TEM Journal. Volume 14, Issue 4, pages 3851-3864, ISSN 2217-8309, DOI: 10.18421/TEM144-88, November 2025.

Empowering Digital Literacy in Indonesian Islamic Education: A Meta-Analytic Exploration of Leadership's Role

Tan Gusli [1], Rusdinal Rusdinal [1], Jasrial Jasrial [1], Jem Cloyd M. Tanucan [2], Dani Harmanto [3], Mohd Rizal Mohd Isa [4], Alfajri Yusra [1]

[1] *Universitas Negeri Padang, Padang, Indonesia*
[2] *College of Education, Cebu Technological University, Philippines*
[3] *Aeronautical Engineering, De Montfort University, Leicester, United Kingdom*
[4] *National Defence University of Malaysia, Kuala Lumpur, Malaysia*

Abstract **– Technology in learning has been shown to positively contribute to improving digital literacy in Islamic schools (madrasahs) in Indonesia. However, there are limited studies that statistically measure the magnitude of this impact, creating an empirical gap that needs to be filled. Therefore, a meta-analysis study was conducted by combining several relevant studies to produce an estimate of the impact of technology on the digital literacy of Islamic school students. This study used a meta-analytic approach by systematically reviewing and synthesizing eight quasi-experimental studies published in the last five years, selected using the PRISMA framework. The analysis was conducted in two stages: (1) Statistical meta-analysis using Microsoft Excel and JASP to calculate the combined effect size, and (2) Qualitative content analysis to examine the role of leadership, challenges, and opportunities in integrating technology to improve students' digital literacy. The statistical results showed an estimated impact of implementing technology and innovation in learning of 0.58, meaning that 58% of the digital literacy of Islamic school students can be achieved through this integration. Second, content analysis. The results of this analysis indicate that leadership plays a significant role in determining technology utilization policies.**

The challenges observed include limited access to technology and reliance on conventional methods, while the potential opportunities include long-term technology adoption. This research is limited to Indonesia, so further global studies are recommended to gain more comprehensive insights into this topic.

Keywords **– Digital literacy, Islamic education, madrasa, leadership, meta-analysis.**

DOI: 10.18421/TEM144-88
https://doi.org/10.18421/TEM144-88

Corresponding author: Alfajri Yusra,
Universitas Negeri Padang, Padang, Indonesia
Email: fyusra@unp.ac.id

Received: 14 January 2025.
Revised: 15 August 2025.
Accepted: 02 September 2025.
Published: 27 November 2025.

1. Introduction

Islamic school or also known as madrasa is an educational institution that organizes education at the level of elementary, junior high, and high school [1]. The main basis of this education is Islamic religious values. Different from public schools, madrasas have learning practices that unite general knowledge such as science, social, art, and language, with religious knowledge, where the teachings of the Qur'an, hadith, fiqh, and morals become the core of the curriculum [2]. The target of this school is for students to have intellectual knowledge in the form of academic intelligence balanced with spiritual intelligence or religious knowledge [3].

The curriculum in Islamic schools is very different from that of general and vocational schools. Overall, the percentage of general knowledge in madrasa is 75% and the percentage of religious knowledge is 25% [4]. Public schools or often called high schools give a large portion of natural and social knowledge. On the other hand, vocational schools have the majority of learning in their respective vocational fields without special emphasis on religious values [5]. Meanwhile, [6], states in their research that madrasas have a broader goal of integrating Islamic values into all aspects of learning, be it in general or specialized subjects. This makes madrasas have their own challenges to stay in line amidst technological advances and rapid social changes, especially in the context of the growing digitalization of education.

Madrasa students are thick with religious knowledge. However, the use of technology cannot be separated from the learning process today [7]. In utilizing digital devices, students must be able to realize what uses and purposes they use these tools for. This awareness is called digital literacy [8]. Digital literacy is not only associated with the ability to read, but to have a critical outlook to search, understand, and evaluate information ethically in accordance with Islamic values [9], [10]. However, the general challenges madrasas face in implementing digital literacy are quite serious. There are limited technological resources and madrasa infrastructure that is different from the infrastructure of technology-specific schools such as vocational schools [11]. In addition, the importance of maintaining harmony between the use of technology and the application of Islamic values is often a challenge that requires determining the right policy direction. The role of leadership is very precise in determining policy direction [12]. The right leadership will be able to consider and balance the need for the application of technological innovation with a commitment to Islamic values, so that every policy taken not only encourages progress, but also continues to balance it with religious principles.

Several previous studies have raised the topic of the positive influence of the application of technology and digital-based learning innovations to improve digital literacy in the field of Islamic education [13], [14], [15]. However, there is limited research that statistically identifies the impact on improving digital literacy in Islamic schools or madrasas, thus creating an empirical gap in this statement. Therefore, a meta-analysis study was conducted to fill this gap. The study summarized and analyzed previous research results to identify patterns, magnitudes of influence, and key variables that impact digital literacy in the context of faith-based education. This method was used to evaluate the diverse experiences and results of previous studies. In addition, new results are presented by analyzing the role of leadership in the development of digital literacy in madrasas in Indonesia. In the context of Islamic education, digital literacy has not been systematically explored in relation to the role of leadership. This study seeks to identify strategies or ways leaders can improve their students' digital literacy, identify barriers or challenges to integration, and analyze opportunities that can be applied to improve students' digital literacy.

In addition to identifying the magnitude of the influence of the application of innovation and technology and digital-based learning models in improving students' digital literacy, this study was written for the noble purpose of developing knowledge. Filling empirical gaps about what has not been discussed before.

It is expected to be a reference and contribute to developing new knowledge about different perspectives because it presents a new analytical concoction on Islamic education reading materials. In addition, the results of the analysis put forward can be a consideration in the formulation of new policies for Islamic education institutions.

Based on the background description, two research questions were raised. The first question will be answered through statistical analysis, and the second question will be answered through content analysis of the selected publications.

RQ1: What is the extent to which the integration of technology and innovation in learning affects the improvement of students' digital literacy in Islamic schools in Indonesia?

RQ2: What are the leadership roles, challenges and opportunities in realizing the integration of technology and innovation to improve students' digital literacy in Islamic schools in Indonesia?

1.1. Madrasa or Islamic School

The history of Islamic education reviews the journey from classical, medieval to modern times. Islamic education has been around for a long time, with a broad sense that the development of Islamic education occurred in line with the emergence of Islam itself, precisely in Asia [16]. In some historical records, it is mentioned that Islam began to develop in the Asian region since the seventh century [17]. This means that at this time there was already applied Islamic education known to be the forerunner of Madrasa [18].

Madrasa was established from the 10th to the 11th century AD, initially teaching various knowledge, thoughts, and schools of thought. Nizham al-Mulk was considered one of Madrasa's first founders as well as the person who popularized it [19]. He was the prime minister of the Seljuk Sultanate and a scholar of Persian descent. Nizham al-Mulk established a number of madrasas known as Nizamiyah in the major cities of the Seljuk Sultanate, such as Baghdad and Nishapur [20]. Here children were taught various fields of knowledge, but not apart from religious knowledge.

Since the 1980s, Islamic schools have sprung up in Australia, Europe and North America. The Islamic education established aims to foster a strong religious and cultural identity among children [21]. These schools strive to integrate religious and secular education within an Islamic framework, promoting the practice of Islamic values and mutual respect. Their educational curriculum development is designed to respect and uphold students' values while ensuring a learning experience. Islamic schools are expanding globally, especially among Muslim diaspora communities who wish to maintain their religious identity amidst marginalization in secular society [22].

These schools are considered essential for providing education aligned with Islamic values and addressing the shortcomings of the state education system, which often fails to meet the cultural and religious needs of Muslim students. These schools contribute positively to educational attainment, providing a sense of belonging and identity in a diverse society.

In Indonesia, the development of madrasa can be divided into pre-independence and post-independence phases. Prior to Indonesia's independence, madrasa emerged as a combination of pesantren and modern schools influenced by the Dutch colonial education system. In the beginning, Islamic education was informal and rooted in mosques or recitations. In the early 20th century, modern madrasas were established across the archipelago, such as (Madrasa Adabiyah) in Padang (1909) and Madrasa Qudsiyah in Kudus (1918), which integrated Islamic teachings with general subjects to overcome the educational gap of the colonial period. Despite their growth, madrasa faced challenges under Dutch policies, which viewed Islamic education as a potential threat to colonial control.

In the modern era, the development of madrasa in Indonesia continues to show progress. Since the post-independence period, madrasas have been increasingly recognized as playing a significant role in the national education system. The introduction of reforms, such as the 1984 and 1994 curricula, have sought to standardize madrasa education alongside public schools. At these times students received a balanced religious and general education. The Indonesian government has also promoted the concept of (Madrasa Unggulan), which is intended to set high standards in terms of facilities, qualified teachers and student performance [23]. These madrasas are seen as models for other institutions, with the hope that their success will lead to a wider improvement in the quality of madrasa across the country. However, the main challenges faced in those days were inadequate resources, outdated infrastructure, and a lack of qualified teachers, especially for general subjects. Many madrasas, especially those in rural or privately-run areas, struggle with limited financial support, which affects their ability to modernize facilities and provide quality education.

In addition, the lack of professional management and inadequate teacher training in some madrasa hinders their ability to meet the demands of modern education. Nevertheless, madrasa remain a good educational option for many families, especially in rural areas where access to other forms of education may be limited.

1.2. Leadership

States that a leader is someone who has the ability to organize their group to work together to achieve the desired goals [24]. On the other hand, leadership is an art that can influence, invite, and motivate others to act voluntarily [25], [26]. Everyone can obey and submit to his orders. He is respected and appreciated, but not feared. A leader should also have good managerial skills. He should be able to manage whatever is under his authority. One form of leadership in madrasa is the head of madrasa. His job is to direct, supervise and promote the institution. As a leader, the head of madrasa is not only responsible for operational management, but also has an obligation to maintain the spirit of education in madrasa that upholds Islamic values. The head of the madrasa must be able to carry out Islamic leadership principles such as trustworthiness, fairness, and steadfastness so that he or she can be a role model for teachers, staff, and students, as well as understand technology and digitalization, which currently cannot be ignored.

As a digital leader, there are at least seven abilities that must be mastered, namely (1) The ability to communicate through digital platforms [27], (2) The ability to use digital assets to make quick and precise decisions [28], (3) Skills to manage connectivity and collaboration with various stakeholders for problem solving [29], (4) Skills to handle disruptive changes for organizational service innovation [30], (5) The ability to think analytically and work without time and space constraints in managing work effectively virtually [31], (6) The ability to adapt to changes in the technological environment [32], maintaining relationships between members/teams in managing cross-generational human resources between Baby Boomers, generation X, generation Y or Millennials, and Generation Z [33].

1.3. Digital Literacy

The term digital literacy was first proposed by Paul Gilster in 1997 [34]. His thoughts paved the way for a discussion on the skills needed in the digital age, especially since the internet was also growing rapidly at that time. On the other hand, Marc Prensky added a new perspective with terms digital natives and digital immigrants, which describes the differences in the way young people who grew up with digital technology process information compared to previous generations [35]. These two concepts became the initial development of the discussion and trend of digital literacy skills. Both provide a definition that a person who is able to master digital literacy will easily process and evaluate information well.

Digital literacy is a condition where students realize and understand their position and purpose of using technology properly. They can assess and evaluate each technology used wisely so that it becomes something appropriate. They can easily explain what is the background or reason for using the technology. Realizing what are the advantages and disadvantages when using it. Then, they can predict how the long-term use will affect them. Islamic schools, which are religious schools, must be able to balance mastery of technology with character building based on religious teachings for their students. Students can master digital devices but can also apply them in religious learning.

2. Methodology

This study is a meta-analysis, a summary consisting of several independent studies [36]. The scientific stage as a research method used statistical analysis and content analysis. The first method, statistical analysis, was used to calculate the combined effect size of different studies that had been conducted previously.

Thus, conclusions were drawn from the different studies to provide a complete picture of how much technology and learning innovations can improve students' digital literacy in Islamic schools. The second stage was content-based qualitative analysis. The researcher identified and described the challenges and opportunities in the application of technology, as well as the role of leadership discussed in the articles analyzed one by one.

2.1. Data Collection and Review Process

All publications were collected from Google Scholar metadata “digital literacy” AND “islamic” AND “school” and "literasi digital" AND "islam" AND "madrasa". Next, the articles were selected based on inclusion and exclusion criteria tailored to the requirements and objectives of the study. Some of the inclusion criteria applied were as follows: (1) The publication topic addressed digital literacy in Islamic schools in Indonesia, (2) The publication year range was 2020-2024, i.e. the last five years of data, (3) The articles were written in English and Indonesian, and (4) The research design was a quasi-experiment with complete data, such as pre-test and post-test scores, sample size (n), mean (M), and standard deviation (SD).

Along with the inclusion criteria, this study also applied exclusion criteria, namely: (1) Publications that addressed digital literacy in public schools or outside Indonesia, (2) Publications published before 2020, (3) Articles written in languages other than English and Indonesian, and (4) Research designs that were correlations, case studies, or methods other than quasi-experiments. The Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) method was applied to guide the article selection process [37].

This method not only allows researchers to clearly document each stage of the search, but also has the opportunity to obtain relevant literature presented in Figure 1.

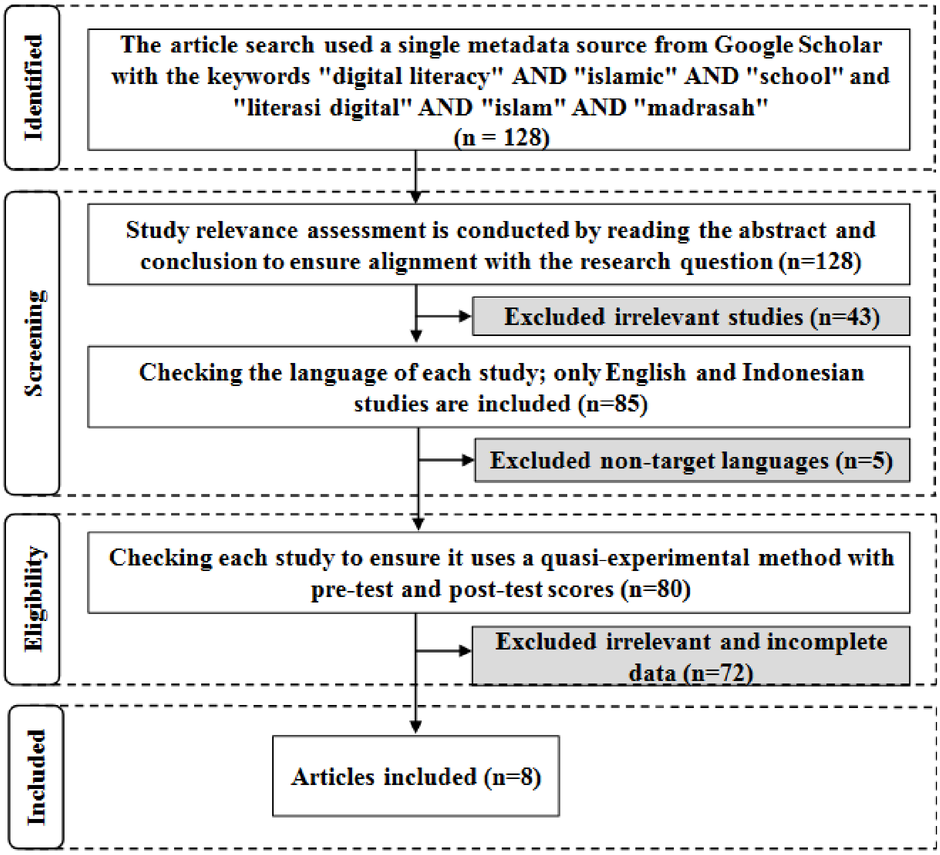

Figure 1. Prisma flow diagram

2.2. Statistical and Content Analysis

The first stage is statistical analysis. Collecting data in the form of total sample (n), mean (M), and standard deviation (SD) values from all selected publications. From these data, the effect size and standard error of each study were calculated using Microsoft Excel. Further analysis using JASP software with the random effects classical meta-analysis method to obtain an estimate of the combined effect of all studies [38].

The second stage is content analysis based on Kleinheksel's research [39]. Each selected publication will be analyzed one by one to identify how the role of the school principal, the challenges faced, and the opportunities that can be achieved in the integration of technology and innovation in Islamic education. The role of leadership is measured through policies or rules that enable the application of technology and innovation, especially in the form of learning models that support the improvement of students' digital literacy. Providing freedom and support for teachers and students in applying technology and innovative strategies that are relevant to the development of digital literacy [40]. In addition to the role of leadership, barriers and implementation challenges were also explored. Barriers are measured by factors that hinder or slow down the integration of technology and innovation in education [41].

Furthermore, opportunities that can be exploited are analyzed. Indicators measured are factors that can accelerate the improvement of digital literacy [42]. To strengthen the content analysis, VOSviewer software was used to see trends in publications and explore relationships between concepts, keywords, and the occurrence of certain topics in the analyzed literature.

3. Results and Discussion

The prism flow diagram illustrates the systematic selection process, only substantially relevant and methodologically sound studies met the criteria for analysis. The initial search identified a total of 128 articles. At the screening stage, relevance was evaluated through critical analysis of titles and abstracts to assess their cohesion with the research focus, which eliminated 43 inappropriate articles, leaving 85 studies for further review. The next step applied language criteria, including only studies published in English and Indonesian to fit the context of the study and ensure readability. This selection excluded 5 articles in non-target languages, leaving 80 studies for the next stage. At the eligibility stage, each remaining study was evaluated again to ensure compliance with the quasi-experimental methodology, specifically involving pre-test and post-test data, which are required for robust inferential analysis.

Through this rigorous evaluation, 72 studies were excluded due to irrelevant or insufficient data, resulting in 8 studies that met the rigorous standards for further analysis.

A recapitulation of these 8 studies is shown in Table 1.

Table 1. Data recapitulation

Study	Author (year)	Experiment Group			Control Group			g	SEg
		N	M	SD	N	M	SD		
1	[43]	33	1,98	0,52	32	1,81	0,47	0,34	0,25
2	[44]	15	61,25	7,79	15	57,91	6,64	0,45	0,36
3	[45]	22	28,41	3,26	22	27,00	3,05	0,44	0,30
4	[46]	70	87,02	10,32	70	78,63	12,17	0,74	0,17
5	[47]	29	84,03	4,50	28	79,61	4,91	0,93	0,28
6	[48]	134	79,81	10,10	134	74,25	8,65	0,59	0,12
7	[49]	36	81,53	16,25	36	68,89	19,02	0,71	0,24
8	[50]	40	88,83	4,17	40	87,44	7,32	0,23	0,22

Table 1 is a recapitulation of the data obtained from the 8 selected articles, containing information on sample size (N), mean (M), and standard deviation (SD) for the experimental and control groups, as well as effect size (g) and standard error (SEg) [51]. This dataset served as the main data for further meta-analysis conducted in the JASP software.

RQ1: What is the extent to which the integration of technology and innovation in learning affects the improvement of students' digital literacy in Islamic schools in Indonesia?

In this meta-analysis study, a random effects meta-analysis approach was applied to account for heterogeneity between studies. The random effects model assumes that the measured effect has real variability across studies, allowing for estimates that are more representative of conditions in the field [52]. The model views each study as a sample from a different distribution of effects, allowing for more valid generalization of findings across diverse research contexts and populations. The dataset in Table 1 will be used to calculate the pooled effect size and produce a summary effect, which is an overall estimate that reflects the average effect size of all analyzed studies (Table 2).

In visualizing the results of the analysis, the summary effect is displayed as a vertical line on the forest plot diagram, giving an indication of the overall effect size [53]. Meanwhile, the 95% confidence interval (denoted by the region around the dashed line or interval on the plot) indicates the precision of the estimate and indicates the significance of the effect [54]. The bias analysis then identifies potential distortions in the results due to publication imbalances [55]. Both visuals are shown in Figure 2.

Table 2. Summary effect result

				95% Confidence Interval	
Estimate	SE	z	p	Lower	Upper
0.576	0.073	7.938	< .001	0.434	0.719

The significant intercept result ($p < 0.001$), with a confidence interval that does not involve zero, indicates a strong consistency of effects across the studies analyzed. This finding suggests that the underlying factor reflected by the intercept (0.576) has a significant and consistent effect. In other words, this intercept depicts a stable and relevant effect, which is broadly applicable across the different research contexts that have been considered.

The value of 0.57 falls into the medium category, as suggested by [56], that a value of 0.1 is low, 0.5 is medium, and 0.8 is high. The 95% confidence interval for the intercept is between 0.434 and 0.719, meaning that 95% are confident that the true value of the intercept falls within this range. These results suggest that the application of technology and educational innovations in the context of Islamic schools or madrasa can make a significant positive contribution to the improvement of digital literacy of about 58%. Although the other 42% of external factors or independent variables have not been fully addressed specifically in the model, the application of technology in accordance with the principles of Islamic education can have a strong influence on improving digital literacy skills among students.

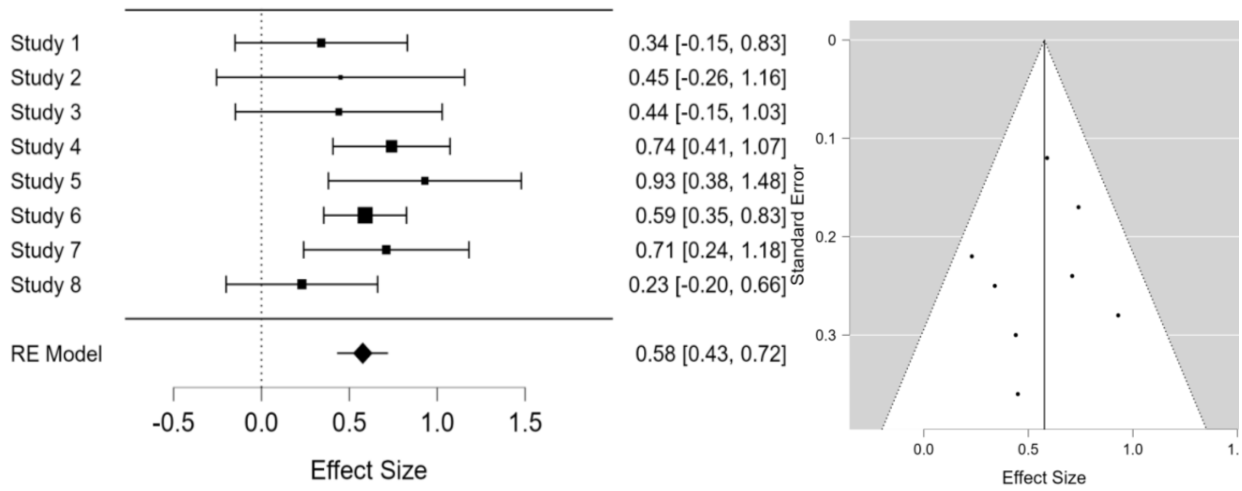

Figure 2. Total effect size (forest plot) and publication bias (funnel plot)

Figure 2 shows the forest plot and funnel plot. First, the forest plot. Each horizontal line represents a particular study and shows the confidence interval (usually 95%) for the effect size of that study, with the box showing the point estimate of the effect size. The size of the box reflects the weight or sample size of the study, so larger boxes indicate studies that have more influence on the overall effect size. The diamond shape at the bottom, under the RE Model label, represents the pooled effect size estimate from the random-effects model, with the width of the diamond indicating the confidence interval of the pooled estimate [57]. The vertical dashed line indicates the null value (often set at zero), which serves as a reference point. If the confidence interval of a study crosses this vertical line, it indicates that the study results may not be statistically significant at conventional levels [58]. In the forest plot of this study, most of the individual studies had confidence intervals that crossed the null value, implying a degree of uncertainty. However, the pooled effect size represented by the diamond does not cross the null line, indicating that the pooled evidence shows a statistically significant effect. This suggests that despite the variation among individual study results, there is an overall significant effect observed in this meta-analysis. The visualization results show in agreement with the table contents, that the effect of technology application and learning innovation is 0.58. This statistically proves that the use of technology and learning innovations is positive and significant if continuously applied. This means that 58% of digital literacy can be improved by the application of learning technologies and innovations.

In addition, there are visual results of publication bias depicted through funnel plots. Funnel plots show the relationship between the effect size (x-axis) and the standard error of the effect size (y-axis) [59]. Each point on the plot represents an individual study or data in the meta-analysis. The plot has a symmetrical inverted funnel shape, which indicates that studies with smaller sizes are more widely dispersed at the bottom due to higher standard errors, while larger studies with lower standard errors are clustered closer to the peak around the mean effect size [60]. The vertical line in the middle represents the overall pooled effect size estimate, while the triangular region bounded by the dashed line indicates the 95% confidence limits. Typically, a study is considered to have publication bias if the distribution of studies is not symmetrical around the center line [61]. The results displayed in Figure 2 have shown that there is no significant publication bias, as the distribution of the data already shows symmetry around the center line.

To ensure the quality of data and information of each study, it is necessary to analyze the heterogeneity and normality of the data. The JASP software used in the meta-analysis study also displays radial plots and normal Q-Q plots as visual tests of heterogeneity and normality [62]. Radial plots show the relationship between study effect size and study precision [63]. The center line represents the overall trend, while the shaded area shows the confidence interval. Dots closer to the line indicate studies that align with the overall results, while dots further away indicate outliers or studies with higher uncertainty. The curved lines represent the study weights, providing additional information on how individual studies impact the combined results. In addition, the Normal Q-Q plot indicates whether the residuals from the meta-analysis model follow a normal distribution. This plot compares the observed data to what would be expected in a normal distribution. The results are displayed in Figure 3.

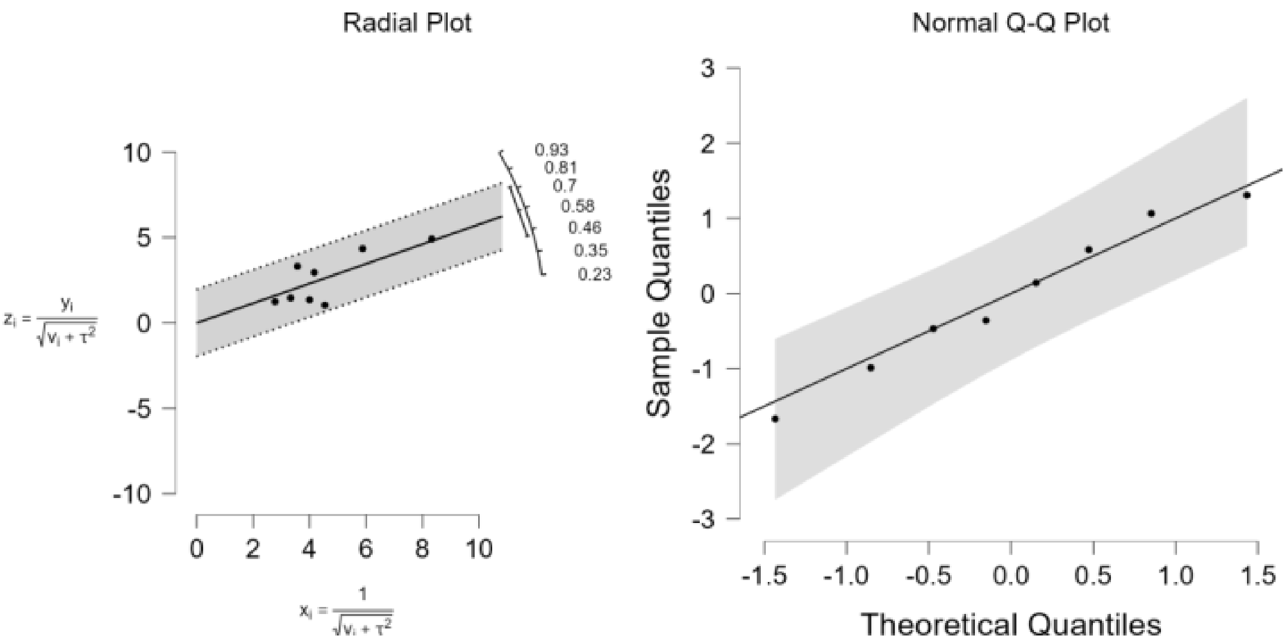

Figure 3. Heterogeneity and normality

Figure 3 presents two important diagnostic results: The radial plot and the normal Q-Q plot. Overall, the radial plot reveals that the majority of studies show alignment with the overall trend pattern, illustrated by the clustering of points close to the center line and within the shaded confidence intervals. This result indicates a relatively homogeneous relationship between study effect size and precision, with heterogeneity between studies appearing to be minimal. There is no significant variation or deviation between the studies. The points within the shaded area reinforce this assumption, while the absence of significant points outside the area indicates no significant outliers or deviations from the normal distribution.

RQ2: What are the leadership roles, challenges and opportunities in realizing the integration of technology and innovation to improve students' digital literacy in Islamic schools in Indonesia?

The second research question is closely related to the exploration of the discussion sections of the selected articles.

The researcher tried to reveal content that was not always displayed with numbers and statistical data, but rather descriptive narratives put forward by each author of the study. The researcher sought to be consistent in understanding the intentions conveyed, so as to capture the core narrative of the leadership role, challenges faced, and opportunities available in efforts to integrate technology and innovation to improve students' digital literacy in Islamic schools. This information is obtained from the ways in which leadership in Islamic schools facilitates the adaptation of technology in the context of education based on religious values, and explores information related to the ways applied to overcome obstacles and maximize opportunities in supporting the strengthening of digital literacy. Then the challenge indicators studied are the obstacles that hinder the technology integration process. On the other hand, the opportunity indicator is an opportunity in the form of steps to accelerate the improvement of digital literacy in Islamic schools.

Table 3. Data recapitulation

No.	Author (year)	Leadership role	Challenge	Opportunity
1	[43]	Influencing educators and policymakers in promoting and implementing innovative learning models.	a. Students had low digital literacy, especially in internet searching and knowledge assembly. b. Despite using models like OLS-CMPBL, improvement in students' digital literacy remained low.	Refining and optimizing the OLS-CMPBL model.
2	[44]	Guiding and supporting the integration of laptop-based media.	a. Limited familiarity with digital tools b. Inadequate instructional strategies	Use of laptop-based media to enhance media literacy and cognitive abilities.
3	[45]	Supporting the integration of digital media tools.	Dependence on conventional teaching methods.	Optimizing the long-term implementation of the Project-Based Learning (PjBL) model.
4	[46]	Initiating, monitoring, and evaluating the training program.	The lack of critical skills to effectively evaluate and filter the vast amount of online information.	Empowering students with digital literacy skills to evaluate, filter, and use information responsibly, fostering informed and ethical digital citizens.
5	[47]	Raising awareness, promoting a long-term vision, and providing resources and infrastructure.	The exposure to misinformation limited digital literacy skills.	Developing critical thinking skills, utilizing available resources, promoting digital citizenship.
6	[48]	Strategic planning and vision, resource allocation, and encouraging the adoption of digital tools.	Obstacles in adapting the Tahsin Al-Quran mentoring program during the pandemic.	Leveraging technology in education by training educators and staff in digital tools.
7	[49]	Guiding the adaptation and successful implementation of the Tahsin Al-Quran mentoring program.	Disruption of the in-person learning model and adaptation to new formats.	The enhancement of digital literacy among employees and educators.
8	[50]	Adapting to generational needs, strategically integrating technology, and promoting Islamic digital literacy, especially VR.	Challenges include the accessibility of VR technology, high development costs, limited content, and the diversity of learning styles.	Enhanced learning engagement and improved knowledge retention.

Table 3 has included descriptions relating to the leadership roles, challenges and opportunities of each of the selected studies in improving digital literacy. In column 2, the leadership roles reflected in these studies are very diverse and consist of various aspects ranging from policy influence, technical support, to alignment with religious values.

Leadership in technology integration and innovation to improve digital literacy in Islamic schools can be grouped into several categories, ranging from policy development, support for technology integration, direct development towards improving students' literacy, and customizing technology to students' needs.

First, in the category of developing educational policies and visions, as seen in the studies of [43], [47], they focus on influencing educational policies and building a long-term vision to support technology adoption. They are instrumental in ensuring that innovative learning models and necessary resources are in place to accelerate digital transformation. Second, in supporting the integration of technology and digital tools, leaders can facilitate the application of technology in daily learning. This is stated in the research of [44], [45], [48], which shows that if there are leaders who are willing to integrate technology, the school will easily transform towards modern digital.

Thirdly, mentoring and monitoring, in [46], [49] research, showed their role in developing students' digital skills directly, either by monitoring digital literacy training or by facilitating relevant technology-based programs, such as mentoring Tahsin Al-Quran which switched to digital format. Finally, in adapting technology to the needs of the digital generation, leaders as found in [50] research play an important role in adapting the use of technology, such as virtual reality (VR), to the needs and characteristics of today's young generation.

Overall, the role of leadership in Islamic schools is very diverse and applies to various aspects, ranging from educational policies, integration of digital tools, to the development of students' digital literacy skills. This result is very much in line with what has been stated by several studies [64], [24], [65], that the role of the leader is to guide, support, monitor, and evaluate all aspects of his authority. Leaders in Islamic schools are not only tasked with adapting technology but also ensuring that the technology brings benefits to improve the quality of learning without neglecting the religious values on which education is based. Principals have the authority to organize workshops and provide examples of digital literacy to improve teachers' skills as suggested by [66].

In improving students' digital literacy, schools experience obstacles that make the implementation and expected results less than optimal. The challenges consist of various interrelated obstacles. First, there are limited skills and familiarity with technology faced by educators and school staff. Research by [44], shows that educators' lack of understanding in using laptop-based digital tools hinders the integration of technology in learning. Similarly, a study by [48], found challenges in adapting a digital Tahsin Al-Quran mentoring program during the pandemic, which required improved technological skills for educators and students. Furthermore, reliance on traditional teaching methods is also a major obstacle. Research by [45], noted that the use of conventional teaching methods hinders the adoption of digital tools in project-based learning (PjBL). Research by [49] also pointed out the difficulty in transforming traditional methods in Quran mentoring into a digital format that is more relevant to technological developments. In addition, students' low initial digital literacy is a big challenge. In line with research [43] which revealed that despite using technology-based learning models, students' digital literacy is still hampered, especially in the ability to search and organize information. Research by [46] found that students' critical skills to filter information in the digital world are low. On the other hand, misinformation circulating in cyberspace is an obstacle to the literacy process faced by [47], which can reduce the quality of students' digital literacy and critical thinking skills.

Another challenge that arises is related to limited access to advanced technology, such as VR, which can improve Islamic digital literacy. Research by [50], shows that although VR technology can increase students' engagement and knowledge absorption, the challenges of high cost, limited accessibility, and lack of appropriate content are the main obstacles. Finally, the obstacles in adapting and implementing digital-based learning programs, as pointed out by [49], indicate that changes in learning methods, such as from face-to-face to digital, should be sensitive to Islamic educational values. In the implementation of any form of technology, there will be many challenges and obstacles that arise in the process. Such as the high cost of technology [67], difficulty in understanding complexity of new technology [68], and reliance on conventional methods [69].

Along with the challenges, there will be many opportunities to be seized. The opportunities identified in this research suggest various steps that can be taken to improve digital literacy in Islamic schools through the integration of technology and innovation. Some opportunities include improving students' digital and cognitive skills, such as through the development of critical thinking skills and responsible digital citizenship [46], [47], and improving media literacy through the use of laptop technology [44]. In addition, there are opportunities to optimize learning models, such as Project-Based Learning (PjBL) and OLS-CMPBL in the long term, which can help improve digital literacy outcomes [43], [45]. Another opportunity is in the capacity building of educators and staff through training and utilization of technology in teaching, as described by [48], [49]. Finally, advanced technologies such as VR also offer opportunities to improve student engagement and knowledge retention, as described by [50].

All the opportunities found in the related articles already summarize what opportunities are found in general. Long-term technology implementation [70], teacher training and competency development [71], and instilling digital literacy awareness directly to students.

All the challenges become an urgency that needs greater attention in improving technology readiness in Islamic schools in Indonesia. Small things can become new challenges if they are not resolved, resulting in sub-optimal implementation of technology in the long run. Alongside challenges, opportunities present themselves as a chance to take actions or decisions that can result in a positive impact. Therefore, the successful integration of technology in education requires the participation of all parties, not only leaders, but also teachers, students, education personnel, parents, and the government, who must work together to create an educational ecosystem that supports the development of digital literacy.

Along with the increasing focus on digital literacy, the publication trends resulting from the keyword analysis in the selected articles provide an overview of the emerging topics in technology integration in Islamic education.

The keyword mapping identified through the software is used as supporting qualitative data in this study. The results are shown in Figure 4.

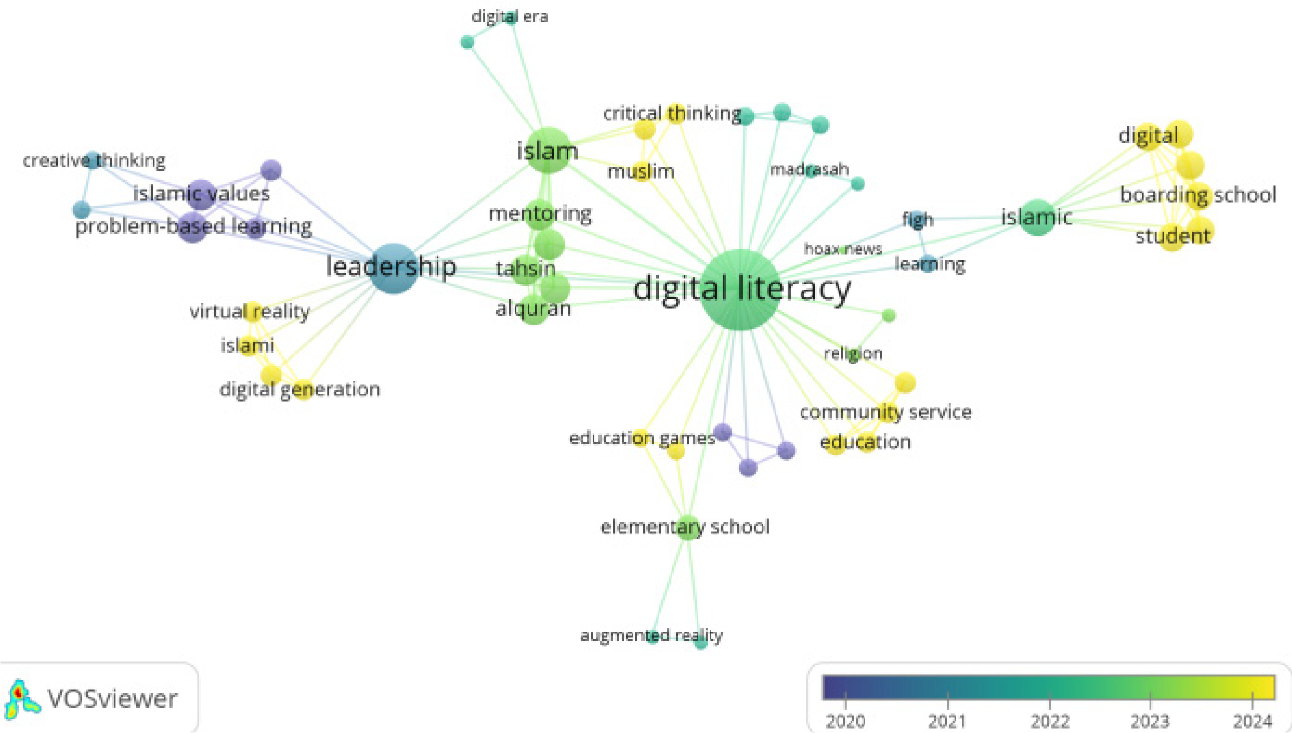

Figure 4. Trends of digital literacy in Islamic schools

The VOSviewer network visualization in Figure 4 presents digital literacy as a central theme, connected to various interdisciplinary research areas. Positioned in the center, digital literacy is connected to several sub-themes, with the thickness of the edges reflecting the strength of co-occurrence or thematic relevance between the terms. The network shows a strong connection between digital literacy and educational contexts, with terms such as elementary school, community service and hoaxes, which focus on building digital competencies among young students. This indicates an emphasis on educating children to critically engage with digital information and combat misinformation. In addition, this visualization reflects the intersection of digital literacy with religious and ethical dimensions, as present in terms such as Islam and fiqh. This intersection suggests research examining how digital literacy interacts with Islamic values, ethical principles and religious education, potentially addressing how digital competencies can be aligned with a moral framework.

Furthermore, terms such as leadership, suggesting a focus on developing leadership qualities and character education in digital literacy programs, that the urgency in preparing students for responsible digital engagement [72].

The network also explores emerging technologies, such as Augmented Reality (AR) and Virtual Reality (VR), indicating that research in digital literacy consists of the exploration of advanced tools and their integration into educational practices. Temporal patterns are visible through the color gradient, ranging from blue (2020) to yellow (2024), signifying the evolution of these themes over time. Notably, recent interest has emerged around concepts such as critical thinking, VR, and digital, which are new to madrasa research. Overall, this visualization underscores the multifaceted approach to digital literacy, which includes educational, ethical, religious and technological dimensions. The timeline also hints at a shift in interest to incorporate cultural and ethical considerations into digital literacy, reflecting adaptability to contemporary societal concerns.

4. Conclusion

This study highlights that approximately 58% of the increase in digital literacy among Indonesian madrasah students can be attributed to the adoption of technology and innovative teaching strategies supported by visionary school leaders. These leaders play a crucial role in shaping policies, providing resources, and ensuring that technological tools align with the moral and cultural framework of Islamic education. These findings offer important implications not only for Indonesia but also for other countries with faith-based education systems. They suggest that leadership development programs, teacher training, and investment in digital infrastructure are key to preparing students for the demands of a digital society. Despite these positive results, the study also reveals persistent challenges, including unequal access to technology, reliance on conventional teaching methods, and varying levels of teacher preparedness.

Future research could expand on this study by examining global comparisons, adopting a long-term approach to assess sustainability, and exploring how emerging technologies, such as VR and AI, can be integrated in ways that respect ethical and cultural values. By addressing these areas, future research could create a more comprehensive roadmap for digital transformation in Islamic education. Overall, this study not only fills an empirical gap but also provides a foundation for developing a leadership-based digital literacy model. It invites educators, policymakers, and the public to collaborate to create an educational ecosystem that embraces technological advancements without neglecting religious and cultural principles.

Acknowledgements

This research was supported by the Institute for Research and Community Service (LPPM), Universitas Negeri Padang. The author expresses his deepest gratitude for the support that made this research possible.

References:

[1]. Ibrahim, B. (2019). Madrasah transformation into modern educational institutions during the new order. *Istawa: Jurnal Pendidikan Islam*, *4*(2), 196-216.

[2]. Rohman, A., et al. (2023). Integrating traditional-modern education in madrasa to promote competitive graduates in the globalization era. *Cogent Education*, *10*(2), 2268456.

[3]. Kurniawati, A., Sutarno, S., & Sariman, S. (2022). Integration of Islamic spiritual emotional and intellectual education in vocational high schools. *Ta Dib Jurnal Pendidikan Islam*, *11*(2), 229-240.

[4]. Mubarok, H. (2023). Analisis Kurikulum Madrasah Tsanawiyah Dan Madrasah Aliyah Pesantren Modern Unggulan Terpadu Darul Mursyid Sidapdap Simanosor Kecamatan Saipar Dolok Hole Kabupaten Tapanuli Selatan. *Jurnal Penelitian Ilmu Pendidikan Indonesia*, *2*(3), 306-316.

[5]. Hidayat, H., et al. (2019). The contribution of technopreneurship scientific learning and learning readiness towards the entrepreneurship learning outcomes in higher vocational education. *Jurnal Pendidikan Vokasi*, *9*(1), 21-32. Doi: 10.21831/jpv.v9i1.20466.

[6]. Azra, A., Afrianty, D., & Hefner, R. W. (2007). Pesantren and madrasa: Muslim schools and national ideals in Indonesia. *Schooling Islam: The culture and politics of modern Muslim education*, 172-198.

[7]. Nurdin, H. (2020). Problems and crisis of Islamic education today and in the future. *International Journal of Asian Education*, *1*(1), 21-28.

[8]. Hidayat, H., et al. (2024). Metacognitive Awareness Determination through Technology: A Problem-Solving Android Gamification App. *International Journal of Information and Education Technology*, *14*(8), 1099-1108.

[9]. Anurogo, D., et al. (2023). Digital Literacy 5.0 to enhance multicultural education. *Multicultural Islamic Education Review*, *1*(2), 95-104.

[10]. Ibrahim, M., et al. (2024). Addressing contemporary ethical and moral issues through islamic education. *Journal on Islamic Studies*, *1*(1), 36-51.

[11]. Sawamoto, A., & Marshall, J. H. (2020). *Infrastructure, Learning Complements, and Student Learning: Working Together for a Brighter Future*. World Bank Group.

[12]. Qorib, M., & Afandi, A. (2024). Implementing prophetic values in the islamic life guidelines for Muhammadiyah citizens: A qualitative analysis for transforming science and technology. *MIQOT: Jurnal Ilmu-ilmu Keislaman*, *48*(1), 1-24.

[13]. Nurhayati, S., et al. (2024). Analysis of the implementation of training on digital-based learning media to enhance teachers' digital literacy. *Al-Ishlah: Jurnal Pendidikan*, *16*(1), 545-557.

[14]. Kharismatunisa, I. (2023). Innovation and Creativity of Islamic Religious Education Teachers in Utilizing Digital-Based Learning Media. *Scaffolding: Jurnal Pendidikan Islam Dan Multikulturalisme*, *5*(3), 519-538.

[15]. Rizal, S. U., Anshari, M. R., & Hikmah, N. (2022). Utilization of Digital Learning Media in Islamic Education to Increase Literacy and Innovation in the Era of Modern Technology. *Proceeding of Saizu International Conference on Transdisciplinary Religious Studies*, 48-55.

[16]. Günther, S. (2020). Islamic education, its culture, content and methods: An introduction. *Knowledge and Education in Classical Islam: Religious Learning between Continuity and Change, 2,* 1–39. Brill.

[17]. Wink, A. (2021). *Al-Hind, Volume 1 Early Medieval India and the Expansion of Islam 7th-11th Centuries*. Brill.

[18]. Syar'i, A., & Akrim, A. (2020). The development of Madrasa education in Indonesia. *Revista Argentina de Clínica Psicológica*, *29*(4), 513.

[19]. Al-Hasani, S. M. A. (2019). Learning institutes of pre-Islam and early Islamic century and their transformation into formal madrasah in 11th Century. *Asian Journal of Education and Social Studies*, *3*(2), 1-9.

[20]. Bulliet, R. W. (1978). Local politics in Eastern Iran under the Ghaznavids and Seljuks. *Iranian Studies*, *11*(1-4), 35-56.

[21]. Memon, N. A. (2019). *A history of Islamic schooling in North America: Mapping growth and evolution*. Routledge.

[22]. Fandy, M. (2023). Enriched Islam: the Muslim crisis of education. *Survival 49.2*, 77–97. Routledge.

[23]. Mahsusi, et al. (2024). Achieving excellence: the role of digital transformation in madrasah management and Islamic culture. *Cogent Arts & Humanities*, *11*(1), 2304407.

[24]. Uy, F. T., Sasan, J. M., & Kilag, O. K. (2023). School principal administrative-supervisory leadership during the pandemic: a phenomenological qualitative study. *International Journal of Theory and Application in Elementary and Secondary School Education*, *5*(1), 44-62.

[25]. Syafrudin, O., Junaedi, J., & Maulana, Y. (2024). The Influence Of Transformational Leadership And Work Motivation On Employee Work Discipline. *Indonesian Journal Of Business And Economics*, *7*(1).

[26]. Dewi, F. K., et al. (2024). The impact of entrepreneurship education, emotional quotient and parental support on students' entrepreneurial interest. *Jurnal Pendidikan Ilmu Sosial*, *34*(1), 106-117.

[27]. Benitez, J., et al. (2022). Impact of digital leadership capability on innovation performance: The role of platform digitization capability. *Information & Management*, *59*(2), 103590.

[28]. Fachrunnisa, O., et al. (2020). Towards SMEs' digital transformation: The role of agile leadership and strategic flexibility. *Journal of Small Business Strategy (Archive Only)*, *30*(3), 65-85.

[29]. Modha, B. (2021). Collaborative leadership with a focus on stakeholder identification and engagement and ethical leadership: A dental perspective. *British Dental Journal*, *231*(6), 355-359.

[30]. Morgeson, F. P. (2005). The external leadership of self-managing teams: intervening in the context of novel and disruptive events. *Journal of applied Psychology*, *90*(3), 497.

[31]. Efimov, I., et al. (2022). Virtual leadership in relation to employees' mental health, job satisfaction and perceptions of isolation: A scoping review. *Frontiers in psychology*, *13*, 960955.

[32]. Bagwell, J. (2020). Leading through a pandemic: adaptive leadership and purposeful action. *Journal of school administration research and development*, *5*, 30-34.

[33]. George, A. S., Baskar, T., & Srikaanth, P. B. (2024). Bridging the generational divide: Fostering intergenerational collaboration and innovation in the modern workplace. *Partners Universal International Innovation Journal*, *2*(3), 198-217.

[34]. Gilster, P. (1997). *Digital Literacy.* Wiley.

[35]. Prensky, M. (2012). *From digital natives to digital wisdom: Hopeful essays for 21st century learning*, 67–85. Corwin.

[36]. Berkhout, S. W., et al. (2023). A tutorial on Bayesian model-averaged meta-analysis in JASP. *Behavior Research Methods, 56(3), 1260-1282.*

[37]. Navarro, Z. I. T. (2021). Metacognitive strategies for reading comprehension in basic education students. *Asian Journal of Education and Social Studies*, *14*(4), 34-46.

[38]. Kristiana, H., Bangun, B., & Simanjuntak, D. C. (2022). The Effects of Vocabulary Mastery on English-Speaking Ability: A Meta-Analysis Study. *Journal of Languages and Language Teaching*, *10*(2), 211–222.

[39]. Kleinheksel, A. J., et al. (2020). Demystifying content analysis. *American journal of pharmaceutical education*, *84*(1), 7113.

[40]. Cheng, E. C. K., & Wang, T. (2023). Leading digital transformation and eliminating barriers for teachers to incorporate artificial intelligence in basic education in Hong Kong. *Computers and Education: Artificial Intelligence*, *5*, 100171.

[41]. Kurzhals, C., Graf-Vlachy, L., & König, A. (2020). Strategic leadership and technological innovation: A comprehensive review and research agenda. *Corporate Governance: An International Review*, *28*(6), 437-464.

[42]. Hidayat, H., et al. (2024). The Influence of Augmented Reality Mobile App on Electronics Engineering Students' Self-Competence. *TEM Journal*, *13*(3), 2310.

[43]. Perdana, R., et al. (2021). Elementary students' attitudes towards STEM and 21st-century skills. *International Journal of Evaluation and Research in Education (IJERE)*, *10*(3), 1080-1088.

[44]. Mainofriwita, & Hadiyanto. (2021). The Effect of Media Literacy and Cognitive Ability on Recognition Laptop-Based Media for Children. *JPUD - Jurnal Pendidikan Usia Dini*, *15*(2), 361–378.

[45]. Faridah, N. R., Afifah, E. N., & Lailiyah, S. (2022). Efektivitas Model Pembelajaran Project Based Learning Terhadap Kemampuan Literasi Numerasi dan Literasi Digital Peserta Didik Madrasah Ibtidaiyah. *Jurnal Basicedu*, *6*(1), 709–716.

[46]. Sa'id, M., et al. (2022). Information literacy training for teenager-students of Islamic boarding school on the digital era. *Abdimas: Jurnal Pengabdian Masyarakat Universitas Merdeka Malang*, *7*(2), 329-343.

[47]. Munawar, R. M., Jaenudin, D., & Retnowati, R. (2023). Project-based learning with digital storytelling to improve science literacy of 10th-grade students in MA al manshuriyah school. *Journal of Science Education and Practice*, *7*(1), 46-52.

[48]. Sulaiman, M., & Julianto, R. D. (2023). The Effect of Tahsin Al-Quran Mentoring on Increasing Al-Quran Reading Competence of the Muhammadiyah Palembang Institute of Health Science and Technology Employees. *European Journal of Education and Pedagogy*, *4*(1), 154-158.

[49]. Susilawati, D., Iswara, P. D., & Aeni, A. N. (2024). Development of Digital Literacy Educational Game for Elementary School Students to Be Wise in Using the Internet. *Journal of Education Research*, *5*(1), 525-536.

[50]. Sari, R. C., et al. (2024). Virtual Reality-Based Media for Islamic Financial Literacy: A Shift in the New Anti-Usury Educational Strategy. *Journal of Technology and Humanities*, *5*(1), 1-12.

[51]. Fey, C. F., Hu, T., & Delios, A. (2023). The measurement and communication of effect sizes in management research. *Management and Organization Review*, *19*(1), 176-197.

[52]. Antonakis, J., Bastardoz, N., & Rönkkö, M. (2021). On ignoring the random effects assumption in multilevel models: Review, critique, and recommendations. *Organizational Research Methods*, *24*(2), 443-483.

[53]. Kant, S. (2023). Meta Analysis of Marketing Innovation on Firm's Performance of Small & Medium Enterprises with the Moderating effect of Government Support Program: In case of Selected Sub-Cities of Addis Ababa, Ethiopia. *OPSearch: American Journal of Open Research*, *2*(2), 152-164.

[54]. Ammer, T., et al. (2021). refineR: a novel algorithm for reference interval estimation from real-world data. *Scientific reports*, *11*(1), 16023.

[55]. Akbar, S. A., & Fazli, R. R. (2023). Meta-Analysis: The effectiveness of artificial diets to increase on survival rate of vannamei shrimp (Litopenaeus vannamei). *IOP Conference Series: Earth and Environmental Science*, *1221*(1), 012066.

[56]. Cohen, J. (2013). *Statistical power analysis for the behavioral sciences*. Routledge.

[57]. Lewandowska, K., & Węziak-Białowolska, D. (2023). The impact of theatre on social competencies: a meta-analytic evaluation. *Arts & Health*, *15*(3), 306-337.

[58]. Wang, G. (2022). The 95% confidence interval for GNSS-derived site velocities. *Journal of Surveying Engineering*, *148*(1), 04021030.

[59]. van der Willik, E. M., et al. (2021). Funnel plots of patient-reported outcomes to evaluate health-care quality: Basic principles, pitfalls and considerations. *Nephrology*, *26*(2), 95-104.

[60]. Afonso, J., et al. (2024). The perils of misinterpreting and misusing "publication bias" in meta-analyses: An education review on funnel plot-based methods. *Sports medicine*, *54*(2), 257-269.

[61]. Berkhout, S. W., et al. (2024). A tutorial on Bayesian model-averaged meta-analysis in JASP. *Behavior Research Methods*, *56*(3), 1260-1282.

[62]. Liu, Z., et al. (2023). The normality assumption on between-study random effects was questionable in a considerable number of Cochrane meta-analyses. *BMC medicine*, *21*(1), 112.

[63]. Garea, S. S., et al. (2021). Meta-analysis of the relationship between problem gambling, excessive gaming and loot box spending. *International Gambling Studies*, *21*(3), 460-479.

[64]. Sabzalieva, E., & Valentini, A. (2023). *ChatGPT and artificial intelligence in higher education: quick start guide.* UNESCO / International Institute for Higher Education in Latin America and the Caribbean (IESALC).

[65]. Miller, P. (2023). Anti-racist school leadership: Making 'race'count in leadership preparation and development. *Leading Socially Just Schools*, 9-23. Routledge.

[66]. Johanes, V. E., Suroyo, S., & Budiastra, A. K. (2022). Analisis hubungan gaya kepemimpinan kepala sekolah dan literasi digital dengan kinerja guru sekolah dasar. *Jurnal Basicedu*, *6*(2), 2793-2801.

[67]. Le, T. T., et al.. (2024). Fueling the future: A comprehensive review of hydrogen energy systems and their challenges. *International Journal of Hydrogen Energy*, *54*, 791-816.

[68]. Volberda, H. W., et al. (2021). Strategizing in a digital world: Overcoming cognitive barriers, reconfiguring routines and introducing new organizational forms. *Long Range Planning*, *54*(5), 102110.

[69]. Nama, P. (2024). Integrating AI in testing automation: Enhancing test coverage and predictive analysis for improved software quality. *World Journal of Advanced Engineering Technology and Sciences*, *13*(1), 769-782.

[70]. Liu, Z. J., et al. (2020). Retracted Article: Digital Literacy and Digital Didactics as the Basis for New Learning Models Development. *International Journal of Emerging Technologies in Learning (iJET)*, *15*(14), 4-18.

[71]. Hidayat, H., et al. (2021). The Empirical Analysis of Industrial Work Challenges in the Industrial Revolution 5.0 Towards a Grade Point Average (GPA) for Electronic Engineering Education Students. *International Journal of Online & Biomedical Engineering*, *17*(9).

[72]. Crosby, B. C., & Bryson, J. M. (2005). *Leadership for the common good: Tackling public problems in a shared-power world*, *264.* John Wiley & Sons.