for more specific, detailed, and targeted evaluations. This is in line with Rahman (2019), who stated that technology expands the capacity of academic supervision by providing empirical evidence that can be reviewed at any time.

2. Teacher Development Strategy Towards AI Literacy

Teacher development towards AI literacy is carried out through various layered strategies, including:

a. **Basic and advanced training on AI in education** , including the use of learning chatbots, automated media, and pedagogical applications of AI.
b. **Mentoring intensive in AI -based RPP preparation** , where teachers are guided For utilizing AI lesson generator.
c. A **digital media development workshop** integrating AI image generator, AI video maker, and adaptive learning applications .
d. **Establishing a digital learning community** to share best practices.

Sari (2021) emphasized that AI literacy is a mandatory competency for 21st-century teachers to innovate and solve learning problems more effectively. A sound coaching strategy will make teachers more confident in using new technologies. In this study, teacher coaching towards AI literacy was conducted through several strategic, layered and continuous approaches. Basic training on AI is the initial stage that teachers must master, particularly understanding fundamental concepts such as how AI works, how it is used in learning, and its impact on students' thinking processes. Advanced training then focuses on the use of applications such as learning chatbots, automatic question generators, AI-based lesson plan development applications, and tools for analyzing learning outcomes.

Intensive mentoring is also a crucial part of the AI literacy development process. Teachers are not only provided with training but also guided to directly practice using AI in the classroom. Each lesson plan prepared by teachers is analyzed by supervisors to ensure AI integration is carried out appropriately and not simply following trends. Teachers are given the opportunity to pilot AI-based learning and are then guided through a process of pedagogical reflection to help them understand the relationship between technology, teaching strategies, and student learning outcomes. This type of mentoring has proven highly effective, as teachers feel more confident when using new technologies.

AI-based digital media workshops also make a significant contribution to improving teacher competency. Teachers are trained to create media in the form of automated videos, AI-based infographics, learning simulations, and interactive modules tailored to student abilities. Each media is tested in classroom settings and assessed by supervisors using a special rubric that measures creativity, effectiveness, and curriculum alignment. Furthermore, the formation of digital learning communities further strengthens the coaching process by enabling teachers to share best practices, exchange ideas, and provide mutual support in technology use.

These strategies emphasize that AI literacy development is not merely technical training, but a holistic and sustainable process of changing teaching culture. Sari (2021) states that AI literacy is a competency needed by teachers to navigate the dynamics of modern education, and systematic development will enhance teachers' ability to optimally utilize technology.

3. Challenges in Implementing Technology-Based Academic Supervision

Although technology-based supervision provides significant benefits, there are a number of obstacles found in the field, such as:

a. Lack of digital infrastructure, especially in regional schools.
b. Variations in teachers' digital literacy levels.

c. Resistance to change and technological anxiety.
d. Lack of consistent and ongoing training.
e. There is no specific national standard regarding AI-based supervision.

Kurniawan (2022) stated that human resource readiness and facility support are key factors in the success of educational technology transformation. Therefore, schools need to invest in training, equipment, and internal policy development. The implementation of technology-based academic supervision faces several structural and cultural challenges that impact its effectiveness.

The first challenge is the limited digital infrastructure that is not evenly distributed across schools. Schools located in remote areas or lacking budgetary support often struggle to provide adequate equipment, stable internet connections, and digital platforms to support the supervision process. This limited infrastructure prevents supervision from being effective, even when teachers are highly motivated to learn.

The second challenge lies in the variation in teachers' digital literacy. More senior teachers tend to experience anxiety and resistance to technology due to unfamiliarity or fear of making mistakes. This hinders the adoption of AI in learning and requires supervisors to adopt a more personalized approach to boost teacher confidence. The third challenge is school culture resistance to change. Some schools still maintain conventional supervision patterns, perceived as easier, even though they are no longer relevant to developments in educational technology.

The fourth challenge is the lack of ongoing training. While many training programs are available, not all of them have sufficient continuity to ensure teachers truly master the technology. Teachers require long-term mentoring, not just short-term training. The fifth challenge is the lack of a national regulatory framework specifically governing the use of AI in academic supervision. This leaves schools operating under their own guidelines, which are often inconsistent from one institution to another. Kurniawan (2022) emphasized that human resource readiness and supporting facilities are key to overcoming this challenge, necessitating stronger and more focused school policies.

4. The Impact of Technology-Based Academic Supervision on Teachers' AI Literacy

Research shows that technology-based supervision can improve teachers' understanding and skills in utilizing AI. Teachers become more skilled in :

a. Using generative AI applications for learning planning.
b. Analyze achievements Study student through learning analytics.
c. Using automated assessment tools to evaluation formative .
d. Create AI-based learning media such as automated videos, simulations, and interactive modules.

Technology-based academic supervision has a significant impact on improving artificial intelligence (AI) literacy among teachers, particularly in the context of modern education, which continues to move toward comprehensive digitalization. Recent studies, including those conducted by Lestari (2023), show that implementing supervision that integrates digital devices, analytical platforms, and AI-based applications can accelerate teachers' adaptation to educational innovations. Teachers who previously faced challenges in understanding the functions and potential of AI now demonstrate a significant increase in competence after participating in technology-based coaching. These changes occur not solely because teachers have technological facilities, but because the supervision process provides consistent direction, guidance, and support, enabling teachers to understand the practical steps in utilizing AI for various learning needs.

The development of teachers' AI literacy is evident when they begin to operate generative AI applications to support lesson planning. While previously it took teachers a long time to develop lesson plans, teaching modules, and other administrative tools, this process can now be done more quickly and creatively thanks to the assistance of AI tools. Teachers no longer simply copy the results provided by the application but also process, modify, and refine the lesson plans to suit the context of their respective classes. Technology-based supervision, in this case, provides reinforcement so that teachers maintain originality, creativity, and pedagogical sensitivity when using AI. Mentoring provided by supervisors or principals typically emphasizes the importance of digital literacy skills and ethical use of AI, enabling teachers to become more than passive users but also to act as designers and controllers of technology-based learning.

Beyond planning, teachers have also demonstrated improved ability to analyze student learning outcomes using learning analytics. By utilizing digital dashboards, progress charts, and automated reports, teachers can identify student learning patterns, difficulties, and progress in greater detail and accuracy. Technology-based academic supervision introduces teachers to various analytical features that were

previously rarely recognized. Teachers can now read data more critically and use it to design remedial and enrichment learning strategies. This impact is particularly pronounced for teachers teaching large classes, where manual analysis is often time-consuming and error-prone. Through technology-based supervision, teachers learn how to interpret data, draw conclusions, and make more objective and measurable learning decisions. This directly improves the quality of learning, as teacher decisions are now based on data evidence, rather than mere intuition.

Another significant impact is the increased ability of teachers to use automated assessment tools for formative assessment. AI is now widely used to create automated quizzes, evaluation assignments, adaptive-based questions, and even assessment rubrics. Teachers who previously felt burdened by correction tasks are now empowered by automated assessment systems that provide immediate feedback to students. Academic supervision helps teachers understand how these features work and how to ensure assessments remain valid, reliable, and aligned with competency standards. Supervisors or mentors typically demonstrate how teachers can set assessment parameters, avoid AI bias, and consistently cross-check automated assessment results. Thus, the use of technology does not replace teacher professionalism, but rather supports efficiency and accuracy in the evaluation process.

Furthermore, technology-based supervision can improve teachers' capacity in creating AI-based learning media. Teachers can now produce automated learning videos, interactive simulations, explanatory avatars, and even digital modules tailored to students' needs. This progress doesn't happen overnight, but rather through a structured supervision process, where teachers are introduced to various tools such as video generator platforms, simple augmented reality applications, and AI-based simulations that can be used for science, mathematics, and even religious education. Teachers feel more confident because they are not only shown how to use these tools but also given examples of their own classroom applications. Technology-based supervision helps teachers think creatively, explore, and try various forms of innovation without fear of making mistakes. Ultimately, AI-based learning media not only increases student engagement but also significantly enriches the learning experience.

The impact of academic supervision is also felt psychologically in teachers. Many studies show that adapting to new technologies often causes anxiety, especially for teachers unfamiliar with digital devices. Technology-based supervision reduces this anxiety because teachers receive consistent, gradual guidance and support. Increased self-confidence makes teachers more willing to try new things and less afraid of potential technical errors. Lestari (2023) noted that teachers who participate in intensive mentoring are more enthusiastic about developing learning innovations because they feel valued, supported, and well-facilitated. Furthermore, technology-based supervision also strengthens teachers' confidence in adapting to the 21st-century workplace, which demands technological mastery as part of basic literacy.

In the context of school culture, the impact of technology-based supervision has also brought about significant changes. Schools that previously paid little attention to technology use are now starting to build a more conducive digital ecosystem. Teachers share experiences with each other regarding AI applications, collaborate on creating digital learning media, and discuss data-driven teaching strategies. This collaborative environment accelerates knowledge transfer and narrows the gap in technological skills among teachers. Academic supervision plays a crucial role in initiating this culture through training programs, workshops, and monitoring technology use in the classroom. Principals and supervisors are also starting to utilize digital reports to assess teacher competency development, making the entire supervision process more transparent and measurable.

Furthermore, the impact of technology-based supervision on teachers' AI literacy is also evident in their ability to reteach artificial intelligence concepts to students. Teachers who understand the basics of AI can explain to students how modern technology works, the ethics of using AI, and its benefits and risks in everyday life. This is especially relevant given that the Merdeka curriculum provides space for project-based learning and strengthens the Pancasila student profile, where digital literacy and technological understanding are essential. Effective academic supervision ensures that teachers are not only technology users but also educators capable of providing the younger generation with a critical understanding of global technological developments.

In terms of professionalism, teachers who received technology-based supervision demonstrated improvements in learning documentation, digital classroom management, and platform-based assignment management. For example, teachers became accustomed to using a Learning Management System (LMS) to upload materials, assign assignments, monitor student progress, and interact through discussion forums.

Academic supervision introduced various LMS functions and how to integrate them with AI applications such as learning chatbots or automated content generators. These skills are crucial in the digital age as they serve as indicators of teacher professionalism in navigating changing educational paradigms.

Overall, the impact of technology-based academic supervision on teachers' AI literacy can be seen in the interconnected improvement of technical, pedagogical, and professional competencies. Teachers are not only able to use various AI applications but also understand the principles of ethics, data security, and professional responsibility in their use. Technology-based supervision ensures that teachers are not caught up in the euphoria of technology alone, but continue to place pedagogical values as the primary foundation of innovation. Thus, the development of teachers' AI literacy is not merely a technical phenomenon, but a comprehensive transformation in the way they think, plan, and implement learning in the digital age. If academic supervision continues to be carried out consistently and collaboratively, the quality of education will improve significantly as teachers' ability to integrate artificial intelligence into the learning process increases, making it meaningful, effective, and relevant to the needs of the times.

5. Strengthening School Digital Policies and Culture

Strengthening school digital policies and culture is a crucial element in ensuring the successful implementation of technology-based academic supervision, particularly in the context of the use of artificial intelligence. Supervision implementation utilizing technology will not be optimal if it is not supported by clear, systematic, and consistent regulations implemented by all school members. Therefore, schools need to have clear SOPs regarding the use of AI, both for lesson planning, assessment, and teacher administrative documentation. These SOPs must cover ethical aspects of technology use, limitations on the use of generative AI, plagiarism checking mechanisms, and academic integrity standards that must be upheld by teachers and students. Thus, the use of AI is seen not only as a technical innovation but also as part of a professional culture that maintains the credibility of education. Data security policies are also crucial, given that many AI applications and digital platforms require the storage of student data, grades, and important school documents. Schools need to establish rules that ensure the secure management of all sensitive data, including encryption mechanisms, access restrictions, and the use of authorized platforms that meet data protection standards. Through strong and targeted policies, schools can avoid the risk of technology misuse and safeguard the privacy of school members.

Beyond regulations, schools must develop a healthy and progressive digital culture. This doesn't emerge overnight, but rather through conscious and consistent habits formed by teachers, students, and all school components. The use of collaborative applications such as Google Workspace, Microsoft Teams, or LMS platforms becomes part of the work routine, allowing teachers to store documents in the cloud, share materials digitally, and collaborate online. This also makes the academic supervision process more efficient, as supervisors can monitor teacher documents in real time, provide direct feedback, and access various evidence of teacher performance through digital systems. These habits not only increase the effectiveness of supervision but also foster teachers' awareness that technology is an integral part of learning management.

Regular training is a crucial component in building a digital culture. Teachers need space to learn, experiment, and deepen their digital skills without fear of making mistakes. Continuously designed training allows teachers to adapt to rapid technological developments, especially the constantly updated applications of AI. Through this training, teachers can understand how to maximize AI features, learn the ethics of its use, and apply critical digital literacy principles. This culture of continuous training will create an open, innovative, and adaptive learning environment, where teachers feel that mastery of technology is part of their professional growth. When teachers have mature digital skills, they can make significant contributions to improving the quality of learning, including assisting colleagues who need technological assistance.

The school's digital culture is also strengthened by a technology-based communication system. School announcements, teacher coordination, activity reporting, and various administrative processes are now largely conducted online. This digital communication system makes academic supervision faster and more transparent, as all information is easily accessible and well-documented. Principals and supervisors can monitor the progress of various programs, read teacher reports, and provide feedback without having to wait for face-to-face meetings. This creates a flexible, modern, and efficient work environment.

Ultimately, strengthening schools' digital policies and culture serves as the foundation for the entire technological transformation process in educational settings. Without clear policies and a strong culture, the use of AI and technology-based supervision will be fleeting and unsustainable. However, with a regulatory

system, a collaborative culture, and ongoing training, schools can create a digital ecosystem that supports teacher professional development while improving the quality of learning. This ecosystem not only prepares teachers to face the challenges of 21st-century education but also creates a progressive, safe, and highly competitive learning environment.

6. Projections for Future Supervision Development

The future of academic supervision is expected to increasingly move towards the use of advanced AI such as:

a. AI-driven teaching performance analysis.
b. Automated recommendation system for teacher competency development.
c. Virtual/AI supervisor as companion teacher's daily .
d. Integration of school data into a single digital ecosystem that can be accessed by supervisors.

The implementation of technology-based academic supervision, while offering numerous opportunities and improving the quality of learning, still faces a number of complex challenges, both in terms of human resources, infrastructure, and school cultural readiness. The first challenge arises from the disparity in digital literacy among teachers. Not all teachers possess the same technological skills, so some struggle to understand the features of digital applications or AI introduced during the supervision process. Older teachers or those less familiar with technology often experience digital anxiety, fear of making mistakes, or worry about not being able to keep up with the rapid pace of development. This situation requires a more inclusive, patient, and personalized approach to supervision. Supervisors and principals need to understand that this diversity of abilities is not a barrier, but rather a starting point for developing differentiated mentoring strategies tailored to each teacher's individual needs.

On the other hand, infrastructure challenges also pose a crucial obstacle. Schools located in areas with limited internet access often struggle to effectively implement technology-based supervision. Unstable connections, a lack of devices such as laptops or tablets, and limited software support are factors that hinder the use of digital platforms for supervision. Although AI tools are increasingly accessible, adequate hardware support is still required to ensure smooth technology use. Without robust infrastructure, digital supervision will only increase teachers' burdens, not simplify their work. Therefore, schools need to clearly plan their budgets for device procurement and network improvements, in collaboration with local governments, school communities, or external partners who can support technological upgrades.

Besides teacher and infrastructure factors, another challenge comes from time management. The use of technology in supervision often requires new adaptations that take more time initially, especially when teachers are learning to use digital applications or systems. Teachers must prepare digital documents, upload evidence of performance, record learning activities, and conduct data analysis based on digital platforms. While this process ultimately simplifies the job, it can increase the workload and lead to burnout in the initial phase. Academic supervisors must take this into account and avoid placing excessive demands on teachers too quickly. Technology-based supervision should be implemented gradually, following the teacher's adaptation pace, and should not become an additional administrative burden that adds to teacher stress.

Another significant challenge is the issue of data security and privacy. The implementation of digital technology and AI always involves storing student data, assessment records, and important school documents. If schools lack robust data security policies, there is a risk of information leaks or data misuse by irresponsible parties. Teachers often lack a grasp of digital security principles, such as password management, encryption, or privacy constraints when using cloud-based AI applications. Academic supervision in this context serves not only to provide pedagogical guidance but also to ensure that teachers have a sufficient understanding of digital ethics and security. Strengthening privacy literacy is crucial for schools to be not only technologically superior but also secure from cyber threats.

Besides technical challenges, cultural resistance is also a major obstacle. Many teachers feel that the use of AI or digital platforms can diminish the role of humans in learning. Some even perceive technology as a threat to their professionalism, or feel that digital supervision is too controlling and reduces their teaching freedom. These perceptions must be managed with a good communication approach, so that teachers understand that technology is not meant to replace their role, but to support their work to be more effective and efficient. Academic supervision needs to be emphasized as a collaborative process, not a one-sided control, so that teachers feel they are part of the digital transformation process, not objects to be forcibly changed.

Ultimately, these challenges demonstrate that the success of technology-based academic supervision is determined not only by the availability of devices or applications, but also by the mental readiness, culture, regulations, and infrastructure of schools. Digital transformation in education requires a comprehensive paradigm shift, from how teachers work, how schools manage data, to how supervisors provide guidance. While these challenges are significant, various studies show that schools that successfully manage these challenges experience more significant improvements in learning quality, thanks to their mature and sustainable digital ecosystems. With the right strategy, technology-based academic supervision can become a major force in enhancing teacher professionalism and creating education that is relevant to the demands of the 21st century.

CONCLUSION

Technology-based academic supervision has become one of the most effective strategies for improving teachers' digital literacy and artificial intelligence (AI) literacy in the current era of educational transformation. Rapid technological developments require teachers to master not only conventional pedagogical competencies but also an understanding of the use of digital devices, AI-based applications, and the principles of data analysis in learning. Through supervision that integrates digital platforms, LMS, cloud supervision, video conferencing, and automated analytical tools, the teacher development process becomes more flexible, objective, accurate, and well-documented. The development strategy, which includes basic and advanced AI training, intensive mentoring in developing AI-based learning tools, digital media workshops, and the development of learning communities, has significantly improved teachers' ability to utilize technology as a pedagogical tool. Technology-based academic supervision not only improves teachers' technical skills but also builds self-confidence, motivation to innovate, and reflective skills in managing the learning process in line with the needs of 21st-century learners.

However, the implementation of technology-based supervision still faces several challenges, such as limited digital infrastructure, varying levels of teacher digital literacy, school cultural resistance to change, and the lack of national policies specifically governing AI-based supervision. These challenges demonstrate that digital transformation in teacher development cannot rely solely on technological devices but requires the support of a school ecosystem that includes clear regulations, commitment from school leaders, and a healthy digital culture. Strengthening internal school policies, including SOPs for AI use, ethical technology implementation, data security, and academic integrity standards, is a crucial foundation for a safe and sustainable supervision process. A digital culture built through online collaboration habits, cloud-based documentation, and regular training helps create a work environment that is ready to adapt to technological innovation and global educational developments.

The impact of technology-based academic supervision on teachers' AI literacy is evident in their increased ability to use generative AI applications for lesson planning, utilize learning analytics to more accurately read student achievement, and use automated assessment tools in formative assessments. Teachers are also becoming more skilled at creating creative and interactive AI-based learning media, making student learning experiences more engaging and relevant to technological developments. Beyond improving technical competency, technology-based supervision is also influencing teachers' thinking, evaluating, and designing lessons in a more data-driven way. Teachers are no longer relying solely on intuition but are beginning to utilize digital empirical evidence that helps them make more informed pedagogical decisions. These changes strengthen teacher professionalism and significantly improve the quality of learning.

Looking ahead, academic supervision is expected to increasingly adopt advanced AI technologies, such as AI-based teaching performance analysis, automated recommendation systems for teacher competency development, and the use of AI supervisors as daily companions for teachers in designing and evaluating learning. This indicates that technology will increasingly play a role in the academic supervision process. However, future success depends heavily on schools' readiness to build adequate digital infrastructure, improve teachers' AI literacy, and foster an inclusive and collaborative digital culture. With a planned and comprehensive approach, technology-based academic supervision can become a key driver in improving teacher quality, strengthening 21st-century competencies, and creating more innovative, adaptive, and relevant learning. Overall, technology-based supervision is not simply a modern guidance process, but a comprehensive transformation of the educational ecosystem that connects technology, pedagogy, school culture, and teacher professionalism within a sustainable framework to realize superior and globally competitive future education.

BIBLIOGRAPHY

Andi, A. (2020). *Educational Technology and Learning Innovation* . Jakarta: Prenada Media.

Creswell, J. W. (2018). *Qualitative Inquiry & Research Design: Choosing Among Five Approaches* . Sage Publications.

Kurniawan, R. (2022). The Influence of Technology on Educational Supervision. *Journal of Educational Management* , 14(2), 112–125.

Lestari, D. (2023). Improving Teacher AI Literacy through Digital Mentoring. *Journal of Educational Innovation* , 7(1), 55–68.

Rahman, H. (2019). Utilization of Technology in Academic Supervision. *Journal of Modern Education* , 5(3), 210–222.

Sari, M. (2021). AI Literacy in 21st Century Learning. *Journal of Educational Media* , 11(4), 98–110.