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Development and validation of a deep learning-based physical education e-module for fundamental movement skills

Lahmuddin Lahmuddin, Rika Sepriani*), Asep Sujana Wahyuri, Padli Padli, Ardo Okilanda
Universitas Negeri Padang, Padang Indonesia

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ABSTRACT

This study aimed to develop and determine the feasibility and practicality of a Deep Learning-based Physical Education e-module for teaching fundamental movement skills to Grade IV elementary-school students. A Research and Development approach using the ADDIE model was employed. Data were collected through needs analysis, expert validation, and practicality questionnaires and analyzed using descriptive statistics, Aiken's V, item validity, and Cronbach's alpha. Expert validation demonstrated good content (84%; V = 0.795) and media feasibility (83%; V = 0.783) and very good language feasibility (97%; V = 0.958). The practicality instruments showed high reliability (α = 0.862–0.876), while teacher/practitioner assessment indicated very high practicality (92.50%). The developed e-module was feasible, reliable, and highly practical for supporting fundamental movement instruction through mindful, meaningful, and joyful learning in elementary Physical Education.

Corresponding Author:

Rika Sepriani,
Universitas Negeri Padang
Email: rikasepriani@fik.unp.ac.id

Introduction

Physical Education at the elementary-school level plays a fundamental role in developing fundamental movement skills, which provide the motor foundation for children's participation in physical activity and the acquisition of more complex movement skills (Bartolo et al., 2024; N. Lander et al., 2017). Locomotor, non-locomotor, and manipulative skills should therefore be developed through learning experiences that integrate conceptual understanding, direct movement practice, active participation, and reflection. However, evidence indicates that the development of fundamental movement skills depends substantially on the quality of instructional experiences, teacher practices, and opportunities for children to engage actively in structured movement activities (Noonan et al., 2022; Wibowo et al., 2021). Instruction that relies predominantly on teacher demonstrations and repetitive movement practice may provide insufficient opportunities for students to understand why and how movements are performed, connect movement concepts with everyday situations, and evaluate their own performance. Consequently, elementary Physical Education requires instructional resources that can support not only motor practice but also conceptual understanding, active engagement, contextual application, and reflective learning.

The increasing integration of digital technology into education offers an opportunity to address these instructional requirements through interactive and systematically designed learning resources. E-modules can combine textual explanations, movement illustrations, instructional videos, hyperlinks, QR codes, task sheets, games, and formative assessments to provide students with multiple representations of movement concepts and

learning activities. Such features are particularly relevant to Physical Education because visual demonstrations can assist students in recognizing movement sequences, body positions, and movement directions that may be difficult to communicate solely through verbal explanations. Nevertheless, simply converting conventional materials into digital formats does not necessarily improve instructional quality; multimedia components must be purposefully aligned with learning objectives, movement activities, assessment, and learners' developmental characteristics (Ayuningtyas et al., 2025; Dier et al., 2025). Accordingly, an effective Physical Education e-module should function as an integrated instructional resource in which content, visual representations, movement practice, and assessment are systematically connected to promote understanding and active participation rather than merely presenting digital information (Chan et al., 2023; Q. Liu et al., 2026).

Within this context, the pedagogical concept of Deep Learning provides a relevant framework for designing learning experiences that move beyond superficial knowledge acquisition toward understanding, application, engagement, and reflection. In this study, Deep Learning refers specifically to a pedagogical approach rather than artificial intelligence or computational deep learning. Within the Indonesian educational context, this approach emphasizes mindful, meaningful, and joyful learning. Mindful learning encourages students to consciously understand learning objectives, movement principles, and their own learning processes; meaningful learning connects movement concepts with authentic activities and students' everyday experiences; and joyful learning creates engaging, supportive, and enjoyable opportunities for movement practice. These principles are particularly relevant to fundamental movement skills because students need to understand movement concepts, perform locomotor, non-locomotor, and manipulative tasks in varied contexts, and reflect on their performance rather than simply imitate demonstrated movements (Sholikhah et al., 2025; Sufaidah & Wijaya, 2025; Ulfa et al., 2023). Integrating these principles into Physical Education may therefore provide a pedagogical structure that connects cognitive understanding with motor participation, contextual application, engagement, and reflection (Butler et al., 2022; Dobell et al., 2021).

Despite the growing literature on digital learning resources and Deep Learning-oriented instruction, their systematic integration into elementary Physical Education, particularly for fundamental movement skills instruction, remains insufficiently investigated. Previous research has demonstrated the importance of structured Physical Education interventions and appropriate instructional strategies for developing movement competence; however, evidence concerning digital instructional products that explicitly operationalize Deep Learning principles within fundamental movement skills learning remains limited. Existing e-module studies have also largely focused on academic or non-Physical Education learning contexts, leaving uncertainty regarding how digital resources can be pedagogically structured to support the distinctive requirements of movement-based learning. More specifically, limited evidence is available on e-modules that integrate locomotor, non-locomotor, and manipulative skills with visual movement demonstrations, contextual practice, games, reflection, assessment, and mindful, meaningful, and joyful learning within a single instructional system. Furthermore, few development studies have combined systematic needs analysis, multidisciplinary expert validation, measurement-quality assessment, and classroom practicality evaluation to establish whether such resources are both pedagogically feasible and practically usable in elementary Physical Education settings (Salters & Benson, 2025; Wu et al., 2024). This gap highlights the need for an empirically developed digital resource that translates Deep Learning principles into concrete instructional activities appropriate for fundamental movement learning.

Accordingly, the contribution of this study lies not merely in combining multiple digital features but in systematically operationalizing Deep Learning principles within an e-module specifically designed for Grade IV fundamental movement skills instruction. The module integrates locomotor, non-locomotor, and manipulative skills into a structured sequence of understanding, applying/performing, and reflecting, while mindful, meaningful, and joyful learning is embedded through contextual movement activities, task sheets, games, visual demonstrations, instructional videos, QR codes, assessment, and structured reflection (Ha et al., 2026; Saputra et al., 2026). This design establishes an explicit connection between pedagogical principles, movement content, digital media, learning activities, and assessment rather than treating Deep Learning as an abstract instructional concept or digital technology as an isolated learning feature. The e-module was developed through the ADDIE framework and examined through needs analysis, content, media, and language expert validation, Aiken's V analysis, psychometric evaluation of practicality instruments, and teacher/practitioner assessment. Therefore, this study aimed to develop and determine the feasibility and practicality of a Deep Learning-based Physical Education e-module for teaching fundamental movement skills to Grade IV elementary-school students, providing empirical evidence regarding the translation of mindful, meaningful, and joyful learning principles into a structured digital resource for elementary Physical Education.

Method

Research Design

This study employed a Research and Development approach using the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) model to develop a Deep Learning-based Physical Education e-module for teaching fundamental movement skills to Grade IV elementary-school students. The study was specifically designed to examine product development, feasibility, instrument quality, and practicality rather than the effectiveness of the e-module in improving students' fundamental movement skills. The Analysis stage identified instructional needs and product requirements; the Design stage translated these needs into the structure, content, learning activities, media, and assessment components of the e-module; the Development stage produced and validated the initial product; the Implementation stage examined its use with the intended users; and the Evaluation stage synthesized expert judgments, instrument-quality evidence, user responses, and practicality findings for product refinement. Accordingly, the principal outcomes of the study comprised needs-analysis findings, e-module design characteristics, expert-assessed feasibility, validity and reliability of the practicality instruments, and user-rated practicality.

Research Setting and Participants

The study was conducted in elementary-school settings in Pasaman, with participant groups selected according to their specific roles in the development and evaluation process. Three experts were involved in product validation, consisting of one content expert, one instructional media expert, and one language expert whose expertise corresponded to the respective validation domains. A preliminary implementation involved 29 Grade IV students at SDN 19 Pasaman to identify initial usability problems and provide information for product refinement. Following revision, the main implementation was conducted with 43 Grade IV students at SDN 13 Pasaman to examine students' responses to the refined e-module and to evaluate the student-practicality instrument. In addition, 17 teachers/practitioners participated in the assessment of product practicality from an instructional-user perspective. Participants were selected purposively according to their relevance to the development and evaluation stages. Each participant group served a distinct methodological function; therefore, expert-validation, preliminary implementation, student-response, and teacher-practicality data were analyzed separately to avoid conflating evidence derived from different stages and respondent groups.

Development Procedures

The development procedures were systematically organized according to the five stages of the ADDIE model. During the Analysis stage, classroom observations, structured teacher interviews, curriculum analysis, student-characteristic analysis, and reviews of existing instructional materials were conducted to identify instructional problems and establish product-development requirements. Particular attention was given to the availability of digital learning resources, student participation, instructional practices, curriculum alignment, and the extent to which existing materials supported fundamental movement learning.

During the Design stage, the identified needs were translated into learning objectives, content organization, movement activities, digital-media components, task sheets, reflection activities, and assessment procedures. The content covered locomotor, non-locomotor, and manipulative fundamental movement skills. Deep Learning was operationalized pedagogically through mindful, meaningful, and joyful learning. Mindful learning was represented through explicit learning objectives, movement awareness, and structured reflection; meaningful learning was incorporated through contextual movement tasks connected with students' everyday experiences; and joyful learning was facilitated through games, varied movement activities, interactive visual resources, and collaborative learning experiences. Learning activities were organized through the sequence of understanding, applying/performing, and reflecting.

During the Development stage, the initial e-module was produced by integrating textual explanations, illustrations, instructional videos, digital links, QR codes, movement activities, games, task sheets, reflection, and assessment. The initial product was then evaluated separately by content, instructional media, and language experts. Quantitative ratings and qualitative recommendations from each expert were used formatively to revise content accuracy, movement terminology, visual representation, layout, readability, and instructional clarity before implementation.

The Implementation stage consisted of preliminary and main implementation. The preliminary implementation with 29 students was used to identify usability difficulties and areas requiring refinement before broader use. The revised product was subsequently implemented with 43 Grade IV students in the main educational setting, while teachers/practitioners evaluated its practicality for instructional use. The Evaluation stage was formative throughout the development process and summative at the end of implementation. Evidence from needs analysis, expert validation, preliminary implementation, instrument-quality testing, student responses, and teacher/practitioner assessments was integrated to determine the feasibility and practicality of

the developed e-module. No experimental comparison or measurement of learning effectiveness was conducted because effectiveness testing was beyond the scope of the present development study.

Research Instruments and Data Collection

Data were collected using classroom observation sheets, structured teacher-interview guides, document-analysis forms, expert-validation questionnaires, and teacher and student practicality questionnaires. Classroom observations and teacher interviews were conducted during the Analysis stage to identify existing instructional practices, availability and limitations of learning resources, student participation, and requirements for digital Physical Education materials. Curriculum documents and existing instructional materials were also examined to determine the alignment among learning outcomes, learning objectives, fundamental movement content, instructional activities, media, and assessment.

Product feasibility was assessed using separate validation instruments for content, instructional media, and language. The content-validation instrument examined the accuracy, relevance, organization, and presentation of fundamental movement material. The instructional-media instrument evaluated visual design, layout, movement representation, navigation, and organization of digital content. The language-validation instrument assessed readability, clarity, linguistic accuracy, and developmental appropriateness for Grade IV students. Expert ratings were supplemented with qualitative comments and recommendations that were used as the basis for formative product revision.

Practicality was examined from both teacher/practitioner and student perspectives using separate 10-item questionnaires. The teacher questionnaire assessed ease of use, clarity of instructions, visual attractiveness, usefulness of multimedia, curricular relevance, comprehensibility, support for Deep Learning principles, potential to facilitate student engagement, instructional usefulness, and overall practicality. The student questionnaire was used during the main implementation to examine students' responses to the usability and accessibility of the e-module. Keeping teacher and student assessments separate enabled practicality to be considered from both the instructional-user and learner-user perspectives.

Validity and Reliability of the Instruments

The psychometric quality of the teacher and student practicality questionnaires was examined before their scores were interpreted as evidence of product practicality. Item validity was evaluated using Corrected Item–Total Correlation, with coefficients greater than 0.30 used as the predetermined criterion for retaining an item. The teacher practicality questionnaire consisted of 10 items and was evaluated using responses from 17 teachers/practitioners, whereas the 10-item student practicality questionnaire was evaluated using responses from 43 students involved in the main implementation. Internal consistency was subsequently examined using Cronbach's alpha to determine the consistency of responses across items within each instrument.

Product validation was conceptually distinguished from the psychometric evaluation of the practicality questionnaires. Expert judgments regarding content, instructional media, and language were summarized descriptively using mean scores, percentages, and Aiken's V coefficients. However, because each validation domain was assessed by only one expert, the Aiken's V coefficients were treated as descriptive indices of the judgments provided within the respective domains and not as evidence of inter-rater agreement or comprehensive content validity. This limitation was considered when interpreting the feasibility findings. Consequently, expert quantitative ratings were interpreted together with qualitative recommendations and subsequent product revisions rather than being treated as standalone evidence of product validity.

Data Analysis

Quantitative and qualitative data were analyzed according to their methodological purposes and stages of development. Data obtained from classroom observations, teacher interviews, curriculum analysis, and reviews of existing instructional materials were organized by recurring instructional issues, including instructional practices, availability of digital resources, student participation, curriculum alignment, and requirements for fundamental movement instruction. The identified issues were subsequently translated into specific product-development requirements, thereby establishing a direct connection between the Analysis and Design stages.

Expert-validation data were analyzed descriptively using total scores, mean scores, percentages, feasibility categories, and Aiken's V coefficients. Qualitative comments from the content, instructional media, and language experts were examined according to the aspects requiring revision and used to guide formative improvements to the e-module. Given the use of one expert for each validation domain, Aiken's V was interpreted cautiously and descriptively rather than as evidence of agreement among multiple validators.

The psychometric analysis of the teacher and student practicality questionnaires used Corrected Item–Total Correlation to examine item discrimination and Cronbach's alpha to assess internal consistency. A Corrected Item–Total Correlation coefficient above 0.30 was used as the item-retention criterion. Practicality scores were

calculated by dividing the obtained score by the maximum possible score and multiplying the result by 100. The resulting percentages were interpreted using the predetermined categories of not practical (0–20%), less practical (21–40%), moderately practical (41–60%), practical (61–80%), and very practical (81–100%). Teacher/practitioner and student data were analyzed separately because the two groups represented different perspectives on product usability. The overall analytical process generated evidence concerning instructional needs, product characteristics, expert-assessed feasibility, instrument quality, and product practicality; it was not intended to establish the causal effectiveness of the e-module in improving fundamental movement skills.

Results and Discussions

The development of the Deep Learning-based Physical Education e-module followed the ADDIE framework. The results presented in this section focus on five major components: needs analysis, e-module design, expert validation, instrument quality, and product practicality. The initial analysis showed that existing PE instruction had not fully integrated Deep Learning principles and that digital instructional materials remained limited, providing an empirical basis for the development of the e-module.

Table 1. Needs Analysis and Development Implications

Component	Key Findings	Development Implications
Learning conditions	Conventional instructional practices remained dominant, while Deep Learning principles had not been optimally implemented.	Activities were designed to promote mindful, meaningful, joyful, active, and reflective learning.
Learning media	Digital learning materials were not optimally available, and instruction relied largely on teacher demonstrations.	The e-module incorporated text, illustrations, videos, links, and QR codes.
Teacher needs	Teachers required structured materials aligned with the Kurikulum Merdeka and appropriate instructional resources.	Clear instructions, learning activities, games, assessments, and visual resources were incorporated.
Student needs	Student participation remained limited and learning needs were not fully accommodated.	Activities were designed to be varied, collaborative, game-based, practical, and reflective.
Curriculum	Learning outcomes, objectives, activities, media, and assessment were not fully integrated.	Curriculum components were aligned within a systematic instructional sequence.
Existing materials	Existing teaching materials had not systematically incorporated Deep Learning principles.	A contextual, systematic, visual, and interactive e-module was developed.

The needs analysis revealed a clear discrepancy between existing PE instructional practices and the desired implementation of Deep Learning. Classroom instruction remained predominantly conventional, digital learning resources were limited, and student participation was not yet optimal. Curriculum and teaching-material analyses also indicated insufficient alignment among learning outcomes, objectives, instructional activities, media, and assessment. Consequently, the e-module was designed to address these limitations by providing a systematic digital learning environment integrating visual resources, contextual movement activities, games, reflection, and assessment within mindful, meaningful, and joyful learning experiences.

Table 2. Design Characteristics and Structure of the Developed E-Module

Component	Design Characteristics
Learning content	Fundamental locomotor, non-locomotor, and manipulative movements
Deep Learning principles	Mindful, meaningful, and joyful learning
Learning sequence	Understanding, applying/performing, and reflecting
Digital media	Text, illustrations, instructional videos, links, and QR codes
Learning activities	Movement exercises, task sheets, games, practical activities, and reflection
Assessment	Diagnostic, formative/process, reflective, and final assessment
Main module structure	Cover, instructions, learning outcomes and objectives, concept map, content, illustrations/videos, task sheets, games, reflection, assessment, and digital links
Graduate profile dimensions	Faith and morality, citizenship, collaboration, health, and communication

The design stage transformed the identified instructional needs into a structured digital learning product covering locomotor, non-locomotor, and manipulative fundamental movement skills. Deep Learning was operationalized through mindful, meaningful, and joyful learning principles and organized into three interconnected processes: understanding, applying, and reflecting. Digital resources, including videos, illustrations, links, and QR codes, were incorporated to facilitate movement visualization, while task sheets, games, practical activities, reflection, and multiple forms of assessment connected conceptual knowledge with authentic movement experiences. Thus, the e-module was structured as an integrated instructional system rather than merely a digital presentation of learning materials.

Table 3. Expert Validation and Aiken's V Results

Validation Domain	Mean Score	Percentage	Category	Aiken's V	Interpretation
Content	4.18	84%	Good	0.795	Feasible
Media	4.13	83%	Good	0.783	Feasible
Language	4.83	97%	Very Good	0.958	Highly Feasible

Expert evaluation demonstrated satisfactory to excellent feasibility across all validation domains. Language obtained the highest evaluation (97%; V = 0.958), followed by content (84%; V = 0.795) and media (83%; V = 0.783). At the subdomain level, media content design reached 90%, while language clarity, accuracy, and appropriateness each achieved 100%. Expert recommendations subsequently resulted in targeted revisions, including the addition of contextual movement examples, correction of typographical errors, improvement of movement-direction illustrations, and refinement of movement terminology. Because only one expert assessed each validation domain, the Aiken's V coefficients should be interpreted as descriptive indicators of expert judgment rather than measures of inter-rater reliability.

Table 4. Validity and Reliability of the Practicality Instruments

Instrument	N	No. of Items	Corrected Item–Total Correlation	Validity Decision	Cronbach's α	Reliability
Teacher practicality	17	10	0.391–0.709	All items valid	0.862	High
Student practicality	43	10	0.419–0.727	All items valid	0.876	High

The measurement-quality analysis confirmed that both practicality instruments demonstrated adequate psychometric properties. Corrected Item–Total Correlation coefficients ranged from 0.391 to 0.709 for the teacher questionnaire and from 0.419 to 0.727 for the student questionnaire, with all coefficients exceeding the criterion of 0.30; therefore, all items were retained. Furthermore, Cronbach's alpha coefficients of 0.862 and 0.876 indicated high internal consistency for the teacher and student instruments, respectively. These results provide adequate evidence that both instruments were suitable for collecting practicality data during the implementation stage.

Table 5. Practicality Assessment of the Developed E-Module

Respondent	N	Obtained Score	Maximum Score	Percentage	Category
Teachers/Practitioners	17	630	680	92.50%	Very Practical

The practicality assessment demonstrated a high level of usability of the developed e-module. The teacher/practitioner evaluation yielded a total score of 630 out of 680, corresponding to a practicality level of 92.50% and placing the product in the Very Practical category. Teachers generally perceived the e-module as easy to use, understandable, visually attractive, and beneficial for facilitating PE instruction. The qualitative responses further supported the quantitative findings, indicating that the e-module provided practical instructional support and facilitated the integration of Deep Learning principles into fundamental movement instruction. Therefore, the combined validation and practicality evidence indicates that the developed e-module was sufficiently feasible and practical for subsequent implementation and effectiveness testing.

The needs analysis identified pedagogical and technological gaps in fundamental movement instruction, including conventional teaching practices, limited digital resources, low student participation, and insufficient alignment among learning outcomes, activities, media, and assessment. These conditions may limit opportunities for students to understand, perform, and reflect on locomotor, non-locomotor, and manipulative movements. Therefore, the e-module was designed to integrate contextual activities, games, digital resources, collaboration, and reflection through mindful, meaningful, and joyful learning. This approach is consistent with evidence emphasizing structured, active, and meaningful movement experiences for developing fundamental movement skills (Adnan et al., 2026; Kalaja et al., 2012; Li et al., 2022; B. Liu et al., 2025).

Expert evaluation indicated adequate feasibility for content (84%; M = 4.18), media (83%; M = 4.13), and language (97%; M = 4.83). The higher language score indicates strong clarity and developmental appropriateness, whereas the lower media score suggests that visual organization and movement representation required greater refinement. Expert recommendations concerning movement illustrations, terminology, contextual examples, and typographical accuracy supported these interpretations. However, the Aiken's V values of 0.795, 0.783, and 0.958 should be interpreted cautiously because each domain was assessed by only one expert; thus, they provide preliminary expert-based evidence rather than strong evidence of content validity (Ali et al., 2021; Grady et al., 2025; N. J. Lander et al., 2015; Salters & Scharoun Benson, 2022).

Formative revision strengthened the pedagogical and visual quality of the e-module. Media content design reached 90%, while visual design, aesthetics, and layout each reached 80%, leading to improvements in movement illustrations, contextual examples, terminology, and typographical accuracy. Language clarity, accuracy, and appropriateness reached 100%, although readability reached 87%, indicating that further simplification remained necessary. These revisions were important for ensuring that visual and linguistic information accurately supported students' understanding and performance of fundamental movements (Afif & Komari, 2024; Budiono et al., 2026; O'Brien et al., 2023; Susilowati et al., 2026).

The practicality instruments demonstrated adequate item discrimination, with Corrected Item–Total Correlation coefficients of 0.391–0.709 for teachers and 0.419–0.727 for students, while Cronbach's alpha values were 0.862 and 0.876, respectively. These findings support the internal consistency of both instruments; however, they should not be interpreted as comprehensive evidence of construct validity. In particular, the small teacher sample (n = 17) limits the strength of the psychometric evidence, indicating the need for further validation with larger samples and more rigorous construct-validity analysis (Noviana et al., 2025; Riski et al., 2025; Susilowati & Maria, 2026; Vrimesty & Fauzi, 2026).

The teacher/practitioner practicality score of 92.50% (630/680) indicates that the e-module was perceived as highly practical for classroom use. Combined with the expert-validation findings, this result supports its feasibility and teacher-perceived usability for integrating fundamental movements with mindful, meaningful, and joyful learning. Nevertheless, the evidence primarily reflects teacher perceptions, while student-based practicality evidence remains insufficiently reported. More importantly, high feasibility and practicality cannot be interpreted as evidence that the e-module improves students' fundamental movement skills; therefore, future studies should involve multiple validators, broader student samples, and controlled experimental designs to establish its instructional effectiveness (Al Mudhotin et al., 2026; Nurhidayat et al., 2026; Nurlaela et al., 2025; Selano et al., 2024).

Conclusions

This study successfully developed a Deep Learning-based Physical Education e-module for fundamental movement skills among Grade IV elementary-school students using the ADDIE development framework. The findings demonstrated that the e-module met the required feasibility standards, achieving expert validation scores of 84% for content, 83% for media, and 97% for language, with corresponding Aiken's V coefficients of 0.795, 0.783, and 0.958. The practicality instruments also demonstrated high internal consistency, with Cronbach's alpha coefficients ranging from 0.862 to 0.876. Furthermore, the teacher/practitioner assessment yielded a practicality score of 92.50%, indicating that the e-module was highly practical for classroom use. Overall, the findings confirm that the developed e-module is a feasible and highly practical digital learning resource for supporting fundamental movement instruction through mindful, meaningful, and joyful learning in elementary Physical Education.

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