International Journal of Research Studies in Education
2026 Volume 15 Number 23, 269-281



Electronic Strategic Intervention Materials in physical education: Development, validation, and pretest–posttest evaluation among Grade 12 learners

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ISSN: 2243-7703
Online ISSN: 2243-7711

Received: 9 August 2026 **Revised**: 10 November 2026 **Accepted**: 18 November 2026 OPEN ACCESS
Available Online: 20 November 2026 **DOI**: 10.5861/ijrse.2026.26390

Abstract

Physical Education (PE) contributes to learners' physical, cognitive, social, and affective development; however, mastery of selected competencies remains challenging among senior high school learners. This study developed, validated, and evaluated Electronic Strategic Intervention Materials (ESIMs) designed to address identified least-mastered competencies in Grade 12 PE. A research and development design guided by the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) model was employed. The ESIMs incorporated inquiry-based learning principles and multimedia resources organized through Guide Cards, Activity Cards, Assessment Cards, Enhancement Cards, and Reference Cards. Six expert evaluators assessed the materials in terms of content quality, instructional quality, technical quality, and other quality indicators. Twenty-four Grade 12 learners participated in an eight-week implementation consisting of two approximately 60-minute sessions per week, for a total of 16 sessions. Learner competency was measured using a validated teacher-made achievement test administered before and after the intervention. The ESIMs received very satisfactory evaluations across the assessed dimensions, with mean ratings ranging from 3.80 to 4.00. Learners demonstrated higher posttest than pretest scores across all four targeted competencies: organizing fitness events, observing safety protocols during moderate-to-vigorous physical activity, setting Frequency, Intensity, Time, and Type (FITT) goals, and analyzing physiological indicators. Paired-samples t-test results indicated statistically significant pretest-posttest differences at the .05 significance level. The findings provide evidence that the developed ESIMs were instructionally appropriate and that their implementation was associated with substantial improvement in learners' competency scores. However, interpretation is limited by the small sample, single-school setting, one-group design, and absence of a comparison group. Further research using larger samples and controlled or quasi-experimental designs is recommended.

Keywords: senior high school learners; inquiry-based learning; digital learning resources; competency mastery; instructional intervention

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1. Introduction

Physical Education (PE) is an essential component of basic education because it contributes not only to physical fitness but also to cognitive, social, emotional, and behavioral development. Through structured physical activity and health-related learning experiences, learners develop knowledge and skills associated with fitness, safety, decision-making, teamwork, discipline, and lifelong participation in physical activity. In contemporary educational settings, PE therefore extends beyond participation in physical activities and requires learners to understand and apply principles related to health, fitness, physiological responses, and safe participation.

The cognitive dimension of PE has become increasingly important as learners are expected to make informed decisions about physical activity and health. Senior high school learners, for example, are expected to establish fitness goals, monitor physiological responses, apply training principles, observe safety protocols, and participate in or organize activities addressing health and fitness concerns. The Philippine Department of Education (DepEd) Senior High School Physical Education and Health curriculum explicitly includes competencies involving the Frequency, Intensity, Time, and Type (FITT) principle, moderate-to-vigorous physical activities (MVPAs), physiological indicators such as heart rate and rate of perceived exertion, personal safety protocols, and participation in organized health- and fitness-related events.

The Department of Education's learning resources further demonstrate the continuing instructional importance of these competencies. Its Senior High School PE resources include modules on setting FITT goals, engaging in moderate-to-vigorous physical activities, observing personal safety protocols, analyzing physiological indicators, and organizing fitness events. Despite their importance, mastery of these competencies may remain difficult for learners. Physical Education instruction often requires learners to connect conceptual knowledge with actual performance and decision-making. Difficulties may arise when learners have limited access to instructional resources, insufficient opportunities for guided practice, or difficulty translating abstract concepts into concrete physical activity situations.

The Philippine educational context has also experienced continuing demands for flexible and resource-responsive learning. DepEd's Most Essential Learning Competencies (MELCs) were introduced to identify essential competencies and guide schools in designing learning delivery approaches and instructional resources responsive to local contexts and learner diversity. The MELCs specifically serve as a reference for the development of learning activity sheets, self-learning modules, and other instructional materials.

Digital technology provides an opportunity to strengthen instructional support in PE. Technology can facilitate the presentation of demonstrations, visual explanations, interactive activities, immediate feedback, and self-paced learning experiences. In PE specifically, digital tools can complement physical practice by helping learners visualize procedures, understand physiological concepts, monitor performance, and review concepts beyond direct classroom explanation. A review of technology use in PE reported that digitalization has become an important component of PE teaching and learning and has supported adaptations in educational practice (Marín-Suelves et al., 2023). However, the mere availability of technology does not guarantee improved learning. Digital resources must be deliberately designed, curriculum-aligned, accessible, and responsive to identified learner needs. The ADDIE model provides a systematic framework for instructional design through the phases of Analysis, Design, Development, Implementation, and Evaluation. Recent literature describes ADDIE as an adaptable framework for integrating technology into instructional design and emphasizes its usefulness in systematically developing technology-supported learning resources (Abuhassna et al., 2024).

Strategic Intervention Materials (SIMs) provide another relevant foundation for addressing learning gaps. SIMs are designed to provide focused instructional support for competencies that learners have not adequately mastered. Previous research in the Philippine context has reported positive learning outcomes associated with SIM use. For example, Suarez and Casinillo (2020) reported improved performance among learners exposed to a strategic intervention material addressing a least-mastered Science competency. Similarly, Rosal et al. (2022) developed an Electronic Strategic Intervention Material for Grade 11 General Chemistry and reported significant improvement between pretest and posttest performance.

The transition from printed SIMs to electronic or digital formats is particularly relevant in contemporary learning environments. Electronic Strategic Intervention Materials (ESIMs) can combine the targeted remediation characteristics of SIMs with multimedia, interactive activities, digital assessment, hyperlinks, videos, and other technology-supported resources. Such integration may provide learners with more varied opportunities to encounter, practice, and apply difficult concepts. The pedagogical organization of digital materials is equally important. Inquiry-based learning (IBL) positions learners as active participants in the learning process by encouraging them to explore questions, examine information, investigate ideas, evaluate evidence, and construct understanding. Ernst et al. (2017) describe IBL as an approach that can take different forms across learning environments but emphasizes active engagement with disciplinary ideas rather than passive reception of information.

A constructivist perspective similarly emphasizes that learners actively construct knowledge through meaningful interaction with experiences. From this perspective, instructional materials should not merely provide information; they should create opportunities for learners to connect new concepts with prior knowledge, engage in activities, reflect on their understanding, and apply concepts in meaningful situations. The combination of ADDIE, inquiry-based learning, and digital instructional resources therefore provides a potentially useful foundation for developing ESIMs in PE. ADDIE provides the development process, inquiry-based learning provides the pedagogical organization of activities, and digital technology provides the medium through which multimedia and interactive learning experiences can be delivered.

Despite the growing literature on educational technology and intervention materials, there remains a need for studies specifically examining electronic intervention materials designed around least-mastered competencies in Senior High School Physical Education. Existing studies on SIMs and ESIMs have predominantly focused on areas such as Science, Chemistry, and Mathematics. Evidence concerning their application to PE competencies remains comparatively limited. The present study addresses this gap by developing and evaluating ESIMs for Grade 12 Physical Education. The materials targeted four competencies identified as least mastered: organizing fitness events, observing safety protocols during moderate-to-vigorous physical activity, setting FITT goals, and analyzing physiological indicators. The study examined the quality of the developed materials through expert evaluation and investigated changes in learner competency following an eight-week implementation.

The study was guided by the following objectives: (a) to develop ESIMs addressing identified least-mastered Grade 12 PE competencies; (b) to determine the quality of the developed ESIMs in terms of content, instructional, technical, and other quality indicators; (c) to determine learners' competency levels before and after ESIM implementation; (d) to determine whether a statistically significant difference existed between pretest and posttest scores; and (e) to determine the magnitude of improvement in learner competency scores.

The study is significant because it provides an example of how curriculum-aligned digital intervention materials can be developed to respond directly to identified learning gaps. For PE teachers, the materials may provide an additional instructional resource for remediation and reinforcement. For school leaders and learning resource developers, the findings may provide evidence for the systematic development and evaluation of digital instructional materials. For researchers, the study provides a basis for further investigation using larger samples and stronger experimental designs.

1.1 Theoretical and Conceptual Framework

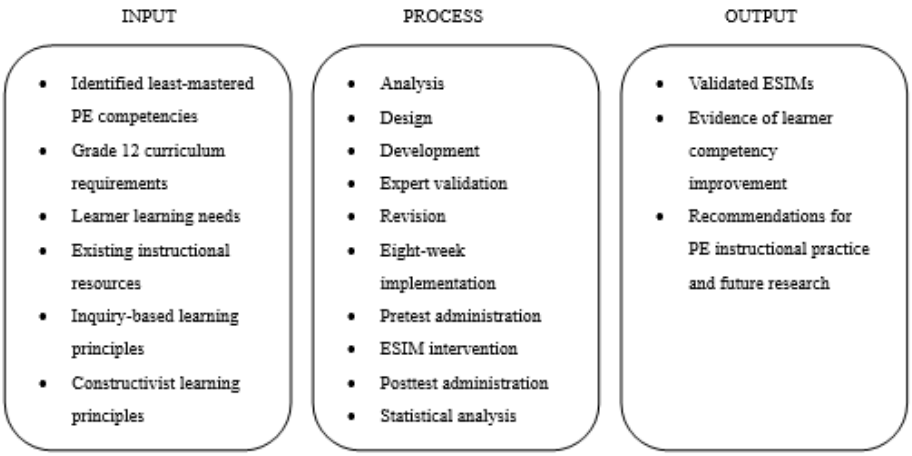
Constructivist Learning Theory - The study is grounded partly in constructivist learning theory, which views learners as active participants in constructing knowledge rather than passive recipients of information. Learning occurs when learners interact with experiences, connect new information to existing knowledge, and develop understanding through meaningful activities. The ESIMs were designed according to this perspective by providing learners with opportunities to explore concepts, perform activities, examine information, assess their understanding, and apply knowledge. The materials therefore functioned not simply as electronic repositories of information but as structured learning environments. The constructivist perspective is particularly relevant to PE because learners must connect conceptual knowledge with actual decision-making and physical activity. Understanding the FITT principle, for example, requires learners to move beyond memorizing the four components and apply them in establishing realistic fitness goals.

Inquiry-Based Learning - Inquiry-based learning served as the principal pedagogical structure of the ESIMs. The approach encourages learners to engage with questions, information, activities, and evidence in order to develop understanding. The materials were organized around four broad inquiry-oriented stages: (a) Inquire—learners were introduced to a problem, question, or learning situation through the Guide Card; (b) Reflect and Research—learners examined information and completed activities using the Activity Card; (c) Evaluate—learners demonstrated their understanding through assessment tasks; and (d) Construct and Extend—learners applied and expanded their knowledge through enhancement activities. This sequence was intended to move learners from initial exploration toward application and deeper understanding.

ADDIE as the Instructional Design Framework - ADDIE provided the systematic development framework for the study. The five phases were Analysis, Design, Development, Implementation, and Evaluation. The Analysis phase identified learning needs and least-mastered competencies. The Design phase established learning objectives, content structure, and instructional activities. The Development phase produced the electronic materials. The Implementation phase involved classroom use of the materials. The Evaluation phase examined both expert assessments of material quality and changes in learner performance. The distinction between ADDIE and inquiry-based learning is important. ADDIE functioned as the development framework, whereas inquiry-based learning functioned as the instructional approach embedded within the developed ESIMs.

1.2 Conceptual Framework

The study followed an input-process-output structure. The conceptual framework integrated curriculum requirements and identified least-mastered competencies (inputs), the systematic development and validation of ESIMs through the ADDIE model and inquiry-based organization (process), and expert quality ratings together with learner pretest–posttest competency outcomes (outputs).



1.3 Research Questions

The study sought to answer the following questions:

- What Electronic Strategic Intervention Materials can be developed to address the identified least-mastered competencies in Grade 12 Physical Education?
- What is the level of quality of the developed ESIMs in terms of content quality, instructional quality, technical quality, and other quality indicators (including conceptual, factual, grammatical, and typographical accuracy)?
- What are the competency levels of Grade 12 learners in the identified Physical Education competencies before and after implementation of the ESIMs?
- Is there a significant difference between the pretest and posttest competency scores of Grade 12 learners following implementation of the ESIMs?
- What is the magnitude of improvement in learners' competency scores following implementation of the ESIMs?

2. Method

Research Design - The study employed a research and development design to develop, validate, and evaluate ESIMs for Grade 12 Physical Education. The ADDIE model was used as the instructional design framework. For the learner-outcome component, a one-group pretest–posttest design was employed. The design involved administering an achievement test before the intervention and again after implementation of the ESIMs. This design was appropriate for an initial evaluation of the developed instructional materials because it allowed the researchers to determine whether learner competency scores changed following exposure to the intervention. However, because there was no control or comparison group, the design does not permit definitive causal attribution of all observed changes to the ESIMs alone.

Research Locale - The study was conducted in a public secondary school in the Schools Division of Candon City, Philippines. The school was selected because available school-level performance evidence and classroom observations indicated learning difficulties in selected Grade 12 Physical Education competencies. The study setting represents a Philippine public-school context in which teachers are expected to address curriculum competencies using available learning resources while responding to identified learner needs.

Participants - The study involved two groups. The first group consisted of six expert evaluators who assessed the developed ESIMs. The evaluators included professionals with expertise relevant to Physical Education, instructional supervision, language, and educational technology. The second group consisted of 24 Grade 12 learners who participated in the implementation of the ESIMs. The learners were selected based on their exposure to the identified least-mastered competencies and their eligibility for participation in the intervention. All 24 learners completed both the pretest and posttest. Consequently, the study had a complete paired dataset with no reported attrition between the two assessments.

Target Competencies - Four Grade 12 PE competencies were targeted: (a) organizing a fitness event for a target health issue or concern; (b) observing personal safety protocols during moderate-to-vigorous physical activity; (c) setting FITT goals based on training principles to achieve or maintain health-related fitness; and (d) analyzing physiological indicators such as heart rate, rate of perceived exertion, and pacing associated with moderate-to-vigorous physical activity. These competencies are represented in DepEd's Senior High School Physical Education and Health curriculum and related learning resources.

Development of the ESIMs

- *Analysis Phase* - The Analysis phase focused on identifying the learning needs of the target learners. Available performance evidence, classroom observations, and curriculum requirements were reviewed to identify competencies requiring additional instructional support. Four competencies were subsequently prioritized for intervention.

- *Design Phase* - During the Design phase, the researchers established the learning objectives, content sequence, instructional activities, assessment tasks, and multimedia components. The ESIMs were structured into five major components: Guide Card (provided orientation, learning objectives, directions, and initial inquiry prompts); Activity Card (provided learning tasks, exploration activities, multimedia resources, and guided practice); Assessment Card (provided activities for checking learner understanding); Enhancement Card (provided enrichment, application, and higher-order activities); and Reference Card (provided supplementary information and learning resources). The structure was designed to support inquiry-based learning and progressive learner engagement.

- *Development Phase* - The Development phase involved producing the electronic materials. Multimedia components included instructional videos, interactive activities, quizzes, digital references, and gamified learning tasks. The content was aligned with the targeted competencies and reviewed for conceptual accuracy, factual correctness, language quality, instructional appropriateness, and technical functionality.

- *Validation and Revision* - The preliminary ESIMs were submitted to six expert evaluators. The evaluators assessed the materials using the DepEd evaluation criteria for non-print learning resources. Evaluator ratings and comments were reviewed, and appropriate revisions were incorporated before classroom implementation.

- *Implementation Phase* - The finalized ESIMs were implemented over eight weeks, with two sessions per week, each lasting approximately 60 minutes. The intervention therefore consisted of 8 weeks, 2 sessions per week, 16 total sessions, and approximately 16 instructional hours. A pretest was administered before the intervention. Learners then participated in the ESIM-based instructional activities. After completion of the eight-week intervention, the same validated achievement test was administered as the posttest. All 24 learners completed both assessments.

- *Evaluation Phase* - Evaluation occurred at two levels. First, expert evaluation determined the quality of the ESIMs. Second, learner performance was evaluated by comparing pretest and posttest competency scores. The combination of expert validation and learner-outcome evidence provided complementary information regarding the instructional quality and potential usefulness of the developed materials.

Research Instruments

- *ESIM Evaluation Instrument* - The developed materials were evaluated using the Department of Education evaluation criteria for non-print learning resources. The criteria examined content quality, instructional quality, technical quality, and other quality indicators, including conceptual, factual, grammatical, and typographical accuracy. The rating scale used in the study interpreted a score of 4 as Very Satisfactory, consistent with the DepEd evaluation framework, in which 4 represents Very Satisfactory, 3 Satisfactory, 2 Poor, and 1 Not Satisfactory.

- *Achievement Test* - A validated teacher-made achievement test was used to assess learner competency before and after the intervention. The test was designed to measure the four targeted competencies and was administered under comparable conditions during the pretest and posttest.

Data-Gathering Procedure - Data gathering followed this sequence: (a) identification of least-mastered

competencies; (b) analysis of learner needs and curriculum requirements; (c) design and development of the ESIMs; (d) expert evaluation of the preliminary materials; (e) revision based on expert feedback; (f) administration of the pretest; (g) eight-week implementation of the ESIMs; (h) administration of the posttest; (i) coding and organization of the data; and (j) statistical analysis and interpretation. Participant codes were used to match pretest and posttest scores while maintaining confidentiality.

Data Analysis - Means were used to summarize expert ratings and learner competency scores. Mean gain was calculated by subtracting the pretest mean from the posttest mean. A paired-samples t-test was used to determine whether the difference between pretest and posttest scores was statistically significant. The significance level was set at $\alpha = .05$. Because the same learners completed both assessments, the paired-samples test was appropriate for analyzing within-participant changes. Because individual scores and standard deviations of paired differences were not supplied in the present dataset, no effect size is reported here.

Ethical Considerations - The study observed applicable ethical principles for educational research involving learners. Permission to conduct the research was secured from the appropriate school authorities. Participants were informed about the study's purpose, procedures, and voluntary nature. Where required, appropriate parental or guardian consent and learner assent were obtained. Participant identities were protected by assigning codes rather than using names in the research dataset and manuscript. Data were treated confidentially and used solely for research purposes. Participation in the study did not affect learners' academic standing, grades, or access to regular instruction. The intervention was designed to provide additional instructional support for identified learning needs.

3. Results

3.1 Developed Electronic Strategic Intervention Materials

The ESIMs were developed around four inquiry-oriented stages and five instructional components, as summarized in Table 1.

Table 1
Structure of the ESIMs Based on Inquiry-Based Learning

Inquiry-oriented stage	ESIM component	Primary function
Inquire	Guide Card	Introduces the learning problem, objectives, directions, and inquiry prompts
Reflect and Research	Activity Card	Provides exploration, guided practice, multimedia resources, and investigation
Evaluate	Assessment Card	Checks learner understanding and competency attainment
Construct and Extend	Enhancement Card	Provides application, enrichment, and higher-order learning activities
Support and Reference	Reference Card	Provides supplementary information and learning resources

Note. The structure demonstrates that the ESIMs were designed as an integrated instructional package rather than a collection of independent digital activities.

3.2 Content Quality

The ESIMs received a total rating of 39.80 out of 40 for content quality (see Table 2). All indicators received a mean rating of 4.00 except freedom from bias, which received 3.80. The results indicate that the expert evaluators considered the content highly aligned, accurate, organized, relevant, and appropriate for the intended learners. The slightly lower rating for freedom from bias suggests a minor area for refinement, particularly in ensuring that examples and contextual representations remain inclusive and sensitive to diverse learner experiences.

Table 2
Expert Evaluation of ESIMs in Terms of Content Quality

Criterion	Mean	Interpretation
Alignment with learning competencies	4.00	Very Satisfactory
Contribution to mastery of objectives	4.00	Very Satisfactory

Table 2 …continued

Accuracy of content	4.00	Very Satisfactory
Up-to-date content	4.00	Very Satisfactory
Logical organization	4.00	Very Satisfactory
Freedom from bias	3.80	Very Satisfactory
Promotion of critical thinking	4.00	Very Satisfactory
Relevance to real-life situations	4.00	Very Satisfactory
Appropriateness of language	4.00	Very Satisfactory
Promotion of positive values	4.00	Very Satisfactory
Total	39.80/40	Passed

3.3 Instructional Quality

The ESIMs obtained a total rating of 39.80 out of 40 for instructional quality (see Table 3). The findings indicate that the materials were considered clear, appropriately structured, engaging, and responsive to learner needs. Creativity stimulation received the only rating below 4.00. Although still interpreted as Very Satisfactory, this result suggests that future versions could incorporate additional open-ended and learner-generated activities.

Table 3
Expert Evaluation of ESIMs in Terms of Instructional Quality

Criterion	Mean	Interpretation
Clear purpose	4.00	Very Satisfactory
Achievement of purpose	4.00	Very Satisfactory
Clear learning objectives	4.00	Very Satisfactory
Appropriate difficulty	4.00	Very Satisfactory
Use of multimedia elements	4.00	Very Satisfactory
Engagement and motivation	4.00	Very Satisfactory
Creativity stimulation	3.80	Very Satisfactory
Effective feedback	4.00	Very Satisfactory
Learner control	4.00	Very Satisfactory
Integration with prior learning	4.00	Very Satisfactory
Total	39.80/40	Passed

3.4 Technical Quality

The ESIMs obtained the maximum rating across all technical indicators (see Table 4). The findings indicate that the materials were considered visually clear, navigable, compatible, and free from identified technical problems.

Table 4
Expert Evaluation of ESIMs in Terms of Technical Quality

Criterion	Mean	Interpretation
Readability of screen display	4.00	Very Satisfactory
Clarity of visuals	4.00	Very Satisfactory
Visual engagement	4.00	Very Satisfactory
Accuracy of visuals	4.00	Very Satisfactory
User support materials	4.00	Very Satisfactory
Navigation design	4.00	Very Satisfactory
Ease of independent use	4.00	Very Satisfactory
System compatibility	4.00	Very Satisfactory
Absence of technical errors	4.00	Very Satisfactory
Total	36/36	Passed

3.5 Other Quality Indicators

All four indicators obtained the maximum rating (see Table 5). The expert evaluators therefore found no identified conceptual, factual, grammatical, or typographical errors in the final materials.

Table 5
Expert Evaluation of ESIMs in Terms of Other Quality Indicators

Criterion	Mean	Interpretation
Conceptual errors	4.00	Very Satisfactory

Table 5 …continued

Factual errors	4.00	Very Satisfactory
Grammatical errors	4.00	Very Satisfactory
Typographical errors	4.00	Very Satisfactory
Total	16/16	Passed

3.6 Learner Competency Before and After Implementation

The results demonstrate improvement across all four targeted competencies (see Table 6). The largest mean gain occurred in organizing fitness events (2.67), followed by analyzing physiological indicators (2.54), observing safety protocols (2.46), and setting FITT goals (2.37). The mean across the four competencies increased from 1.67 before the intervention to 4.18 after implementation, corresponding to a mean increase of 2.51 scale points.

Table 6
Pretest and Posttest Competency Scores

Competency	Pretest M	Interpretation	Posttest M	Interpretation	Mean Gain
Organizing fitness events	1.79	Needs Improvement	4.46	Excellent	2.67
Observing safety protocols	1.71	Needs Improvement	4.17	Very Satisfactory	2.46
Setting FITT goals	1.63	Needs Improvement	4.00	Very Satisfactory	2.37
Analyzing physiological indicators	1.54	Needs Improvement	4.08	Very Satisfactory	2.54
Mean across competencies	1.67	Needs Improvement	4.18	Excellent	2.51

Note. Overall values are calculated as the arithmetic mean of the four competency means.

3.7 Difference Between Pretest and Posttest Scores

The computed t-values for all four competencies exceeded the critical value of 2.07 at the .05 significance level (see Table 7). Thus, the null hypothesis of no significant difference between pretest and posttest performance was rejected for each competency. The results indicate statistically significant improvement in learner scores following implementation of the ESIMs.

Table 7
Paired-Samples t-Test of Pretest and Posttest Scores

Competency	t(23)	Critical value (α = .05)	Decision
Organizing fitness events	10.85	2.07	Reject H_0
Observing safety protocols	10.55	2.07	Reject H_0
Setting FITT goals	11.48	2.07	Reject H_0
Analyzing physiological indicators	9.69	2.07	Reject H_0
Overall	23.03	2.07	Reject H_0

Note. Exact p-values were not available from the original statistical output; decisions are based on comparison with the critical value.

4. Discussion

Quality of the Developed ESIMs - The expert evaluation results indicate that the ESIMs achieved a high level of quality across content, instructional, technical, and accuracy-related dimensions. The results suggest that the materials were appropriately aligned with the targeted competencies and designed in a form considered suitable for the intended learners. The strong content ratings are particularly important because intervention materials should be directly connected to the competencies they are intended to remediate. The use of curriculum-based competency identification ensured that the ESIMs were not developed as general digital resources but as targeted responses to specific learning difficulties. The alignment of the ESIMs with DepEd curriculum requirements further strengthens their contextual relevance.

Instructional Structure and Inquiry-Based Learning - The ESIMs incorporated inquiry-oriented activities to move learners beyond passive reception of information. The Guide Card provided an entry point into the learning problem, while the Activity Card enabled exploration and practice. Assessment and enhancement components then provided opportunities for checking understanding and extending application. This organization is consistent with inquiry-based learning, which emphasizes active engagement with questions, ideas, evidence, and disciplinary practices (Ernst et al., 2017). The present findings should not be interpreted as proving that

inquiry-based learning itself caused the observed gains because the study did not experimentally isolate inquiry-based learning from the other components of the intervention. Rather, the results suggest that an ESIM structured using inquiry-oriented activities can function as a coherent instructional intervention.

Digital Resources in Physical Education - The findings support the potential contribution of digital resources to PE instruction. The ESIMs incorporated videos, interactive activities, quizzes, and digital references, allowing learners to access information through multiple forms of representation. This is particularly relevant for PE competencies involving procedural knowledge. Learners may benefit from seeing demonstrations of appropriate practices rather than relying exclusively on verbal descriptions. Similarly, concepts such as heart rate, rate of perceived exertion, pacing, and FITT planning can be represented through visual examples and interactive tasks. The role of technology in PE has received increasing attention. Marín-Suelves et al. (2023) reported that technology has become an important component of PE teaching and learning, particularly following the educational changes associated with the COVID-19 pandemic. The present study extends this discussion by applying digital resources specifically to targeted intervention rather than using technology only as a general teaching medium.

Improvement in Learner Competency - The learner results demonstrated consistent improvement across all four targeted competencies. Pretest scores indicated that learners initially experienced difficulty, whereas posttest scores were substantially higher after the eight-week intervention. The largest mean gain occurred in organizing fitness events. This may reflect the benefit of providing learners with structured procedures, examples, and guided planning activities. Organizing a fitness event requires learners to integrate several types of knowledge, including identifying a health concern, planning activities, considering participants, and applying safety principles. Digital step-by-step guidance may therefore reduce the cognitive burden associated with organizing complex tasks. The improvement in analyzing physiological indicators is also notable. This competency involves interpreting information such as heart rate, rate of perceived exertion, and pacing. Multimedia and interactive representations may help learners connect physiological concepts with actual physical activity experiences. The improvement in FITT goal setting is similarly relevant. The ESIM activities provided opportunities for learners to practice applying the four FITT dimensions rather than simply recalling their definitions.

Relationship to Previous Intervention-Material Studies - The findings are consistent with previous research on strategic intervention materials. Suarez and Casinillo (2020) reported that SIM use improved academic performance among Science learners and demonstrated the usefulness of targeted intervention materials for addressing least-mastered competencies. Rosal et al. (2022) similarly found significant improvement following the implementation of an electronic strategic intervention material in General Chemistry. The present study contributes to this literature by extending the application of electronic intervention materials to Physical Education. The results suggest that the intervention-material concept is not restricted to traditionally academic subjects but can also be adapted to competency-based areas involving health, fitness, physical activity, and performance.

ADDIE and Systematic Development - The ADDIE framework helped organize the development process from identification of learner needs to evaluation of the finished product. This systematic sequence is important because digital instructional materials can become technically attractive but pedagogically weak when development begins with technology rather than learning needs. In the present study, the Analysis phase began with identified competency gaps. This ensured that subsequent design and development decisions were connected to a specific instructional problem. The validation stage then provided external evaluation before implementation. The systematic nature of ADDIE is consistent with literature describing the model as adaptable for technology-integrated instructional design (Abuhassna et al., 2024).

Statistical Evidence and Interpretation - The paired-samples t-test showed statistically significant differences between pretest and posttest scores across all four competencies. The consistency of the findings across the competency areas strengthens the descriptive evidence that learners performed better following implementation. However, statistical significance alone does not establish that the ESIMs were solely responsible for the observed

improvement. The one-group pretest–posttest design is susceptible to alternative explanations, including maturation, repeated testing, exposure to regular classroom instruction, teacher influence, and other learning experiences occurring during the eight-week period. Accordingly, the present findings should be interpreted as evidence of improvement following ESIM implementation, rather than definitive proof of a causal treatment effect.

Areas for Further Improvement - Although the ESIMs received very satisfactory ratings, two areas obtained slightly lower ratings: freedom from bias and creativity stimulation. Future versions should therefore include more culturally and contextually diverse examples and provide additional opportunities for learners to generate their own fitness plans, propose health-related activities, solve authentic PE problems, and reflect on personal physical activity experiences. These refinements could shift the materials from primarily guided remediation toward a balance between structured support and learner autonomy.

Limitations - The study has several limitations that should be considered when interpreting its findings. First, the sample consisted of only 24 Grade 12 learners from one public secondary school. The findings therefore cannot automatically be generalized to all Grade 12 learners or other educational settings. Second, the study employed a one-group pretest–posttest design without a control or comparison group. Consequently, although significant improvement was observed after the intervention, alternative explanations for the change cannot be completely excluded. Third, the implementation lasted eight weeks. The study did not include a delayed posttest; therefore, the persistence of the observed learning gains remains unknown. Fourth, the learner outcome measure was a teacher-made achievement test. Although the instrument was validated for the study, future research could strengthen measurement through independently validated assessments and performance-based measures. Fifth, the study focused primarily on competency scores and did not systematically measure learner motivation, engagement, usability, satisfaction, or actual changes in physical activity behavior. Finally, the study evaluated the ESIM package as a whole. It did not isolate the individual contribution of videos, gamification, inquiry activities, assessment features, or other multimedia components.

5. Conclusions

The study successfully developed Electronic Strategic Intervention Materials designed to address identified least-mastered competencies in Grade 12 Physical Education. The materials were developed systematically using the ADDIE framework and organized around inquiry-based learning principles. Expert evaluation indicated that the ESIMs achieved very satisfactory ratings in content quality, instructional quality, technical quality, and other quality indicators. These findings indicate that the materials were considered appropriate, accurate, relevant, and technically functional for the intended instructional context.

The implementation of the ESIMs over eight weeks, consisting of 16 approximately 60-minute sessions, was followed by substantial improvement in learners' competency scores across all four targeted areas. The largest mean gain was observed in organizing fitness events, followed by analyzing physiological indicators, observing safety protocols, and setting FITT goals. The paired-samples t-test further demonstrated statistically significant differences between pretest and posttest scores across all four competencies. However, because the study used a small one-group pretest–posttest design, the findings should not be interpreted as definitive causal evidence that the ESIMs alone produced the observed gains. Instead, the study provides contextual and preliminary empirical evidence supporting the instructional value of the developed materials. Overall, the findings indicate that curriculum-aligned electronic intervention materials can provide a promising form of targeted instructional support in Physical Education. The materials may be particularly useful when they are developed from documented learning gaps, systematically validated, and integrated with teacher-guided instruction and actual physical activity experiences.

5.1 Implications for Teachers and Learners

Implications for Teachers - The findings of this study offer several practical implications for PE teachers.

First, ESIMs can serve as a structured, curriculum-aligned resource for remediation and reinforcement of least-mastered competencies. Teachers can use or adapt the five-card structure (Guide, Activity, Assessment, Enhancement, and Reference) to create targeted interventions that address specific learning gaps identified through formative assessment or classroom observation. Second, the systematic use of the ADDIE model demonstrates a replicable process for developing digital instructional materials. Teachers are encouraged to begin with a clear analysis of learner needs and curriculum requirements before designing content or selecting technology tools. This needs-first approach helps ensure that digital resources remain pedagogically purposeful rather than merely technologically attractive. Third, digital intervention materials should complement—not replace—physical activity and teacher facilitation. PE remains fundamentally experiential. ESIMs are most effective when integrated with opportunities for learners to perform, practice, and apply skills in authentic physical settings. Teachers should therefore plan for a balanced combination of digital exploration, guided practice, and active physical engagement. Fourth, teachers developing or adapting digital materials are advised to subject their resources to systematic content, instructional, technical, and accuracy evaluation before classroom implementation. Expert or peer review can identify areas for refinement and strengthen the quality of the materials. Finally, schools may consider building teacher capacity in instructional design and digital learning resource development. Professional development focused on ADDIE, inquiry-based learning, and the creation of electronic intervention materials can empower teachers to respond more effectively to local learning gaps.

Implications for Learners - For learners, ESIMs offer structured, self-paced opportunities to revisit and master difficult PE competencies. The inquiry-oriented organization encourages active engagement: learners begin with a guiding question or problem, explore information and multimedia resources, check their understanding through assessment tasks, and extend their learning through application activities. The materials support multiple pathways to understanding. Visual demonstrations, interactive tasks, and digital references can help learners who struggle with purely verbal or text-based explanations. This multimodal approach is particularly valuable for competencies that require connecting conceptual knowledge (for example, the FITT principle or physiological indicators) with practical decision-making and physical activity. ESIMs also promote greater learner autonomy and self-regulation. Because the materials are electronic and can be accessed outside direct teacher supervision, learners can review content at their own pace, revisit challenging sections, and take greater ownership of their progress toward competency mastery. Importantly, the benefits of ESIMs are maximized when learners actively engage with the materials and connect digital learning experiences to actual physical practice. Learners are encouraged to use the knowledge and skills developed through the ESIMs—such as setting realistic FITT goals, monitoring physiological indicators, observing safety protocols, and organizing fitness activities—in their personal physical activity routines and school-based programs.

5.2 Recommendations

Based on the findings, the following recommendations are proposed:

- PE teachers may use or adapt the ESIM structure as supplementary remediation material for learners experiencing difficulty with specific competencies.
- Schools and learning resource developers may develop additional electronic intervention materials based on locally identified learning gaps.
- Teachers developing digital materials should subject their resources to systematic content, instructional, technical, and accuracy evaluation before implementation.
- Future ESIM development should strengthen creativity-oriented activities, learner-generated tasks, culturally responsive examples, and opportunities for independent application.
- Future researchers should use larger samples involving multiple schools to improve the generalizability of findings.

- Quasi-experimental or randomized controlled designs should be employed in future research to provide stronger evidence regarding the causal contribution of ESIMs.
- Delayed posttests should be incorporated in subsequent studies to determine whether competency gains are retained over time.
- Future studies should examine additional outcomes such as learner engagement, motivation, usability, satisfaction, and actual physical activity behavior.

Acknowledgements **-** The author expresses appreciation to the school administrators, expert evaluators, teachers, and Grade 12 learners who contributed to the development, validation, and implementation of the Electronic Strategic Intervention Materials. The author also acknowledges the support of the relevant educational authorities and school personnel who facilitated the conduct of the study.

Funding **-** This research received no external funding.

Author Contributions **-** The sole author was responsible for the conceptualization, methodology, development of the Electronic Strategic Intervention Materials, investigation, data collection, formal analysis, interpretation of findings, manuscript preparation, revision, and final approval of the manuscript.

Conflict of Interest **-** The author declares no conflict of interest related to the conduct, development, evaluation, or publication of this study.

AI Use Disclosure **-** Generative artificial intelligence was used to assist with language refinement, manuscript organization, and academic presentation. All AI-assisted content was reviewed, verified, revised, and approved by the author. The author retains full responsibility for the accuracy, originality, interpretation, and integrity of the manuscript and its reported findings.

Data Availability **-** The data supporting the findings of this study are not publicly available because they contain information derived from a small group of student participants and are subject to confidentiality and privacy considerations. Aggregated data may be made available by the corresponding author upon reasonable request, subject to applicable institutional and ethical requirements.

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