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Research Article

Developing an Emancipated Learning Model to Enhance High School Students' Understanding of Physics Concepts

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ABSTRACT

Introduction: This research focuses on developing the emancipated learning model for high school Physics students.

Objective: The study aimed to improve students' understanding of Physics concepts by creating a model based on project-based, differentiated, and technology-based learning approaches.

Method: The model development followed the Plomp and Nieveen method, with data obtained on criteria for validity, effectiveness, and students' responses.

Results: The syntax of the emancipated learning model consists of seven stages, namely (1) diagnostics of students' diversity, (2) the essential question, (3) setting study groups and facilitating the learning environment, (4) discussing ideas and determining the schedule for project work, (5) project implementation and learning progress monitoring, (6) project presentation, and (7) assessment. Experts validated the emancipated learning model with a score of 88.87%, classifying it as highly suitable for learning model books and 91.20% as ideal for textbooks. The model effectively improved students' understanding of the concepts of work and energy, with a medium effectiveness criterion of 0.64. Student responses to the emancipated learning model were 83.8%, indicating positive feedback.

Conclusion: Therefore, this model can be an innovative method to enhance the understanding of Physics concepts.

Keywords: emancipated learning, learning model, understanding concepts.

INTRODUCTION

The emancipated learning model evolves from Project-Based Learning (PjBL) by incorporating differentiated and technology-based learning approaches. PjBL engages students in project management, from investigating a problem to a science-based solution [1]. In Indonesia, differentiated learning is promoted within the National Curriculum to tailor the learning process to students' diverse needs and backgrounds, fostering the development of the Pancasila Student Profile [2]. The National Curriculum also advocates for using technology tools in the learning process and assessment, providing a support system for teachers [3].

Differentiated learning integrates various theories and practices to enhance student achievement by addressing their readiness, ability, motivation, and interests [4]. This approach encourages teachers to be more creative in their teaching methods [5]. In the context of Education 4.0, teachers must adapt their teaching strategies to include independent learning, hybrid learning, and virtual learning, which cater to the diverse needs of students [6], [7]. By tailoring these learning patterns, differentiated learning fosters a more personalized and effective educational experience, promoting creativity and innovation in the teaching process.

The transformation to technology-based learning is crucial for 21st-century education [8]. This shift necessitates that teachers step outside their comfort zones to develop new learning processes [9]. The technological revolution has significantly benefited education, making integrating technology into learning essential [10]. Information technology has fundamentally altered and disrupted traditional learning models [11].

Project-Based Learning (PjBL) is a learning model anticipated for inclusion in the National Curriculum. PjBL extends problem-based learning by involving students in authentic investigations to create products or artifacts, often

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incorporating technology in the inquiry process [12]. Teachers widely use this approach to develop learning processes that present challenges or problems, guiding students to investigate, make decisions, design, and produce products [13]. PjBL is versatile and can be applied across various disciplines, including social sciences, science, technology, language, and mathematics [14]. To be effective, PjBL should be integrated into the curriculum, focusing on learning practices that enable all students to produce meaningful products [15].

Despite implementing the National Curriculum, students' understanding of scientific concepts remains low. This issue is primarily due to difficulties grasping science content and mathematical tools, invariable learning models, and teaching materials that do not cater to students' needs [16], [17]. Additionally, simple and non-interactive learning media negatively affect students' concentration, contributing to poor conceptual understanding [18]. To address these challenges, teachers must diagnose the diversity in student understanding, as a low initial grasp of concepts can lead to significant difficulties in the learning process [19], [20].

One element that high school students must master in the learning process of Physics of the Emancipated Curriculum, which has been established as the National Curriculum in Indonesia, is understanding the concept. Understanding the concepts that must be mastered can be optimized to compete in the era of the 4.0 revolution [21], [22]. Concept understanding can be influenced by the teacher's approach to the learning process [23].

A solid understanding of physics concepts is essential to effectively solving and applying theoretical physics problems in daily life [24]. This conceptual understanding should be cultivated from an early age, as science education in elementary school builds cumulatively over time [25]. The primary goal of physics education in high school is to ensure that students grasp the fundamental principles of physics and their practical applications [26]. Therefore, introducing physics concepts early is crucial for addressing both theoretical and practical problems, which is the main objective of secondary school physics education.

Improving students' understanding of concepts is crucial and can be achieved through a learning model aligned with the National Curriculum. Such a model enhances students' grasp of concepts by ensuring a correlated relationship between concepts and theories [27], [28]. According to Lin et al. (2021), using a curriculum-aligned learning model significantly boosts conceptual understanding. This understanding encompasses concepts' scientific meanings and real-world applications [30]. Therefore, adopting a learning model that adheres to the National Curriculum in Indonesia is essential for deepening students' comprehension of physics concepts and enabling them to apply them effectively in everyday life.

Developing the emancipated learning model is crucial for aligning with the characteristics of the National Curriculum, ensuring that learning is project-based, personalized to student needs, and technology-based. This study aims to develop the emancipated learning model to enhance high school student's understanding of physics concepts, particularly in Lhokseumawe City.

This study aims to develop the emancipated learning model to enhance high school students' understanding of physics concepts. Specifically, it focuses on its feasibility, improving students' understanding of physics concepts in work and energy and their perceptions of its implementation.

METHOD

This research is categorized as research and development (R&D) to develop an emancipated learning model for high school physics that meets the criteria for a feasible and effective product. The R&D model employed is the Plomp and Nieveen model [31], which includes three phases: (1) preliminary research, (2) prototype phase, and (3) assessment phase.

The research sample consists of 35 students from a population of 324 grade XI students at SMAN 1 Lhokseumawe, Aceh, Indonesia, for the 2023/2024 school year. Data collected includes validation, student responses, and pretest and posttest scores to determine the improvement in students' understanding of concepts.

Quantitative descriptive analysis is used for data analysis. In contrast, qualitative analysis is applied to qualitative data, which includes categories such as the feasibility of the emancipated learning model and student responses. Quantitative data comprises pretest and posttest scores of students' understanding of concepts.

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Before conducting field trials, the emancipated learning models and products were validated by experts in models, media, and learning materials, who are professors at Medan State University and Syiah Kuala University. The resulting products include learning model books and textbooks.

FINDINGS AND DISCUSSION

Finding

Emancipated learning

The emancipated learning model integrates the Project-Based Learning (PjBL) model with differentiated learning, utilizing a technology-based approach. It employs various media and technological resources to offer students a more engaging, interactive, and self-directed learning experience. The syntax of the Emancipated learning model is illustrated in Figure 1 and detailed in Table 1 below.

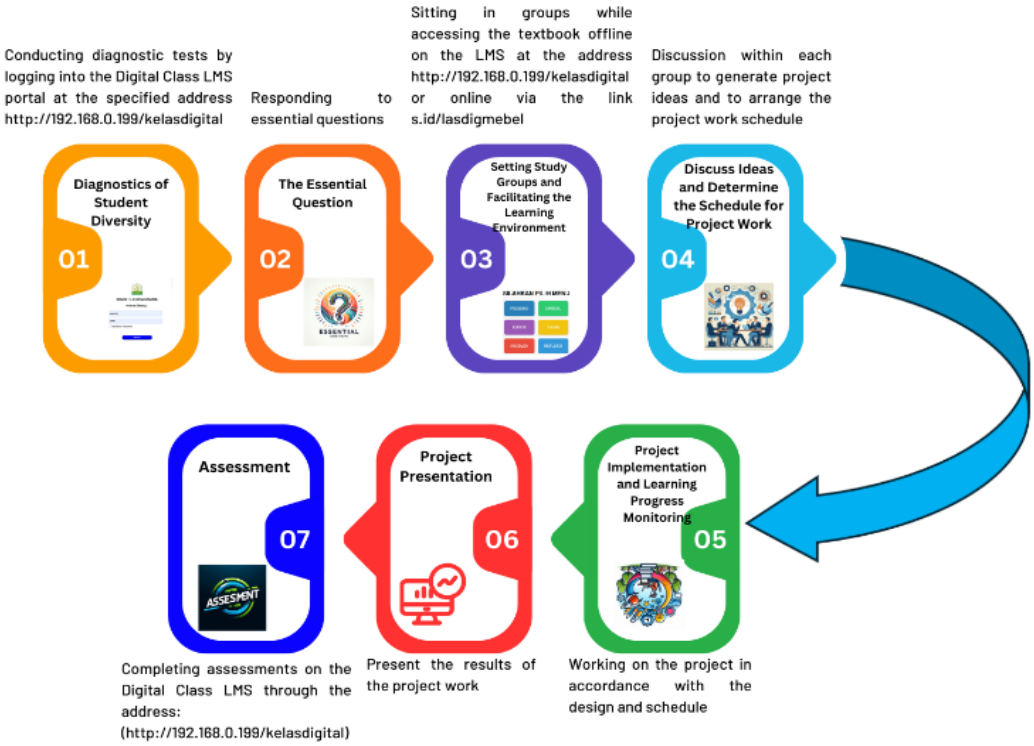

Figure 1. Stage of syntax of emancipated learning model

Table 1. Syntax of emancipated learning model

Emancipated learning syntax	Activity stages learning	
	Teachers	Students
Diagnostics of Students Diversity	Teachers administer a digital-based diagnostic test to assess the diversity of students.	Students take a digitally-based diagnostic diversity test.
The Essential Question	• Teachers explain the learning goals and desired outcomes. • Teachers provide essential questions to guide students in their project work.	• Students understand the learning goals and desired outcomes. • Students respond to the essential questions provided by the teacher.

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Setting Study Groups and Facilitating the Learning Environment	• The teachers explain the duties and responsibilities of each group. • The teachers ask students to arrange group study sessions. • The teachers instruct students to access digital-based textbooks.	• Students take notes on the duties and responsibilities of each group. • Students sit based on group study. • Students access digital-based textbooks.
Discuss Ideas and Determine the Schedule for Project Work	• The teachers direct students to make a design project. • The teachers direct group students to compile a project timetable.	• Students discuss future project ideas. • Students, together in groups, make a design project. • Each group discusses compiling a project timetable.
Project Implementation and Learning Progress Monitoring	• The teachers ask the students to complete the project according to the specified design. • The teachers supervise and monitor the progress of the students' projects.	• Students process projects. • Students process projects following the design.
Project Presentation	The teachers ask the students to present the results of their project processing.	Group students present the results of their project processing.
Assessment	The teachers provide evaluations based on digital criteria.	Students follow digitally based evaluations.

Validation of Emancipated Learning Model

Before field testing, the Emancipated learning model was validated to assess its validity. Design, materials, and learning media experts evaluated the learning model books and textbooks. The results of these validations are presented in Tables 2 and 3.

Table 2. Results of expert validation of learning model books

Expert	Results validation expert	
	Average percentage	Criteria
Learning Design	87,50	Highly Suitable
Learning Material	91,52	Highly Suitable
Learning Media	87,59	Highly Suitable
	88,87	**Highly Suitable**

Table 3. Results of expert validation of textbooks

Expert	Results validation expert	
	Average percentage	Criteria
Learning Design	90,625	Highly Suitable
Learning Material	91,22	Highly Suitable
Learning Media	91,76	Highly Suitable
	91,20	**Highly Suitable**

Enhancing understanding concepts

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Using the emancipated learning model, the N-Gain formula was used to measure the improvement in students' understanding of physics concepts. The N-Gain value was derived from the average pretest and posttest scores. The results of the N-Gain for these scores are presented in Table 4 and Figure 2.

Table 4. Value of n-gain understanding concepts

Data source	Average	N-gain	Criteria
Pretest	45,71	0,64	Sedang
Posttest	80,43		

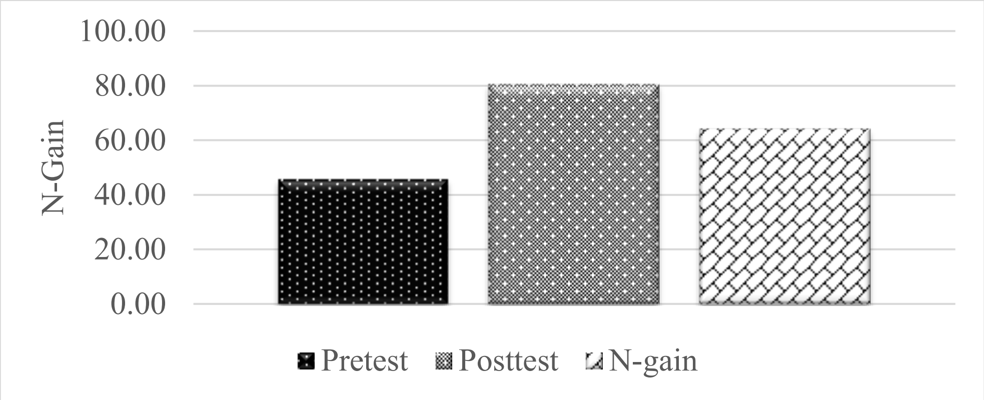

Figure 2. Improved understanding concepts

Students' responses to the emancipated learning model

After the learning session, a questionnaire collected students' responses to the emancipated learning model. The data on these responses are presented in Table 5.

Table 5. Students' responses to emancipated learning model

No	Indicator	Average
1	The implemented emancipated learning model has helped me overcome difficulties in teaching physics concepts.	82,29%
2	The applied emancipated learning model is highly suitable for teaching Physics concepts, particularly work and energy.	92,71%
3	The implemented emancipated learning model should be maintained to deliver physics material.	82,29%
4	The applied emancipated learning model is highly effective because it aligns with the characteristics of the National Curriculum.	81,25%
5	The worksheets used have significantly guided me in executing physics projects.	82,29%
6	Teachers should adopt a more project-based approach in delivering physics material, such as using the emancipated learning model.	86,46%
7	Teachers should adopt methods that adapt to students' differentiation and incorporate technology-based approaches in delivering physics material.	85,42%
8	The knowledge of physics concepts gained through the implemented emancipated learning model proves to be more lasting because students experience the project process directly.	78,13%
9	The applied emancipated learning model has greatly motivated me to study physics, particularly the concepts of work and energy.	83,33%
Average		**83,80%**

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Discussion

Emancipated learning

In the first syntax (Diagnostics of Students Diversity), students take a diagnostic test to determine their initial understanding of the learning material and to address their individual needs and potential. This approach aligns with the findings of Chernikova et al. (2024), which indicate that students' diagnostic accuracy correlates with their learning experience in a correlation-based environment with objective performance. Learning through prototypical video-based simulations can also enhance students' diagnostic skills [33]. Similarly, Radkowitsch et al. (2023) found that the frequency and variation of student involvement in the diagnostic process correlate with their knowledge level, task value, and accuracy.

The diagnostic test in the first stage utilizes an Ispring-based LMS, which students access via their smartphones on the intranet. This approach is chosen for its efficiency and effectiveness. Additionally, access to e-books on the LMS has been shown to motivate students to learn [35].

In the second syntax (The Essential Question), students are given essential questions both verbally and in writing to encourage them to identify problems related to project ideas. Issues in science form the basis for students' understanding of scientific processes and developing project ideas [36]. Increasing the number of resolutions, teachers prompt enhances students' cognitive contributions to understanding physical phenomena [37].

In the third syntax (Setting Study Groups and Facilitating the Learning Environment), students organize study groups to foster collaboration [38], encourage active learning [39], and create an environment that supports exploration and discovery [40]. During this phase, teachers can distribute digital-based textbooks to student groups. These textbooks can be accessed offline via intranet and online through an Ispring-based LMS [41].

In the fourth syntax (Discuss Ideas and Determine the Schedule for Project Work), students engage in the project planning process and establish the work schedule. This process fosters the development of creativity [42], critical thinking skills [43], and teamwork abilities [44].

In the fifth syntax (Project Implementation and Learning Progress Monitoring), teachers engage students in executing their projects and ensure they achieve the learning goals. This process not only enhances their understanding of concepts but also helps develop problem-solving skills [45], critical thinking abilities [46], and teamwork skills [47].

In the sixth syntax (Project Presentation), student groups present their project results to share knowledge, demonstrate progress, and receive feedback from peers and teachers. The project presentation aims to actively involve students in learning [48], [49]. Presentations utilize technology, and students are given the freedom to choose their presentation tools.

In the seventh syntax (Assessment), teachers provide students with assessments aligned with the learning objectives. These assessments are conducted digitally and can be accessed offline [50] and on a smartphone [51].

Implementing activities in the stages of the emancipated learning model involves a series of concrete steps to design, implement, and evaluate the learning model [52]. The implementation of these activities is as follows:

a. Social System

The social system consisted of interactions between teachers and students during the learning process, forming the model's syntax. Interactions included students collaborating on project idea discussions, design and execution activities, and presentations. Students actively participated in question-and-answer sessions with teachers during the project work monitoring process. Teachers controlled the class to create an effective and efficient learning atmosphere.

b. Support System

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The support system involved teachers providing students with worksheets for constructing hypotheses, guiding project work, and analyzing projects. Additionally, an LMS was used to access textbooks, assisting in project completion.

c. Principle of Reaction

The reaction principle states that teachers control and facilitate learning activities. Teachers motivate students, guide them in discussing project ideas, assist in designing project plans, organize project work schedules, and oversee project execution according to the design and timetable. They also aid in information gathering, analyzing project outcomes, and directing the presentation process. Teachers actively respond to students' questions during learning activities.

d. Instructional Impact

Instructional impact was manifested in the enhancement of learning outcomes, improvement of students' representational abilities, and advancement of students' understanding of Physics concepts and scientific processes.

e. Nurturant Impact

The nurturant impact was reflected in students' increased collaborative skills and scientific attitudes.

Table 2 presents the validation results of the model books by various experts. The learning material expert's average validation value was 91.52%, indicating high suitability. The learning design expert's average validation value was 87.9%, indicating high suitability. Similarly, the learning media expert's average validation value was 87.59%, confirming high suitability. Overall, the total validation percentage achieved an average value of 88.87%, which falls within the criteria of high suitability.

Table 3 presents the results of various experts' validation of the textbooks. The learning media expert's average validation value was 91.76%, indicating high suitability. The learning material expert's average validation value was 91.22%, indicating high suitability. The learning design expert's average validation value was 90.63%, confirming high suitability. Overall, the total validation percentage achieved an average value of 91.207%, which falls within the criteria of high suitability.

Based on the expert validation results of the emancipated learning model, it was concluded that the development of this model could proceed to the field trial stage.

Enhancing understanding concepts

Table 4 and Figure 2 indicate that the average N-Gain percentage in understanding student concepts, based on pretest and posttest scores, was 0.64% of the ideal value. According to the interpretation criteria in Table 2, this value falls into the medium category. Quantitatively, students' understanding of concepts improved after participating in education using the emancipated learning model. Therefore, the emancipated learning model effectively enhanced high school students' understanding of concepts.

The improvement in students' understanding of concepts was attributed to the emancipated learning model. This model allowed students to initiate projects with ideas agreed upon in their groups, create project designs, and work on the projects according to pre-established designs and schedules. Students applied their creative ideas to projects and committed to continuing their use [53]. According to Donelan & Kear (2023), a design exploration for knowledge creation can resonate with project work. Mursid et al. (2022) emphasized that students' creative thinking abilities should be developed when designing projects that systematically solve problems.

Therefore, students' knowledge of the material on work and energy was constructed through the Emancipated learning model, which involved them directly and made the knowledge development process more meaningful.

Students' responses to the emancipated learning model

Based on students' responses to the learning process using the emancipated learning model for work and energy, a total score of 83.80% was obtained across all indicators, placing it in the 'excellent' category. Consequently, it was concluded that the learning process with the emancipated learning model received extremely positive student feedback. Students reported that the model effectively overcame difficulties in teaching physics concepts and was highly effective as it aligned with the National Curriculum.

Additionally, students expected teachers to deliver more project-based lessons tailored to their differentiation and technology-based methods. Positive interactions were observed between students and teachers, among students in study groups, and while working on projects. The implemented emancipated learning model greatly motivated students to learn physics, particularly the concepts of work and energy.

CONCLUSION

In conclusion, the emancipated learning model features a syntax that includes Diagnostics of Students' Diversity, the Essential Question, Setting Study Groups and Facilitating the Learning Environment, Discussing Ideas and Determining the Schedule for Project Work, Project Implementation and Learning Progress Monitoring, Project Presentation, and Assessment. This model encompasses a social system, reaction principles, a support system, and instructional and mentoring impacts. Expert validation of the model produced a score of 88.87%, categorizing it as highly suitable. Similarly, the textbooks were validated with a score of 91.20%, indicating they are ideal for learning activities.

Field trials to measure the model's effectiveness in enhancing understanding of concepts resulted in an N-Gain value of 0.64, which falls into the medium category. Therefore, the model effectively improved high school Physics students' understanding of concepts. Student responses were recorded at 83.80% and categorized as very positive, indicating that teachers could utilize the model as one of the best methods for improving students' understanding of concepts.

Based on this discussion, the emancipated learning model aligns with the characteristics of the National Curriculum and can effectively improve the understanding of Physics concepts for students at SMAN 1 Lhokseumawe. The generalization of this study's results refers to applying this model in other contexts, populations, or environments.

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