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Integrating the STEMQ approach and digital flipbooks to enhance students' science and digital literacy in basic physics courses

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ABSTRACT

The integration of digital technology into physics education has created new opportunities to improve teaching effectiveness and student engagement, particularly in complex subjects such as basic physics. This study examined instructional needs for developing flipbook-based digital teaching materials using the STEMQ approach, which integrates science, technology, engineering, mathematics, and Qur'anic values. A descriptive survey method was employed, with data collected from 20 lecturers and 95 pre-service physics teachers through questionnaires, interviews, and concept mastery tests. The results showed that lecturers had strong digital readiness, while students expressed a high demand for interactive, accessible, and spiritually relevant learning materials. Electricity and magnetism were identified as the most difficult topics in basic physics, which was confirmed by diagnostic test results revealing substantial conceptual gaps across different academic levels. The institutional infrastructure was found to be adequate, with sufficient digital facilities and internet access to support digital learning. The study concludes that developing flipbook-based digital teaching materials using the STEMQ approach is both pedagogically appropriate and contextually relevant. This needs analysis indicates that the proposed model has the potential to enhance digital and scientific literacy while integrating moral and spiritual values, in line with the objectives of Islamic higher education.

1. Introduction

In recent decades, rapid advancements in digital technology significantly transformed various domains of education, fostering new pedagogical models and resources that support interactive, engaging, and autonomous learning experiences (Kotlyarova et al., 2021; Purina-Bieza, 2021). The incorporation of technology enabled the development of digital teaching materials that accommodate diverse student needs and improve learning effectiveness, particularly in science education. The role of digital teaching materials was reinforced by increasing evidence that technology-enhanced learning environments improved students' understanding of complex concepts (Wulandari and Nurharini, 2023), fostered interest in scientific subjects (Lossjew and Bernholt, 2024), digital literacy (Feng and Liang, 2024; Siyi et al., 2023; Ussarn et al., 2024), and scientific literacy.

Within this context, the demand for innovative digital teaching materials rose substantially in the teaching of physics, especially for foundational topics like electricity and magnetism, which were commonly perceived as abstract and difficult by undergraduate students. One emerging tool that aligns with modern pedagogical needs is the digital Flipbook. This interactive, visually engaging medium supported both self-directed and collaborative learning and was accessible across multiple digital platforms (Yani et al., 2023). Flipbooks demonstrated potential to enhance motivation, foster independent learning, and cultivate digital literacy (Yani et al., 2023). The integration of Flipbook technology in physics instruction,

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therefore, offered a promising pathway to improve students' engagement and comprehension.

Despite these technological advances, physics remained a subject where students struggled to grasp fundamental concepts due to their abstract nature and the inadequacy of conventional teaching materials (Faresta et al., 2024; Stojanović and Maksimović, 2022). The need for teaching materials that simplify these concepts while enhancing digital engagement was evident. While PowerPoint presentations and printed textbooks remained the most used media, these tools often fell short in engaging learners and addressing diverse learning styles. Consequently, educators were urged to consider alternative instructional media that incorporate digital innovations and interdisciplinary learning approaches.

One promising instructional framework was the STEM (Science, Technology, Engineering, Mathematics) approach, which promoted interdisciplinary, problem-based learning and real-world relevance. The implementation of STEM in science education was proven effective in enhancing students' critical thinking, problem-solving skills, and conceptual understanding (Bakirci et al., 2022). Furthermore, in the context of Islamic higher education institutions, the integration of STEM with Islamic values drawn from the Qur'an—referred to as the STEMQ approach—provided a more holistic and spiritually grounded educational model. This integration ensured that students developed not only cognitive and technical competencies but also spiritual and ethical awareness. For instance, a lesson on Newton's laws can be meaningfully connected to the Qur'anic concept of sunan Allah—the divine principles that govern the natural world. Such analogies can help students see scientific laws not only as mechanical but also as reflections of divine order, fostering both deeper conceptual insight and spiritual reflection.

The incorporation of Islamic values into science education served to balance the cognitive and spiritual dimensions of learning, aligning with the mission of many faith-based universities. Unfortunately, the development of instructional materials that integrate both STEM and Qur'anic values remained limited. Most of the digital teaching materials in scientific learning (Physics) were limited in their orientation to simultaneously support both scientific and digital literacy. In addition, existing digital materials focused solely on either scientific literacy or religious education, rather than integrating the two (Gu and Kim, 2025; Pribadi and Susanti, 2025). This fragmented approach failed to provide the comprehensive educational experience that students in Islamic institutions required. Thus, there was an urgent need to design and implement instructional tools that integrate scientific rigor with spiritual context.

Several studies emphasized the pedagogical advantages of integrating STEM with Qur'anic values (Sari and Duran, 2023). Elbashir et al. (2024) proposed a STEM-Islam integration model to support spiritual and scientific balance in learning, while Sarwi et al. (2024) showed that Qur'an-based STEM learning improved both students' conceptual understanding and spiritual literacy. Similarly, Rahmawati et al. (2024) underscored the importance of developing digital literacy through religiously contextualized materials. These findings suggested that a STEMQ-based digital resource effectively addressed the dual needs of scientific and religious education.

However, few studies operated this integration in practical, accessible formats such as Flipbook-based materials. Most research on Flipbooks in education focused on their impact on student motivation and digital literacy without considering interdisciplinary content or religious integration. Furthermore, there was limited empirical evidence examining students' perceptions of topic difficulty in physics and how this informed the development of appropriate instructional content. As a result, existing digital materials often failed to meet the cognitive demands and contextual needs of pre-service physics teachers.

This study addressed this gap by conducting a comprehensive needs analysis to inform the development of Flipbook-based digital teaching materials integrated with the STEMQ approach. The research investigated the readiness of lecturers, the needs and perceptions of students, institutional support, and students' baseline conceptual understanding, particularly concerning electricity and magnetism. This dual-focused inquiry on pedagogical and content-specific needs aimed to produce materials that were both scientifically robust and religiously contextualized.

The novelty of this study lay in its methodological and pedagogical synthesis: it combined quantitative and qualitative data to build a detailed picture of learner and instructor needs while proposing an instructional solution rooted in both technological and religious frameworks. The findings provided empirical justification for the development of STEMQ-integrated Flipbook teaching materials to improve students' scientific and digital literacy. The scope of this study included the identification of instructional gaps, evaluation of institutional readiness, assessment of conceptual difficulties, and the formulation of a contextually grounded instructional design framework.

2. Methodology

This research was a descriptive study using a survey method. The population consisted of 20 lecturers teaching in the Physics Education study program and 95 students. The sample included all lecturers and students, selected through a saturated sampling technique. Data were collected using questionnaires, interviews, and concept mastery tests. The questionnaire comprised 30 Likert-scale items covering five domains: (1) lecturers' readiness, (2) student needs, (3) institutional support, (4) perceptions of basic physics instruction, and (5) perceptions of concept difficulty.

The concept mastery test consisted of 40 multiple-choice questions distributed across ten subtopics (e.g., electric current, resistance, magnetic force). Each correct answer received one point, yielding a total possible score of 40. A scoring rubric aligned with the test objectives was used. The instruments underwent expert validation by three specialists in physics education, and the content validity index (CVI) reached 0.92, indicating high validity. The questionnaire's reliability coefficient (Cronbach's alpha = 0.87) and test reliability (α = 0.82) demonstrated strong internal consistency. Data analysis employed both qualitative and quantitative descriptive approaches. Quantitative analysis included descriptive statistics (percentages, means, and standard deviations) and inferential statistics to examine differences in conceptual mastery across grade levels using the Kruskal–Wallis test. The Kruskal–Wallis test was selected after confirming non-normal distribution through the Shapiro–Wilk test ($p < 0.05$), justifying the use of non-parametric analysis. All analyses were performed using SPSS version 17.

3. Research results

This section presents the findings from the descriptive needs analysis conducted to support the development of Flipbook-based digital teaching materials with a STEMQ approach. The data were collected through questionnaires, interviews, and concept mastery tests administered to 20 physics education lecturers and 95 pre-service physics teacher students. The analysis was structured according to six major sub-themes derived from the research objectives: lecturer readiness, student needs, perceived material difficulty, institutional support, student perceptions of instructional strategy, and initial concept mastery in electricity and magnetism. All findings were presented through descriptive qualitative and quantitative interpretations, supported by figures and tables.

3.1. Lecturer readiness

The first major finding concerned the readiness of lecturers to adopt Flipbook-based digital teaching materials integrated with the STEMQ framework. The survey and interviews revealed that most lecturers already employed various digital tools in their instruction. As shown in Fig. 1, digital platforms such as Microsoft PowerPoint, Zoom, Flash, Canva, Google Classroom, and Quizizz were frequently utilized to deliver content. These tools, however, were often used in a conventional manner, without the pedagogical coherence of a STEMQ framework. The dominant use of basic digital aids indicated that while the infrastructure and skills for digital learning existed, their integration into holistic instructional design was still limited.

The lecturers expressed strong interest in innovative digital teaching tools, particularly those that were more interactive, flexible, and visually appealing. As presented in Fig. 2, the majority of lecturers responded positively to questions assessing their openness to adopting Flipbooks, on the condition that the materials were contextually relevant and aligned with the curriculum. More importantly, lecturers emphasized that incorporating Islamic values through STEMQ would have provided students with not only conceptual understanding but also spiritual and moral grounding—a concern consistent with the mission of Islamic higher education institutions. The questionnaire contained the following items: 1) Q1 = Do you need additional digital learning materials to support the teaching–learning process?; 2) Q2 = Would Flipbook-based digital learning materials be among the instructional resources you would use frequently?; 3) Q3 = If a Flipbook-based digital learning material were developed for a basic physics course, would you be interested in using it?

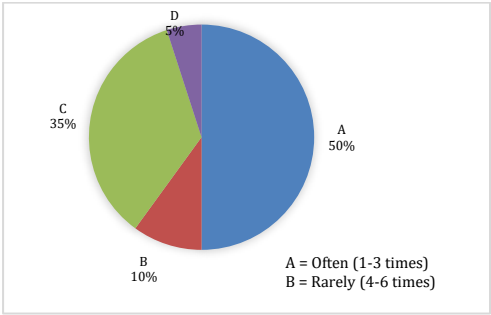


Fig. 1: Physics lecturers' use of digital media

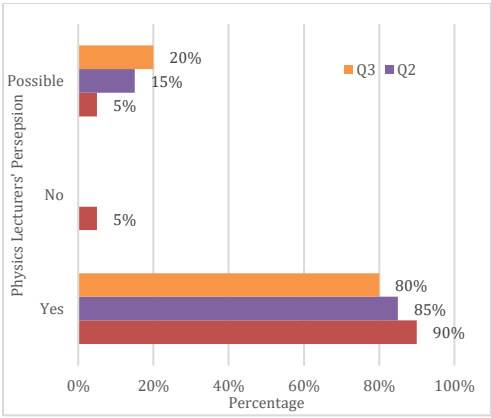


Fig. 2: Physics lecturers' interest in flipbook-based digital teaching material

3.2. Student needs

The second key result pertained to the needs and expectations of students. Feedback from students and lecturer assessments underscored a substantial demand for digital instructional materials that were engaging and easy to understand. Students were familiar with existing digital platforms, and many reported positive experiences using them. According to Fig. 3, approximately 90% of lecturers observed that students responded favorably to technology-enhanced learning environments. This was consistent with previous research showing that digital tools tend to increase student participation and engagement (Gopinathan et al., 2022).

Students expressed a preference for teaching materials that were not only accessible but also supported independent learning. They valued clarity in content delivery and visual quality. However, limitations in digital accessibility were reported; some students lacked reliable internet access or had limited data packages. These challenges notwithstanding, the positive attitudes of students indicated that, with appropriate support and infrastructure, the implementation of Flipbook-based materials was likely to be well received.

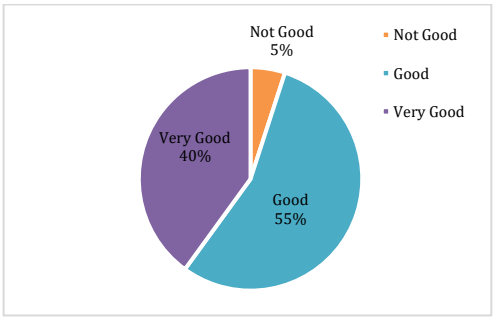


Fig. 3: Physics lecturers' response to the use of flipbook-based digital teaching materials

3.3. Institutional support

Institutional infrastructure and support systems were evaluated to assess feasibility. The data revealed that the target institution was well equipped with essential digital tools such as desktop computers, projectors, and a stable internet connection. Fig. 4 shows that 85% of respondents rated their campus internet as satisfactory for hosting digital instructional content. In addition, Fig. 5 illustrates that most lecturers were adept at using digital teaching aids, further validating the institutional capacity for a transition to Flipbook-based learning. The availability of physical and digital infrastructure suggested that there were no significant institutional barriers to the development and implementation of Flipbook-based digital learning resources. As reported in the literature, institutional readiness played a vital role in successful technological adoption in educational settings. Therefore, the presence of adequate infrastructure strengthened the feasibility of this development initiative.

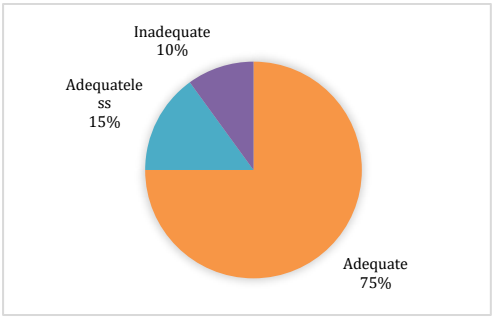


Fig. 4: Condition of internet facilities at the university

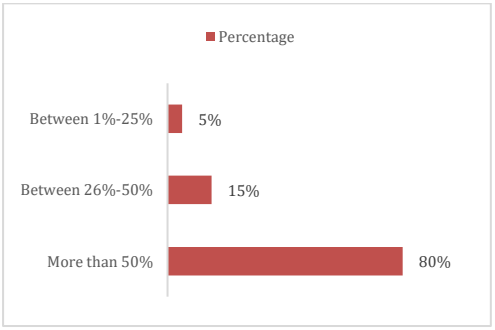


Fig. 5: Proportion of physics lecturers using technology in basic physics courses

3.4. Student perceptions of basic physics instruction

The fourth finding addressed students' perceptions of current instructional strategies and the need for pedagogical reform. Fig. 6 reflected student opinions on twelve key items regarding instructional approaches and the importance of enhancing both scientific and digital literacy. Notably, 90% of students strongly agreed with the statement that effective learning of basic physics required specialized pedagogical approaches. Likewise, 80% of students agreed that digital instructional materials improved understanding, and another 80% supported the integration of the STEMQ approach to strengthen concept mastery and personal development.

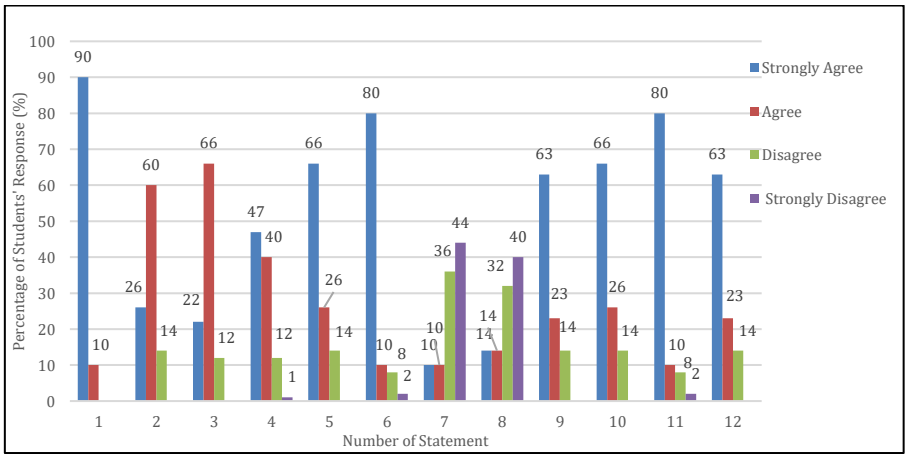


Fig. 6: Student perceptions of basic physics courses by lecturers

The statements provided in the student perception questionnaire consisted of 12 items with four response options: “strongly agree,” “agree,” “disagree,” and “strongly disagree,” as shown in Table 1. The student survey revealed widespread dissatisfaction with conventional teaching strategies. Students preferred more interactive and technologically enhanced instruction, which they believed could help them better grasp abstract physics concepts. In line with these results, a STEMQ-integrated Flipbook approach appeared highly relevant and necessary.

Table 1: Questionnaire items for student perceptions about the importance of science and digital literacy

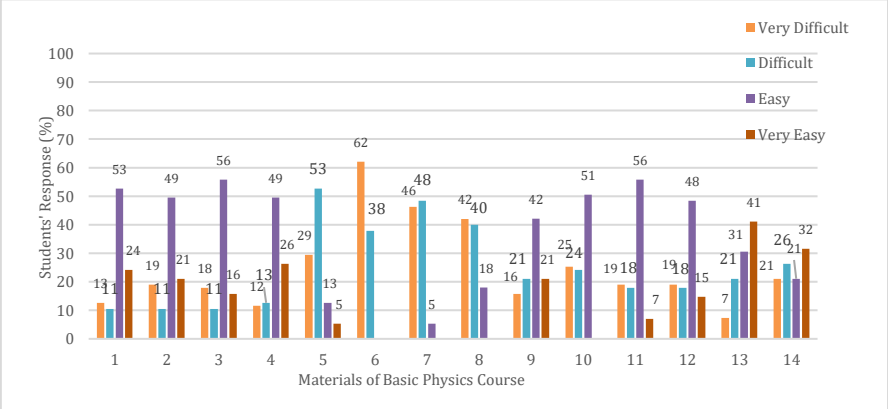
Number of items	Statement
1	A specific learning approach is required to develop a comprehensive understanding of basic physics content.
2	Mastering basic physics content cannot be achieved effectively through rote memorization alone.
3	Learning basic physics through group discussions enhances both understanding and critical thinking skills.
4	Practical, engaging, and appealing instructional materials are essential for effective learning.
5	Integrating digital technology into instructional materials significantly facilitates basic physics learning.
6	Basic physics content is better understood when presented as digital learning materials.
7	Basic physics does not require learning strategies different from those used in other courses.
8	Conventional teaching methods used in the classroom help in understanding the conceptual foundations of basic physics.
9	Developing science literacy is a critical outcome for prospective physics teachers in basic physics.
10	Fostering digital literacy is an essential objective of the basic physics course.
11	Integrating a STEM approach with Qur’anic values can effectively develop both scientific and digital literacy.
12	Combining Qur’anic values with a STEM approach and digital instructional materials offers a comprehensive means of enhancing scientific and digital literacy.

3.5. Student perceptions of concept difficulty

The perception of topic difficulty was another area of investigation. Fig. 7 summarizes student ratings of 14 subtopics in physics. The data indicated that electricity and magnetism were among the most difficult concepts for students. Specifically, magnetic fields, alternating current, and electromagnetic induction were rated as very difficult by more than 60% of respondents. Other topics, such as electric current, electric potential, and dielectrics, were perceived as moderately difficult.

These perceptions aligned with other studies highlighting electricity and magnetism as conceptual bottlenecks in physics education due to their abstract and mathematical nature. These findings further supported the argument for developing targeted materials designed to simplify these challenging concepts.

The Flipbook format, with its interactive visuals and step-by-step animations, offered pedagogical advantages in representing abstract processes that were otherwise difficult to visualize using static media.



1: Electric field; 2: Electric potential; 3: Capacitors; 4: Dielectrics; 5: Electric current; 6: Magnetic field; 7: Magnetic induction; 8: Alternating current; 9: Wave properties; 10: Interference and diffraction; 11: Geometrical optics; 12: Optical instruments; 13: Quantum physics; 14: Atomic models

Fig. 7: Student perceptions of difficulty in physics subtopics

3.6. Initial concept mastery of electricity and magnetism

The final component of the needs analysis involved a concept mastery test administered to students across three academic years (second, third, and fourth years). The purpose was to empirically validate student difficulties with electricity and magnetism. The test covered ten specific topics and was analyzed using descriptive and inferential statistics. Each subtopic was scored on a scale of 0 to 4, yielding a maximum possible score of 40 points for the entire test. Mean values in Table 2 represent average points obtained per item, reflecting relative comprehension levels among different grade levels. The full dataset is shown in Table 2.

According to Table 2, the results of the Kruskal–Wallis non-parametric test revealed significant differences in several subtopics across different grade levels. Specifically, significant differences were found in Electric Current, Electromotive Force (EMF) and Electric Potential Difference, Kirchhoff’s Laws, RC Circuits in Capacitor Charging and Discharging Processes, Magnetic Force, Sources of Magnetic Fields, and the Overall Concept category, with Asymp. Sig. values below the conventional alpha

threshold of 0.05. These findings indicated that students' comprehension or engagement levels in these components varied meaningfully according to grade level. For instance, Electric Current (Asymp. Sig. = 0.002) and Sources of Magnetic Fields (Asymp. Sig. = 0.007) showed clear progression in means from Grade III to Grade IV, suggesting a developmental or curriculum-based effect. Similarly, Electromotive Force (EMF) and Electric Potential Difference and Kirchhoff's Laws subconcepts both recorded the same pattern of mean scores and significance level ($p = 0.020$), possibly reflecting the consistent influence of instructional strategies or learning maturity on students' conceptual grasp of similar content domains. The use of the Kruskal–Wallis test was further validated through the Shapiro–Wilk normality test ($p < 0.05$), confirming non-normal data distribution across groups.

In contrast, other components, such as Resistance, Electrical Energy and Power, Resistors in Series and Parallel Circuits, and the Magnetic Field subtopic did not show statistically significant differences across grades, suggesting either a uniform level of difficulty or similar instructional effectiveness regardless of grade. The Magnetic Field subtopic, however, had an Asymp. Sig. value of 0.032 (below 0.05) and therefore should be correctly classified as "Significant" in Table 2. This correction ensures consistency between statistical outcomes and interpretation. The relatively low mean values across most subtopics indicate that overall student mastery remained modest, reflecting persistent conceptual difficulties in visualizing and applying abstract phenomena such as electromagnetic induction and field interactions.

The significant result in the Overall Concept category (Asymp. Sig. = 0.004) further confirmed that overall, students in higher grade levels (particularly Grade IV) demonstrated better performance or higher engagement with the key learning topics. This trend was likely attributable to increased cognitive development, cumulative exposure to related content, or improved pedagogical interventions. These findings highlight the importance of designing differentiated and scaffolded learning strategies tailored to students' academic progression, particularly in challenging topics like electricity and magnetism. Furthermore, the consistent patterns of significance suggest that developing STEMQ-based digital materials could address these conceptual gaps by integrating interactive visuals and contextualized explanations.

The use of the Kruskal–Wallis test was justified not only due to the small and unequal sample sizes but also based on the results of the Shapiro–Wilk normality test that indicated non-normal data distribution. This non-parametric test allowed the researchers to compare group means without assuming normality. The findings highlighted significant variability in conceptual mastery that correlated with academic progression. Despite observable improvements among higher-grade students, even upper-level participants showed incomplete mastery of foundational concepts, reaffirming the pedagogical need for targeted, digitally enriched instructional design.

Table 2: Descriptive statistics and Kruskal-Wallis test results for concept mastery on electricity and magnetism topics

Subtopics	Grade level	N	Mean (M)	Standard deviation (SD)	Kruskal-Wallis test (Asymp. Sig.)	Remarks
Electric current	Grade II	30	0.97	0.85	0.002	Significant
	Grade III	31	0.87	0.85		
	Grade IV	34	1.56	0.61		
Resistance	Grade II	30	0.83	0.70	0.095	Not significant
	Grade III	31	0.51	0.77		
	Grade IV	34	0.85	0.78		
Electromotive force (EMF) and electric potential difference	Grade II	30	0.10	0.31	0.020	Significant
	Grade III	31	0.09	0.30		
	Grade IV	34	0.38	0.60		
Electrical energy and power	Grade II	30	0.37	0.56	0.162	Not significant
	Grade III	31	0.26	0.44		
	Grade IV	34	0.53	0.61		
Resisters in series and parallel circuits	Grade II	30	0.50	0.57	0.072	Not significant
	Grade III	31	0.61	0.71		
	Grade IV	34	0.88	0.77		
Kirchhoff's laws	Grade II	30	0.10	0.31	0.020	Significant
	Grade III	31	0.09	0.30		
	Grade IV	34	0.38	0.60		
RC circuits in capacitor charging and discharging processes	Grade II	30	0.85	0.72	0.008	Significant
	Grade III	31	0.51	0.77		
	Grade IV	34	0.90	0.80		
Magnetic field	Grade II	30	0.17	0.35	0.032	Not significant
	Grade III	31	0.12	0.32		
	Grade IV	34	0.38	0.60		
Magnetic force	Grade II	30	0.90	0.76	0.002	Significant
	Grade III	31	0.12	0.32		
	Grade IV	34	0.85	0.78		
Sources of magnetic fields	Grade II	30	0.97	0.85	0.007	Significant
	Grade III	31	0.80	0.82		
	Grade IV	34	1.70	0.74		
Overall concept mastery test	Grade II	30	0.58	0.60	0.004	Significant
	Grade III	31	0.40	0.56		
	Grade IV	34	0.84	0.69		

4. Discussion

The findings of this study provided empirical justification for the development of pedagogically sound and spiritually grounded digital teaching materials, especially for basic physics instruction within Islamic higher education institutions. Through a systematic needs analysis, the study demonstrated that integrating STEMQ-based Flipbook materials is a potentially feasible intervention that aligns with pedagogical best practices and addresses the religious and moral context of faith-based education.

A critical element for the success of such interventions was the readiness of lecturers to adopt digital teaching tools. The data indicate that educators had familiarity with mainstream digital platforms such as Microsoft PowerPoint, Google Classroom, and Zoom; however, their application often remained superficial and lacked interactive depth (Kotlyarova et al., 2021; Purina-Bieza, 2021). Notably, lecturers had responded positively to the STEMQ-integrated Flipbook materials, especially those enriched with Qur'anic values, indicating a willingness to transition toward more holistic and spiritually resonant educational frameworks.

Furthermore, the lecturers highlighted the importance of embedding Islamic moral and spiritual values in science instruction—a perspective deeply rooted in Islamic pedagogical philosophy. It is confirmed that integrating spirituality in science education enhances both contextual relevance and character development. Rahmatika et al. (2024) further noted that such integration promoted inquiry and problem-solving skills essential in faith-based learning environments. Similarly, Sarwi et al. (2024) showed that when Qur'anic teachings were integrated into scientific instruction, they meaningfully shaped student character. Parhan et al. (2024) also showed how embedding spiritual practices like prayer within contextual science learning improved academic outcomes and overall personal development. Collectively, these findings supported the holistic nature of the STEMQ model, which merges cognitive rigor with ethical and spiritual education.

On the student side, the study identified a high level of digital receptivity, alongside a demand for more interactive and visually enriched instructional tools. These insights, supported by Gopinathan et al. (2022), confirmed that technology-enhanced learning environments increased student motivation and participation. Students expressed dissatisfaction with the limitations of textbook-driven, memorization-heavy methods in grasping complex physics concepts, a challenge that echoed prior findings by Faresta et al. (2024). Chinwong et al. (2025) also noted that abstract physics concepts were challenging to internalize when presented without real-world linkage or visualization. To address this, Flipbooks—especially those with animated, stepwise explanations—functioned as a critical pedagogical strategy, enhancing comprehension through multimodal interaction.

The Flipbooks' impact on learning received additional support from studies on visual learning in science. Bouchée et al. (2022) showed that structured visual aids mitigated misconceptions and supported conceptual retention in physics. The strong student endorsement for Flipbook use, as seen in Fig. 6, reflected a desire for instructional tools that not only improved engagement but also fostered deeper comprehension.

Beyond digital engagement, the findings also emphasized that scientific literacy must encompass epistemological and ethical dimensions. The STEMQ model directly addressed this, in alignment with the work of Ayata et al. (2024), who found that students with well-developed epistemological beliefs exhibited better scientific reasoning. Wang et al. (2022) confirmed that inquiry-based approaches deepened students' understanding of scientific methods and reasoning. Ethical awareness also played a critical role, as Owens et al. (2022) stated that students needed to evaluate the moral implications of scientific advancements. de la Hoz et al. (2022) and Solomon (2021) further asserted that science education ought to prepare students for real-world ethical decision-making. By integrating Qur'anic reflections within scientific inquiry, STEMQ Flipbooks addressed this intersection of knowledge, belief, and responsibility—helping produce students who were both scientifically literate and morally grounded.

Institutional readiness also emerged as a significant factor in this study. The target university had the necessary infrastructure—digital devices, reliable internet, and learning platforms—to support the integration of e-learning tools. Adequate infrastructure is essential for the successful adoption of educational technology. Conversely, the absence of such resources significantly hindered student experience, as reported by Kusmawan (2024). Furthermore, Bitar and Davidovich (2024) underscored the necessity of coordinated institutional and governmental support to fully realize the benefits of digital transformation in education. In the context of this study, the convergence of infrastructure, lecturer enthusiasm, and student readiness formed an ideal environment for implementing Flipbook-based STEMQ instruction. The study also examined persistent difficulties students faced in mastering electricity and magnetism—an issue frequently cited in the physics education literature (Stojanović and Maksimović, 2022). Survey and assessment data revealed subtopics such as magnetic induction and electric potential as particularly challenging. Kruskal–Wallis test results confirmed statistically significant variation in concept mastery across academic years. Flipbooks, with their capacity for gradual, interactive presentation of content, functioned as effective scaffolding tools that facilitated progressive comprehension, particularly

evident in the improved performance of fourth-year students on advanced subtopics.

The comprehensive, holistic approach embodied in the STEMQ model effectively addressed these conceptual and pedagogical gaps. It is important to integrate spiritual values into science education, enriching learning outcomes and fostering deeper reflection. The spiritual dimension of the model functioned as a contextual anchor that connected abstract scientific ideas with personal and ethical meaning. This proved essential in shaping the learning experiences of pre-service teachers, who must not only grasp subject matter but also embody moral and ethical principles. Research by Bakirci et al. (2022) demonstrated that STEM-based instruction, when framed through Islamic pedagogy, cultivated critical thinking and collaborative competencies alongside spiritual growth.

This study presented a comprehensive framework for advancing science education within Islamic higher education institutions. Through the integration of pedagogical innovation, technological tools, and religious values, the needs analysis supports the potential of the STEMQ Flipbook model to foster both cognitive achievement and character development. For instance, when learning about the consistent behavior of magnetic forces or electric current, instructors could draw parallels to the Qur'anic concept of sunan Allah, the unchanging laws established by God in the universe. This analogy helps students contextualize physics concepts within a spiritual worldview, making the material both intellectually and spiritually meaningful.

5. Conclusion

This study provided empirical justification that the development of Flipbook-based digital teaching materials integrated with the STEMQ approach is both necessary and timely within Islamic higher education institutions. The findings indicated widespread support from both lecturers and students for more engaging, interactive, and spiritually contextualized digital learning tools. Persistent gaps in students' conceptual understanding of electricity and magnetism, even among upper-level students, underscored the pedagogical limitations of current teaching practices. The results demonstrated that existing digital tools are not yet sufficient for supporting holistic science education, especially in learning environments where ethical and spiritual dimensions are integral.

By drawing on the interdisciplinary strengths of STEM while embedding Qur'anic values, the STEMQ approach offers a balanced pedagogical framework that has the potential to foster both intellectual and moral development. The enthusiasm expressed by students and lecturers, coupled with adequate institutional infrastructure, indicates strong potential for the successful development and future implementation of STEMQ-integrated Flipbooks. The needs analysis supports the potential of this model to foster both digital and scientific literacy while embedding moral and spiritual values, aligning with the broader goals of Islamic education.

The contribution of this research lies in its formulation of a localized instructional design framework that responds to cultural, spiritual, and educational needs. It bridges the gap between digital pedagogy and value-based learning by proposing a feasible development pathway for STEMQ-based Flipbook materials. Future research should implement this model on a larger scale, assess long-term learning impacts, and evaluate outcomes across different scientific domains to further refine and validate its effectiveness in diverse educational contexts.

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Compliance with ethical standards

Ethical considerations

Ethical principles were observed throughout the study. Participation was voluntary, and informed consent was obtained from all participants prior to data collection. Participants were informed of the study's purpose and their right to withdraw at any time without penalty. Responses were treated confidentially and analyzed anonymously, with no personally identifiable information collected. The study involved no physical, psychological, or social risk and was conducted in accordance with institutional guidelines and accepted ethical standards for educational research.

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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