MORFAI JOURNAL Multidiciplinary Output Research For Actual and International Issue
Multidiciplinary Output Research For Actual and International Issue (MORFAI Journal) ISSN (e): 2808-6635
Volumes 5 No. 6 (2025)

CREATION OF AN AUTONOMOUS LEARNING MODEL TO IMPROVE THE LEARNING OUTCOMES OF PHYSICS FOR HIGH SCHOOL STUDENTS

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Received	: 21 May 2025	Published	: 07 July 2025
Revised	: 30 May 2025	DOI	: https://doi.org/10.54443/morfai.v5i6.3425
Accepted	: 17 June 2025	Link Publish	: https://radjapublika.com/index.php/MORFAI/article/view/3425

Abstract

This study aimed to enhance high school students' physics learning outcomes by developing the autonomous learning model, a project-based, differentiated, and technology-based learning model. In this context, the syntax of autonomous learning model consisted 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. This was a model development study that followed the Plomp and Nieveen method. The data obtained included criteria for validity, effectiveness, and students' responses. Experts declared the autonomous learning model valid with a validation score of 88.87%, classified as highly suitable for learning model books, and 91.20%, classified as highly suitable for textbooks. Furthermore, it effectively improved student learning outcomes on work and energy, with a medium effectiveness criterion of 0.64. The responses to the autonomous learning model were at 83.8%. Therefore, the model can be an innovative method to enhance physics learning outcomes.

Keywords: ***learning model, autonomous learning, learning outcomes, physics learning***

Introduction

Physics learning in the Curriculum implemented in Indonesia, including the Autonomous Curriculum, which is now called the National Curriculum, requires students to achieve optimal learning outcomes. Learning outcomes are the knowledge, skills, abilities, or attitudes that students must have when participating in the learning process (Ofem et al., 2024; Pan et al., 2024; Yu, 2021). Learning outcomes are the basis of an educational program that must be mastered (Hsu et al., 2019). Learning outcomes are usually related to a specific subject and explain what students should understand, do, or assess after following the learning process (Fandos-Herrera et al., 2023). Learning support, involvement in learning, and self-regulated learning affect the development of the learning process and the learning outcomes students feel (Wei et al., 2023). A student-centered learning process can affect learning outcomes differently (C. C. Cheng & Carolyn Yang, 2023). To gain further insights into the implementation of the National Curriculum in schools, the author collected student learning outcomes in the form of midterm assessments for the subject of Physics. The results showed an average score of 55 in 2022. Meanwhile, the average scores were 60 in 2018, 60 in 2019, 69 in 2020, and 74 in 2021. These results are considered low. Additional learning strategies lead to relatively higher student learning outcomes (Moser & Lewalter, 2024). Teachers should use more varied and innovative learning models, case-based or project-based, to improve student learning outcomes (Al-Balas et al., 2020; K. Liu et al., 2024; Yeo et al., 2021). Learning outcomes are planned based on the competencies students must develop rather than on the content teachers must carry out the learning process (Erikson & Erikson, 2019).
Interviews with students at a high school in Aceh Province revealed that physics lessons are very monotonous. Teachers explain the learning material in front of the class and then provide example problems. Teachers have never

conducted physics practicums, not even simple demonstrations. Project-based learning is even less common. However, physics education in both the 2013 Curriculum and the National Curriculum is required to be project-based, although not for all competencies.

The learning model teachers apply dramatically affects student learning outcomes (Pan et al., 2024). This shows that student learning outcomes can be improved through a learning model implemented by the National Curriculum in Indonesia. The learning model used by teachers according to the characteristics of the National Curriculum uses the concepts of autonomous learning, differentiated learning approaches, and technology-based learning. Considering the importance of active and autonomous learning among students, teachers need to use interactive and student-oriented learning patterns (Nabizadeh et al., 2019). Social and cognitive interactions that occur in the learning process using digital devices and applications allow students to understand the concept of autonomous learning (Limniou et al., 2021). Autonomous learning is a challenge for students and plays a vital role in the success of the learning process (Scheel et al., 2022). To make digital-based learning more accessible, we can organize all learning materials on a single platform and select age-appropriate materials or online applications for self-directed learning. (Lau et al., 2021). Differentiated learning is a compilation of various theories and practices related to effective learning to improve student achievement according to readiness, ability, motivation, and interest (Variacion et al., 2021). Differentiated learning is a unique approach that motivates teachers to be more creative in student learning (Ismail et al., 2021). Teachers need to change learning patterns in the 4.0 education era with differentiated approaches, such as using the concepts of autonomous learning, hybrid learning, and virtual learning that are tailored to the diversity of student learning (Masdoki et al., 2021). Differentiated learning is a unique approach that encourages teachers' creativity in teaching and learning by adjusting learning patterns such as autonomous, hybrid, and virtual learning to the diversity of students in the education era 4.0.

Differentiated learning considers students' initial abilities. Students' initial abilities in physics also influence learning outcomes. Burkholder et al. (2020) found that students who began learning with little explicit knowledge of physics helped reduce imposter syndrome. Additionally, the active learning methods used have been shown to disproportionately benefit underrepresented students. Astuti (2015), concluded that initial abilities affect physics learning outcomes. Halloun & Hestenes (1985), revealed that diagnostic test results showed students' prior knowledge significantly influences their physics performance, where conventional instruction improves students' basic knowledge but to a relatively small extent. Technological advances have revolutionized science learning (Castro & Tumibay, 2021; Kalolo, 2019; Oke & Fernandes, 2020). Technology-based learning transformation is urgently needed in 21st-century learning (Mutohhari et al., 2021). Technology-based learning requires teachers to develop a learning process outside of their comfort zone (Romli et al., 2022). The technological revolution has benefited the world of education, so the use of technology in learning is very important (Alakrash & Razak, 2021). The use of information technology in the learning process has changed and broken the traditional learning model (L. Wang, 2020).

The results of the internal mapping of ICT competencies for teachers and educational staff at the high school, vocational school, and special education levels across Aceh, conducted by the Aceh Education Office in 2022, showed that approximately 12.96% of high school teachers are in the proficient category, 23.13% in the intermediate category, 37.96% in the adequate category, and 25.94% in the low category. For vocational schoolteachers, about 14.19% are proficient, 22.23% are intermediate, 37.78% are adequate, and 25.79% are low. Meanwhile, for special education teachers, around 9.16% are proficient, 17.92% are intermediate, 35.03% are adequate, and 37.88% are low. The mapping results concluded that most of the high school, vocational school, and special education teachers in Aceh have ICT competencies ranging from intermediate to low. One of the recommended learning models that can be applied in the National Curriculum is Project-Based Learning. Project-based learning, or PjBL, expands problem-based learning by creating products or artifacts through authentic investigation and the use of technology during investigation (Marnewick, 2023). Teachers widely use PjBL to develop a learning process that requires challenges or problems so that students are directed to be able to investigate, make decisions, design, and produce products (Sumarni & Kadarwati, 2020). PjBL can be used to learn various science disciplines such as social, science, technology, and even language and mathematics (Miller & Krajcik, 2019). PjBL should not only concentrate on the curriculum but should build a framework by focusing on learning practices so that all students can learn to produce products (Almulla, 2020). Physics learning encompasses various pedagogical approaches and technological advancements that enhance student engagement and understanding. PjBL interventions in high school physics significantly improve student learning outcomes (Schneider et al., 2022). To optimize physics learning outcomes with PjBL, integrating technology can be an effective solution. The use of PBL e-learning platforms can help overcome implementation challenges and facilitate the learning process (Meng et al., 2023). The author developed the autonomous learning model from the PjBL model with a differentiated and technology-based learning approach. PjBL engages students in project management so that when combined with a problem, it will start with an investigation into a problem with a science-based solution (Bascopé et al., 2019). Differentiated learning is an approach that is encouraged in Indonesia when the National Curriculum is implemented so that the learning process can help students have the character of the Pancasila Student Profile according to the needs of students and their backgrounds (Hasanah et al., 2022). The National Curriculum recommends using technology tools in the learning process and assessment as a support system that helps teachers (Santoso et al., 2022). The observation results show that the physics learning outcomes of high school students in Aceh Province, still need to be higher even though they have used the National Curriculum. Students are only involved in data collection and analysis activities and must be given access to the big picture of the scientific approach (Aristeidou et al., 2020). The unhabit of students learning using a constructivist approach that prioritizes memorization and understanding of facts and concepts rather than the discovery process also affects learning outcomes (Yeung et al., 2024). The learning process in the current era requires an appropriate learning model to achieve maximum student learning outcomes (Twizeyimana et al., 2024). Simple and non-interactive learning media affect students' concentration, impacting low learning outcomes (Walid et al., 2019). Teachers need to carry out diagnostics of student diversity because low initial knowledge can result in students experiencing difficulties in the learning process (Cari et al., 2022).

Even though they have implemented the National Curriculum, many teachers must use differentiated and technology-based learning approaches. The National Curriculum recommends using differentiated learning to address the diversity of students, but many teachers still need to understand how to apply it in the classroom (Santoso et al., 2022). The role of technology is vital in the learning process to solve problems by integrating learning and technology as one of the educational strategies (Desriana et al., 2020). Some teachers have used the PjBL model but have yet to be able to improve student learning outcomes. The influence of PjBL on student learning outcomes is primarily determined by the continuity of syntax and student participation in knowledge production and real-world product development (MacLeod & van der Veen, 2020). The extent to which the exploration of the application of PjBL syntax in the classroom effectively encourages the improvement of student learning outcomes needs to be improved (Wu, 2024). The PjBL function has yet to be maximized to enhance the implementation of the PjBL syntax design based on the assumption that although the PjBL syntax is uniform, this diversity is ignored in practice (Chen et al., 2021). The development of the autonomous learning model is essential in finding a learning model based on the characteristics of the national curriculum. The right pedagogical approach for low-achieving students can foster dependence on teachers so that autonomous learning maintains a balance between learning and dependence on teachers (Mazenod et al., 2019). The autonomous learning model is developed based on the characteristics of the National Curriculum, so learning is project-based, according to the needs of student personalization, and technology-based. Therefore, this study aims to develop an autonomous learning model so that high school students experience increased physics learning outcomes, especially in Lhokseumawe City. Differentiated learning can create the potential of students with different levels of achievement, including high-achieving students (Kalinowski et al., 2024). The PjBL model can improve learning outcomes, including creative and critical thinking, collaboration, and communication (Goyal et al., 2022). Technology-based learning through science simulations can increase learning outcomes and engage in higher-level thinking processes (Falloon, 2019).

Method

This research is categorized as research and development (R&D). The aim is to develop an autonomous learning model in high school physics learning that meets the criteria for valid, practical, and effective development products. The R&D model used is the Plomp and Nieveen model (Plomp & Nieveen, 2010), namely: (1) preliminary research, (2) prototyping phase, and (3) assessment phase. The research sample consisted of 35 students from a population of 324 eleventh-grade students at a high school in Aceh Province, Indonesia, for the 2023/2024 academic year. The data collected in this study included validation, effectiveness, and students' responses. A quantitative descriptive analysis method was used for data analysis, while qualitative analysis was employed to analyze quantitative data, which was then converted into qualitative. The qualitative data consisted of categories such as the validity of the autonomous learning model, its effectiveness, and students' responses. Before conducting field trials, the developed learning model and products were validated by experts in models, media, and learning materials, who are professors at the State University of Medan and Syiah Kuala University. Each group consisted of 2 experts in models, media, and learning materials, totaling 6 experts. The resulting products are a learning model book and a textbook. After the autonomous learning model met the suitability criteria, a limited testing phase was conducted on the developed model. The data collected during this limited test included the effectiveness and students' responses. In addition, effectiveness data, which contributed to improving students' physics learning outcomes on work and energy materials, were obtained through a testing method that utilizes pretest before and posttest after learning using the autonomous learning model. Pre-test and post-test data were collected and analyzed using the formulated N-gain calculation. The pretest and posttest questions are in the form of multiple-choice questions designed digitally on the topics of work and energy.

Results and discussion

1. Autonomous learning model

The autonomous learning model integrates the PjBL model with differentiated learning presented through a technology-based method. It uses various types of media and technological resources to provide a more engaging, interactive, and self-directed learning experience for students. The syntax of the Autonomous learning model is depicted in Figure 1 and Table 1 below.

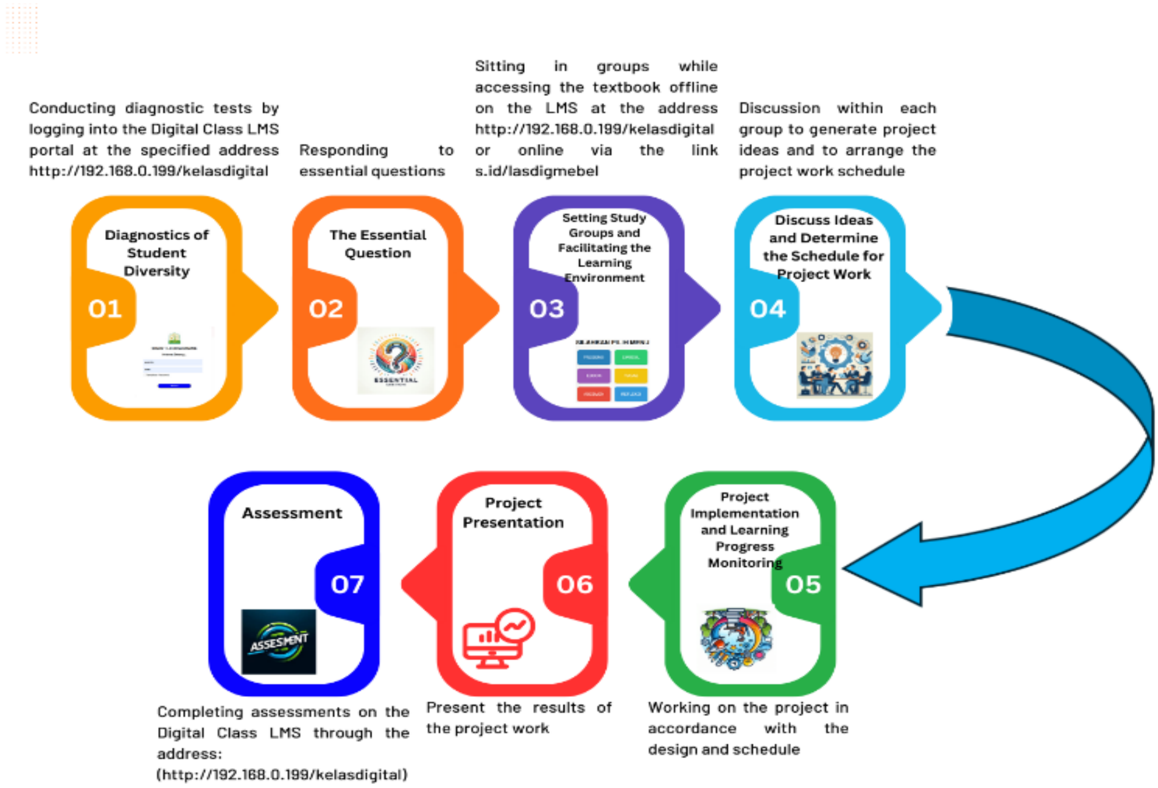

Figure 1. Stage of Syntax of Autonomous learning Model

Table 1. Syntax of autonomous learning model

Autonomous learning syntax	Activity stages learning	
	Teachers	**Students**
Diagnostics of Students' Diversity	The teachers give test diagnostic diversity students digital-based.	Students follow test diagnostic diversity digitally based.
The Essential Question	• The teachers explain the goals and desired results achieved from learning. • The teachers gave several essential questions for directing students in the project.	• Students know the goals and desired results achieved from learning. • Students answer question essentials given by the teacher.
Setting Study Groups and Facilitating the Learning Environment	• The teachers ask students to arrange group study. • The teachers ask students to access digital-based textbooks. • The teachers explain the duties and responsibilities of each group.	• Students sit based on group study. • Students access digital-based textbooks. • Students take notes on the duties and responsibilities of each group.
Discuss Ideas and Determine the Schedule for Project Work	• The teachers direct students to discuss project ideas. • The teachers direct students to make a design project.	• Students discuss future project ideas. • Students together group make a design project.

	• The teachers direct group students to compile a timetable processing project.	• Every group discusses compiling a timetable processing project.
Project Implementation and Learning Progress Monitoring	• The teachers ask the students to do the project according to design. • The teachers supervise and monitor the progress of processing project students.	• Students do process projects following design. • Students do process projects.
Project Presentation	• The teachers ask the group of students to present the results processing project.	• Group students do presentation results processing project.
Assessment	• The teachers give evaluations digitally based.	• Students follow evaluation digitally based.

In the first syntax (Diagnostics of Students Diversity), students take a diagnostic test to determine their initial understanding of the learning material and follow their needs and individual potential. This is in line with the findings Chernikova et al. (2024), which states that students' diagnostic accuracy correlates with the learning experience of students in a correlation-based environment with objective performance. Sommerhoff et al. (2023) found that learning using prototypical video-based simulations can affect students' diagnostic skills. Similarly, Radkowitsch et al. (2023) showed that the frequency and variation of student involvement in the diagnostic process correlated with knowledge level, task value, and accuracy. The diagnostic test in the first stage uses an Ispring-based LMS, which students access using their respective smartphones. It takes place on the intranet. This is done for efficiency and effectiveness (Darmawan et al., 2023; Obeso et al., 2023; Ye & Li, 2024). Access to e-books on LMS motivates students to learn (Fageeh, 2024; Rarugal & Sermona, 2024; Toring et al., 2023).

In the second syntax (The Essential Question), students are given essential questions both verbally and in writing to encourage students to find problems related to project ideas. Problems in science learning are the basis for students' understanding of scientific processes and developing project ideas (Ojetunde & Ramnarain, 2023; Twizeyimana et al., 2024). Increasing the number of resolutions, teachers prompt increases students' cognitive contribution to understanding physical phenomena (Soysal & Yilmaz-Tuzun, 2021). In the third syntax (Setting Study Groups and Facilitating the Learning Environment), students organize study groups to build collaboration between students (Z. Liu et al., 2024), encourage active learning (Na & Kim, 2024) (M. Hu et al., 2024), and create an environment that supports exploration and discovery (Knox, 2022; Korthals Altes et al., 2024). In this phase, teachers can distribute textbooks to groups of students. The textbooks provided are digital-based and can be accessed offline (intranet) and online through an Ispring-based LMS (Rarugal & Sermona, 2024; Sulaiman et al., 2022). In the fourth syntax (Discuss Ideas and Determine the Schedule for Project Work), students carry out the project planning process and determine the work schedule. This process helps them develop creativity (H. Y. Liu, 2020; Weng et al., 2022), critical thinking skills (Saghafi et al., 2024; Xiaolei & Teng, 2024), and teamwork ability (Baviera et al., 2022; Hotapeti et al., 2020).

In the fifth syntax (Project Implementation and Learning Progress Monitoring), teachers involve students in executing their projects and ensuring they achieve the learning goals. This not only helps them understand concepts better but also allows them to develop problem-solving (Amalina & Vidákovich, 2023; Pimdee et al., 2024), critical thinking (Tan et al., 2023; Teng & Yue, 2023), and teamwork skills (Riivari et al., 2021). In the sixth syntax (Project Presentation), the student group presents the results of the project work to share knowledge, show the progress and results of the project, and get feedback from peers and teachers. The project presentation aims to actively involve students in the learning process (Mentzer et al., 2023) and strengthen communication skills (Mathieu et al., 2024; Yoel et al., 2023). Presentations are carried out using technology, and students are given freedom regarding presentation tools. In the seventh syntax (Assessment), teachers provide students with assessments related to the learning objectives developed. The assessment is carried out digitally and can be accessed both offline (intranet) and online using a smartphone (Domínguez-Figaredo & Gil-Jaurena, 2024; Ilgaz & Afacan Adanır, 2020; Kalinich et al., 2022).

2. Autonomous learning model system

Implementing activities in the stages of the autonomous learning model involves a series of concrete steps taken to design, implement, and evaluate the learning model (Joyce & Weil, 2003). The implementation of the activities of the stages of the autonomous learning model is as follows.

a. Social system

The social system consisted of interactions between the teachers and students during the learning process, which formed the syntax of the model. Some interactions that reflected the social system in the Autonomous learning model included students collaborating in project idea discussion activities, design and execution activities, and presentations. In addition, students were active in question-and-answer sessions with the teachers during the project work monitoring process. The teachers controlled the class to create an effective and efficient learning atmosphere. This is consistent with the research by (Novitra et al., 2021), which found that the online-based Inquiry Learning model is designed to promote collaboration and communication among students. It encourages interaction both face-to-face and online, reflecting the need for a social learning environment that supports the development of 21st-century skills.

b. Support system

The support system involved the teachers providing students with worksheets for constructing hypotheses, guiding project work, and analyzing projects. Additionally, an LMS was used to access textbooks, thereby assisting in project completion. This is consistent with the research by Fokides & Antonopoulos (2024), which found that learning content presented using models in immersive virtual reality learning environments helps users navigate the virtual environment, reduces confusion, and enhances learning.

c. Principle of reaction

The principle of reaction states that the teachers act as both a controller and a facilitator in the learning activities. For instance, the teachers motivated students during learning activities, guided them in discussing project ideas, assisted in designing project plans, organized project work schedules, and oversaw project execution according to the design and timetable. They also aided in information gathering, analyzed project outcomes, and directed the presentation process. The teachers actively responded to students' questions during the learning activities. This is consistent with the research by (Lestari et al., 2024), which found that the Inquiry Ethnobotany Learning Model is designed to stimulate students' interest and motivation through hands-on experiences. By engaging in independent research and experiments, students develop critical thinking skills and learn to approach problems systematically.

d. Instructional impact

Instructional impact was manifested in the enhancement of learning outcomes, the improvement of students' representational abilities, and the advancement of students' understanding of Physics concepts and scientific processes. This is consistent with the research conducted by Lutter & Peters (2021), which found that the developed model includes a better understanding of the principles of mechanics in real-world applications and the application of learning technology.

e. Nurturant impact

The nurturant impact was reflected in students' increased collaborative skills and scientific attitudes. This is consistent with the findings of Bermingham et al. (2023), which revealed that the Peer Assisted Learning (PAL) model not only enhances students' motivation but also boosts their self-esteem and confidence in their ability to succeed in their studies.

3. Validation of autonomous learning model

The validation of the autonomous learning model was conducted to assess the model's validity before field testing. The validation was performed by design, materials, and learning media experts on learning model books and textbooks. The results are presented in Table 2 and Table 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**

Table 2 shows the average validation value of the model books was 87.9% by the learning design expert, which indicated that it was highly suitable, 91.52% by the learning material expert, which stated that it was highly suitable, and 87.59% by the learning media expert, which indicated that it was highly suitable. The total validation percentage achieved an average value of 88.87%, which is included in the criteria of highly suitable. Table 3 shows that the textbooks' average validation value by learning design experts was 90.63%, which indicated that they were highly suitable, 91.22% by learning material experts, which indicated that they were highly suitable, and 91.76% by learning media experts, which indicated that they were highly suitable. The total validation percentage achieved an average value of 91.207%, which is included in the criteria of highly suitable. Also, based on the expert validation results conducted on the Autonomous learning model, it was concluded that the development of this Autonomous learning model could proceed to the field trial stage.

4. Improved learning outcomes

The N-Gain formula was used to measure improved learning outcomes when learning Physics using the Autonomous learning model. The N-Gain score was obtained by measuring student learning outcomes based on the average pretest and posttest scores. The results of N-Gain for the average pretest and posttest scores are shown in Table 4 and Figure 2.

Table 4. Value of N-gain learning outcomes

Data Source	Average	N-gain	Criteria
Pretest	42,50	0,64	Medium
Posttest	79,00		

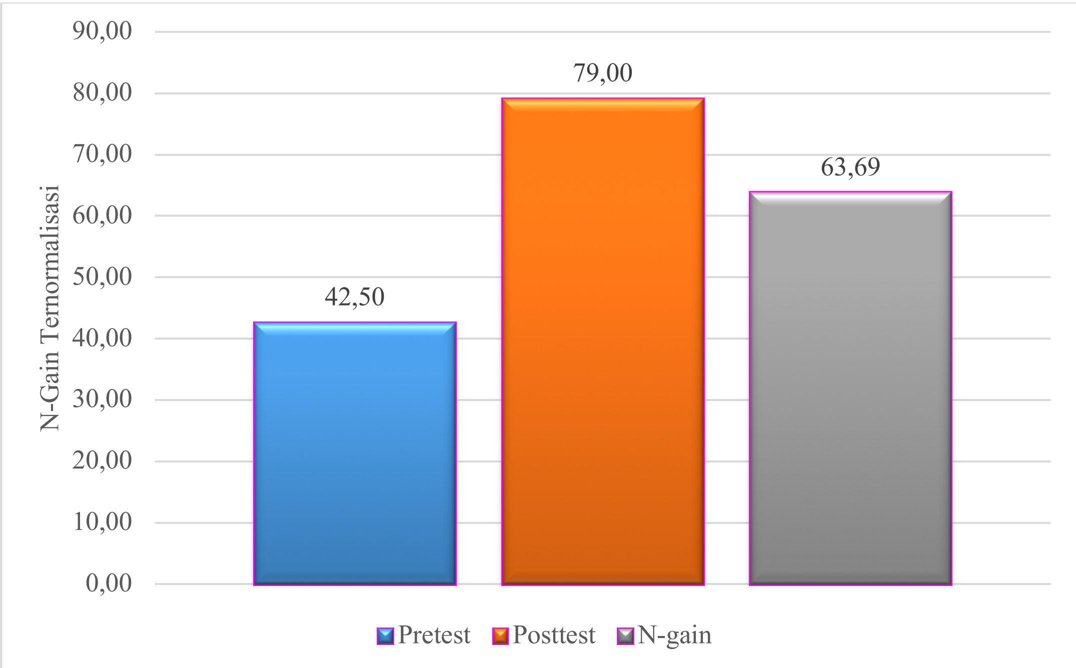

Figure 2. Improved learning outcomes

Table 4 and Figure 2 indicate that the average percentage of N-Gain in student learning outcomes based on this study's pretest and posttest scores was 0.64 of the ideal value. According to the interpretation criteria of Table 2, this value fell into the medium category. Quantitatively, student learning outcomes improved after participating in education using the autonomous learning model. Therefore, the Autonomous learning model effectively enhanced the learning outcomes of high school students. The improvement in student learning outcomes was attributed to the autonomous learning model, which allowed students to initiate projects with their ideas agreed upon in the group, create project designs, and work on the projects according to the pre-established designs and schedules. This is by the findings Nordahl-pedersen & Heggholmen (2024) that students apply their creative ideas in projects and commit to using them. According to Donelan & Kear (2023) and Lee et al. (2023) discovering that through design exploration for knowledge, creation can resonate in the project's work. Mursid et al. (2022) state that students' creative thinking abilities should be developed in designing projects that offer systematic solutions to problems.

These findings are also consistent with the research by Zhai et al. (2019), which found that mobile technology accounts for 10% of the total variance in the model, indicating a positive correlation between the frequency of mobile technology use and students' physics learning outcomes. Similarly, the research by Cheng (2024) found that learners' perceptions of social media affordances and media richness in MOOCs positively influence their cognitive involvement and affective involvement elicited by MOOCs, which concurrently explain their learning persistence in MOOCs and, in turn, enhance their learning outcomes in MOOCs. Solihati et al. (2024) found that there was a significant improvement in students' physics learning outcomes when using interactive learning media based on iSpring Suite 11 compared to conventional methods. Therefore, students' knowledge of the material on work and energy was constructed through the autonomous learning model, which involved them directly and thereby made the process of knowledge development more meaningful.

5. Students' responses to the autonomous learning model

Students' responses to the Autonomous learning model were obtained through a questionnaire after the learning session utilizing the Autonomous learning model. The data on students' responses are presented in Table 7.

Table 7. Students' responses to the autonomous learning model

No	Indicator	Average
1	The Autonomous learning model that has been significantly implemented assisted me in overcoming difficulties in teaching Physics concepts	82,29%
2	The Autonomous learning model that has been applied is very suitable for teaching Physics concepts, particularly Work and Energy	92,71%
3	In delivering Physics material, the Autonomous learning model that has been implemented should be maintained	82,29%
4	The Autonomous learning model that has been applied is highly effective because it aligns with the characteristics of the National Curriculum	81,25%
5	The worksheets used have significantly guided me in carrying out Physics projects	82,29%
6	In delivering Physics material, teachers should teach more based on projects, one of which is using the Autonomous learning model	86,46%
7	In delivering Physics material, the teachers should teach more by adapting to students' differentiation and technology-based method	85,42%
8	The knowledge of Physics concepts gained through the Autonomous learning model that has been implemented proves to be more lasting because students directly experience the project process	78,13%
9	Learning the concept of work and energy with the Autonomous learning model that has been applied has greatly motivated me to study Physics	83,33%
	Average	**83,80%**

Based on students' responses to the learning process using the Autonomous learning model on work and energy, a total score of 83.80% was obtained across all indicators, which was in the 'excellent' category. Consequently, it was concluded that the learning process with the Autonomous learning model on the topic of work and energy received an extremely positive response from students. They reported that the model overcame difficulties in teaching physics concepts. The applied Autonomous learning model was highly effective as it correlated with the National Curriculum. Also, when delivering Physics material, students expected the teachers to teach more project-based lessons tailored to students' differentiation and technology-based. During the learning activities, there was also positive interaction between students and the teacher, among students in study groups and while working on projects.

The implemented autonomous learning model greatly motivated students to learn physics, particularly in work and energy. This is consistent with the research by Solihati et al. (2024), which found that students' responses to interactive learning media based on iSpring Suite 11 were categorized as high, indicating positive acceptance and engagement with the new learning tool. Wang (2024) concluded that student responses were interpreted within the framework of the Learning Partnership Model (LPM) to illustrate how technical automation features and agent autonomy support student-agent learning partnerships. Suryandari et al. (2019) revealed that 95% of students responded positively to the Scientific Reading-Based Project (SRBP) model, showing enthusiasm, happiness, and excitement, which enhanced their critical and creative thinking skills.

Conclusions

In conclusion, the autonomous learning model featured a syntax that included 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 included a social system, reaction principles, a support system, and instructional and mentoring impacts. Expert validation of the model produced a score of 88.87%, categorized as highly suitable. Likewise, the category is ideal with textbooks with a validation score of 91.20%. This shows that the autonomous learning model is perfect for learning activities. Field trials to measure the model's effectiveness in improving learning outcomes resulted in an N-Gain value of 0.64, falling into the medium category. Therefore, the model was declared effective in enhancing the learning outcomes of high school Physics students. The responses were recorded at 83.80% and categorized as very positive. This showed that teachers could utilize the model as one of the best methods for students and capable of improving learning outcomes.

Author contributions

All authors contributed significantly to educational conceptions and projects, data collection, examination, and clarification of results, as well as the preparation of preliminary drafts of documents. All authors studied and analyzed the study's results and received the final form of this document.

Declaration of interest

The Author declares that there is no battle of interest.

Ethical statement

This study followed the principles outlined in the European Journal of Educational Research ethical policy. The authors acknowledged that consent was obtained from all participants and informed them about the anonymous publication of the study results.

Funding

No funding source is reported for this study.

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