



Exploring the Effectiveness of Project-Based Blended Learning in Science E-Books for Improving Digital Literacy

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Abstract: This study addresses the pressing need to enhance digital literacy among students, particularly within the framework of project-based learning that incorporates e-books in the science curriculum. The primary aim is to assess the effectiveness of the Project-Based Blended Learning (PBBL) approach in boosting students' digital literacy. A quasi-experimental design was employed, with pre-test and post-test assessments conducted on two student groups. The experimental group engaged in project-based learning using e-books, while the control group followed traditional teaching methods. Data analysis, performed through t-tests, was used to compare the digital literacy improvements between the groups. The findings revealed that students who participated in PBBL with e-books showed a substantial increase in digital literacy compared to those in conventional learning environments. E-books in project-based learning offer greater flexibility, interactivity, and dynamism, significantly fostering the development of digital literacy skills. This research contributes empirical evidence supporting the effectiveness of PBBL in enhancing digital literacy and offers valuable insights for advancing technology-driven teaching approaches in science education.

Keywords: Digital literacy; Project-based blended learning; Science e-book

Introduction

Education in the 21st century necessitates the cultivation of strong digital literacy skills, particularly in the realm of science, to keep pace with the rapid advancements in technology (Asyari et al., 2024; Berlian et al., 2023; Thornhill-Miller et al., 2023). An effective method for enhancing digital literacy skills is through project-based learning that incorporates technology, such as integrating e-books into science education (Dwyer, 2023; Setianingrum et al., 2023; Wang, 2020). E-books provide students with access to a broader range of interactive and dynamic resources, enhancing their comprehension of scientific concepts (Hafiza et al., 2022; Nurhayati & Junda, 2025; Tang, 2021; Wang, 2020). As a result, students move beyond reliance on traditional textbooks and gain access to interactive media that

sparks their interest and creativity in learning. This approach also offers them the flexibility to learn independently, a key factor in developing essential 21st-century skills (Afandi et al., 2019; Juniawan et al., 2024; Sugiarti et al., 2024; Sullivan et al., 2021).

Despite the vast potential of technology-based learning, there remains a significant gap between the expectation of enhancing digital literacy and the actual outcomes. Many educational institutions, including Madrasah Ibtidaiyah Teacher Education (PGMI) students at Islamic State University (UIN) Mataram, face several challenges in effectively integrating technology. These challenges include limited infrastructure, insufficient training for educators, and uneven access to digital resources. Additionally, the integration of technology in teaching is often not accompanied by

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thorough planning, leading to minimal positive effects on students' digital literacy skills. As a result, while technology is increasingly adopted across campuses, its impact on improving students' digital competencies remains suboptimal. This highlights the need for the development of more effective strategies to address these barriers (Asyari et al., 2024; Sucilestari et al., 2023, 2024; Sucilestari & Arizona, 2020).

Previous studies indicate that project-based learning (PBL) is effective in enhancing students' critical thinking and creativity skills (Davidovitch, 2006; Frank, 2004; Marnewick, 2023; Muwaffaqoh et al., 2021; Setiawan et al., 2023; Stefanou, 2013; Sucilestari et al., 2023). Meanwhile, blended learning (which combines face-to-face and online instruction) has proven to be effective in fostering the development of digital skills (Anggraeni, 2020; Cronin & Caria, 2019; Distyasa et al., 2021; Setiadi et al., 2022; Yustina, 2020). Project-based learning offers students the chance to engage in complex, real-world tasks, helping them gain a profound understanding of scientific concepts (Markula & Aksela, 2022; Penuel et al., 2022; Zhao & Wang, 2022). Moreover, project-based learning fosters collaboration among students and promotes creative problem-solving skills that are essential in the digital age (Kumar, 2021; Lin et al., 2021; Tsibulsky & Muchnik-Rozanov, 2021). On the other hand, blended learning offers flexibility in accessing learning materials, enhancing student engagement and enabling them to learn at their own pace and according to their individual needs (Anggraini et al., 2024; Bakhri et al., 2023; Natsir et al., 2022; Utaminingsih et al., 2023). Although both approaches have been extensively researched, their integration in the context of using e-books for science education at the PGMI UIN Mataram student level remains limited. Furthermore, studies that consider students' prior knowledge as a crucial factor in learning outcomes are still scarce.

This research brings novelty by examining the effectiveness of project-based learning integrated with e-books in a blended learning environment to enhance students' digital literacy. Unlike many previous studies that have focused on a single learning model or technology, this study explores the combination of both (Aprilia et al., 2023; Hr et al., 2024; Ibrahim et al., 2024; Simanullang et al., 2023). This study aims to combine two approaches that have been shown to effectively enhance students' digital skills: PBBL and the use of e-books. By integrating e-books into project-based learning, students gain access to a broader and more diverse range of materials, while blended learning enables them to fully utilize technology both in and outside the classroom.

The primary goal of this research is to assess the impact of the Project-Based Blended Learning (PBBL)

model on improving students' digital literacy. Additionally, it seeks to provide recommendations for developing a more effective curriculum that incorporates technology into science education. To achieve these aims, the study employed a quasi-experimental design, with the experimental group engaging in project-based learning using e-books, while the control group followed traditional learning methods. This approach enabled the researcher to gather robust evidence on the effectiveness of integrating e-books into project-based learning, while also exploring how students' prior knowledge influences the success of technology-driven learning.

The primary contribution of this study is to offer new insights into the integration of the PBBL model in science education at the PGMI UIN Mataram student level and its role in enhancing students' digital literacy. This research also provides practical recommendations for developing more effective technology-driven learning strategies at universities. Furthermore, it aims to support educators and policymakers in designing learning programs that better align with the demands of 21st-century skills, such as digital literacy and the ability to collaborate in solving complex problems. By exploring more effective methods for integrating technology, this study is expected to contribute to improving the quality of innovative and impactful science education at UIN Mataram.

Method

This research utilized a quasi-experimental design involving two separate groups: an experimental group and a control group. The purpose of this design was to assess the effectiveness of the Project-Based Blended Learning (PBBL) model in improving the digital literacy of PGMI (Madrasah Ibtidaiyah Teacher Education) students at UIN Mataram. The experimental group engaged in project-based learning with the integration of e-books within a blended learning environment, while the control group received instruction through conventional methods without the use of technological tools.

Participants

The participants in this study were second-semester PGMI UIN Mataram students with varied backgrounds in science and digital literacy. A total of 78 students were selected through cluster random sampling, based on their availability and willingness to participate. The students were randomly divided into two groups: the experimental group and the control group.

Intervention

The experimental group engaged in project-based learning using an e-book specifically designed to enhance science education for PGMI students. This e-book included interactive materials, videos, quizzes, and simulations aimed at deepening students' understanding of scientific concepts. The learning was conducted in a blended format, combining in-person classroom sessions with online assignments and materials. In contrast, the control group followed conventional learning methods that emphasized the use of textbooks and instructor-led lectures. Classroom instruction for the control group was delivered using traditional teaching approaches, without the inclusion of interactive technologies like e-books.

Instrument

The measurement of students' digital literacy was carried out using a test instrument that included both a pre-test and a post-test. The pre-test was administered before the intervention to assess students' initial digital knowledge and skills, while the post-test was conducted after the intervention to evaluate any changes in digital literacy. The digital literacy test was designed to assess students' ability to use technological devices, search for information online, and evaluate and present information digitally. This study measured three key aspects of digital literacy: namely: 1) Access, 2) Behavioral Engagement, and 3) Socio-Emotional.

Data Analysis

The data collected from the pre-test and post-test were analyzed using both descriptive and inferential

statistical methods. To assess whether there was a significant difference in digital literacy between the experimental and control groups, an independent samples t-test was conducted.

Research Ethics

This study adhered to strict ethical guidelines. All participants were provided with a clear explanation of the study's purpose and procedures, and they were given the opportunity to provide written informed consent before participating. The collected data was kept confidential and used solely for the purposes of this research.

Result and Discussion

The results of the study reveal a significant difference in the improvement of digital literacy between the experimental group, which engaged in project-based learning with e-books, and the control group, which participated in conventional learning. Analysis of the pre-test and post-test data showed that the experimental group experienced a greater enhancement in digital literacy skills.

The results of the study reveal a significant difference in the improvement of digital literacy between the experimental group, which engaged in project-based learning with e-books, and the control group, which participated in conventional learning. Analysis of the pre-test and post-test data showed that the experimental group experienced a greater enhancement in digital literacy skills.

Table 1. Description of Student Digital Literacy Data

Student	Digital Literacy	Group	N	Mean	Std. Deviation	Std. Error Mean
	Using E-Books		39	82.6923	11.17437	1.78933
	Without Using E-Books		39	74.2638	2.43279	.38956

Table 1 presents a summary of the digital literacy data for students divided into two groups: those who used e-books and those who did not. In the e-book group, the average digital literacy score was 82.69 with a standard deviation of 11.17, indicating more variation in the digital literacy scores. In contrast, the non-e-book group had an average score of 74.26 with a lower standard deviation of 2.43, suggesting that the data was more concentrated. Additionally, the standard error for the e-book group was 1.79, while the non-e-book group had a lower standard error of 0.39. These findings imply that the use of e-books in learning contributes to

improving students' digital literacy, with more variation in the results.

According to the results of the independent samples t-test (Table 2), there is a significant difference between the group that used e-books and the group that did not ($p < 0.05$). The variability between the two groups was confirmed by Levene's Test, which showed a significant difference in variability, consistent with the observed differences in standard deviation. The 95% confidence interval (4.73179 to 12.12513) does not include zero, further supporting the conclusion that there is a meaningful difference between the two groups.

Table 2. Results of the t-Test on the Effect of Science E-Books on Students' Digital Literacy

		F	Sig.	t	df	Sig. (2-tailed)
Student Digital Literacy	Equal variances assumed	115.329	.000	4.603	76	.000
	Equal variances not assumed			4.603	41.594	.000

These results have important implications for the development of teaching methods. The use of e-books appears to significantly enhance students' digital literacy. However, the high variability in the e-book group indicates that the impact may not be consistent across all students, suggesting that the effect may vary depending on individual factors.

The following section presents the results of the data analysis regarding the impact of e-book usage on students' digital literacy across three key indicators: access, behavioral engagement, and socio-emotional outcomes.

Access

Table 3 presents a comparison of access to science e-books between the two groups: the e-book user group and the non-user group. The e-book user group had a higher average access score (81.8372) with greater variability (standard deviation of 10.90549), indicating a wider range of access among group members. In contrast, the non-e-book group had a lower average access score (73.8603) with less variability (standard deviation of 3.70126), suggesting more consistent access across the group. These findings imply that the use of e-

books can enhance access to science learning materials, albeit with more variation in the level of access. Without e-books, access to materials tends to be more limited but also more uniform.

Table 4 presents the t-test results assessing the impact of Science E-Books on access to e-books, employing both Equal Variances Assumed and Equal Variances Not Assumed approaches. Levene's Test for Equality of Variances revealed a significant difference in variance between the groups ($F = 47.070$, $p = 0.000$), indicating that the assumption of equal variances is violated. In the t-test with Equal Variances Assumed, the t-value was 4.326 ($df = 76$, $p = 0.000$), showing a significant difference between the groups. The mean difference in access scores was 7.97692, with a standard error of 1.84411, and the 95% confidence interval ranged from 4.30406 to 11.64979. When variances were not assumed, the t-value remained 4.326 ($p = 0.000$), but the degrees of freedom adjusted to 46.640. The mean difference and standard error remained unchanged, although the 95% confidence interval slightly widened to 4.26629–11.68755. These findings confirm that the use of Science E-Books significantly enhances access to e-book materials, irrespective of the variance assumption.

Table 3. Description Data of Access

		Group	N	Mean	Std. Deviation	Std. Error Mean
Access	Using E-Books	39	81.8372	10.90549	1.74628	
	Without Using E-Books	39	73.8603	3.70126	.59268	

Through e-books, students can efficiently search for specific topics using the search feature and access various additional references provided in hyperlinks or digital reference formats. Students reported that this easy access made their learning process more efficient,

as they could access materials anytime and anywhere without the need to carry heavy physical books. The interactive features, such as text search and links to external resources, also added significant value to their learning experience.

Table 4. Results of the t-Test on the Effect of Science E-Books on Access

		F	Sig.	t	df	Sig. (2-tailed)
Access	Equal variances assumed	47.070	.000	4.326	76	.000
	Equal variances not assumed			4.326	46.640	.000

Example of student feedback:

"I find it much easier to find the information I need in E-Books because I only need to enter keywords. This helps me save time and focus on the important parts of the material."

However, challenges remain regarding device accessibility. Some students who do not have personal devices such as tablets or laptops experience difficulties, especially when they have to rely on campus facilities or borrow devices from friends.

Behavioral Engagement

Table 5 presents a comparison of Behavioral Engagement between two groups: the E-Book User Group, which has an average score of 82.8348 and a standard deviation of 11.39748, reflecting considerable variability in engagement levels, and the Non-E-Book User Group, which shows a lower average of 73.2194 with a standard deviation of 4.95624, indicating a more consistent engagement pattern.

Table 5. Data Description of Behavioral Engagement

		Group	N	Mean	Std. Deviation	Std. Error Mean
Behavioral Engagement	Using E-Books	39	82.8348	11.39748	1.82506	
	Without Using E-Books	39	73.2194	4.95624	.79363	

The larger standard error of the mean in the E-Book user group (1.82506) compared to the non-user group (0.79363) indicates more unstable average estimates in the former group. Overall, E-Book use is associated with higher levels of engagement.

Table 6 demonstrates that the use of Science E-Book significantly influences Behavioral Engagement, with a

t-value of 4.831 and a p-value of 0.000. This effect is observed both under the assumption of equal variances (95% confidence interval between 5.65166 and 13.57911) and without this assumption (95% confidence interval between 5.62163 and 13.60914). These results highlight a significant difference in engagement levels between the Science E-Book user and non-user groups.

Tabel 6. Results of the t-Test on the Effect of Science E-Books on Behavioral Engagement

		F	Sig.	t	df	Sig. (2-tailed)
Behavioral Engagment	Equal variances assumed	56.928	.000	4.831	76	.000
	Equal variances not assumed			4.831	51.875	.000

One of the main reasons is the ability of E-Books to facilitate more active learning by providing features such as text highlighting, digital notes, and the ability to save and share learning materials. In addition, E-Books allow students to respond to questions or complete assignments more quickly because they have instant access to various references. During group discussions, they feel more confident because they can prepare better thanks to the ease of access to learning materials.

One student wrote: *"I am more involved in class discussions because with E-Books I can immediately find the material being discussed and share it with my friends in the study group."* However, some students stated that there are still challenges in terms of learning discipline. Although access to E-Books is easy, some feel that

independent learning habits in a digital environment require greater discipline to stay focused.

Socio-Emotional

Table 7 presents a description of socio-emotional data for two groups, namely the E-Book User Group and the Non-E-Book User Group. In the E-Book User Group, the average socio-emotional score was 83.4046, with a standard deviation of 12.21636, suggesting a higher variability in social and emotional engagement. Meanwhile, the group that did not use E-Books had a lower average score of 75.7123, with a smaller standard deviation (3.41505), reflecting lower variation in socio-emotional scores. The standard error of the mean in the E-Book user group (1.95618) is higher than that of the non-user group (0.54685), indicating more unstable average estimates in the E-Book user group.

Tabel 7. Data Description of Socio-Emotional

	Group	N	Mean	Std. Deviation	Std. Error Mean
Socio Emotional	Using E-Books	39	83.4046	12.21636	1.95618
	Without Using E-Books	39	75.7123	3.41505	.54685

Table 8 presents the t-test results examining the impact of the science e-book on socio-emotional aspects. Levene's Test indicated significant differences in variance ($F = 103.202$, $p = 0.000$), violating the assumption of equal variances. In the t-test with Equal Variances Assumed, the t-value of 3.787 and p-value of 0.000 reveal a significant difference between the groups using and not using the e-book, with a mean difference

of 7.69231 and a 95% confidence interval between 3.64686 and 11.73775. The t-test with Equal Variances Not Assumed yielded similar results, with degrees of freedom adjusted to 43.903 and a slightly wider confidence interval (3.59848 to 11.78614). These findings suggest that the use of e-books in science significantly influences socio-emotional outcomes.

Tabel 8. Results of the t-Test on the Effect of Science E-Books on Socio Emotional

		F	Sig.	t	df	Sig. (2-tailed)
Socio Emotional	Equal variances assumed	103.202	.000	3.787	76	.000
	Equal variances not assumed			3.787	43.903	.000

Overall, the t-test results show a statistically significant difference in socio-emotional scores between the group that used E-Books and the group that did not, with the E-Book user group achieving higher scores. However, some respondents revealed that prolonged use of E-Books can cause fatigue, particularly in terms of physical aspects (such as eye strain) and mental aspects

(especially for those who have difficulty understanding digital text). There were also students who felt more isolated when they were overly dependent on technology, as face-to-face interaction with friends and lecturers became less frequent. Examples of responses: *"I feel more confident in my studies because I can manage my own time with E-Books. However, sometimes I feel a bit*

isolated because there is not much direct discussion with friends, everything is done digitally."

Some students also reported that intensive use of E-Books can cause stress, especially when faced with technical challenges such as slow internet connections or unsupported devices.

The findings of this study demonstrate that incorporating e-books into project-based learning (PBL) significantly enhances digital literacy, access to learning materials, as well as behavioral and socio-emotional engagement among students (Moonkum et al., 2024; Muwaffaqoh et al., 2021; Zhang et al., 2021). The group that used E-Books showed greater improvement in digital literacy skills compared to the group that used conventional learning. These findings are in line with previous studies showing that the use of interactive technologies such as E-Books can enrich learning experiences and improve understanding of scientific concepts (Churiyah et al., 2023; Nie et al., 2011; Shiratuddin et al., 2003). The use of e-books in learning not only provides faster and more flexible access to learning materials, but also allows students to access additional resources that are not available in conventional textbooks, such as videos, quizzes, and simulations that can deepen their understanding (Hasibuan et al., 2020; Jumiarni et al., 2023; Sholihah et al., 2022).

In terms of digital literacy, this study found that the experimental group that used E-Books had greater variation in digital literacy scores. This can be explained by the ability of E-Books to provide more dynamic and interactive material, which can stimulate various types of digital skills, including information search, evaluation, and presentation. These findings are consistent with research conducted by Asyari et al. (2024), which shows that technology that enables quick and flexible access to various types of media can improve students' digital literacy skills. Higher variability in the experimental group also shows that although E-Books can improve digital literacy, the effect is not uniform for all students, which may be influenced by factors such as their prior knowledge and comfort level in using technology.

In terms of access to learning materials, the group that used E-Books scored higher than the group that did not use E-Books. This finding shows that E-Books can facilitate faster and more efficient access to learning materials, which can increase student engagement and understanding of the material. This is in line with previous research findings that indicate that the use of digital-based technology, such as E-Books, can speed up the information search process and enrich the learning experience (Tang, 2021; Wang, 2020). In addition, the text search and hyperlink features available in E-Books enable students to find specific topics more easily, which

supports independent and efficient learning. However, challenges in device accessibility remain a barrier, as found in this study, where some students experienced difficulties in accessing E-Books due to limitations in their personal devices.

In terms of behavioral engagement, the use of E-Books in project-based learning has been shown to increase student engagement in the learning process. The experimental group showed higher levels of engagement, with students feeling more active in class discussions and more prepared to share material with their peers. This is in line with research conducted by Dwyer (2023). In terms of behavioral engagement, the use of E-Books in project-based learning has been shown to increase student engagement in the learning process. The experimental group showed higher levels of engagement, with students feeling more active in class discussions and more prepared to share material with their peers (Asyari et al., 2024; Dewi et al., 2022; Eliaumra et al., 2024; Erstad et al., 2024).

In terms of socio-emotional aspects, this study shows that the group using E-Books scored higher in social and emotional engagement. The use of E-Books provides students with the opportunity to engage with the material in a more in-depth and independent manner, which can enhance their confidence in learning. However, some students reported feelings of isolation due to reduced face-to-face interaction, which may diminish the social dimension of learning. This aligns with findings in research by Erstad et al. (2024), which shows that although technology-based learning can increase individual engagement, it can also reduce opportunities for direct social interaction between students and lecturers. Therefore, although E-Books enhance the individual aspects of learning, it is important to balance digital learning with social interaction to prevent feelings of isolation (Kurniawan et al., 2023; Niswah & Dewi, 2024; Rahmatulloh & Napis, 2023; Sofian et al., 2023).

Overall, the results of this study reinforce the argument that the use of E-Books in project-based learning can improve students' digital literacy, access, behavioral engagement, and social-emotional engagement. Although these findings are in line with previous studies that demonstrate the benefits of technology in learning, as explained by Erstad et al. (2024), This study also highlights the importance of considering variability in students' responses to technology. This indicates that the successful implementation of technology in learning is highly dependent on specific contexts, including students' prior knowledge and the availability of adequate infrastructure. Therefore, in designing technology-based learning strategies, it is important to pay attention to factors that can influence learning outcomes, such as

device accessibility and students' readiness to adopt technology (Aprilia et al., 2023; Ibrahim et al., 2024; Natsir et al., 2022; Simanullang et al., 2023; Utaminingsih et al., 2023).

However, although the experimental group showed greater improvement in digital literacy, these results also indicate that technology does not always guarantee significant improvement if it is not supported by an appropriate approach. Project-based learning requires active involvement and collaboration between students, as well as the use of relevant technology to support their learning. Therefore, it is important to ensure that the e-books used truly support the learning objectives and are not merely complementary tools.

Conclusion

The integration of e-books in Project-Based Blended Learning (PBBL) has significantly improved the digital literacy of PGMI students at UIN Mataram. Analysis of pre-test and post-test data reveals that the experimental group using e-books showed more substantial progress in key aspects of digital literacy, including access, behavioral engagement, and socio-emotional engagement, compared to the control group, which participated in conventional learning. E-Books facilitate more dynamic and flexible access to learning materials, which promotes active student engagement and deepens their understanding of scientific concepts. However, challenges such as device accessibility and the potential for digital and physical fatigue must be addressed. To optimize the benefits of technology in learning, it is recommended that educational institutions provide equal access to necessary devices and support facilities. Additionally, training for both lecturers and students on the effective use of E-Books and technology-based learning should be prioritized. Incorporating group discussions or direct interactions in project-based learning could further enhance socio-emotional engagement while mitigating the risks of digital fatigue. Future research should aim to tailor technology to meet the diverse needs of students across various disciplines and investigate more effective teaching strategies to enhance technology-driven learning outcomes.

Author Contributions

The author has contributed to the entire process of creating this article.

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Conflicts of Interest

The authors affirm that there are no competing interests or conflicts that could influence the integrity or impartiality of this research.

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