

Development Of Digital Based Textbooks For Physical Education, Sports And Health Courses For Phase C

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Abstract

This research aims to produce a Digital-Based Textbook for Physical Education, Sports and Health for Phase C Students at Public Elementary Schools in Pemulutan District. The method used in this research is the R & D (Research and Development) method, which is research that produces products in the form of digital-based Physical Education, Sports and Health textbooks. The sampling technique in the research was Phase C Teachers and Students at Pemulutan District Public Elementary Schools. The data collection techniques used are validity test data, practicality test data and effectiveness test data. The instruments in this research are validation sheets, questionnaires, and tests of teacher and student learning outcomes. The data analysis technique is validity analysis, practicality analysis and effectiveness analysis. Based on the research results, it can be concluded from the research that this book can be said to be very valid, seen from the validator research results, the average score for all aspects of the assessment is 4.35 with a very valid classification. Based on teacher and student questionnaire responses, this book is said to be practical to use with a practicality score of 3.65 and a student questionnaire response of 3.51 with a very practical classification. Based on the results of teacher and student learning tests, digital-based Physical Education, Sports and Health textbooks for Phase C students at Pemulutan District Public Elementary Schools are said to be effective in use. The results of the teacher learning outcomes test obtained 100% completeness and student learning results obtained 97.5% completeness which is in the high category. The conclusion of this research is that the digital-based Physical Education, Sports and Health textbook for Phase C Students at the Pemulutan District Public Elementary School is stated to be very valid, in its use this book is also said to be very practical with a very positive classification and this book is also effective for use as a support for learning activities because it is in the high category.

Keywords: Textbook, Digital, Physical Education Sports and Health.

INTRODUCTION

The development of information technology has brought significant changes to the implementation of education in elementary schools, including in the subject of Physical Education, Sports, and Health. Ideally, the learning process in the digital era demands the availability of interactive, easily accessible teaching materials aligned with the Independent Curriculum, particularly those aligned with Decree Number 032/H/KR/2024 concerning Learning Outcomes and Learning Objective Flow (ATP). Ideally, teachers and students should be able to utilize digital textbooks that not only present material systematically but also enable flexible learning through digital devices such as mobile phones and internet access. In the context of physical education (PE), the use of digital technology is not intended to replace students' physical activity experiences, but rather to enhance the delivery of learning materials, access to learning resources, student engagement, and support for the learning process. The literature indicates that the integration of technology in physical education can promote engagement, improve understanding of learning content, and enrich learning experiences when its use is designed in accordance with pedagogical needs and the curriculum context (Mulato et al., 2024; Martín-Rodríguez & Madrigal-

Cerezo, 2025). Recent bibliometric evidence further indicates that technology-enhanced learning has become an expanding research direction in physical education, particularly through interactive and digitally supported learning environments (Krishnan et al., 2026).

In this study, curriculum alignment was a primary requirement because the Phase C physical education textbook used in the learning process needed to comply with the applicable Learning Outcomes (CP) and Learning Objective Flow (ATP) stipulated in Decree No. 032/H/KR/2024. Based on the preliminary study, the identified issue was not that all content in the previous textbook was unusable, but rather that the available learning resources had not been updated and had not been specifically mapped to the relevant CP and ATP. Therefore, the alignment among learning materials, instructional sequence, learning objectives, and the competencies that students were expected to achieve could not be fully ensured through the available textbook. This emphasis on curriculum alignment is consistent with recent work showing that digital pedagogy in physical education should be systematically integrated into curriculum design rather than treated merely as the addition of technological tools (Lan et al., 2025)

However, the actual situation in elementary schools in Pemulutan District still falls far short of these expectations. To provide a clearer empirical basis, a needs analysis was conducted in October 2025 involving 53 respondents, consisting of 47 Phase C students and six physical education (PE) teachers. The results showed that 54% of respondents considered the media used in the learning process to be suboptimal. In contrast, 87.3% stated that digital-based textbooks could support the needs of the learning process, 88.2% considered that the use of learning media could help students understand subject matter concepts, 95.2% indicated a need for textbooks to support learning, 95.1% supported the development of textbook-based learning media, and 96.2% expressed their willingness to use digital-based textbooks. These findings indicate an actual need in the 2025–2026 academic period for physical education learning resources that are better aligned with the curriculum, easily accessible, and relevant to both teachers and students. Evidence from Indonesian elementary-school PE also suggests that technology-supported activities can increase student engagement and complement movement-based learning when digital content is integrated with physical activities rather than used in isolation (Manurung et al., 2025).

Pandemic-related challenges in online physical education should be distinguished from current needs. Previous studies reported pedagogical, interaction, and implementation difficulties in online PE (Konukman et al., 2022). In this study, these findings serve only as historical context and not as direct evidence of conditions in Pemulutan District in 2025–2026. Product development was therefore based primarily on the current needs analysis and the gap between available learning resources and CP/ATP requirements.

The gap between ideal and actual conditions indicates a documented curriculum and learning-resource gap, namely the limited availability of digital PJOK teaching materials for Phase C that are explicitly aligned with the current CP/ATP. This lack of up-to-date learning resources may limit teachers' ability to organize learning materials systematically and may reduce students' opportunities to access learning resources that correspond to current curriculum expectations. Possible effects on motor competence, cooperation, or readiness for subsequent education are therefore regarded as anticipated educational risks rather than outcomes directly measured in the preliminary study.

Given these conditions, a relevant and sustainable solution is needed in the form of developing a web-based digital textbook for sixth-grade Physical Education Phase C. This

textbook is expected to address the limitations of the printed teaching materials currently used, while also supporting teachers in implementing more effective, efficient, and contextual learning in line with technological developments. In this study, web-based refers to a digital textbook accessible through internet-connected devices, particularly mobile phones, allowing teachers and students to access materials flexibly in and outside the classroom. The emphasis is not on complex web features, but on accessibility, organized content, and alignment with the Phase C ATP. Web-based environments can extend instructional flexibility and access to digital resources, although their educational value remains dependent on interaction, feedback, teacher digital competence, and equitable access (W. Liu & Xu, 2026).

Furthermore, various previous studies have shown that the use of digital learning media can provide useful support for physical education learning when the technology is designed according to learning objectives and user needs. Papastergiou and Mastrogiannis (2021), for example, developed interactive digital learning objects for physical education and emphasized the importance of quality, usefulness, interactivity, and pedagogical relevance. Kubiyeva et al. (2020) demonstrated that an electronic physical education textbook incorporating structured modules, learning tasks, tests, and audiovisual resources could support learning more effectively than reliance solely on conventional materials.

More recent evidence also indicates that the digitalization of physical education can contribute to learning experiences and academic outcomes when implemented appropriately (Botagariyev et al., 2024). At the elementary-school level, Nelson et al. (2025) showed that interactive digital media integrating learning content with multimedia elements can be developed and validated for PJOK-related instruction. At the same time, the adoption of digital applications in physical education continues to encounter challenges related to teacher readiness, implementation, infrastructure, and the pedagogical integration of technology (Sorokolit et al., 2025). Teacher competence is also a critical implementation factor, as technology-supported PE requires educators to develop appropriate planning and instructional skills for meaningful integration into learning (Andreadou & Kazanidis, 2025; AL-Sinani & Al Taher, 2023).

Previous studies have shown that e-books, digital learning objects, and interactive media can be developed and used in physical education. Therefore, the use of a digital textbook itself is not the main novelty of this study. The specific gap lies in the limited availability of products designed specifically for Phase C elementary PE, developed from current teacher and student needs, aligned with CP/ATP No. 032/H/KR/2024, and evaluated for validity, practicality, and learning outcomes after implementation.

This distinction is important compared with previous studies. Kubiyeva et al. (2020) examined the effects of physical education e-books on learning, Papastergiou & Mastrogiannis (2021) developed interactive learning objects, and Nelson et al. (2025) developed digital media for Pencak Silat. In contrast, this study develops a Phase C digital PE textbook based on the needs of teachers and students in public elementary schools in Pemulutan District and evaluates it through staged testing in actual user settings. Its contribution lies in integrating local needs, curriculum alignment, digital accessibility, and product-quality evaluation rather than merely applying digital technology.

The problem is seen in the implementation of PJOK subjects in Phase C which may need to be addressed through research entitled "Development of Digital-Based Physical Education, Sports and Health Subject Textbooks for Phase C Students in Public Elementary Schools in

Pemulutan District". More specifically, this study aims to develop a digital Physical Education, Sports, and Health textbook for Phase C students in public elementary schools in Pemulutan District, aligned with the CP/ATP used in the study. Product quality was evaluated through three questions: (1) whether the product met validity criteria based on expert assessment of content, language, and media; (2) whether it met practicality criteria based on teacher and student responses; and (3) whether it met effectiveness criteria based on learning mastery after implementation.

The novelty of this study does not lie in the general concept of digital textbooks, but in developing a Phase C PE product aligned with CP/ATP No. 032/H/KR/2024, based on user needs in Pemulutan District, and evaluated through small-scale, large-scale, and operational testing. The study was limited to PE teachers and Phase C students in public elementary schools in Pemulutan District; therefore, the findings primarily reflect product quality and use within this specific context rather than direct generalization to elementary schools in other regions.

METHODS

Research Design

This study employed a Research and Development (R&D) method to develop a digital Physical Education, Sports, and Health (PE) textbook for Phase C elementary school students. R&D was used to produce an educational product through systematic development, testing, and refinement (Sugiyono, 2022).

The development model adapted the ten stages of Borg and Gall: (1) research and information collection, (2) planning, (3) initial product development, (4) preliminary testing, (5) main product revision, (6) main field testing, (7) product revision, (8) operational testing, (9) final product revision, and (10) product implementation (Borg & Gall, 2003; Borg & Stranahan, 2002). This model enables iterative validation, user testing, and revision before finalization. Similar staged R&D approaches have also been applied in the development of digital learning media in physical education (Arif et al., 2025; Nelson et al., 2025).

The final product was a Phase C digital PE textbook validated by content, language, and media experts and evaluated for practicality and learning achievement. The product was developed as a web-based digital textbook accessible through internet-connected devices. Its content was organized according to the Phase C PE Learning Objective Flow (ATP) and included learning materials, illustrations, and examples of real-life application. Cross-device compatibility and offline use were not examined in this study. The development of digital learning resources should consider content quality, design, user engagement, usability, and instructional value (Papastergiou & Mastrogiannis, 2021).

Participants

The study participants were Phase C PE teachers and students from public elementary schools in Pemulutan District. The small-scale test involved 2 PE teachers and 56 students from two schools, the large-scale test involved 4 teachers and 108 students from four schools, and the operational test involved 6 teachers and 161 students from six schools. The participating schools were SDN 24, SDN 28, SDN 14, SDN 02, SDN 15, and SDN 01 Pemulutan. Eligibility criteria included public elementary schools in Pemulutan District offering Phase C PE, teachers responsible for Phase C PE, and students enrolled in PE classes at the participating schools.

Instrument

The research instruments consisted of validation sheets, teacher and student response questionnaires, and learning outcome tests. Product validation was conducted by three experts in PE content, language, and instructional media. The content validation sheet contained 10 items covering learning, objective alignment, content, curriculum, and feedback. The media validation sheet included 13 items covering color, design, graphics, and instructional function, while the language validation sheet consisted of 12 items covering clarity, communicativeness, interactivity, developmental appropriateness, spelling, and consistency of terms and symbols. All validation items used a five-point scale ranging from 1 (*poor*) to 5 (*very good*). Practicality was assessed using teacher and student questionnaires. The questionnaire consisted of 11 items grouped into three aspects: attractiveness, ease of use, and usefulness. Each item used a four-point Likert scale: strongly agree (4), agree (3), disagree (2), and strongly disagree (1).

The learning outcome test was used to assess students' mastery of the Phase C PE content after using the textbook. The test consisted of 20 items covering the material presented in the product. Student scores served as the primary indicator of learning achievement, while teacher scores were analyzed only as supporting information on content mastery and were not combined with student results when determining classical mastery.

Data Analysis

The data were analyzed descriptively in terms of validity, practicality, and learning achievement. Product validity was determined from the mean expert scores: $3.76-5.00$ = highly valid, $2.51-3.76$ = valid, $1.26-2.51$ = moderately valid, and $0-1.26$ = invalid. Practicality was assessed from the mean teacher and student responses: $3.50-4.00$ = highly positive, $2.50-3.50$ = positive, $1.50-2.50$ = moderately positive, and <1.50 = not positive. Teacher and student responses were analyzed separately at each testing stage. Effectiveness was assessed from post-use learning outcomes. Students were considered to have achieved mastery with a score of ≥ 75 , based on the minimum mastery criterion (KKM) applied at the participating schools. Classical mastery was achieved when at least 80% of students met the KKM.

RESULTS

The research was directed at Elementary School Physical Education Teachers and Elementary School Phase C Students in several Public Elementary Schools in Pemulutan District, to test the practicality and evaluate the effectiveness and validity of the media created. This research is entitled "Development of Digital-Based Physical Education, Sports and Health Textbooks for Phase C Students in Public Elementary Schools in Pemulutan District". The study followed ten development stages: research and information collection, planning, initial product development, initial testing, major revision, main trial, product revision, operational testing, final product revision, and product implementation. All activities reported in this section had been completed during the study.

1. Research and Information Collection Stage

The initial stage of this research involved a needs analysis for a digital-based textbook for Phase C students, tailored to the needs of Physical Education, Sports, and Health teachers and Phase C elementary school students in Pemulutan District. The needs analysis involved interviews with Physical Education teachers and Phase C students and the administration of needs-analysis questionnaires. Supporting information related to the learning materials and Learning Objectives

Flow (ATP) used in the participating schools was also examined. Thus, the interviews and questionnaire represented two complementary but distinct sources of preliminary data.

A. Interviews with Physical Education Teachers Teaching Phase C Students

Interviews identified recurring difficulties in completing learning tasks, continued reliance on textbooks from multiple sources, limited availability of updated Phase C PJOK textbooks, and a need for teaching resources aligned with the current ATP. Teachers also expressed a preference for modern learning resources that could be accessed more easily by both teachers and students. These findings supported the development of a curriculum-aligned digital textbook as a supplementary learning resource.

The interview findings point to curriculum alignment, accessibility, and resource availability as the main reasons for developing the product, consistent with literature emphasizing that digital integration in physical education should respond to pedagogical needs rather than digitalization alone (Martín-Rodríguez & Madrigal-Cerezo, 2025; Mulato et al., 2024).

B. Analysis of Teacher and Student Needs

In October 2025, the needs-analysis questionnaire was administered to teachers and students to identify their responses to the proposed development of a digital Phase C PJOK textbook. The questionnaire sample comprised 53 respondents: 47 students and 6 PJOK teachers. The percentages reported in this subsection refer to this combined needs-analysis sample and are distinct from the preliminary interview-based percentages reported in the Introduction. Separate teacher and student frequency distributions were not available in the article dataset; therefore, subgroup percentages were not reconstructed.

Among the combined respondents, 54% disagreed that the learning media currently used were already very good; 87.3% agreed or strongly agreed that a digital textbook could support learning needs; 88.2% agreed that media could help them understand learning concepts; 95.2% indicated a need for textbooks to support learning activities; 95.1% supported the development of textbook media; and 96.2% agreed to use a digital textbook as learning media.

Taken together, these aggregated responses indicated a strong perceived need for a digitally accessible learning resource. Similar work has shown that well-designed digital learning objects can support usability, engagement, and usefulness when aligned with physical-education pedagogy (Papastergiou & Mastrogiannis, 2021).

2. Planning Stage

The digital textbook for Physical Education, Sports, and Health Phase C serves as a learning medium for teachers and students, providing easy access, allowing them to study freely anywhere and at any time. To enhance the focus of this digital textbook, its content is based on the Learning Objectives Flow (ATP) based on the independent curriculum. This allows teachers and students to learn with a more structured guide tailored to their learning needs. As part of the Learning Objectives Flow (ATP), the compiled material will serve as the basis for further development. This material is sourced from various relevant sources. Therefore, the product creation process is more focused, resulting in an effective and efficient learning tool.

3. Initial Product Development Stage

Researchers developed an initial product in the form of a Phase C Physical Education, Sports, and Health textbook, referring to the material contained in the Learning Objectives Flow (ATP), which serves as a guide for the learning process of Physical Education, Sports, and Health in public

elementary schools in Pemulutan District. Afterward, researchers conducted three validation stages: material validation, language validation, and media validation. The purpose of this validation was to ensure that the textbook's content aligns with learning needs, the language used is clear and appropriate, and the media used is effective in conveying information to teachers and students.

Table 1. Average Validator Assessment Results

Validation	Assessment Results	Category
Material Validation	4.8	Very Valid
Language Validation	4.25	Very Valid
Media Validation	4	Very Valid
Average	4.35	Very Valid

As shown in Table 1, the Phase C PJOK digital textbook achieved an overall validation mean of 4.35, categorized as very valid. The highest score was obtained for material 4.80, followed by language 4.25 and media 4.00. These results indicate that the product met the required validity criteria and was suitable for further user testing. This finding is consistent with Nelson et al. (2025), who emphasized expert validation as an important stage in establishing the feasibility of digital learning media in elementary physical education.

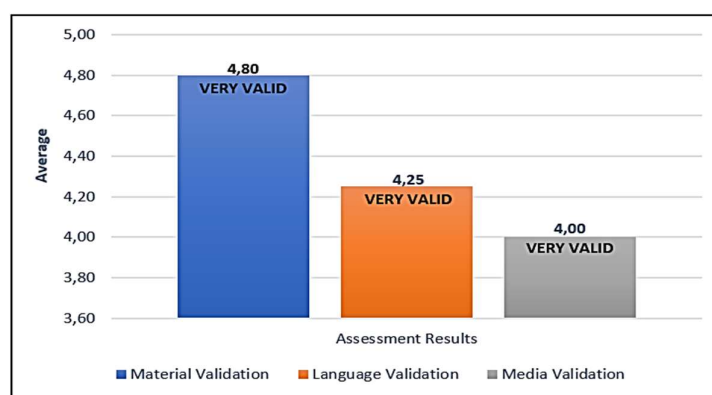


Figure 1. Average Validation Test Results

The figure 1 shows that all validation aspects were categorized as very valid, with the highest score obtained for material validation 4.80, followed by language validation 4.25 and media validation 4.00. These findings indicate that the Phase C PJOK digital textbook met the required feasibility criteria in terms of content, language, and media. This finding is consistent with Arif et al. (2025), who emphasized the importance of systematic development and testing of web-based products before their application in educational and training contexts.

4. Initial Testing

To determine the practicality of the textbook, a first-stage trial was conducted involving 56 students from two schools: Pemulutan Public Elementary School 28 and Pemulutan Public Elementary School 24. The trial involved 56 Phase C students and two PJOK teachers; the duplicated reference to another two Physical Education teachers in the previous manuscript was removed because it referred to the same teacher participants.

The results of the initial trial showed that each descriptor used four response categories: strongly agree (4), agree (3), disagree (2), and strongly disagree (1). Based on the results of the initial trial, the score obtained by students was 3.46, and the score obtained by teachers was 3.82.

Both scores represented user responses at the initial-testing stage. The previously reported “remaining scores” of 0.54 for students and 0.18 for teachers were removed because subtracting the observed mean from the maximum possible score does not identify a specific content, pedagogical, or usability deficiency. Product revisions were therefore based on the documented respondent feedback rather than on these numerical differences.

5. Major Revision

Based on feedback from the initial test, citation-source naming was standardized and numbering rules were corrected for consistency. The documented revision at this stage focused on textual consistency and organization. The available revision record did not identify specific user-reported problems related to navigation, multimedia playback, device compatibility, or digital access, so such revisions are not claimed.

6. Main Trial

To evaluate the practicality of the developed textbook, the first trial involved students from four schools: Pemulutan Public Elementary School 28, Pemulutan Public Elementary School 24, Pemulutan Public Elementary School 14, and Pemulutan Public Elementary School 02. The trial included 108 Phase C students and four Physical Education (PJOK) teachers. The trial assessed the practicality of the digital-based Physical Education, Sports, and Health textbook. Based on the initial trial results of the digital-based Physical Education, Sports, and Health textbook by 108 Phase C students and four PJOK teachers in Pemulutan District, each assessment criteria descriptor was supplemented with four scoring options: strongly agree (score 4), agree (score 3), disagree (score 2), and strongly disagree (score 1). Based on the first test, the total score obtained by students was 3.57, and the total score obtained by teachers was 3.55 indicating that the textbook is classified as very positive and can be used as teaching material in the Physical Education, Sports and Health Phase C subject.

7. Product Revision

Based on input and suggestions from respondents, the researcher made the following improvements: Added examples of applications in everyday life in each chapter. This revision represented a substantive pedagogical change because it strengthened the connection between the learning material and situations encountered in students' daily lives. The documented revision record did not report additional changes to multimedia, navigation, access, or other specifically digital functions at this stage.

8. Operational Testing

The testing was conducted with students from six schools: Pemulutan Public Elementary School 28, Pemulutan Public Elementary School 24, Pemulutan Public Elementary School 14, Pemulutan Public Elementary School 02, Pemulutan Public Elementary School 15, and Pemulutan Public Elementary School 01. A total of 161 Phase C students and six Physical Education (PJOK) teachers were enrolled in Pemulutan District. The researchers asked respondents to assess the practicality and effectiveness of the digital-based Phase C Physical Education, Sports, and Health textbook using a prepared research instrument. The goal was to conduct a corrective evaluation and identify problems and deficiencies, allowing for corrections and improvements to the textbook.

A. Operational Test of Practicality

The operational practicality mean was 3.51 for students and 3.65 for teachers. For clarity, the practicality results from all three development stages are summarized comparatively in Table 2.

Table 2. Comparison of Practicality Results Across Development Stages

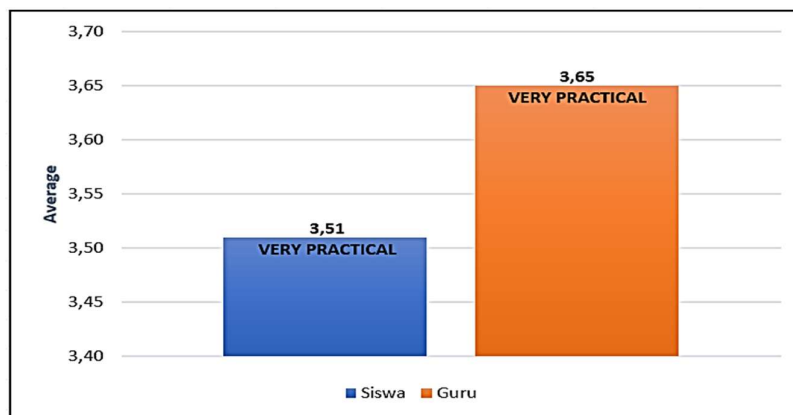
Development Stage	Students (n)	Student Mean	Teachers (n)	Teacher Mean
Initial Test	56	3.46	2	3.82
Main Trial	108	3.57	4	3.55
Operational Test	161	3.51	6	3.65

The student means changed across stages, as did the teacher means. These values therefore represent fluctuations rather than a continuous improvement trajectory. Because the number and context of participants differed across stages, the results are more appropriately interpreted as stage-specific responses. Digital learning research similarly indicates that user acceptance and perceived usability can vary with context and implementation conditions (García-Pinillos et al., 2025; Maramba & Mazongonda, 2020)

Table 3. Summary of Student and Teacher Practicality Test Results

Subject	Total Of Subject	Mean Score	Category
Students	161	3,51	Very Practical
Teachers	6	3,65	Very Practical

As shown in Table 3, the practicality test results indicate a mean score of 3.51 for students and 3.65 for teachers. Both scores were categorized as very practical, indicating that the Phase C PJOK digital textbook was easy to use and well accepted by both user groups. This finding is consistent with García-Pinillos et al. (2025), who highlighted positive user perceptions as an important indicator of the acceptability and practicality of digital learning platforms. The practicality test results presented in Table 3 are further visualized in the following figure 3 to provide a clearer comparison of the mean scores between students and teachers.

**Figure 3.** Mean Practicality Test Scores of Students and Teachers

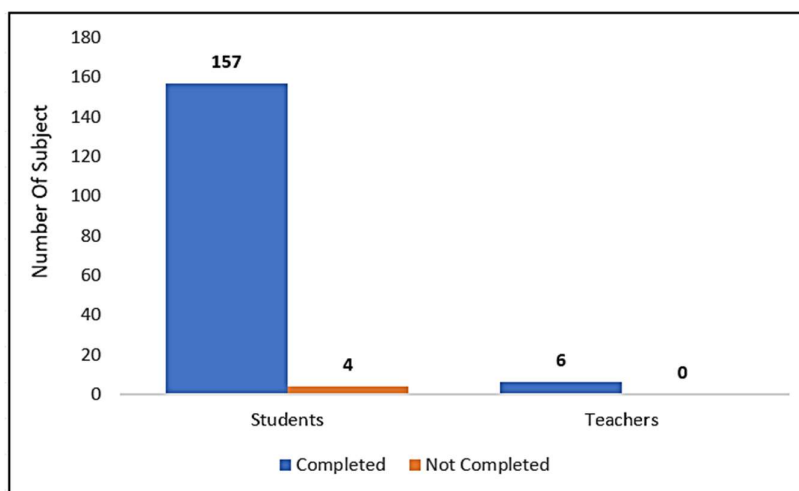
B. Operational Test of Effectiveness

To evaluate post-use learning completion, an operational test was conducted involving 161 Phase C students and six PJOK teachers from six public elementary schools in Pemulutan District. Participants were considered complete if they achieved a score equal to or above the Minimum Competency Criterion (KKM), while classical completion was achieved when at least 80% of participants met the criterion. The following table summarizes the learning-completion results for students and teachers Table 4. Percentage of Student Learning Completion.

Table 4. Percentage of Student Learning Completion.

Subject	Completed	Not Completed	Total	Percentage of Completion	Minimum Competency (KKM)
Students	157	4	161	97.5%	75
Teachers	6	0	6	100%	75

The post-use learning assessment showed that 157 of 161 students achieved the KKM of 75, resulting in a completion rate of 97.5%, while four students did not meet the criterion. All six PJOK teachers achieved the KKM, corresponding to 100% completion. These percentages represent the proportion of participants meeting the predetermined criterion, not mean mastery scores. Overall, the findings indicate a high level of post-use learning completion after the digital textbook was implemented; however, they should not be interpreted as evidence of learning improvement caused by the textbook because no pretest or comparison group was used. The learning-completion results presented in Table 4 are further visualized in the following figure to provide a clearer comparison of the numbers of students and teachers who achieved and did not achieve the KKM after using the digital textbook.

**Figure 4.** Percentage of Student and Teacher Learning Completion in the Effectiveness Test

9. Final Product Revisions

The final revision improved the cover design and added the logos of Sriwijaya University, Merdeka Belajar, and Tut Wuri Handayani, together with the supervisor's name. These visual revisions complemented earlier content-related revisions involving citation consistency, numbering, and the addition of contextual examples. The final revision focused on visual and editorial improvements to the textbook cover, making it more informative, visually appealing, and consistent with the product identity. Navigation, multimedia features, offline access, and device compatibility were not evaluated at this stage. Figure 5 presents the comparison between the cover before and after revision.

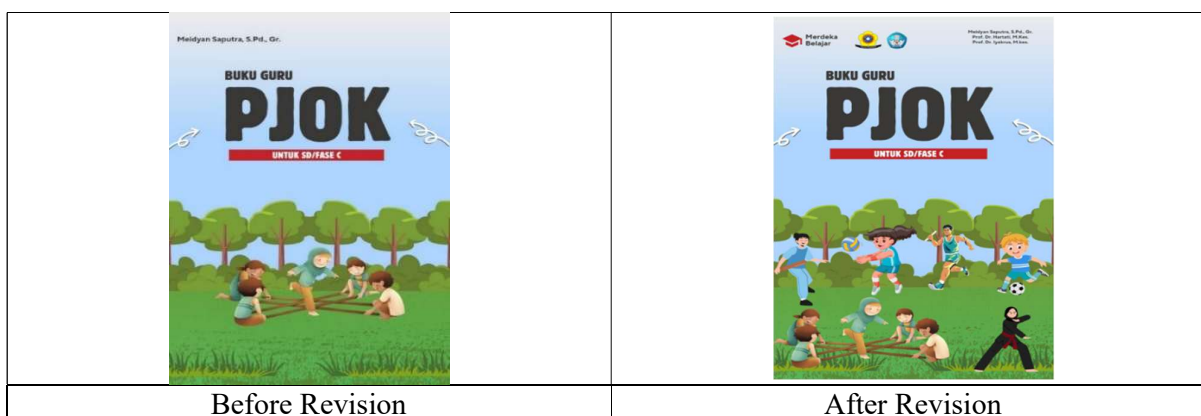


Figure 5. Comparison of the Digital Textbook Cover Before and After Revision

10. Product Implementation

At this stage, the developed Phase C PJOK digital textbook was considered ready for use as a supplementary learning resource within the study context. Product implementation referred to the final preparation and availability of the revised product following operational testing, rather than large-scale dissemination, routine adoption, or mass production beyond the participating schools.

DISCUSSION

Rationality-Based Empirical Finding

The development of the Phase C PJOK digital textbook was based on the needs of teachers and students for learning resources that were more accessible and aligned with curriculum requirements. The rationale for product development was not merely the use of technology, but the effort to bridge user needs, limitations of existing teaching materials, and the alignment of content with the Phase C CP/ATP. This is consistent with Mulato et al. (2024) and Martín-Rodríguez and Madrigal-Cerezo (2025), who emphasized that technology in physical education becomes meaningful when integrated with pedagogical goals and learner needs.

Expert validation indicated that the textbook met feasibility criteria in terms of content, language, and media. This finding suggests that the quality of a digital textbook is multidimensional because accurate content must be supported by clear language and media presentation that is appropriate for user characteristics. Papastergiou and Mastrogiannis (2021) identified design, usability, engagement, and usefulness as important components in evaluating digital learning resources, while Nelson et al. (2025) highlighted the importance of expert validation before digital media are implemented in elementary physical education.

Teacher and student responses indicated that the product could be used practically in learning. However, changes in responses across stages did not show a linear improvement pattern and therefore should not be interpreted as continuously increasing practicality. Such variation is more appropriately understood as reflecting differences in implementation context, participant characteristics, technology experience, and conditions at each trial stage. García-Pinillos et al. (2025), Maramba & Mazongonda (2020), and Yang et al. (2025) showed that acceptance of digital platforms is influenced by perceived usefulness, ease of use, and facilitating conditions. Post-use learning outcomes showed a high level of criterion attainment. These findings should be interpreted as post-use learning completion rather than evidence of the magnitude of learning improvement caused by the textbook because the study did not employ a pretest or comparison group. Kubiyeva

et al. (2020) and Lucena et al. (2020) used comparative conditions, providing a stronger basis for evaluating changes in learning outcomes. Similar findings indicate that usability, engaging presentation, and learner engagement support acceptance and performance in digital PE, while comparative pre-post designs provide stronger evidence of learning change (Alhamad et al., 2023; Y. Liu et al., 2025; Portillo et al., 2026)

Support for Empirical Findings and Contradictions with Previous Research Results

The findings support previous studies demonstrating the potential of digital media in physical education. Papastergiou & Mastrogiannis (2021) showed that digital learning resources can support engagement and usefulness when their design is aligned with learning objectives. Nelson et al. (2025) also demonstrated that interactive digital media can be developed for elementary physical education through expert validation and user evaluation. Kurniawan et al. (2025) found that the use of digital media, including video and simulation, can support students' understanding and engagement. This finding reinforces the present study by suggesting that user acceptance is influenced not only by the substance of the content but also by how the material is presented and used during the learning process.

Arif et al. (2025) showed that web-based approaches can support training when combined with instructor guidance, whereas Safari et al. (2025) demonstrated that multimedia can be integrated with cognitive, psychomotor, and affective learning objectives. These findings strengthen the position of the digital textbook in this study as a supplementary learning resource rather than a replacement for teacher demonstrations, movement practice, and direct physical activity. Other digital technologies have also shown potential for supporting learning. Botagariyev et al. (2024) reported benefits of digitalization in physical education, while Mokmin & Jamiat (2021) showed that virtual fitness applications can support motivation and engagement. Wang et al. (2024) also found that visually based digital presentation can support movement-learning experiences. Conversely, the literature also indicates that successful digital learning cannot be assumed solely from positive user responses to a product. Konukman et al. (2022) identified barriers related to internet access, devices, participation, and limited interaction in online physical education. Kwon (2020) and Phong et al. (2022) likewise showed that the physical nature of PE creates specific challenges when learning is transferred to digital environments.

These differences indicate that the findings of this study should not be interpreted as showing that digital textbooks are always superior to conventional learning resources. Their usefulness depends on how they are integrated with face-to-face instruction, physical activity, and teacher support. Lander et al. (2022) emphasized the importance of teacher readiness, while Hasan et al. (2025) and Hu (2025) showed that facilitating conditions also influence technology acceptance.

Theoretical Support and Developmental Interpretation

Theoretically, the findings can be interpreted through a technology-enhanced pedagogy perspective. Technology is used to extend access to learning materials and support instruction rather than replace the pedagogical role of the teacher. Martín-Rodríguez and Madrigal-Cerezo (2025) explained that technology in physical education has educational value when its use is connected to engagement, knowledge development, skill acquisition, and self-directed learning. Guo (2024) also showed that the benefits of technology depend on how it is positioned within instructional design. In this study, the digital format primarily supported access to material, while its pedagogical value remained dependent on ATP alignment, clarity of content, contextual examples, and integration with PJOK activities.

Product development involved validation, user testing, revision, and repeated evaluation. This iterative characteristic indicates that the product evolved through repeated evaluation rather than through a single development stage. Such an approach allows expert and user feedback to be translated into editorial, pedagogical, and visual improvements. Arif et al. (2025) and Nelson et al. (2025) applied staged development approaches to digital products in sport-related contexts, while Or & Chapman (2022) emphasized the importance of evaluating user acceptance in educational technology implementation.

The addition of everyday-life application examples also has pedagogical significance because it strengthens the connection between textbook content and students' actual experiences. Thus, product revision involved not only visual modification but also improvement in the contextual relevance of the material. The digital characteristics of the product should nevertheless be understood within the scope of the evaluation. The product was delivered through a web-based medium to support access to the material. However, navigation quality, offline access, cross-device compatibility, hyperlinks, and advanced multimedia functions were not specifically evaluated. Therefore, the validity and practicality findings cannot automatically be generalized as evidence of the quality of all technical functions. This is relevant because current developments in digital physical education increasingly include VR, IoT, and connected learning systems that require specific technical evaluation (Qi et al., 2024; Yefremenko et al., 2026)

Practical Implications

Practically, the digital textbook can be used as a supplementary learning resource for Phase C PJOK. Teachers may use the product before practical activities to introduce content, during instruction as a guide, and after lessons to help students review the material. Its use should nevertheless remain combined with movement demonstrations, direct practice, teacher feedback, and social interaction because the characteristics of PJOK learning cannot be reduced to information delivery through digital devices. Lobo et al. (2025) showed that digital platforms can support learning when integrated into a broader instructional sequence, while Shutova et al. (2021) and Topu & Goktas (2019) emphasized the need to combine technology with physical education practice.

Implementation in broader school contexts also requires consideration of technological readiness. Device availability, internet stability, teacher and student digital literacy, teacher readiness, and school infrastructure may determine whether a product perceived as practical in one context provides the same user experience in another. Sorokolit et al. (2025) showed that infrastructure limitations and teacher readiness represent important barriers to the use of digital applications, while Maramba & Mazongonda (2020) highlighted the importance of facilities and institutional support in e-learning implementation.

The generalizability of the findings should also be limited because the study was conducted in public elementary schools in Pemulutan District with a relatively small number of participating teachers. In addition, no pretest-posttest design with a comparison group was used to determine learning changes directly attributable to the product. Future studies may expand the testing sites and employ comparative research designs. Further evaluation should also examine device compatibility, navigation, accessibility, multimedia quality, connectivity conditions, long-term usage patterns, and participant involvement across development stages. Kubiyeve et al. (2020) provides an example of how experimental designs can be used to evaluate the contribution of electronic textbooks to learning outcomes more rigorously.

Accordingly, the Phase C PJOK digital textbook can be positioned as a supplementary learning resource that supports structured and accessible presentation of learning materials. Its benefits in broader implementation will remain dependent on user readiness, school support, integration with physical activity, and further evaluation of both pedagogical and technical aspects.

CONCLUSION

This study developed a digital textbook for Physical Education, Sports, and Health (PJOK) for Phase C students in public elementary schools in Pemulutan District. The product was designed based on the identified needs of teachers and students and aligned with the Phase C Learning Objectives Flow (ATP). Expert evaluation indicated that the textbook met the very valid criteria across material, language, and media aspects, with an overall mean validation score of 4.35. The practicality assessment also demonstrated positive acceptance among both students and teachers, although variations across testing stages reflected differences in user groups and implementation contexts rather than a linear improvement in practicality.

At the operational stage, most students and all participating teachers achieved the predetermined learning-completion criteria after using the textbook. These findings indicate that the developed product is valid, practical, and capable of supporting learning completion within the participating schools. However, because the study did not include a pretest or comparison group, the learning outcomes should be interpreted as post-use completion rather than evidence of improvement directly attributable to the digital textbook. Overall, the product is appropriate for use as a supplementary learning resource for Phase C PJOK. Further studies involving broader school settings, technological-readiness factors, and more rigorous comparative designs are recommended to examine its generalizability and contribution to learning outcomes.

RECOMMENDATION

The developed Phase C Physical Education, Sports, and Health (PJOK) digital textbook should continue to be refined to produce a better product that is more responsive to learning needs. Further refinement should focus particularly on readability, ease of navigation, display across different devices, multimedia quality, and accessibility for both teachers and students.

Future development of the textbook should consider the needs and characteristics of teachers and students in elementary schools in Pemulutan District to better support the learning process. The needs of these two user groups should be analyzed separately because teachers and students may have different priorities. Product implementation should also consider device availability, internet connectivity, digital literacy, and school infrastructure before being expanded to a broader context.

The product may be further developed for wider use in other elementary schools. The implementation stage in this study refers to product use following operational testing and final revision, rather than large-scale dissemination or mass production. Therefore, future studies should conduct implementation trials in a larger number of schools with more diverse characteristics before the product is disseminated more broadly.

Future research should employ a pretest-posttest design with a comparison group so that changes in learning outcomes can be measured more rigorously and the contribution of the digital textbook to learning can be determined more accurately. Participant involvement at each stage should also be documented clearly to reduce uncertainty regarding the possible repeated participation of the same respondents across multiple testing stages.

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