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The underlying physics concept of a soccer game as a catalyst for enhancing creative thinking skills

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ABSTRACT

Teachers need to improve students' creative thinking skills by incorporating relevant everyday contexts. Soccer, as a familiar part of daily life, has not been widely used in education, and its impact on creative thinking requires further study. This research aimed to develop a contextual physics e-module centered on soccer to enhance creative thinking in physics learning. The study followed Rowntree's development model, including planning, development, and evaluation, with Tessmer's formative evaluation through expert reviews, one-on-one assessments, small-group evaluations, and field tests. The creative thinking indicators used in the research are fluency, flexibility, originality, and elaboration. Data were collected from 346 high school students in Palembang via walkthroughs, questionnaires, and written tests, then analyzed using SPSS version 16. The results showed that the soccer-based physics e-module is valid (Sig. 0.00), practical (one-to-one: 82.75%; small group: 91.00%), and in the moderate category for improving creative thinking (N-gain: 0.59). These findings highlight the need to explore other everyday contexts and assess the long-term impact of the e-module across different educational settings.

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1. INTRODUCTION

One of the 21st century skills that students need to master in order to compete in the current era of globalization is creative thinking [1]–[3]. Creative thinking is the ability to generate novel ideas or innovations by leveraging one's own potential and unique perspectives [4]. Developing creative thinking skills in students can help them generate new ideas, synthesize different concepts, and evaluate the effectiveness of their ideas [5]. However, studies have shown that students' creative thinking skills are generally quite low, particularly in subjects such as school physics [6], science education [7], work and energy [8], rectilinear motion [9], and global warming [10]. This lack of creative thinking skills can be attributed to various factors, including the strategies, learning model, teaching materials [11] used by teachers that do not match the characteristics and daily lives of students [9].

One strategy that can be employed to enhance students' creative thinking skills is to relate learning to everyday experiences [12]. However, teachers' efforts to design such learning experiences are inadequate because of the limited availability of appropriate and effective teaching strategies. In the case of physics

learning, incorporating everyday activities into learning can serve as a strategy. Some previous studies that have linked everyday game activities to physics learning include a study by Jusmaniar *et al.* [13] that explored the use of spinning tops in physics learning to increase student engagement and understanding of physics concepts, and other study [14] that integrated the kolecer game into learning physics, which made learning more meaningful. Rasmi *et al*. [15] integrated a slingshot game into physics learning, which was shown to increase students' creativity and activeness. Sari *et al*. [16] implemented basic locomotor movements in basketball to learn meaningful work and energy materials. Students can learn various physics concepts, such as circular motion [13], motion and force [14], elasticity, Hook's law [15], and work and energy [16], by connecting daily activities with learning. However, no studies have yet explored physics learning concepts through soccer, which is a popular game among high school students and the general public and is likely to contain many physics concepts. The potential to enhance students' creative thinking skills is present in the use of soccer in physics learning, as soccer relates to their daily lives [17].

Soccer is a popular sport that is frequently played by students. However, it is rarely integrated into physics education, although several physics concepts, such as parabolic motion and Newton's laws, are applicable to soccer. From this perspective, integrating soccer into physics education is expected to bring meaning to students. In order to apply this integration, a context-based electronic module is needed to provide students with opportunities to be active and participatory, making learning more meaningful [18]. The incorporation of context-based learning is appropriate for addressing the demands of 21st century skills [19], [20], particularly creative thinking skills [21]. Electronic modules are the relevant medium for enhancing creative thinking [22]–[24]. This is because e-modules offer students the flexibility to learn in a more personalized and independent way. These modules provide access to a variety of interactive learning materials, such as videos, simulations, and quizzes, which not only capture students' attention but also help them explore new concepts creatively [25]. In addition, the use of electronic learning modules has been linked to increased student engagement and independent study habits [26].

This study addresses the untapped potential of soccer as a tool for effectively integrating physics concepts with students' real-world experiences, thereby enhancing their creative thinking skills. Despite its potential, soccer has not yet been fully incorporated into teaching strategies, particularly in the context of physics education. To fill this gap, a context-based electronic module is required to provide students with engaging and participatory learning experiences that make the learning process more meaningful. The novelty of this study lies in the development of a context-based electronic module that utilizes soccer as a medium to teach physics concepts to improve students' creative thinking skills. This approach not only links academic content to everyday activities, but also leverages digital learning tools to foster independent learning, address contemporary educational challenges in the future. The objective of this study was to design and assess a module to improve students' creative thinking. Based on these objectives, the following research questions were explored in this study:

i) How to develop a context-based electronic module for teaching physics through the context of soccer?
ii) What is the impact of this context-based electronic module on students' creative thinking skills?

2. LITERATURE REVIEW

2.1. Contextual teaching and learning (CTL)-based electronic module

The advancement of information technology, robotics, nanotechnology, and biotechnology has created a demand for highly skilled professionals capable of adapting to new challenges and innovating creatively [27]. A practical application of this information technology is the development of contextual-based electronic learning modules. These modules serve as educational tools that present concepts and principles through real-world applications and scenarios. Contextual teaching and learning (CTL) enable students to connect academic subjects with their everyday lives, making the learning experience more meaningful and engaging [28]. However, the relationship between students and science education in schools is often viewed as challenging, with a common belief that motivation, attitudes, and interest in science decline as students' progress through their education [29]. This highlights the need for e-modules that bridge learning with real-life contexts. CTL-based e-modules are specifically designed to link theoretical knowledge with practical situations, such as environmental issues and everyday experiences, helping students grasp complex concepts through familiar contexts [30]. Research has demonstrated that these e-modules significantly enhance students' critical thinking skills, particularly in analyzing and evaluating information [31]. Moreover, students using context-based e-modules tend to show increased motivation, as they find the material more relevant and engaging, promoting active participation in their learning process [32].

CTL-based e-modules can also be integrated with AI. The integration of AI in language learning and other subjects allows students to engage with the material in a way that reflects real-world applications, enhancing their motivation and understanding [33]. These modules also support self-directed learning, enabling students to access content at their own pace and convenience [34]. Incorporating multimedia

elements such as videos, animations, and interactive activities enhances the learning experience by providing visual and practical examples that improve understanding [28]. By integrating theoretical knowledge with practical scenarios, context-based e-modules help students see the relevance of what they are learning. This connection not only aids comprehension but also prepares students for real-world challenges by applying academic concepts to practical situations [30]. Students using these modules often achieve better results compared to those relying solely on traditional teaching methods [30], [31]. Therefore, by integrating theoretical knowledge with practical scenarios, CTL-based e-modules enhance student engagement and understanding, making the learning process more effective and relevant to real-world applications.

2.2. Creative thinking

Creativity is an individual's capacity for creative expression, which is reflected in their thoughts, emotions, communication, and various activities [35]. Creative thinking involves a cognitive process that generates new ideas through the combination of existing concepts [36]. The process of creative thinking can be enhanced through problem identification and problem resolution. The thinking strategies that students can employ to foster creative thinking include: defining the problem, proposing solutions or suggestions, establishing criteria, exploring different perspectives, selecting the most effective solutions, and engaging with various viewpoints to encounter diverse angles [37]. Thus, creative thinking is the ability to generate original and innovative ideas, solutions, or approaches when facing a problem or situation. The ability to think creatively is positively linked to science learning outcomes [38].

Creative thinking skills consist of four indicators: fluency, flexibility, originality, and elaboration [39]. According to Handayani *et al*. [39], fluency refers to an individual's capability to generate a wide range of ideas, suggestions, questions, and alternative responses. Flexibility involves the ability to produce diverse ideas, answers, and questions from multiple perspectives. Originality pertains to the capacity to develop unique and innovative solutions to problems. Finally, elaboration encompasses the ability to expand upon ideas by incorporating additional details.

3. METHOD

The methodology employed in this study was a developmental research approach with a Rowntree developmental design. This study was divided into three phases: planning, development, and evaluation [40]. During the evaluation phase, Tessmer's formative assessment model was applied and conducted in five stages: self-evaluation, expert review, one-to-one evaluation, small-group evaluation, and field test [41]. The sample consisted of 346 eleventh-grade students from state high schools in Palembang, Indonesia, selected through purposive sampling. This method was chosen to ensure the study's findings are generalizable and that the collected data is consistent, reliable, and meaningful [42]. The research process is shown in Figure 1.

The study on eleventh grade students of state high schools in Palembang was conducted in the small-group evaluation stage. To validate the results, the walkthrough technique was used in the expert review stage, while a questionnaire was employed to determine the practicality of context-based electronic modules for learning physics concepts in soccer game at the one-to-one and small-group evaluation stages. The effectiveness of a context-based electronic module in improving students' creative thinking skills was evaluated using a written pre-test and post-test, which were analyzed using Microsoft Excel and SPSS version 16. The validity of the module was confirmed by two experts using Pearson's product-moment correlation. In this study, we used Pearson's product-moment correlation for validation, which can be conducted by two experts. This approach aligns with the research by Hidayati *et al*. [43], who also used two experts for validation. According to the criteria, it is considered valid if the significance value is less than 0.05.

The student's creative thinking instrument consisted of four indicators: fluency, flexibility, originality, and elaboration [7], [39]. There are eight questions used in the assessment instrument, with a scoring rubric as: no answer provided (score: 0), providing an idea/answer that is irrelevant with an incorrect concept (score: 1), providing an idea/answer that is relevant with a correct concept (score: 2), providing more than one relevant idea/answer, though with an incorrect concept (score: 3), and providing more than one relevant idea/answer with a correct and clear concept (score: 4). The reliability of the instrument was determined by Cronbach's alpha, which had a value of 0.726, indicating that it was reliable. The instrument is considered reliable when the Cronbach's alpha value is above 0.7 [44]. The effectiveness of electronic modules in improving students' creative thinking skills before and after the learning process using context-based electronic modules on physics concepts in soccer games was analyzed based on the N-gain score using SPSS version 16. The learning strategy employed involves utilizing the developed e-module. In this context, to support learning activities, all materials, media, and assessments are designed within the e-module. Students are guided to read, watch videos, and complete assessments provided in the e-module. The classification of the interpretation of the N gain calculation results is presented in Table 1.

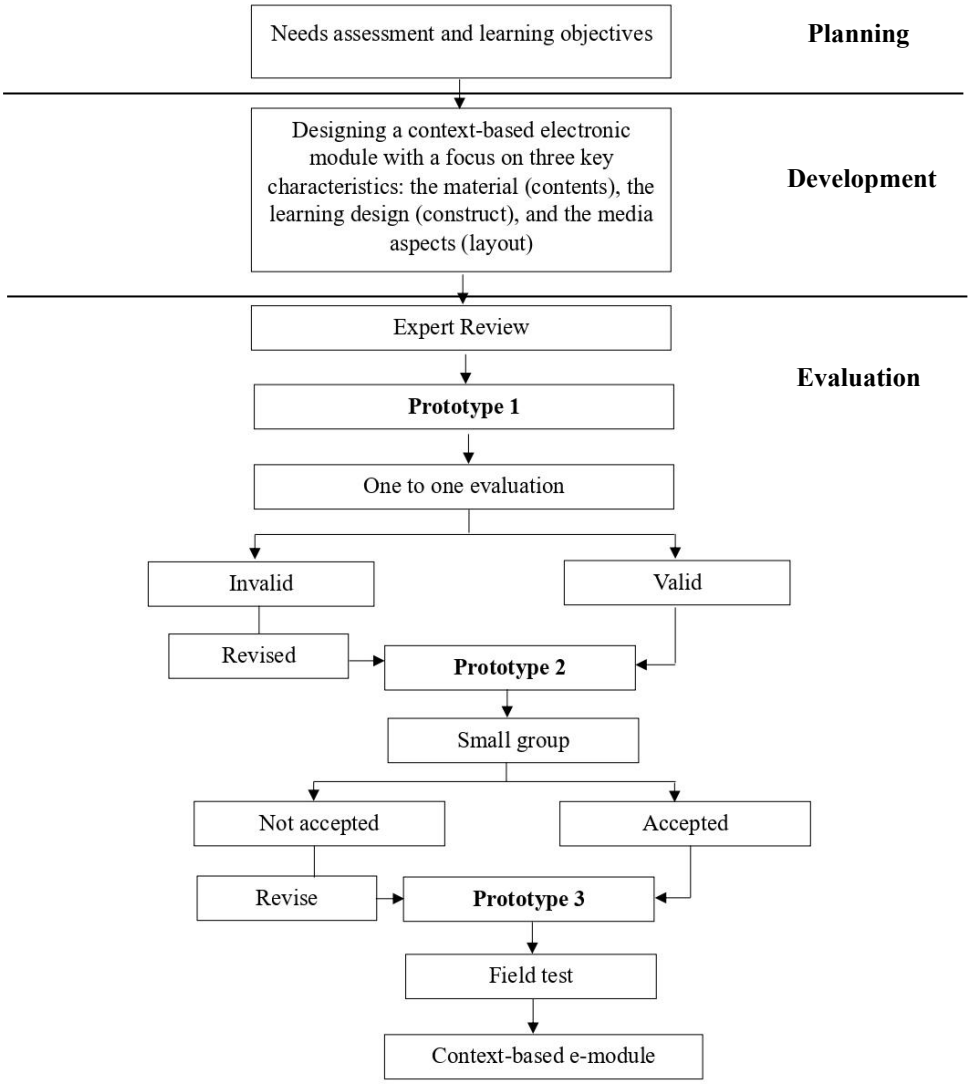

Figure 1. Research procedure

Table 1. N-gain classification [45]

Normalized gain index	Classification
(g)≥0.70	High
0.30≤(g)<0.70	Moderate
(g)<0.30	Low

4. RESULTS

4.1. Development of a context-based electronic module for teaching physics through the context of soccer

The development of a context-based electronic module for teaching physics in soccer consists of three phases: planning, development, and evaluation. In the planning phase, a needs assessment was conducted to determine the suitability of the module for research subjects. In the development phase, a context-based electronic module was developed. In the evaluation phase, Tessmer's formative evaluation was implemented to assess the electronic modules under development. The results of the development of the electronic modules based on context are as:

4.1.1. Planning phase

In this phase, a needs assessment was conducted on the context-based electronic module on physics concepts in soccer to determine the suitability of the module for the research subjects, who were students, and to identify the learning objectives to be achieved. The learning objectives to be achieved are: i) analyzing

physical quantities involved in motion during a soccer game; ii) analyzing the relationship between physics concepts of parabolic motion and the game of soccer; and iii) analyzing the relationship between physics concepts of Newton's Laws and the game of soccer. During this phase, data were collected using Google Forms. The results of the students' need assessment are presented in Table 2.

Table 2. Results of the assessment of students' needs

Category	Percentage (%)
Understanding of the material	18.9
Too many mathematical formulas	52.7
Knowledge of physics concepts in soccer game	48.6
Improvement in creative thinking skills	81.1

4.1.2. Development phase

This phase encompassed topic development, drafting, and prototyping. The process began with the identification of appropriate learning resources and the creation of a detailed outline for an electronic module focused on the physics principles of soccer. This outline served as a blueprint for the design and assembly of the electronic module. The components of the electronic module included a cover, preface, table of contents, description of the electronic module, instructions for using the electronic module, learning outcomes, learning objectives, flow of learning objectives, concept map, introduction, subject matters, which in this study were parabolic motion and Newton's laws, creative thinking box, practice questions, evaluation and competency tests with answer keys and self-assessment, bibliography, glossary, index, and author profile. These components were adapted from a study by Daryono and Rochmadi [46], which stated that modules must contain learning instructions, competencies to be achieved, supporting information, practice questions, work instructions, evaluation, and feedback on evaluation results. After the preparation process, the draft was completed and edited according to the planned electronic module product using the Heyzine website facilities to input several elements, including text, images, and videos. The result was referred to as Prototype 1. The table of contents of the electronic module is shown in Figure 2.

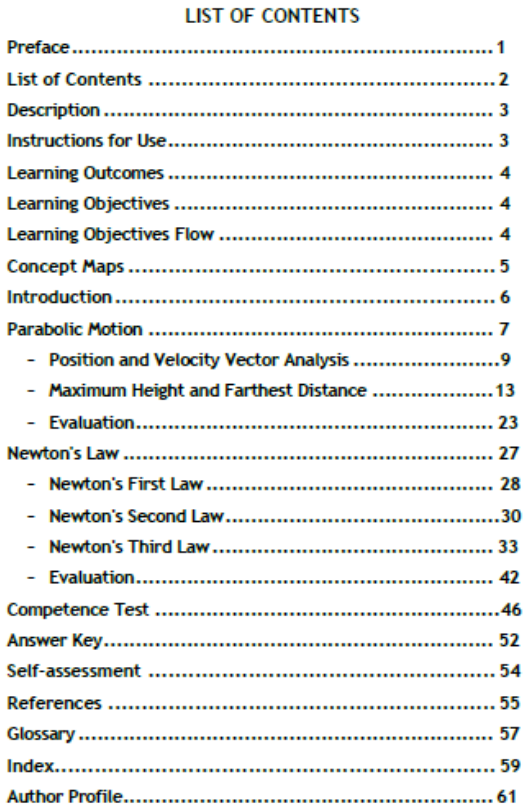

Figure 2. Table of contents of the electronic module

The e-module developed highlights physics concepts in soccer, focusing on parabolic motion and Newton's laws. The application used to develop this e-module is Heyzine Flipbook. Heyzine Flipbook offers advantages over other e-module development tools, making it a beneficial choice for creating interactive educational content. Heyzine Flipbook supports a highly engaging, tactile reading experience with features like realistic page-flipping and multimedia embedding (videos, audio, and links), which can enhance students' interaction with the content and improve retention. This functionality is particularly useful for contextual learning as it allows content to be presented in a visually appealing format, closely resembling a traditional book, but with digital enhancements that increase engagement [47]. Table 3 lists specific physics concepts in soccer game. This module is designed to enhance students' creative thinking skills through these real-world examples. The electronic module was empirically tested through a formative evaluation by Tessmer. This evaluation aimed to assess the module's validity, practicality, and effectiveness. The focus was on its application to the subjects of parabolic motion and Newton's laws.

Table 3. Application of physics concepts in a soccer game [48]

No	Physics concept	Application in a soccer game as presented in the e-module
1	Parabolic Motion	The movement of the ball as it is kicked toward the goal formed a parabolic trajectory. This is consistent with the statement of Li [49] that the path followed by the ball takes on a parabolic form.
2	Newton's first law	When a player kicks a ball, the ball continues to move forward unimpeded until it encounters an opposing force, such as another player, the ground, or an obstacle. Therefore, an object will continue in its current condition, whether it is at rest or moving at a constant speed along a straight path, unless influenced by an external force. This idea is consistent with Newton's First Law, which states that when the total force acting on an object is zero, the object will maintain its motion without any change. The object will either stay still or continue moving uniformly [50].
3	Newton's second law	A soccer player propels a powerful kick toward a ball that is initially at rest. The greater the force applied, presumably due to stronger legs or employing better technique, the greater the acceleration of the ball becomes. Moreover, when the ball is heavier, it means its mass is larger, which in turn influences how quickly it can accelerate. This illustrates Newton's second law, which states that how quickly an object accelerates is influenced by the amount of force acting on it and how much mass the object has. In other words, a larger force leads to greater acceleration, but as the mass increases, acceleration becomes smaller for the same amount of force [50].
4	Newton's third law	A ball kicked with force toward the goal post will bounce back with equal force in the opposite direction. This scenario illustrates that a force is being applied to another object. When a player kicks the ball toward the goal post, they apply force to the ball. Upon striking the post, the ball experiences an equal force in return from the post. This interaction aligns with Newton's third law, which explains that whenever one object applies force to another, the second object responds with an equal force directed in the opposite way, often referred to as the action and reaction pair [51].

4.1.3. Evaluation phase

In this phase, Tessmer's formative evaluation was implemented to assess the electronic module under development. The initial stage in Tessmer's formative evaluation involves a self-evaluation. In the self-evaluation stage, the electronic module was subjected to a re-examination to identify any inconsistencies in its operational and functional aspects. Following the evaluation, a number of errors were identified, including the use of bookmarks that were not present, video playback that did not load new tabs, an inefficient display of the electronic module, and several instances of suboptimal sentence structure within the electronic module. The errors were then revised before continuing to be validated by experts at the expert review stage.

The second stage is expert review. The resulting electronic module, designated Prototype 1, had undergone a self-evaluation process validated by experts using the Pearson product-moment correlation coefficient. The recapitulation of the validation results is shown in Table 4.

Table 4. The results of the expert review

Indicator	Sig. value	Validator findings	Revision
Content	0.00	The initial concept map was inaccurate.	The revised concept map is now accurate and reflects changes made during the revision process.
		Improvements to the image illustration required improvements for realism.	The image has been enhanced and transformed from an illustrative to a realistic depiction, offering a more accurate representation of the real-world scenario.
Physics component	0.00	The graphical representation needed improvements.	The graph has been updated with enhancements to improve clarity and accuracy, resulting in a final version that aligns with the intended representation.
Creative thinking skill	0.00	-	No revisions were required.
Design	0.00	-	No revisions were required.
Grammar	0.00	Typographical errors were found.	The text has been revised, and all typographical errors have been corrected, ensuring proper grammar.
Average sig. value	0.00		

Following expert validation, the contextual-based electronic module about physics concepts in the game of soccer was tested on three students in class. The use of three participants in one-to-one evaluations is a common practice in instructional design, particularly during the formative stages of developing educational materials like e-modules. This aligns with Pishtari *et al*. [52] who state that three participants are considered sufficient to identify major usability issues and provide diverse perspectives. The objective was to ascertain students' perceptions of the practicality of the contextual-based electronic modules regarding physics concepts in the game of soccer. The results of the recapitulation of the one-to-one evaluation tests are presented in Table 5.

Table 5. Results of one-to-one evaluation test recapitulation

Indicator	Percentage (%)	Comments and suggestions	Revision
User convenience	85.00	The practicality of the module is evident.	-
Visual presentation	83.25	The aesthetic appeal of the cover appearance could be enhanced.	The cover display has been enhanced.
Benefit	80.00	The addition of a section on example questions and solutions would be beneficial.	A new section on example questions and solutions has been added.
Average	82.75		

4.2. Impact of a context-based electronic module on students' creative thinking skills

The impact of context-based electronic modules on students' creative thinking skills can be seen through the implementation of the electronic module. The second prototype was evaluated for implementation. The second prototype was evaluated with a small group of eleventh-grade high school students. The same instruments used in the one-to-one assessments were applied. The evaluation results are presented in Table 6.

In the field test stage, pre-tests and post-tests were conducted with a group of eleventh-grade students, totaling 346 participants. The validity and reliability of the assessment instrument are reported in Table 7. These measurements confirm that the instrument is both valid and reliable for this evaluation.

According to Table 7, the assessment instrument used is valid, as a Pearson's significance value of less than 0.05 indicates validity [43]. Additionally, the instrument is reliable, with a Cronbach's alpha value exceeding 0.7, which meets the threshold for reliability [44]. The effectiveness of the electronic module in enhancing creative thinking skills was evaluated through the utilization of N-gain analysis, processed with SPSS version 16. The results of the pre-test and post-test N-gain analysis are presented in Table 8.

Table 6. The results of the small group evaluation

Indicator	Percentage (%)
User convenience	90.25
Visual presentation	90.75
Benefit	91.75
Average	91.00

Table 7. Validity and reliability of the assessment instrument

Description	Value
Sig. (2-tailed) Pearson correlation	0.000
Cronbach's alpha	0.726

Table 8. N-gain analysis results

Description	Pre-test	Post-test	N-Gain	Category
Maximum	62.50	100.00	0.75	High
Minimum	25.00	62.50	0.40	Moderate
Average			0.59	Moderate

As illustrated in Table 8, the N-gain value for the eleventh-grade students who engaged in the learning process utilizing the context-based electronic module was 0.59, indicating a moderate level of effectiveness in enhancing their creative thinking skills. This also indicated that the contextual-based electronic module for physics concepts applied to soccer games was effectively employed in the classroom

setting to enhance the creative thinking skills of the students. The e-module is used in the learning process through the following steps: i) students observe videos and images in the e-module related to parabolic motion or Newton's laws within the context of soccer; ii) students ask questions about any concepts they do not understand regarding parabolic motion or Newton's laws based on their observations; iii) students process data and analyze the information or answers they have gathered from the e-module; iv) the teacher and students verify the data processing results and review the physics material presented in the e-module; v) students gain an understanding of the explanations about parabolic motion or Newton's laws within the e-module; and vi) students complete problems related to parabolic motion or Newton's laws provided by the teacher in the e-module. The e-module includes quizzes and questions or problems. However, pre-tests and post-tests are conducted separately from the learning process. The N-gain results of creative thinking skills are presented in Table 9.

Table 9. N-gain analysis results for each aspect of creative thinking skills

Aspects of creative thinking	N-Gain
Fluency	0.71
Flexibility	0.51
Originality	0.40
Elaboration	0.75

As evidenced in Table 9, the aspect that exhibited the most pronounced increase in the high category (N-gain 0.75) was the elaboration aspect. The elaboration aspect exhibited the highest increase, as the majority of students were able to provide comprehensive and precise explanations regarding the solution to the problem. An example of an elaborate question is presented in Figure 3. The fluency aspect was elevated to the high category, with an N-gain of 0.71. This indicates that the contextual e-module utilizing a soccer context is effective in enhancing fluency. An example of a fluency question is provided in Figure 4.

A soccer player with a mass of 70 kg is running at a speed of 5 m/s when he is suddenly pushed from behind by a force of 200 N for a period of 4 seconds. Calculate the player's final velocity after receiving the push and explain how Newton's law of motion applies in this situation! **(Elaboration)**

Figure 3. An example of a question pertaining to the elaboration aspect

A ball is propelled at an angle θ relative to the ground, without the use of numerical values. Discuss and analyze the factors that affect the horizontal range of the ball! **(Fluency)**

Figure 4. An example of a question pertaining to the fluency aspect

The flexibility aspect showed an increase in the moderate category (N-gain 0.51). This is indicating that a contextual e-module with a soccer context is more effective in enhancing flexibility. Examples of questions pertaining to flexibility are shown in Figure 5.

The originality aspect exhibited the lowest level of increase within the moderate category (N-gain 0.40). The originality factor was the lowest because the majority of students continued to experience difficulty in solving problems using novel, distinctive, or unconventional approaches. An example of an originality aspect question can be observed in Figure 6. The overall results indicated that the context-based electronic module on physics concepts in soccer was deemed feasible. This module was developed specifically to enhance students' creative thinking skills. Its effectiveness supports its use in educational settings.

Provide at least two examples from the context of a soccer game in which the principles of Newton's laws of motion are applied in a manner that differs depending on the position of the player in question. Please elucidate how a player occupying that position can utilize Newton's laws of motion in that specific situation! **(Flexibility)**

Figure 5. An example of a question on the flexibility aspect

Describe the methods by which a soccer player's throwing power can be enhanced, thereby ensuring that the ball follows an optimal parabolic trajectory! **(Originality)**

Figure 6. An example of a question on the originality aspect

5. DISCUSSION

Based on the result in Table 2, the students identified the difficulty of understanding the subject matter as a significant obstacle to their learning of physics. Other identified causes included the presence of too many mathematical formulas, which students perceived as not particularly relevant in real-life contexts, and the absence of indicators to enhance creative thinking skills related to parabolic motion and Newton's laws. Based on the needs analysis, an innovative electronic module is required to connect their everyday lives with learning. A study by Mariskha *et al*. [53] found that the use of learning models that integrate applicable examples from everyday life can improve the understanding of physics concepts, including parabolic motion and Newton's laws. Sasmita *et al*. [54] discovered that contextual learning models can improve students' creative thinking skills. The use of clear and measurable indicators to assess creative thinking skills is also very important to measure students' progress and provide useful feedback for students to develop their thinking skills more effectively [4]. Furthermore, research by Asrizal *et al*. [25], indicates that contextual e-modules can enhance creative thinking. Based on this, students need learning media that facilitate relevant, real-life contexts, as this strategy can significantly improve creative thinking skills. Therefore, this study aimed to develop a context-based electronic module for physics concepts applied to the sport of soccer.

Based on the result that presented in Table 4, it was established that the results of content validation using the Pearson product-moment correlation test yielded a significance (Sig.) value of less than 0.05 for the context-based electronic module focused on physics concepts in soccer games. This indicates that the module was deemed to be within the content-valid category. The results of the discussion validation, obtained using a significance value of 0.00, indicated that the electronic module is valid in terms of readability. Similarly, the significance value of 0.00 for the physics component within the electronic module indicated that it was valid. The validation of creative thinking skills using the significance value of 0.00 demonstrated that the indicators for creative thinking skills within the electronic module were valid. The media validation in the form of design yielded a significance value of 0.00, indicating that it fell within the valid category in terms of electronic module design. Therefore, the average Sig. value of the expert validator's assessment of the content and media aspects, including content, language, physics components, and the feasibility of creative thinking, as well as design, on Prototype 1 of the electronic module was 0.00, indicating that the product was valid. In addition to providing an assessment in the form of numbers, the experts provided suggestions for revising Prototype 1 of the electronic module. Among these suggestions were corrections of numerous typographical errors in the electronic module, the use of real image displays from illustration images, and improvements to graphic images and concept maps. The module was then revised according to the experts' suggestions.

At the one-to-one evaluation stage, the average response of the students to the questionnaire regarding aspects of use, the attractiveness of the module presentation, and the benefits of Prototype 1 of the electronic module was 82.75%. This indicated that the module was both practical and user-friendly in its capacity as a teaching tool. Moreover, students provided constructive feedback and recommendations for further enhancements to Prototype 1 of the electronic module that had been developed. All feedback and comments from the students, along with suggestions for revision from experts, were considered and incorporated into the development of Prototype 2, which was then evaluated in the small group testing phase. The analysis of the students' responses to the questionnaire revealed that the average score for the assessment of Prototype 2 of the electronic module was 91%, indicating a practical level of ease of use for classroom implementation. During the testing phase of Prototype 2, students provided positive feedback and offered constructive suggestions for minor improvements, which were incorporated into the development of Prototype 3. The final result was a valid and practical electronic module. It is anticipated that the implementation of context-based electronic modules on physics concepts within the context of soccer games will facilitate student understanding and enhance their creative thinking skills. This expectation is supported by Baring and Berame [55], which indicated that electronic modules can simplify material comprehension and are practical for use in learning. Moreover, context-based learning has been demonstrated to enhance creative thinking skills [56]–[58]. Subsequent to the development of a valid and practical electronic module, a field test was conducted to assess its effectiveness in fostering students' creative thinking skills.

As illustrated in Table 8, the N-gain value for the eleventh-grade students who engaged in the learning process utilizing the context-based electronic module was 0.59, indicating a moderate level of effectiveness in enhancing their creative thinking skills. This also indicated that the contextual-based

electronic module for physics concepts applied to soccer games was effectively employed in the classroom setting to enhance the creative thinking skills of the students. This finding is consistent with those of the studies [45], [58], which both demonstrated that context-based e-modules are an effective method for fostering students' creative thinking skills.

As evidenced in Table 9, the aspect that exhibited the most pronounced increase in the high category (N-gain 0.75) was the elaboration aspect. This finding aligns with the previous study by Nada and Sari [59], which also reported high scores on the elaboration aspect. However, it contrasts with the results of research by Oktavia [60], that employed a guided inquiry-based learning model aimed at improving creative thinking but yielding low scores on elaboration. In comparison, this study shows that a contextual e-module using a soccer context is more effective in enhancing elaboration. The elaboration aspect exhibited the highest increase, as the majority of students were able to provide comprehensive and precise explanations regarding the solution to the problem. This result is consistent with the assertion made by Busyairi *et al*. [61], that the elaboration aspect, or detailed thinking, refers to a student's ability to provide in-depth explanations and explore multiple approaches to solving problems.

The fluency aspect was elevated to the high category, with an N-gain of 0.71. This result is consistent with the previous research reported by Oktavia [60], which demonstrated a significant enhancement in fluency among students as they could articulate problems more effectively and generate a greater number of potential solutions. Furthermore, the observations of Nada and Sari [59] also indicated that fluency is associated with an individual's ability to generate a multitude of potential answers and solutions to a given problem. However, it contrasts with the previous research by Witdiya *et al*. [62], who used STEAM to improve students' creative thinking skills and achieved a fair result (N-gain 0.49). This difference indicates that the contextual e-module utilizing a soccer context is more effective in enhancing fluency.

The flexibility aspect showed an increase in the moderate category (N-gain 0.51). This finding aligns with the previous research by Parani *et al*. [63], which used augmented reality application media to improve students' creative thinking skills and reported a moderate result (N-gain 0.34). Although both studies yielded moderate outcomes, the N-gain in this study was higher, indicating that a contextual e-module with a soccer context is more effective in enhancing flexibility. According to Sapriadil *et al*. [64], students still need improvement in this aspect, as some demonstrated difficulty in generating ideas, answers, or reasons. Yayuk *et al.* [65] further noted that flexibility is shown when students can accurately utilize various ideas and strategies to solve problems.

The originality aspect exhibited the lowest level of increase within the moderate category (N-gain 0.40). This finding aligns with the previous research by Oktavia [60] which employed a guided inquiry-based learning model aimed at improving creative thinking, and reported an increase in the moderate category (N-gain 0.37). Although both studies resulted in moderate outcomes, the N-gain in this study was higher. This indicates that the use of a contextual e-module with a soccer context is more effective in enhancing fluency. The originality factor was the lowest because the majority of students continued to experience difficulty in solving problems using novel, distinctive, or unconventional approaches. According to Trisnayanti *et al*. [7], originality is defined as the ability to produce novel and distinctive ideas.

6. CONCLUSION

This study shows that the context-based electronic module, designed by integrating soccer into physics education, enhances students' creative thinking skills, particularly fluency and elaboration, which are categorized as high. The module connects theoretical knowledge with real-world scenarios, helping students understand concepts more deeply and improve their problem-solving skills. However, there were limitations in developing flexibility and originality, which were categorized as moderate, as students had difficulty generating novel ideas and solutions. These findings suggest that, while the module encourages creativity, it may not fully support more innovative thinking. Future research should focus on creating more diverse modules that offer broader contexts and interactive strategies to help students explore new methods and generate new solutions. Additionally, examining other everyday contexts and studying the long-term effects of e-modules in different educational settings will offer more insight into its potential to foster creative thinking.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

INFORMED CONSENT

Informed consent was obtained from all participants prior to inclusion in the study.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author [IS], upon reasonable request.

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