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Research Article

Effectiveness of a Problem-Based Learning Module in Improving Sports Injury Management Skills among Prospective Elementary School Teachers

Anton Sukowati[1,*], Supriyati Fatma Rabia[2], Meilin A. N. Azizah[2], M. Fadli[2]
[1] Department of Physical Education, Universitas Pendidikan Muhammadiyah, Papua Barat Daya, Indonesia
[2] Department of Elementary School Teacher Education, Universitas Pendidikan Muhammadiyah, Papua Barat Daya, Indonesia

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ABSTRACT

Purpose of the study: This study aims to evaluate the validity, practicality, and effectiveness of a Problem-Based Learning (PBL) module designed to strengthen sports injury management competence among prospective elementary school teachers.

Methodology: The research employed a Research and Development design using the ADDIE model, with data collected through expert validation sheets, lecturer and student practicality questionnaires, and pretest–posttest learning outcome tests. Data analysis was conducted using descriptive statistics, paired sample t-tests, and N-Gain analysis with SPSS software.

Main Findings: The results showed that the module achieved high expert validity (92%) and strong curriculum alignment (96%). Practicality evaluation indicated very good acceptance from students (88.2%) and lecturers (91.6%). Learning outcomes improved significantly from a pretest mean score of 63.5 to a posttest mean score of 84.2 ($p < 0.05$), supported by a moderate N-Gain value of 0.567.

Novelty/Originality of this study: The novelty of this study lies in the development of a PBL-based module specifically focused on sports injury management and first aid training for prospective teachers, supported by a multi-party evaluation approach involving experts, lecturers, and students, which provides a comprehensive assessment of the module's feasibility and contributes to strengthening safety literacy in physical education contexts.

Corresponding Author:
Anton Sukowati,
Department of Physical Education, Universitas Pendidikan Muhammadiyah,
Jl. Pendidikan No.27, Kelurahan Klabulu, Malaimsimsa, Sorong City, Southwest Papua, 98416 Indonesia
Email: sukowatianton79@gmail.com

1. INTRODUCTION

Physical education in elementary schools plays a strategic role in developing the cognitive, affective, and psychomotor aspects of students through structured physical activities [1]–[3]. In addition to providing fitness benefits and developing basic motor skills, physical activities also have the potential to cause injuries if not accompanied by adequate supervision and first aid knowledge. Therefore, elementary school teachers are required to have basic competencies in sports injury management to ensure the safety of students during the learning process. A number of studies show that the success of injury prevention and treatment is greatly

influenced by the understanding of teachers and prospective teachers of the mechanisms of injury and appropriate initial treatment procedures [4], [5].

However, elementary school teacher education students, as future educators, still demonstrate limited understanding and skills in sports injury management. This condition is inseparable from the elementary school teacher education curriculum, which emphasizes general pedagogical aspects, while content related to physical health, injury prevention, and first aid is still relatively limited. Previous research findings even show that students with a background in sports are still prone to making mistakes in the initial handling of injuries, so it can be assumed that the competency gap among elementary school teacher education students in general tends to be greater [6]. In addition, other studies emphasize the importance of systematic assessment of the disposition and competence of prospective teachers to ensure their readiness to face real situations in schools, including in handling student injuries [7].

The Problem-Based Learning (PBL) approach has been widely recommended as an effective learning strategy for improving learning engagement, analytical abilities, and problem-solving skills through the presentation of authentic problems [8]–[10]. In the context of teacher education, PBL has been shown to strengthen case-based learning, collaboration, and deep reflection, which contribute to the development of conceptual understanding and practical skills [14], [15]. A number of studies also show that the integration of PBL with technological support can increase the motivation and readiness of prospective teachers in facing modern learning challenges [16]–[18]. These characteristics make PBL theoretically relevant for application in sports injury management learning, which requires situational analysis, quick decision-making, and appropriate responses based on real conditions.

However, the development of PBL-based teaching materials in the context of sports injury management specifically aimed at elementary school teacher education students is still very limited. Previous studies have generally focused only on improving understanding or learning outcomes, without comprehensive product evaluation covering aspects of validity, practicality, and effectiveness [19], [20]. On the other hand, the need for systematic evaluation instruments to assess the competence of prospective teachers, particularly in learning practices and handling field situations, has also not been optimally met [21], [22]. This condition indicates a research gap in the development and comprehensive evaluation of PBL-based sports injury management modules for elementary school teacher education students.

From an educational evaluation perspective, the quality of learning modules needs to be tested through formative and summative evaluation mechanisms that assess content suitability, practicality of use, and impact on student learning outcomes. Although the ADDIE model provides a systematic development framework, the final quality of the module must still be proven through product evaluation that reflects user needs and learning effectiveness. Therefore, the urgency of this research lies in the effort to provide PBL-based sports injury management modules that are not only supported by a strong pedagogical approach, but also empirically tested in terms of validity, practicality, and effectiveness, so as to improve the readiness and safety literacy of prospective elementary school teachers in physical education learning.

2. RESEARCH METHOD

This study applies the ADDIE development model as shown in Figure 1. This model places the Evaluate stage as an evaluative component that occurs continuously at each stage of development. Each stage of Analyze, Design, Develop, and Implement is connected through a revision flow that allows for the review of interim results so that the quality of the developed modules can be maintained. This cyclical pattern enables a more dynamic development process because the product can be refined based on formative evaluation findings before proceeding to the next stage. This approach is relevant for the development of Problem-Based Learning (PBL) modules that require multi-level validation and continuous contextual adjustments.

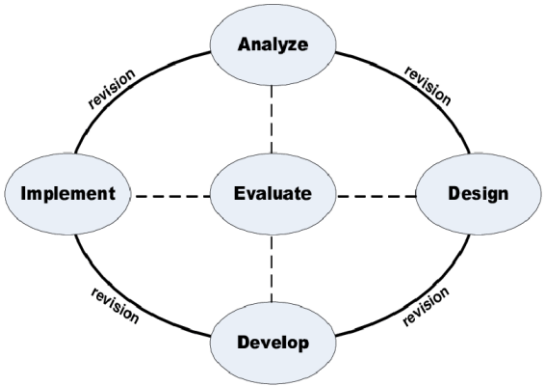

Figure 1. Steps in the ADDIE development model [23]

In addition, this research falls under the category of Research and Development (R&D), with the aim of producing and testing the quality of PBL-based sports injury management learning modules. The research sample consisted of 70 elementary school teacher education students, selected using purposive sampling, as research participants must have experience in taking physical education courses and be involved in sports injury treatment simulations. This study also involved five experts for the validation process, namely sports injury material experts, PBL experts, media experts, elementary school teacher education lecturers, and elementary school teachers.

The instruments used in this study consisted of expert validation sheets, practicality questionnaires, and learning outcome tests. The expert validation instrument was adapted from [24] formative evaluation framework and [25] criteria for learning product quality. This instrument assessed the suitability of the material, the accuracy of the concepts, the accuracy of the case studies, and the suitability of the modules to the basic education context. The reliability of the validation sheet was calculated using Cronbach's Alpha and obtained a value of $\alpha = 0.89$, which indicates high reliability. The practicality questionnaire for lecturers and students was adapted from the practicality evaluation instruments according to [24], which included aspects of ease of use, clarity of the PBL flow, readability of the material, and the usefulness of the module in the learning process. The reliability test results showed a Cronbach's Alpha value of 0.91 for students and 0.88 for lecturers.

The learning outcome test (pretest–posttest) was adopted and modified from the first aid competency assessment instrument used in the research by [26]. The reliability of this test was examined using KR-20 and obtained a value of 0.84, indicating excellent reliability. Data collection was carried out through the completion of expert validation sheets, practicality questionnaires, learning outcome tests, and observation of student activities during the implementation of the module. Data analysis was performed using descriptive statistics to assess the validity and practicality of the module, as well as a paired sample t-test and N-Gain calculation to measure the effectiveness of the module. The analysis was performed using standard statistical tools.

Analyze, The Analyze stage in this cyclical model serves to identify the needs, characteristics, and readiness of elementary school teacher education students in understanding sports injury management material. The analysis was conducted through surveys, interviews, and literature reviews on common injuries in elementary school students and the level of students' knowledge of first aid. In the cyclical model, the results of the analysis not only form the basis for the initial design but can also be revised when the next stage reveals deficiencies or inconsistencies. The findings of [27]-[29] are important references in this stage, showing that students' understanding of injuries is still low, so the developed module must provide contextual, visual, and applicable material. The Analyze stage is iterative because formative evaluation can return the process to the analysis stage to correct conceptual errors or inaccuracies in user needs. Design, The Design stage involves developing a PBL-based module framework that includes learning structures such as problem presentation, material exploration, group discussion, and reflection. In the cyclical model, the design that has been developed is not final, because the formative evaluation process that takes place in the next stage can return the development team to the Design stage if deficiencies are found in the problem scenario, material visualization, or learning activity flow. The design principle is oriented towards contextual learning so that the module must provide injury case studies that are relevant to the field experience of elementary school teachers. The research by Amerstorfer and Münster-Kistner [11], and [30] Melovitz-Vasan [30] serves as a reference in ensuring that the PBL approach in module design truly encourages active engagement, critical analysis, and collaboration among students. The module design is then forwarded to the development stage to be realized in the form of a concrete product.

Develop, The Develop stage is the process of realizing the module design into a complete learning product that includes sports injury material, first aid steps, illustrations, PBL activities, and student worksheets. In accordance with the ADDIE cyclical diagram, this stage is also supervised by a formative evaluation process that allows for revisions before the module is tested. At this stage, validation is carried out by five experts, namely injury material experts, PBL experts, media experts, elementary school teacher education lecturers, and elementary school teachers. Validation includes content feasibility, conceptual correctness, case study accuracy, and the suitability of the module to the basic education context. Validation results that indicate deficiencies in material or visual appearance can return the process to the Design stage for improvement. This iterative approach is in line with the findings of [31], which emphasize that repeated revisions improve the final quality of learning media. Implement, The implementation stage was carried out by testing the module on 70 elementary school teacher education students in practical activities and sports injury management simulations. Students were asked to analyze injury cases, discuss collaboratively, perform first aid, and develop solutions according to PBL principles. In the cyclical model, the implementation results not only became the basis for summative evaluation but also an important source of information in formative evaluation. This means that if during implementation, parts of the module are found to be unclear, ineffective, or difficult for students to understand, the module is revised before being used more widely. This approach is in line with the research by Ngereja et al [32], and Sukackė et al [33], which emphasizes that PBL is only effective if implementation is followed by close observation and continuous improvement to ensure optimal learning.

Evaluate, The Evaluate stage in the ADDIE cyclical model is a central process that takes place at two levels: formative evaluation and summative evaluation. Formative evaluation is carried out at each stage (Analyze, Design, Develop, and Implement) to identify and correct product weaknesses directly through the revision flow shown in the diagram. Summative evaluation is conducted after implementation to assess the final quality of the module through three main indicators: validity, practicality, and effectiveness. Validity is analyzed through expert assessment, practicality through student and lecturer perception questionnaires, while effectiveness is measured using pretest-posttest, paired t-tests, and N-Gain calculations. This layered evaluative approach is in line with the recommendations of [34], [35], which emphasize the importance of structured evaluation in the development of learning products. Thus, the Evaluate stage in this cyclical model ensures that the resulting modules are of high quality and ready for use in the context of elementary school teacher education.

3. RESULTS AND DISCUSSION

3.1 Characteristics of the Evaluated Module

The Problem-Based Learning (PBL)-based sports injury management module developed in this study was designed to provide elementary school teacher education students with a structured and contextual learning experience relevant to physical education safety in elementary schools. The module begins with a contextual cover illustrating students engaged in sports activities, emphasizing the focus on injury prevention and management. This is followed by a preface outlining the learning objectives, targeted competencies, and the urgency of mastering basic first aid skills for prospective elementary school teachers, thereby providing clear orientation regarding the learning flow and scope of the material. The overall visualization of the module structure is presented in Figure 2.

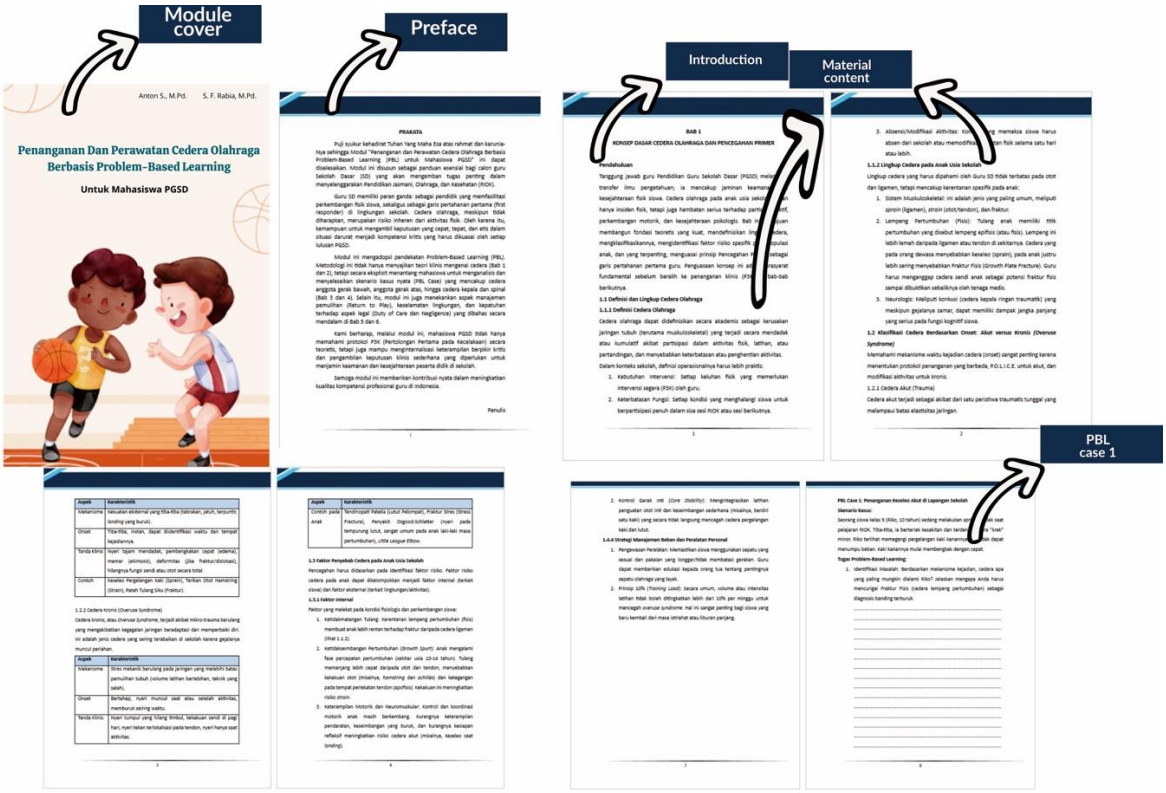

Figure 2. PBL-based Sports Injury Management module display

The core content of the module is organized into sequential topics, including basic concepts of sports injuries, injury classification, causes of injuries, and standard first aid principles. The material is presented progressively from conceptual understanding to practical application through explanatory text, summary points, comparative tables, and visual illustrations. This staged presentation supports systematic knowledge construction and reflects the fundamental principles of PBL, which emphasize the integration of theory and practice. Visual elements such as initial diagnosis tables and treatment flow diagrams facilitate students' ability to identify injury symptoms and prioritize appropriate actions.

The final section of the module emphasizes case-based learning activities that represent authentic injury situations commonly encountered in elementary school physical education. Each case includes incident

descriptions, problem indicators, and guided analysis tasks requiring students to identify injury causes, determine first aid measures, and formulate follow-up plans. The inclusion of structured worksheets encourages reflection, collaboration, and independent problem-solving. This design strengthens students' decision-making skills in real-world contexts and demonstrates the direct integration of injury management content with PBL-based problem-solving activities.

3.2 Validity of the PBL-Based Module

The validation results from five experts show that the PBL-based sports injury management learning module has a very high level of validity, with an average percentage of 92% and is classified as highly valid. The validators involved include experts in sports injury material, PBL experts, learning media experts, elementary school teacher education lecturers, and elementary school teachers. The diversity of the validators' backgrounds strengthened the accuracy of the evaluation, as each component of the module was assessed in a multidisciplinary manner according to their respective fields of expertise. Details of the percentage of each aspect of validation are shown in Figure 2.

The aspect of curriculum suitability received the highest score, namely 96%, followed by the aspects of material, learning media, and practical implementation with a score of 92%. Meanwhile, the PBL suitability aspect scored 88%, remaining in the highly valid category. These results show that all elements of the module meet academic, pedagogical, and technical eligibility for use in elementary school teacher education student learning. These findings directly answer the first research question regarding the validity level of the PBL-based sports injury management learning module. Based on the validity percentage analysis, the module is declared to meet all eligibility standards and is therefore suitable for further testing at the implementation stage.

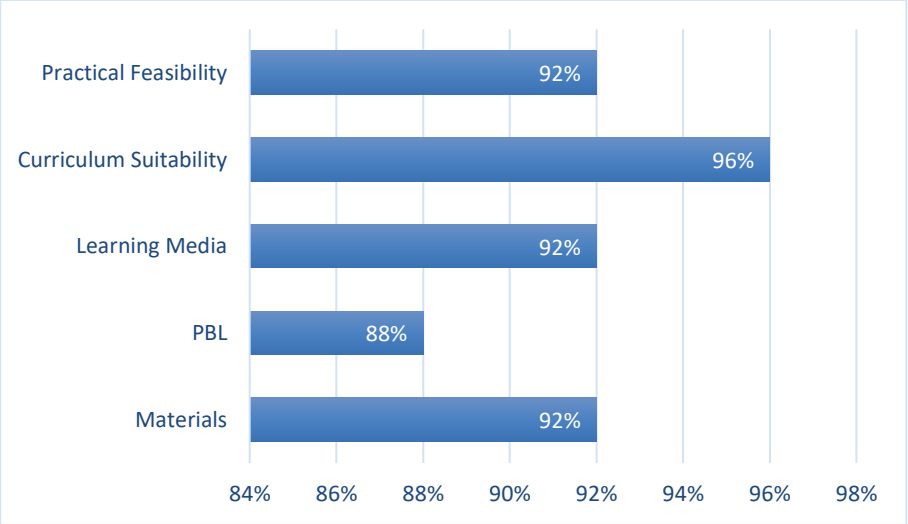

Figure 3. Teaching module validation results

The high validity score obtained indicates that the structure of the developed module is in line with the learning design principles recommended in the development of physical education teaching materials. This result is in line with the findings [19], which confirm that teaching materials on sports injuries must present accurate, contextual content supported by visual examples to make it easier for prospective teachers to understand the mechanism of injury and the steps to treat it. The developed module has fulfilled these characteristics through the integration of authentic injury scenarios, which are at the core of the PBL approach.

In addition, the curriculum validity score of 96% indicates that the module material is appropriate for the learning needs of elementary school teacher education students. This finding supports the view [7], [36]-[39], which emphasizes that the alignment between learning content and the professional competencies of prospective teachers is an important prerequisite for ensuring their readiness to face real situations in schools, including when injuries occur to students. Strong validation of the curriculum aspect shows that this module has been able to bridge conceptual and pedagogical practice needs.

Compared to previous studies, similar modules developed [20], [40], [41] are still limited to partial evaluations, such as material feasibility or initial effectiveness, without integrating comprehensive assessments from various parties. This study provides a new contribution through a multi-stakeholder evaluation involving subject matter experts, learning approach experts, media experts, lecturers, and elementary school practitioners. This combination of perspectives improves the quality of the assessment and ensures that the module is ready for use in the context of elementary school teacher education.

The implications of this research indicate that this module can be a reliable learning resource in equipping elementary school teacher education students with analytical skills and quick responses to injury cases, in line with the professional demands of elementary school teachers. In addition, the high level of validity opens up opportunities for further development in the form of e-modules or interactive digital media so that learning becomes more adaptive and flexible. In terms of novelty, this study offers a comprehensive integration of PBL and sports injury management material specifically tailored to the elementary school teacher education context, a topic that has not been widely discussed in previous studies. The layered validation approach used also provides scientific added value because it ensures the quality of the modules not only from one perspective, but through cross-disciplinary collaboration.

3.3 Practicality of the Module

The practicality of the module was measured through a questionnaire given to elementary school teacher education students and lecturers after the module was used in learning. The results of the analysis showed that students gave an average score of 88.2%, which is classified as practical, while lecturers gave a score of 91.6%, which is classified as very practical. These high practicality scores indicate that the module is easy to use, easy to understand, interesting, and suitable for learning needs in the classroom. The systematic structure of the module, the use of relevant visual illustrations, the presentation of injury treatment steps in sequence, and the existence of PBL scenarios were considered to help students understand the injury treatment process comprehensively.

These findings answer the research question regarding the practicality level of the PBL-based sports injury management learning module. Based on the percentage data, the module is considered practical and can be implemented effectively in learning. The complete results of the practicality test are presented in Table 1.

Table 1. Practicality test results

Respondents	Aspects Assessed	Maximum Score	Average Score	Percentage	Category
Students	Readibility, Comprehensibility, Interest	100	88.2	88.2%	Practical
Lecturers	Presentation suitability and material flow	100	91.6	91.6%	Very Practical

The high practicality score indicates that the module has fulfilled the PBL principle, which emphasizes active student involvement through authentic problems and a clear learning flow. This result is in line with the findings [11], [42], [43], which state that the effectiveness of PBL increases when the material is systematically organized and contextualized with real-world problems. Students assessed that the injury scenarios, visual illustrations, and first aid instructions made the relationship between theory and practice clearer and easier to understand. These findings are also reinforced by [30], which show that the clarity of the PBL flow greatly determines the level of student understanding and participation. Thus, the organized structure of the module and the sequential presentation of injury management steps provided a learning experience that was in line with the constructivist principles of PBL.

From the lecturer's perspective, a score of 91.6% indicates that the module is not only suitable for learning in large classes and small groups but also in line with modern PBL practices that emphasize student-centered learning. This shows that the module can function as a flexible and adaptive learning tool in various elementary school teacher education lecture contexts. The implications of this study indicate that this module can improve learning efficiency because students can follow the PBL flow independently and purposefully. This has the potential to reduce the facilitation burden on lecturers and at the same time increase student involvement in injury management simulations. In terms of novelty, this study adds empirical evidence that PBL modules that specifically combine sports injury management material with real-life scenarios can improve the practicality of learning in elementary school teacher education an area that is still relatively unexplored in the literature.

3.4 Effectiveness of the Module

The effectiveness of the module was evaluated using pretest and posttest scores from 70 elementary school teacher education students. The results showed an increase in the mean score from 63.5 in the pretest to 84.2 in the posttest, indicating a gain of 20.7 points, as illustrated in Figure 4. As summarized in Table 2, the paired sample t-test yielded a significance value of $p = 0.000$ ($p < 0.05$), confirming a statistically significant difference between pretest and posttest scores. In addition, the N-Gain value of 0.567 falls within the moderate category, indicating that the module demonstrates proportional effectiveness in improving students' understanding of sports injury management. These findings provide empirical evidence that the developed PBL-based module is effective in enhancing elementary school teacher education students' learning outcomes in sports injury management.

Table 2. Results of Paired Sample t-Test and N-Gain Analysis

Analysis Type	Statistical Value	Criterion	Interpretation
Paired sample t-test	p = 0.000	p < 0.05	Statistically significant
N-Gain	0.567	0.3 ≤ g < 0.7	Moderate effectiveness

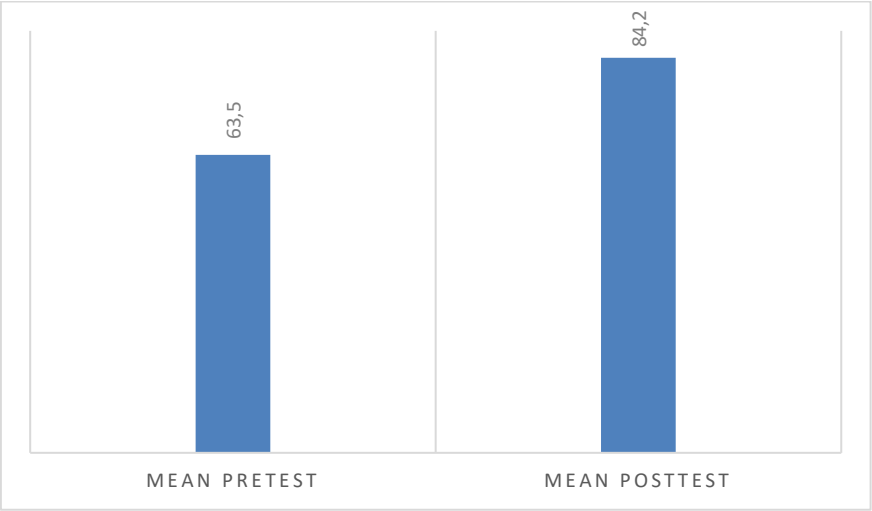

Figure 4. Diagram of average pre-test and post-test scores

The increase in scores shown in Figure 4 indicates that the PBL-based module has a positive impact on improving students' understanding of sports injury management. PBL allows students to actively engage in the analysis of real injury scenarios, thereby deepening their conceptual understanding. This is in line with the findings [44]-[46], which state that PBL can improve critical thinking, analytical, and problem-solving skills through the provision of contextual problems. This module not only presents theory but also provides opportunities for students to practice first aid procedures through simulations and case discussions.

These findings support the statement [47] that practical simulations can strengthen students' psychomotor competencies, especially regarding injury management steps. Thus, the effectiveness of the module is not only reflected in posttest scores but also in a more applicable and meaningful learning experience. Additionally, the effectiveness of the module shown in Figure 4 is consistent with research [48], [49], which confirms that sports injury material presented in a structured and realistic manner can improve prospective teachers' readiness to face real situations in schools. The steady improvement in the learning outcome graph indicates that this module successfully integrates theory and practice optimally.

In terms of generalization, the results of this study indicate that the developed PBL module can be widely adopted in elementary school teacher education, especially in subjects that require quick response skills and procedural understanding. The moderate N-Gain score also indicates that even students with low initial abilities achieved significant improvement. The implications of this research indicate that this module can be used as standard teaching material in physical education in elementary school teacher education, especially to equip students to deal with emergency situations that may occur when teaching elementary school students. In terms of novelty, this research offers a unique contribution in the form of integrating the PBL module with authentic sports injury scenarios specifically designed for the elementary school teacher education context, which is a field that has been rarely explored in the literature.

The results of the study show that the sports injury management learning module based on Problem-Based Learning (PBL), which was developed through the ADDIE cyclical model, successfully met the three main indicators of teaching material quality, namely validity, practicality, and effectiveness. The high level of validity an average of 92%, with curriculum validity reaching 96% indicates that the module has been designed with a logical learning flow, accurate material, and a PBL activity structure that supports students' thinking processes. This is in line with modern learning design approaches as stated by Tessmer [24], which emphasize that quality teaching materials not only convey information but also facilitate knowledge construction through the stimulation of authentic problems. The very high curriculum validity indicates that the module is able to meet the needs of elementary school teacher education students to understand the aspects of physical safety and health of elementary school students.

The practicality of the module is also an important indication of the product's readiness for use in a real learning context. Student (88.2%) and lecturer (91.6%) assessments show that the module is accessible, easy to understand, and flexible to use in both group discussions and field practice. These findings are in line with Almulla [10], which confirms that PBL will be effective if supported by teaching materials that are clearly structured, interesting, and guide the problem-solving process systematically. In the context of elementary school

teacher education, these findings are strategically valuable because elementary school teacher education students generally do not have a background in sports. Thus, the presence of visual illustrations, case studies, and problem-solving stages in the module helps students visualize injury situations concretely and systematically.

In terms of effectiveness, the increase in learning scores shown in Figure 4 indicates the significant impact of the module on student understanding. The pretest–posttest score difference of 20.7 points, significance value p = 0.000, and N-Gain of 0.567 (moderate category) show that the module is able to proportionally improve mastery of injury management concepts. These results are consistent with the findings [33], [50], which show that PBL improves students' readiness to face real situations through case analysis, critical discussion, and practice-based simulations. In sports injury material, first aid simulation helps develop students' psychomotor skills, as emphasized [44].

Overall, this PBL module makes an important contribution to the development of elementary school teacher education students' professional competencies, especially in the aspect of student physical safety. Contextual and interactive module-based learning has been proven to bridge the gap between theory and practice, as emphasized by Goossens et al [4], which states that injury prevention training is an essential component in the physical education of prospective teachers. The findings of this study are also in line with trends in teaching material innovation in higher education, as shown in Sirojjuddin et al [47], which emphasizes that learning modules need to integrate scientific context, technology, and user needs. The accuracy of the design, content validity, and suitability of the module to student characteristics three aspects that were carefully maintained in this study are key indicators of the quality of modern teaching materials.

This study presents a PBL module specifically designed for the context of elementary school teacher education an area that has been understudied in relation to sports injury management learning. The resulting module not only covers theoretical knowledge but also supports the development of practical skills through simulations that are appropriate for elementary school classroom situations. However, this study has limitations, including a focus on evaluating effectiveness that is still predominantly on cognitive aspects, while psychomotor and affective aspects have not been analyzed in depth. In addition, implementation is still limited to one institution, so cross-institutional generalization needs to be followed up. Based on these findings, recommendations for further research include: (1) Developing a digital version or e-module to make learning more interactive; (2) Testing the effectiveness of the module in various elementary school teacher education institutions to see the consistency of the results; (3) Integrating simulation technology such as interactive videos or augmented reality to enrich the learning experience. Thus, the PBL-based module developed in this study not only provides theoretical contributions but also offers significant practical implications for improving the quality of elementary school teacher education, particularly in the field of student safety and health.

4. CONCLUSION

This study aims to evaluate a sports injury management learning module based on Problem-Based Learning (PBL) for elementary school teacher education students based on three indicators of teaching material quality, namely validity, practicality, and effectiveness. All of the research objectives have been achieved. The developed module was proven to be highly valid according to expert assessment, practical for use by students and lecturers, and effective in improving student understanding, as indicated by an increase in pretest–posttest scores and a moderate N-Gain score. Based on these findings, this study contributes theoretically that the integration of the PBL structure with authentic sports injury scenarios is an effective approach to building the conceptual competence and practical skills of prospective elementary school teachers. This finding reinforces the theory that problem-based teaching materials not only improve cognitive knowledge but also facilitate decision-making and practical responses relevant to the context of physical education. In addition, the use of the cyclical ADDIE model gives rise to the concept of layered evaluation, which emphasizes the importance of revision at each stage of development to produce quality learning products.

In practical terms, this module has the potential to be further developed into an interactive e-module or integrated with digital technologies such as video simulations or case-based multimedia to enrich the learning experience of students. Further research is recommended to test the module in a broader institutional context, evaluate its long-term impact, and develop additional evaluation instruments to measure affective and psychomotor dimensions in greater depth. Thus, the PBL-based module developed not only addresses the learning needs of elementary school teacher education students, but also makes a real contribution to pedagogical innovation in the field of physical education and elementary school student safety.

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AUTHOR CONTRIBUTIONS

AS was responsible for the research design, data collection, data analysis, and manuscript preparation. SFR, MANA, and MF, contributed to conceptual development, research methodology guidance, and critical review of the manuscript. All authors have read and approved the final version of the manuscript.

CONFLICTS OF INTEREST

The author(s) declare no conflict of interest.

USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

The authors declare that no artificial intelligence (AI) tools were used in the generation, analysis, or writing of this manuscript. All aspects of the research, including data collection, interpretation, and manuscript preparation, were carried out entirely by the authors without the assistance of AI-based technologies.

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