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DIGITAL LITERACY DEVELOPMENT IN MADRASAH ALIYAH: EVIDENCE FROM A WEB-BASED LEARNING INTERVENTION

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ABSTRACT
In the global digital era, digital literacy has emerged as a critical educational concern, extending beyond merely technical competence to encompass ethical awareness, social integration, and responsible participation in increasingly polarized digital environments. This study, therefore, examines the effectiveness of the MPIS application in enhancing digital literacy among students in Madrasah Aliyah. A quasi-experimental design with a pre-test and post-test control group was employed, involving 64 Madrasah Aliyah students selected through cluster random sampling from a population of 150 students across twelve classes. Data were collected using a validated digital literacy assessment consisting of 20 multiple-choice items, which were then analyzed using normalized gain (N-gain) analysis and independent samples t-tests. The results show that students who used the MPIS application demonstrated higher post-test digital literacy scores; specifically, their mean scores increased from 35 to 85, with an N-gain of 0.75. In contrast, the control group receiving conventional instruction showed an N-gain of 0.45. These findings, therefore, indicate that web-based learning interventions can effectively support the development of students' digital literacy in Madrasah contexts. Moreover, the study suggests that integrating digital learning tools into Islamic education has the potential to support character-oriented learning, encourage ethical and responsible technology use, and ultimately contribute to more inclusive and constructive digital engagement.

Keywords: Literacy, Good Citizenship, Digital, MPIS App, Polarization, Social integration

INTRODUCTION
The rapid expansion of the internet and digital media has fundamentally reshaped how individuals learn, communicate, and participate in social and political life worldwide (Dhingra et al., 2026). Digital technologies now function not merely as tools for information access but as platforms for interaction, identity formation, and civic engagement (Feezell & Ortiz, 2021; Moeller & de Vreese, 2019). In response to these transformations, contemporary educational paradigms increasingly emphasize the integration of innovative technologies and digital devices into teaching and learning processes (Mamlok, 2025; Burkle & Cobo, 2018; Delponte et al., 2015). Such integration is essential for preparing students to navigate complex digital environments and to develop the competencies required in a rapidly evolving global society (Sharma et al., 2025).

Within this context, digital literacy has emerged as a core educational priority. Digital literacy encompasses the ability to access, evaluate, create, and share information critically through digital technologies, including computers, mobile devices, and online platforms (Fan et al., 2026; Buckingham, 2010; Audrin & Audrin, 2022). The evolution of the internet from a

predominantly unidirectional medium to an interactive, participatory space has enabled individuals not only to consume information but also to produce and disseminate it autonomously (Paniszyn et al., 2026; Bennett et al., 2011). Consequently, strengthening digital literacy within educational curricula is no longer optional but necessary to ensure that students can engage meaningfully, ethically, and critically in digital public spheres.

Moreover, recent scholarship emphasizes that digital literacy extends beyond technical proficiency to include critical thinking, media awareness, and an understanding of the social and political implications of digital communication (Kuehn, 2023; Yang & Guo, 2025). Currently, debates on the digital divide increasingly focus not only on access to devices or connectivity but also on individuals' capacity to participate responsibly and reflectively in digital practices (Tate & Warschauer, 2017). This concern is particularly salient, especially given the prevalence of political discourse in digital media, which in turn requires learners to develop skills in evaluating online content, navigating information ecosystems, and understanding the broader socio-political and economic power dynamics embedded in digital platforms (Polizzi, 2020; Wu, 2024; Polizzi, 2023). Additionally, fostering these competencies is crucial for enabling responsible digital citizenship in an interconnected world.

Furthermore, a critical challenge arising from inadequate digital literacy is social polarization, which is often intensified through digital media. Online environments enable users to express opinions, respond to opposing views, and engage in discussions that can either foster dialogue or deepen divisions (Coles & Saleem, 2021). Exposure to contrasting perspectives may promote tolerance when accompanied by critical awareness, yet it can also trigger polarization when mediated by filter bubbles, echo chambers, misinformation, and hate speech (Spohr, 2017; Wollebæk et al., 2019; Tsang, 2024; Kumar & Maurya, 2024). In Indonesia, digital polarization has become particularly visible during electoral periods, where political discourse in cyberspace frequently escalates into prolonged social conflict (Afrimadona, 2021; Soderborg & Muhtadi, 2021). Conversely, effective digital literacy has been shown to support social integration by encouraging inclusive communication, cross-cultural interaction, and the dissemination of tolerance values (Aleke et al., 2011; Noe et al., 2021).

Numerous studies have explored the use of web-based applications, mobile technologies, and digital media to enhance digital literacy in fields like science, mathematics, and health education (Sudha & Amutha, 2015; Moretti et al., 2023). However, research on digital citizenship education within Islamic institutions is limited. While prior work shows the effectiveness of web-based learning models, educational games, and mobile applications in promoting information literacy, digital ethics, and online safety (Arachchilage & Beznosov, 2016; Nawaila et al., 2022; Zheng et al., 2024), few address digital literacy in relation to social polarization and social integration in Madrasah contexts. This study fills this gap by evaluating the effectiveness of the MPIS web-based application in improving digital literacy among Madrasah Aliyah students, focusing on fostering responsible digital citizenship, reducing polarization, and promoting social integration in Islamic education.

METHOD

This study is grounded in an integrated framework that combines perspectives on digital citizenship, critical digital literacy, and Islamic character education. It draws primarily on the Digital Citizenship model proposed by Mike Ribble (2011), which frames digital literacy as ethical, responsible, and participatory technology use. Additionally, this framework is strengthened by foundational digital literacy theory articulated by David Buckingham (2010), which is further extended through critical digital literacy. This extension emphasizes critical evaluation of information, awareness of misinformation, and understanding of socio-political dynamics in digital media (Gianna Polizzi, 2020). Furthermore, these perspectives are

interpreted within the Islamic educational context through the concept of *adab*, as articulated by Syed Muhammad Naquib al-Attas (1995). This interpretation positions ethical conduct, respect, and social harmony as central aims of digital literacy education in Madrasah Aliyah.

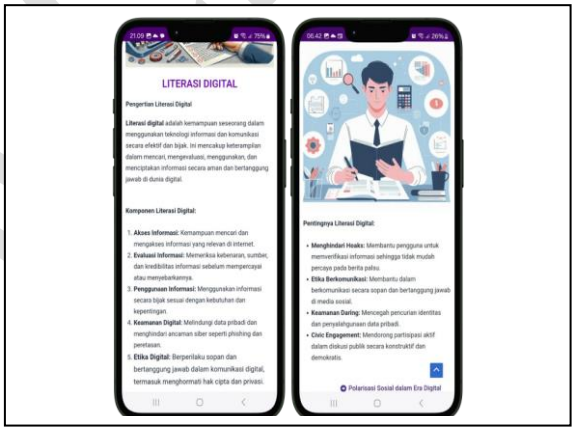
Methodologically, the study employed a quasi-experimental design with a pre-test and post-test control group to examine the effectiveness of the MPIS application in enhancing students' digital literacy. Students' literacy levels were measured before and after the intervention using a standardized assessment, with learning gains analyzed through normalized gain (N-gain) scores categorized as high, moderate, or low. Statistical analyses were conducted using Microsoft Excel 2021 and SPSS version 26 to compare outcomes between the experimental and control groups. This approach enables a systematic evaluation of the instructional impact of the MPIS application and provides empirical evidence for integrating technology-based learning tools that support responsible digital citizenship, critical awareness, and character development within Islamic secondary education.

To strengthen the validity of the findings, this study employed quantitative triangulation through multiple analytical methods, including descriptive statistics, normalized gain analysis, and inferential testing. The consistent results across these analytical layers strengthens the validity of conclusions about changes in students' digital literacy after the intervention. Additionally, process-level observations were conducted during the implementation of the MPIS application implementation documented students' engagement with digital content and learning activities. These observations provided context for the quantitative data and helped align instructional design with learning outcomes.

RESULTS AND DISCUSSION

Description of the MPIS Application (Intervention Overview)

To provide contextual clarity for the quantitative findings, this section begins with a brief description of the MPIS application as the instructional intervention used in the experimental group. Specifically, Figure 1 presents the overall structure of the MPIS application, which was developed as a web-based learning medium accessible on Android devices.



(a) (b)

Figure 1. Presentation of digital literacy resources within the MPIS App

Figure 1 shows that the application consists of four main learning sections: (1) fundamental digital literacy concepts, (2) social polarization in digital media, (3) social integration in the digital era, and (4) digital literacy as a strategy for ethical and responsible digital participation. These sections are followed by an integrated assessment module. This structure aims to facilitate a comprehensive understanding of the topics covered, thereby supporting the

overall objectives of the intervention. The MPIS application guided students from conceptual understanding to applied reflection on digital literacy, polarization, and social integration and was used as the primary learning medium in the experimental group, while the control group received conventional instruction. Students' digital literacy was measured through pre-test and post-test assessments, with the quantitative results presented in the following subsection.

Descriptive Statistics of Students' Digital Literacy

This subsection presents the descriptive statistics of students' digital literacy scores before and after the intervention. As shown in Table 1, students in the experimental group demonstrated relatively low initial digital literacy at the pre-test stage, with a mean score of 35, scores ranging from 20 to 50, and a standard deviation of 10.14. Following the implementation of the MPIS application, students' post-test performance increased, with the mean score rising to 85, a score range of 80 to 90, and a reduced standard deviation of 7.20. Overall, the descriptive statistics indicate improved digital literacy performance and more consistent achievement among students from pre-test to post-test, providing a foundation for subsequent learning gain and inferential analyses.

Table 1. Descriptive Statistics of Students' Digital Literacy Scores

Stages	N	Value			
		Min	Max	Mean	Stdev
Pre-test	32	20	50	35	10.14
Post-Test	32	80	90	85	7.20
N-gain	32	0.65	0.91	0.75	0.05

As shown in Table 1, students' digital literacy scores increased from pre-test to post-test, with the mean rising from 35 to 85 and reduced score variability. The N-gain value of 0.75 reflects a high level of improvement, while the decrease in standard deviation indicates more consistent student performance, providing a basis for subsequent gain and inferential analyses.

Effect of the MPIS Application on Overall Digital Literacy

To examine the effect of the MPIS application, mean digital literacy scores of the experimental and control groups were compared across pre-test, post-test, and normalized gain (N-gain), as shown in Figure 2.

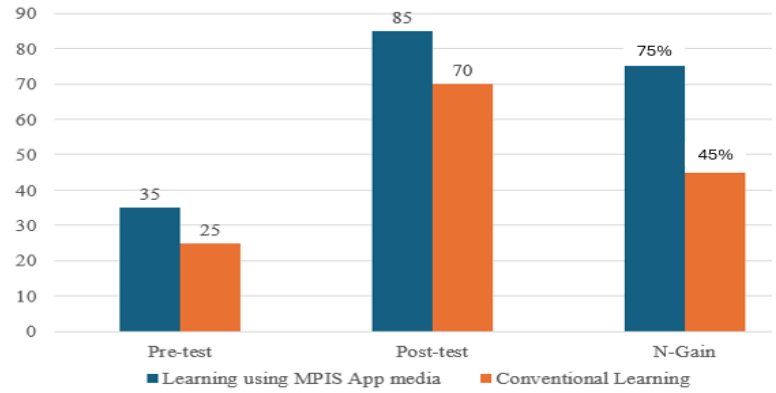


Figure 2. Comparison of Mean Pre-test, Post-test, and N-gain Scores between the MPIS App Class and the Conventional Class

As illustrated in Figure 2, prior to the intervention, the experimental group had a mean pre-test score of 35, while the control group's mean was 25. These initial results indicate that both groups had limited digital literacy initially, with the experimental group displaying a slightly higher baseline ability. Although minor, this difference suggests some variation in digital skills, which could impact the intervention's outcomes. Understanding these baseline levels is essential for accurately interpreting any subsequent changes in digital literacy due to the intervention.

Following the instructional period, both groups demonstrated increased post-test scores. The experimental group achieved a mean post-test score of 85, whereas the control group attained a mean score of 70. In terms of learning gains, the experimental group obtained an N-gain value of 0.75, while the control group recorded an N-gain value of 0.45. These descriptive comparisons indicate larger improvements in digital literacy scores among students who used the MPIS application compared to those who received instruction through conventional learning media. Further statistical testing of these differences is presented in the subsequent subsection.

Analysis of Learning Gains Using Normalized Gain (N-Gain)

Learning gains were examined using normalized gain (N-gain) scores to assess the relative improvement in students' digital literacy following instruction. As shown in Table 2, the experimental group achieved a mean N-gain score of 0.75, while the control group recorded a mean N-gain score of 0.45.

Table 2. N-Gain Scores of Students' Digital Literacy

Group	N	Min	Max	Mean	SD	Category
Experimental	32	0.65	0.91	0.75	0.05	High
Control	32	0.30	0.60	0.45	0.07	Moderate

Based on commonly used N-gain classification criteria, as captured in Table 2, the experimental group's gain falls within the high category, whereas the control group's gain falls within the moderate category. These descriptive results indicate a greater increase in digital literacy scores among students who participated in learning activities using the MPIS application.

Normality and Assumption Testing

Before performing inferential statistical analysis, the distribution of digital literacy scores was examined to verify if it met the assumptions of parametric tests. Normality was tested using the Kolmogorov–Smirnov test with Monte Carlo significance correction. Then, the Kolmogorov-Smirnov test was used to determine whether the data followed a normal distribution. If the p-value was greater than 0.05, the data were considered normally distributed, which is necessary for using parametric tests. The normality test results for both pre-test and post-test data on students' digital literacy, based on the Kolmogorov-Smirnov test, are provided in Table 3.

Table 3. One-Sample Kolmogorov-Smirnov Test of Digital Literacy Scores

Test Stage	N	Mean	SD	Monte Carlo Sig. (2-tailed)
Pre-test	64	30.0	12.11	0.218
Post-test	64	77.5	14.89	0.081

In addition, Table 3 portrays the Monte Carlo significance values for both pre-test and post-test scores, which exceeded the 0.05 threshold, indicating that the data were normally distributed. These results confirm that the digital literacy data met the assumptions required for subsequent parametric inferential testing. The results of the inferential analysis are presented in the following subsection.

Inferential Analysis of Digital Literacy Improvement

Following confirmation that the data met the assumptions for parametric testing, an independent samples t-test was conducted to examine differences in digital literacy scores between the experimental group and the control group. The results of the analysis are presented in Table 4.

Levene's test indicated homogeneity of variances ($F = 1.675$, $p = 0.202$), allowing interpretation of the t-test results under the assumption of equal variances. The independent samples t-test revealed a statistically significant difference between the two groups, $t(62) = 6.523$, $p < .001$, with a mean difference of 20.587 points. The 95% confidence interval for the mean difference ranged from 14.567 to 28.765.

These results indicate that students in the experimental group achieved higher digital literacy scores than those in the control group. Further interpretation of these findings is provided in the Discussion section.

Table 4. Independent Samples t-Test Results for Digital Literacy

Test Condition	F	p (Levene)	t	df	p (2-tailed)	Mean Difference	95% CI
Equal variances assumed	1.675	0.202	6.523	62	< .001	20.587	[14.567, 28.765]

As shown in Table 4, the independent samples t-test indicated a statistically significant difference in digital literacy scores between the experimental and control groups, with the experimental group achieving higher mean scores and a mean difference of 20.587 points (95% CI [14.567, 28.765]). Consistent patterns were observed across descriptive statistics, normalized gain analysis, and inferential testing, with higher post-test scores and learning gains in the experimental group following the intervention. In addition to these quantitative results, classroom observations during implementation noted increased student engagement, particularly in interactive activities related to polarization and digital ethics, which aligns with the observed performance trends and suggests more active participation during learning.

The findings indicate that students who learned using the MPIS application achieved higher levels of digital literacy than those taught with conventional media, reinforcing the effectiveness of web-based learning environments in supporting digital literacy development. By enabling multimodal engagement through text, images, and interactive digital features, the MPIS application aligns with contemporary literacy practices that emphasize multiple representations to foster deeper understanding and meaningful learning (Flewitt et al., 2015; Zammit & Downes, 2002). From a digital citizenship perspective, these results support the view that digital literacy encompasses not only technical competence but also responsible and participatory engagement in digital spaces, as articulated in Ribble's (2011) Digital Citizenship framework, which highlights ethical technology use, digital etiquette, and civic responsibility as essential learning outcomes.

The results can also be interpreted through a sociocultural learning perspective, which conceptualizes learning as a socially mediated process shaped by interaction with cultural tools and artifacts (Vygotsky, 1978; Kumpulainen & Renshaw, 2007). The MPIS application functions

as a digital cultural tool that supports interaction, reflection, and meaning-making. By engaging with digital content that addresses real-world issues such as misinformation and social polarization (Choiri et al., 2025), students are not merely consuming information but actively constructing understanding within a shared digital context (Erydani et al., 2025)

The superior performance of students using the MPIS application further aligns with research on web-facilitated learning, which demonstrates that interactive digital environments can improve learning performance and task achievement by enabling direct engagement with content through images, text, and touch-based interfaces (Chen et al., 2006). This is particularly relevant for contemporary learners, often described as *digital natives*, who have grown up immersed in digital technologies and have preferences for visually rich, interactive media (Prensky, 2001; Ng, 2012). Prior studies indicate that such learners respond more positively to instructional media that incorporate visual and multimedia elements rather than text-dominated formats (Prensky, 2005; Abe & Jordan, 2013; Teo et al., 2016; Bennett et al., 2008).

Beyond cognitive and technical dimensions, the findings highlight the role of digital literacy in addressing social polarization and social integration, which are increasingly prominent challenges in digital societies. The inclusion of learning materials related to polarization, misinformation, and ethical communication in the MPIS application aligns with critical digital literacy, as articulated by David Buckingham (2010) and further developed by Gianna Polizzi (2020). From this perspective, digital literacy involves the capacity to critically evaluate information, recognize ideological influences, and understand the broader social and political implications of digital media use (Yudhiantara & Martitia, 2023).

The findings suggest that strengthening digital literacy through structured digital learning media can enhance students' awareness of the ethical and civic dimensions of online participation (Wahib & Raushan, 2026). This aligns with research indicating that digital literacy plays a key role in reducing the negative effects of polarization and supporting constructive engagement in digital public spaces (Sarwatay et al., 2021; Nuryadi & Widiatmaka, 2023). By equipping students with skills to verify information, communicate ethically, and engage with diverse perspectives, digital literacy education can contribute to more inclusive and tolerant forms of digital interaction.

Within the context of Islamic education, these outcomes are particularly significant when interpreted through the concept of *adab*, as articulated by Syed Muhammad Naquib al-Attas (1995). From this perspective, education aims not only to transmit knowledge but also to cultivate ethical conduct, social harmony, and moral responsibility. The integration of digital literacy with themes of polarization and social integration in the MPIS application supports the development of ethical digital behavior that aligns with Islamic values of respect, moderation, and communal harmony (Syarif et al., 2024).

The study also reinforces the importance of selecting learning media that align with educational objectives and learner characteristics. As emphasized by Qureshi et al. (2022), instructional media must be chosen strategically to support intended learning outcomes. In this study, the MPIS application effectively functioned as a medium for both skill development and character formation, demonstrating that digital tools can simultaneously support academic learning and moral education in Madrasah contexts (Tan et al., 2018).

The findings indicate that the MPIS application represents a promising model for integrating digital literacy education within Islamic secondary education. By combining digital citizenship, critical digital literacy, and Islamic character education, the application addresses contemporary digital challenges while remaining aligned with the values and mission of Islamic education. The results suggest that similar web-based applications can be developed and implemented across subjects to enhance students' digital literacy, promote social integration, and support character development in response to the global challenges of the digital age.

CONCLUSION

This study ultimately concludes that the MPIS application serves as a highly effective and innovative digital learning platform specifically designed to enhance students' digital literacy skills within the unique context of Madrasah Aliyah. The findings clearly demonstrate that web-based, multimodal learning environments hold substantial potential to significantly improve students' capabilities in accessing, critically evaluating, and responsibly utilizing digital information, especially when compared to traditional instructional methods. Furthermore, by thoughtfully integrating core principles of digital citizenship, digital literacy, and Islamic character education (*adab*), the MPIS application not only fosters technical competence but also promotes ethical awareness, social responsibility, and sensitivity to social issues such as polarization and community cohesion. These comprehensive results underscore the promising role of technology-enhanced learning tools in contributing positively to character development and civic education tailored to Islamic educational settings. Overall, this study emphasizes the critical importance of aligning digital innovation with educational and cultural values, suggesting that carefully designed digital applications can empower Islamic schools to prepare students to navigate the complexities of the digital age with wisdom, ethical integrity, and constructive engagement.

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