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Development of Merdeka Flow-Based Physics Teaching Modules to Improve Physics Learning Outcomes

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Abstract: This research is a type of Research and Development (R&D) study utilizing the 4D model development method (Define, Design, Development, and Dissemination). The study was conducted at MAN 1 Buton Selatan with the aim of designing and analyzing a valid, practical, and effective Merdeka flow-based physics teaching module that can improve student learning outcomes. The developed Merdeka flow-based physics teaching module was then tested on 25 students of class X-1 and evaluated by 10 practitioners or physics teachers from Siompu District and West Siompu District, Buton Selatan. The instruments used in this study included a validation sheet for the physics teaching module, practitioner assessment questionnaires, and a validated student learning outcomes test. The results showed that the Merdeka flow-based physics teaching module at MAN 1 Buton Selatan was valid, with an Aiken's V value of 0.74, practical, with a practitioner response score of 92.44%, and effective, with 80% of students showing a high category improvement in physics learning outcomes based on the N-gain calculation. Based on the results, the Merdeka Flow-based physics teaching module is overall considered valid, practical, and effective for use in the physics learning process.

Keywords: Merdeka flow; Physics learning outcomes; Physics teaching modules

Introduction

Education is a fundamental pillar of national development, with the quality of human resources serving as the foundation for social, economic, and political progress. To achieve this goal, an effective and innovative education system is required, including the use of teaching media that facilitates the learning process (Manalu et al., 2022; Nazifah et al., 2021). Professional teachers must possess pedagogical, personal, social, and professional competencies to conduct effective teaching, which includes designing systematic lessons and selecting appropriate teaching media (Jatmiko, 2023; Sapriyah, 2019)

Currently, physics education in Indonesia has implemented the Merdeka Curriculum as a replacement for the 2013 Curriculum. The Merdeka Curriculum focuses on essential content, allowing students sufficient time to explore concepts and strengthen their competencies (Khoirurrijal et al., 2022; Masbukhin & Sausan, 2023). The Merdeka Learning Curriculum is designed to address educational challenges, aiming to create a learning environment that is adaptive, creative, collaborative, and innovative according to students' needs. This curriculum is expected to enhance learning competencies in educational institutions (Amalia et al., 2024; kemendikbudristek, 2022). Teachers play a crucial role in determining the effectiveness of learning in schools and educational outcomes. However, in practice, many teachers still do not fully understand the components of the Merdeka Curriculum (Ardianti & Amalia, 2022; Swandana et al., 2023)

The transition in the learning environment, as a characteristic of implementing the Merdeka Learning

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Curriculum, also demands readiness from teachers as educators. Teachers must be able to adapt and implement various requirements of execution and work plans outlined in the teaching procedures (Sumanti et al., 2022). Adjustments are also made to ensure that educational goals, whether institutional or instructional, can be achieved (Hartoyo et al., 2023). However, this curriculum change has raised many issues in the education sector, particularly regarding the development of teaching materials or modules that align with the Merdeka Curriculum (Dawana & Setiani, 2023).

The Merdeka Curriculum emphasizes that teachers should prepare teaching modules as part of the learning process (Nurhayati et al., 2022). A teaching module is a learning tool designed to achieve curriculum competency standards and support teachers in designing lessons (Panis et al., 2023). Creating teaching modules requires innovation and teachers' cognitive abilities, enhancing their skills to teach effectively and efficiently (Maulida, 2022). However, in practice, many teachers still do not understand how to create teaching modules that align with the Merdeka Curriculum requirements, especially in schools located in remote areas (Saragih & Marpaung, 2024).

Teaching that is not supported by well-designed teaching modules can lead to unsystematic material delivery and less engaging lessons (Jannah et al., 2022). As a result, only the teacher or some students may be active, leading to uneven learning outcomes because the teacher has not adequately prepared the teaching materials (Michailidi & Stavrou, 2021). For example, in physics instruction, which should be enjoyable for students, the learning becomes boring if the teaching strategies prepared by the teacher do not align with the students' characteristics (Widiasih et al., 2023).

Based on the observation results, the researcher identified several issues in the implementation of the Merdeka Curriculum at MAN 1 Buton Selatan, Southeast Sulawesi, Indonesia. The findings show that in physics instruction, teachers did not use teaching modules or continued to apply teaching materials from the 2013 curriculum. This has led to less effective teaching and difficulties for students in understanding the physics material being taught. Additionally, there is a high dependency among teachers and students on physics textbooks from the library that do not cover all components of the Merdeka Curriculum. The physics teachers at this school have experienced challenges in developing teaching modules that meet students' needs and translating learning outcomes into learning objectives. Consequently, physics instruction at this school has become monotonous, with students tending to be passive and less creative during the learning process.

To address these issues, there is a need for a physics teaching module as a learning resource that can foster student independence, stimulate and enhance their enthusiasm for learning, and align with the requirements or aspects of the Merdeka Curriculum. The application of teaching modules in physics education can be implemented through project-based activities, which provide students with broader opportunities to actively explore physics concepts, contribute to character development, and achieve the goals outlined in the Pancasila Student Profile (Dewi & Safitri, 2023; Husnadi et al., 2024; Kaiss et al., 2023). Given this context, it is time to develop a new approach to the learning process. The proposed new approach is to implement the Merdeka Flow approach in physics instruction.

The Merdeka Flow is a learning concept based on the Merdeka Flow model, which is represented through the MERDEKA cycle consisting of steps: Start from Self, Explore Concepts, Collaborative Space, Contextual Demonstration, Elaboration of Understanding, Connection between Materials, and Real Action (Al Ihsan et al., 2024; Jamaludin et al., 2023). Learning by applying the Merdeka Flow can encourage students to develop themselves, enhance their self-confidence, skills, and ability to adapt to their social environment (Yolanda, 2023)

The Merdeka Flow can also enhance collaboration or teamwork in learning. Additionally, it can improve student learning outcomes. Therefore, the presence of the Merdeka Flow is highly relevant to the current educational needs and demands (Yolanda & Fathurohman, 2023). Thus, Merdeka Flow-based teaching modules can serve as examples or guidelines for physics teachers in developing flexible and contextual teaching strategies. Furthermore, Merdeka Flow-based physics teaching modules are designed to improve student learning outcomes (Wulandari & Widiyatmoko, 2023). The creation of teaching modules follows principles that consider the developmental stages of students, taking into account their characteristics, differences in understanding levels, age gaps across competence levels, and the maturity of each student (Saputri et al., 2023; Wahyuni et al., 2024).

Learning outcomes refer to the skills that students acquire as a result of the learning process and can be observed through the learner's performance (Hsieh & Maritz, 2023; Nurmahasih & Jumadi, 2023). In the Merdeka Curriculum, learning outcomes can be achieved if the learning process aligns with the Learning Achievements (Capaian Pembelajaran, CP). Learning Achievements (CP) are the competencies that students must attain at each phase (kemendikbudristek, 2022; Nurmahasih & Jumadi, 2023; Saputri et al., 2023;

Wahyuni et al., 2024). Learning outcomes can be measured using the Revised Bloom's Taxonomy, as revised by Anderson and Krathwohl in 2001, which includes cognitive aspects such as Remembering (C1), Understanding (C2), Applying (C3), Analyzing (C4), Evaluating (C5), and Creating (C6) ((Efendi et al., 2024; Kusumadani et al., 2023; Liou et al., 2023).

Based on the above discussion, the author is interested in conducting research on the development of a physics teaching module titled "Development of Merdeka Flow-Based Physics Teaching Modules to Improve Physics Learning Outcomes." According to Bloom's Taxonomy as revised by Anderson and Krathwohl, the Merdeka Flow-based physics teaching module being developed will incorporate three cognitive aspects: Understanding (C2), Analyzing (C4), and Evaluating (C5). Research applying the Merdeka Flow in physics instruction represents a novel approach that has not yet been widely implemented. This could open new avenues for future research and serve as a model for addressing issues in physics education.

Method

Type of Research

This research is a Research and Development (R&D) study using the 4D development model, which refers to the development model created by Thiagarajan. The 4D model consists of Define, Design, Development, and Dissemination.

Research Subjects

The subjects of this study are students from class X-1, semester 2 of the 2023/2024 academic year. The product trial was conducted with 25 students from class X-1 using the One-Group Pretest-Posttest Design model as described by Sugiyono (2019), as shown in the following diagram.

$$O_1 \quad X \quad O_2$$

Figure 1. One-Group Pretest-Posttest Design Model

Research Procedure

The research procedure followed is illustrated in the figure 2.

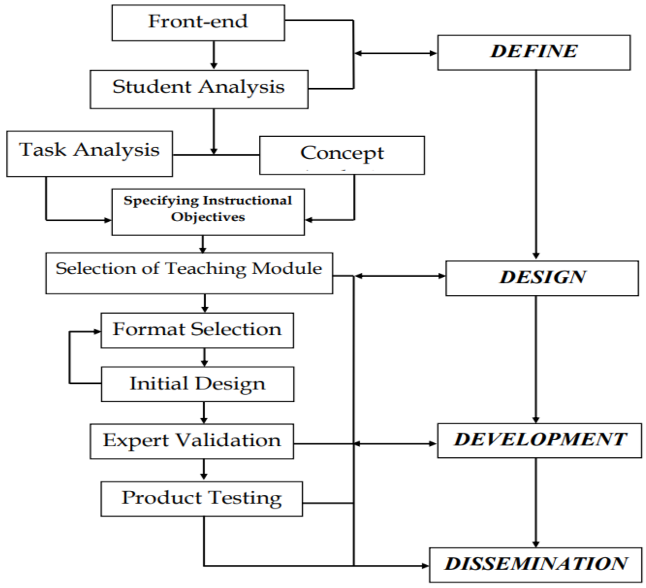

Figure 2. 4D Model Development Procedure Adapted from Thiagarajan (Sugiyono, 2019)

Define

At this stage, various analyses are conducted. Each analysis is useful for determining different objectives and constraints of the learning materials. The Define phase in this research includes five main steps: Front-end Analysis, student analysis, task analysis, Concept Analysis, and Specifying Instructional Objectives.

Front-end Analysis aims to identify the problems faced by teachers and students in the learning process. At this stage, an analysis is conducted based on observations and open interviews with physics teachers at MAN 1 Buton Selatan regarding the learning resources used in the teaching process. This is done to understand student characteristics, student engagement, and the learning outcomes in physics.

Student Analysis is conducted to understand student characteristics, including their background knowledge and learning styles, through open interviews with physics teachers, direct classroom observations, and a distribution of learning style questionnaires to 25 students from class X-1. Task Analysis is performed to understand the tasks students complete to master specific elements and learning outcomes. These elements and learning outcomes include topics such as climate change and global warming for class X.

Concept Analysis involves identifying key concepts systematically according to the learning achievements to be attained, serving as a reference for the researcher. This stage is crucial to determine appropriate reading materials for inclusion in the Merdeka Flow-Based Physics Teaching Module. Specifying Instructional Objectives involves creating learning objectives based on the Merdeka Curriculum's learning outcomes and aligning them with the Merdeka Flow.

Design

After identifying the problems in the defining stage, the next step is the design phase. The design phase aims to create a Merdeka Flow-Based Teaching Module that can be used in physics instruction. This phase includes selecting the teaching module and materials, choosing the format of the teaching module, and developing the initial design of the teaching module.

Develop

Module based on feedback from experts, specifically faculty members from the Physics Education Program at the Postgraduate School of Makassar State University, and trials with students at MAN 1 Buton Selatan. At this stage, the components of the teaching module have been created, printed, and bound to form a complete Merdeka Flow-Based Physics Teaching Module ready for use. Activities at this stage include validating the content of the developed module. Validity is assessed using Aiken's V analysis. The items validated include is the complete teaching module, the learning outcome tests, the teacher/practitioner response questionnaire. After validating all the instrument items, revisions are made if there are any deficiencies in the instruments.

Disseminate

In the dissemination stage, learning outcome tests, including pretests and posttests, are conducted, along with trials of the revised Merdeka Flow-Based Physics Teaching Module and analysis of the trial results. Additionally, this stage aims to distribute the developed Merdeka Flow-Based Physics Teaching Module. In this research, dissemination is limited, focusing on distributing and promoting the final product within MAN 1 Buton Selatan.

Research Instruments and Data Collection Techniques

Validation Sheets for the Merdeka Flow-Based Teaching Module, which are provided to three experts from the Physics Postgraduate Program at Makassar State University, response Sheets (Questionnaires) for teachers/practitioners, which are given to ten physics teachers from schools in Siompu and Siompu Barat districts, physics learning outcome tests in the form of pretest-posttest multiple-choice questions, which are administered to 25 students from class X-1.

Data Analysis Technique

The data collected using the available instruments were subsequently analyzed quantitatively. Each instrument produces data that is analyzed in a general context to assess the process and outcomes of developing physics teaching modules based on the Merdeka Learning flow, ensuring they meet the criteria of validity, practicality, and effectiveness. Below is the plan for analyzing the validity, practicality, and effectiveness of the developed physics teaching modules.

Analysis of Module Validity

To determine the validity relevance of the teaching module as assessed by three experts, the content validity coefficient (Aiken's V) was used. The Aiken's V formula is employed to calculate the content validity coefficient based on the assessment results from each expert regarding an item, using the equation 1, proposed (Retnawati, 2016).

$$V = \frac{\sum s}{n\,(c-1)} \tag{1}$$

Explanation

V : index of rater agreement on the validity of an item

s : The score assigned by each rater minus the lowest score in the category used (s = r – Io, where r is the rater's category score and Io is the lowest score assigned)

n : number of raters

c : number of categories selected by the raters

The criteria for Aiken's V test indicate that if V ≥ 0.4, then the index of expert agreement is considered valid (Retnawati, 2016).

Analysis of Module Practicality

The analysis of practicality is based on a questionnaire given to practitioners/teachers. Data on the practitioners' evaluations of the Merdeka Learning flow-based physics teaching module, as recorded in the questionnaire, are analyzed using the formula proposed by Trianto (2017), as equation 2.

$$PRS = \frac{\sum A}{\sum B} \times 100\% \tag{2}$$

Note:

PRS: The percentage of practitioners who responded to the category stated in the instrument.

$\sum A$: The total score obtained for each category as stated in the questionnaire.

$\sum B$:The maximum score for each category that responds to the questionnaire.

A Merdeka Learning flow-based physics teaching module is considered practical if it meets the following criteria (Riduwan, 2022):

Table 1. Practitioner Assessment Score Criteria

Percentage (%)	Criteria
81 - 100	Very Practical
61 - 80	Practical
41 - 60	Moderately Practical
21 - 40	Not Practical
0 - 20	Not at All Practical

Analysis of Module Effectiveness

The effectiveness of the Merdeka Learning flow-based physics teaching module on learning outcomes can be determined by analyzing the results of posttests and pretests of students using the gain score formula according to Hake, as cited in (Rahma, 2021), as equation 3.

$$\text{N} - \text{Gain} = \frac{\text{posttest score} - \text{pretest score}}{\text{maximum} - \text{pretest score}} \quad (3)$$

A Merdeka Learning flow-based physics teaching module is considered effective if it meets the following criteria:

Table 2. Criteria for Gain Score Distribution Meltzer & David as cited in (Hasanah et al., 2021).

Nilai N-Gain	Categories
$g \geq 0.70$	High
$0.30 \leq g < 0.70$	Medium
$g < 0.30$	Low

Result and Discussion

The research data includes the feasibility of the Merdeka Learning flow-based physics teaching module, evaluated through expert validity analysis (content validity), practitioner assessment, and the effectiveness of the module as measured by improvements in student learning outcomes. This was conducted during the development phase, specifically in a trial with Class X 1 at MAN 1 Buton Selatan. The following explains the research results.

Results of Validation for the Merdeka Learning Flow-Based Physics Teaching Module

During the development phase of the Merdeka Learning flow-based physics teaching module, the module was validated by three experts. The aspects evaluated for the Merdeka Learning flow-based physics teaching module include content feasibility, presentation feasibility, language feasibility, and graphic feasibility. Content validity indicates that the content reflects a complete set of attributes being studied. The scores obtained from the validators for each component—content feasibility, presentation, language, and graphics—are summarized in Table 3 below

Table 3. Average Content Validity Assessment for the Merdeka Learning Flow-Based Physics Teaching Module with Aiken's V Index

Assessment aspects feasibility	Total validator score	Percentage (%)	V	Information
Content	303	81.45	0.75	Valid
Presentation	77	80.21	0.74	Valid
Language	87	80.56	0.74	Valid
Graphic	117	81.25	0.75	Valid

Table 3 shows the average percentage for each aspect of the Merdeka Learning flow-based physics teaching module evaluation. For the content feasibility aspect, the module received a total validator score of 303, with a percentage of 81.45% from 31 statement items. For presentation feasibility, the module received a total validator score of 77, with a percentage of 80.21% from 8 statement items. For language feasibility, the module received a total validator score of 87, with a percentage of 80.56% from 9 statement items. For graphic feasibility, the module received a total validator score of 117, with a percentage of 81.25% from 12 statement items.

Overall, these results indicate that the Merdeka Learning flow-based physics teaching module is valid and can be used in practice with minor revisions. These findings are consistent with previous research by Camelia, Mawardi, and Suryani (2023) on the development of teaching materials to support Merdeka Curriculum learning on the concept and impacts of global warming for SMA/MA Phase E, which also achieved a valid content validity rating (Camelia et al., 2023). Similarly, Rasyid (2023) reported that the content validity of their Merdeka Curriculum-based teaching module for integrated local wisdom in Batik Bondowoso in SMKN 1 Tamanan Bondowoso was rated as highly valid and suitable for implementation (Rasyid, 2023) .

Practitioners' Assessment of the Quality of the Merdeka Learning Flow-Based Physics Teaching Module

To determine the quality of the Merdeka Learning flow-based physics teaching module in practice, data from practitioner responses are needed. The practitioners' evaluations are calculated by considering the percentage of scores given by practitioners in each category stated in the questionnaire. The practitioners who filled out the evaluation questionnaire for the Merdeka Learning flow-based physics teaching module were 10 physics teachers from SMA/MA in Siompu and Siompu Barat Subdistricts. The results of the practitioners' responses are summarized in Table 4.

Table 4. Average Validity Assessment with Aiken's V Index

Assessment aspects feasibility	Practitioner score	PRS (%)	Criteria
Content	112.80	91.69	Very Practical
Presentation	30.10	94.06	Very Practical
Language	32.80	91.11	Very Practical
Graphic	44.60	92.91	Very Practical

From Table 4, the cumulative practitioner response scores for each aspect are as follows: content feasibility received a percentage of 91.69%, presentation feasibility received 94.06%, language feasibility received 91.11%, and graphic feasibility received 92.91%. Based on the cumulative percentage score interpretation criteria, each aspect of the assessment falls under the "very practical" category. These results are consistent with the study conducted by Madani, Sirait, and Oktavianty (2023) on the development of a kinematics teaching module based on differentiated learning within the Merdeka Curriculum, which was found to be valid and very practical for use in physics education (Madani et al., 2023).

Effectiveness of Using the Merdeka Learning Flow-Based Physics Teaching Module on Students' Physics Learning Outcomes

Data analysis was conducted based on pretest-posttest results using 40 multiple-choice questions. The analysis of learning outcomes was differentiated by cognitive domain aspects, with 20 questions targeting the understanding aspect (C2), 10 questions targeting the analyzing aspect (C4), and 10 questions targeting the evaluating aspect (C5). The following presents the data on the improvement of students' learning outcomes in the understanding aspect (C2).

Table 5. Pretest-Posttest Results for the Understanding Aspect (C2)

Questions	Total test score	Test scores obtained	Percentage (%)
Pretest	20	9	45
Posttest	20	15	76

From Table 5 above, the difference between the students' pretest and posttest scores can be observed through the graph presented in figure 3.

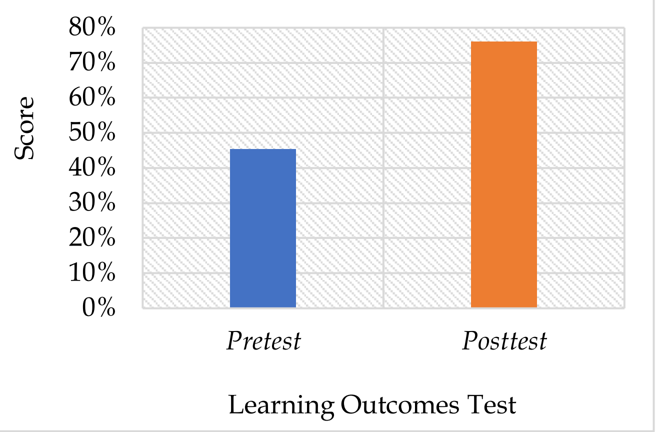

Figure 3. Bar Diagram of Percentage Scores for Students in the Understanding Aspect (C2)

From Table 5 and Figure 3 above, the pretest and posttest scores for students in the understanding aspect (C2) are as follows: the total pretest score was 45%, and the total posttest score was 76%. This result indicates that there was an improvement in the test scores for students' learning outcomes before and after the implementation of the physics teaching modules based on the Merdeka Flow Learning approach.

Next, the analysis of pretest and posttest scores for 25 students in the analyzing aspect (C4) is as tabel 6.

Table 6. Pretest-Posttest Results for the Analyzing Aspect (C4)

Questions	Total Test Score	Test Scores Obtained	Percentage (%)
Pretest	10	2	20
Posttest	10	8	80

From Table 6 above, the difference in pretest and posttest scores for students can be observed through the graph presented in Figure 4.

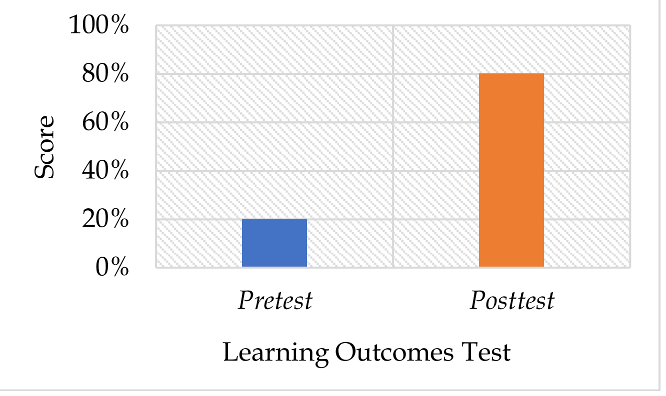

Figure 4. Bar Diagram of Percentage Scores for Students in the Understanding Aspect (C4)

From Table 6 and Figure 3 above, the pretest and posttest scores for students in the analyzing aspect (C4) are as follows: the total pretest score was 20%, and the total posttest score was 80%. This result indicates that there was an improvement in the test scores for students' learning outcomes in the analyzing aspect (C4) before and after the implementation of the physics teaching modules based on the Merdeka Flow Learning approach.

The analysis of pretest and posttest scores for 25 students in the evaluating aspect (C5), using 10 multiple-choice questions, is as tabel 7.

Table 7. Pretest-Posttest Results for the Evaluating Aspect (C5)

Questions	Total test score	Test scores obtained	Percentage
Pretest	10	4	40%
Posttest	10	8	80%

From Table 7 above, the difference in pretest and posttest scores for students can be observed through the graph presented in the following figure.

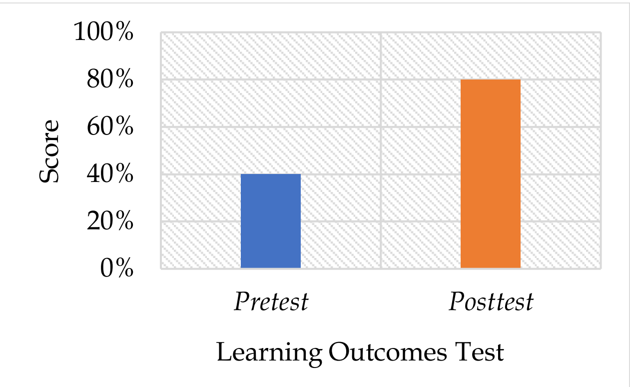

Figure 5. Bar Diagram of Percentage Scores for Students in the Understanding Aspect (C5)

From Table 7 and Figure 5 above, the pretest and posttest scores for students in the evaluating aspect (C5) are as follows: the total pretest score was 40%, and the total posttest score was 80%. This result indicates that there was an improvement in the test scores for students' learning outcomes in the evaluating aspect (C5) before and after the implementation of the physics teaching modules based on the Merdeka Flow Learning approach.

The effectiveness of the physics teaching modules based on the Merdeka Flow Learning approach can be determined based on the scores obtained by students. The pretest and posttest scores for the physics learning outcomes of class X-1 MAN 1 Buton Selatan are presented in the following table 8.

Tabel 8. Normalized Gain (N-Gain) Analysis of Students' Physics Learning Outcomes

Parameter	Category	Number of students	N-Gain	Interpretation
$g \geq 0.70$	High	20	0.78	Effective
$0.30 \leq g < 0.70$	Medium	3	0.46	Ineffective
$g < 0.30$	Low	2	0.18	Ineffective

The improvement in students' physics learning outcomes based on pretest and posttest results is fully presented in the bar diagram shown in Figure 6.

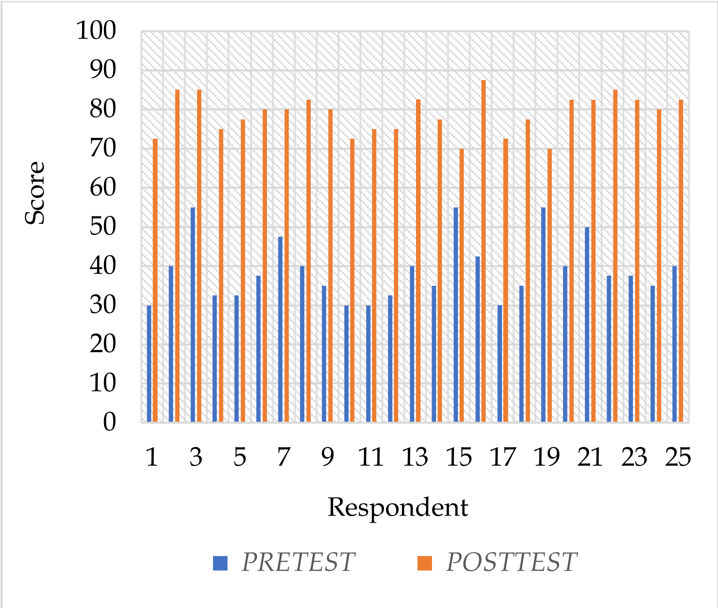

Figure 6. Pretest and Posttest Scores of Student Learning Outcomes

The data in Table 8 and Figure 6 represent the physics learning outcomes obtained from posttest and pretest results. On average, all students showed an increase in scores after participating in the teaching and learning activities using the Merdeka Flow-based physics teaching modules. Out of 25 students, 20 students, or 80%, fall within the N-Gain parameter range of > 0.7 with a High category; 3 students, or 12%, fall within the N-Gain parameter range of > 0.3 with a Medium category; and 2 students, or 8%, fall within the N-Gain parameter range of < 0.3 with a Low category. The analysis also shows that the use of the Merdeka Flow-based physics teaching modules led to an improvement in physics learning outcomes. This improvement indicates that 20 students, or 80%, are in the High category, suggesting that the Merdeka Flow-based physics teaching module is effective during the physics learning process. This finding is consistent with research on the application of the Merdeka Flow Learning approach to enhance creative thinking skills and student learning outcomes, as conducted by Wulandari, Rachayuni, and Widiyatmoko (2023), which shows that student learning outcomes improved after implementing the Merdeka Flow Learning approach in the learning process (Wulandari & Widiyatmoko, 2023).

Conclusion

Based on the research findings and discussion, it can be concluded that the Merdeka Flow-based physics teaching module is considered valid, with an Aiken's V value of 0.74, making it suitable for use. The practicality of the Merdeka Flow-based physics teaching module, as indicated by the practitioners' response score of 92.44%, falls into the "very practical" category. Additionally, the effectiveness of using the Merdeka Flow-based teaching module, as measured by the N-gain calculation, shows that 80% of students achieved a significant improvement in learning outcomes, categorized as high and effective. Therefore, the Merdeka Flow-based physics teaching module is overall deemed valid, practical, and effective for use in the physics learning process.

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Authors Contribution
Nursyahitna: Conceptualization, methodology, writing—original draft preparation, formal analysis, investigation, visualization, writing—review and editing. Helmi and Kaharuddin Arafah: Validation, supervision, and resources. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest
The authors declare no conflict of interest.

References

Al Ihsan, M., Syamsuyurnita, S., Sari, S. P., & Nasution, I. S. (2024). Pengaruh Penerapan Alur Merdeka Terhadap Kemampuan Literasi Finansial Siswa di Kelas V. *Edusaintek: Jurnal Pendidikan, Sains dan Teknologi*, *11*(2), 463–472. https://doi.org/10.47668/edusaintek.v11i2.1042

Amalia, S., Safrida, S., & Ulva, S. M. (2024). Differentiated learning integrated with social emotional awareness and digital learning media in improving the students motivation and learning outcomes. *Jurnal Penelitian Pendidikan IPA*, *10*(1), 239–245. https://doi.org/10.29303/jppipa.v10i1.5354

Ardianti, Y., & Amalia, N. (2022). Kurikulum merdeka: Pemaknaan merdeka dalam perencanaan pembelajaran di sekolah dasar. *Jurnal Penelitian Dan Pengembangan Pendidikan*, *6*(3), 399–407. https://doi.org/10.23887/jppp.v6i3.55749

Camelia, S., Mawardi, M., & Suryani, O. (2023). Pengembangan Bahan Ajar untuk Menunjang Pembelajaran Kurikulum Merdeka pada Materi Konsep dan Dampak Pemanasan Global Fase E SMA/MA. *Jurnal Pendidikan Mipa*, *13*(2), 530–537. https://doi.org/10.37630/jpm.v13i2.1091

Dawana, I. R., & Setiani, R. (2023). Validity of Teaching Modules with Problem-Based Learning (PBL) Model Assisted by E-Book to Improve Problem-Solving Skills on Renewable Energy Material and Implementation of Independent Learning Curriculum. *Journal of Physics: Conference Series*, *2623*(1), 012015. https://doi.org//10.1088/1742-6596/2623/1/012015

Dewi, W. S., & Safitri, G. (2023). The Practicality of the Physics Module Based on the PjBL Model with a Portfolio Assessment to Improve Students' Critical Thinking Skills. *Journal of Physics: Conference Series*, *2582*(1), 012054. https://doi.org//10.1088/1742-6596/2582/1/012054

Efendi, R., Liliawati, W., Muslim, M., & Ariantara, R. G. (2024). Development of Three-Dimensional Light Wave Test Based on Three-Dimensional Learning Framework. *Jurnal Penelitian Pendidikan IPA*, *10*(7), 4203–4211. https://doi.org/10.29303/jppipa.v10i7.8119

Hartoyo, A., Melati, R., & Martono, M. (2023). Dampak Perubahan Kurikulum Merdeka Dan Kesiapan Tenaga Pendidik Terhadap Penyesuaian Pembelajaran Di Sekolah. *Jurnal Pendidikan Dasar Perkhasa: Jurnal Penelitian Pendidikan Dasar*, *9*(2), 412–428.

Hasanah, S. I., Susilawati, S., & Rokhmat, J. (2021). Pengaruh Model Pembelajaran Fisika Berbasis

Masalah untuk Meningkatkan Kemampuan Berpikir Kritis. *Jurnal Penelitian Dan Pembelajaran Fisika Indonesia*, *3*(1). https://doi.org/10.29303/jppfi.v3i1.117

Hsieh, H.-M., & Maritz, A. (2023). *Effects of flipped teaching on entrepreneurship professional student'learning motivation, self-directed learning, and learning outcome*. *Contemporary Educational Technology*, 15(4), ep472. https://doi.org/10.30935/cedtech/13649

Husnadi, M., Budiawanti, S., & Ekawati, E. Y. (2024). Feasibility Analysis of Subject Specific Pedagogy Physics Learning Module Based on Project Based Learning Integrated with Merdeka Curriculum on Alternative Energy Material. *Jurnal Penelitian Pendidikan IPA*, *10*(2), 449–458. https://doi.org/10.29303/jppipa.v10i2.3774

Jamaludin, U., Pribadi, R. A., & Zahara, G. (2023). Pengembangan Media Pembelajaran Berbasis Alur Merdeka. *Jurnal Ilmiah Wahana Pendidikan*, *9*(14), 710–716. https://doi.org/10.5281/zenodo.8186852

Jannah, F., Irtifa'Fathuddin, T., & Zahra, P. F. A. (2022). Problematika penerapan kurikulum merdeka belajar 2022. *Al Yazidiy: Jurnal Sosial Humaniora Dan Pendidikan*, *4*(2), 55–65. https://doi.org/10.55606/ay.v4i2

Jatmiko, A. (2023). Competency of Science Vocational Teachers in the Industrial Revolution 4.0 Era. *Jurnal Penelitian Pendidikan IPA*, *9*(12), 11592–11602. https://doi.org/10.29303/jppipa.v9i12.5698

Kaiss, W., Mansouri, K., & Poirier, F. (2023). Effectiveness of an Adaptive Learning Chatbot on Students' Learning Outcomes Based on Learning Styles. *International Journal of Emerging Technologies in Learning*, *18*(13). https://doi.org/10.3991/ijet.v18i13.39329

kemendikbudristek, B. S. K. dan A. P. (2022). *Capaian Pembelajaran Mata Pelajaran Fisika Fase E – Fase F untuk SMA/MA/Program Paket C*. Retrieved from https://kurikulum.kemdikbud.go.id/file/cp/dasmen/15.%20CP%20Fisika.pdf

Khoirurrijal, F., Sofia, M. A. D., Gandi, S., Muin, A., Tajeri, F. A., & Hamdani, S. (2022). *Pengembangan Kurikulum merdeka*. Malang: CV Literasi Nusantara Abadi.

Kusumadani, A. I., Rahardjo, S. B., Yamtinah, S., & Prayitno, B. A. (2023). Development of High-Order Thinking Skills (HOTs) Instruments with a Socio-Scientific Problem-Based Learning Approach on the Subject of Viruses. *Eurasian Journal of Educational Research*, *107*(107), 140–164. Retrieved from https://ejer.com.tr/manuscript/index.php/journal/article/view/1442/340

Liou, S., Cheng, C., Chu, T., Chang, C., & Liu, H. (2023). Effectiveness of differentiated instruction on learning outcomes and learning satisfaction in the evidence-based nursing course: Empirical research quantitative. *Nursing Open*, *10*(10), 6794–6807. https://doi.org/10.1002/nop2.1926

Madani, N., Sirait, J., & Oktavianty, E. (2023). Pengembangan modul ajar kinematika gerak lurus berbasis pembelajaran berdiferensiasi pada kurikulum merdeka belajar. *Jurnal Pendidikan Fisika*, *11*(2), 206–219. http://dx.doi.org/10.24127/jpf.v11i2.8626

Manalu, J. B., Sitohang, P., & Henrika, N. H. (2022). Pengembangan perangkat pembelajaran kurikulum merdeka belajar. *Prosiding Pendidikan Dasar*, *1*(1), 80–86. https://doi.org/10.34007/ppd.v1i1.174

Masbukhin, F. A. A., & Sausan, I. (2023). Analyzing the Implementation of Kurikulum Merdeka: Insights from Chemistry Educators in Gunung Kidul Vocational Schools. *Jurnal Penelitian Pendidikan IPA*, *9*(12), 11250–11260. https://doi.org/10.29303/jppipa.v9i12.5991

Maulida, U. (2022). Pengembangan modul ajar berbasis kurikulum merdeka. *Tarbawi*, *5*(2), 130–138. https://doi.org/10.51476/tarbawi.v5i2.392

Michailidi, E., & Stavrou, D. (2021). Mentoring in-service teachers on implementing innovative teaching modules. *Teaching and Teacher Education*, *105*, 103414, 2-15. https://doi.org/10.1016/j.tate.2021.103414

Nazifah, N., Azmi, N., Nurhaliza, P., & Desnita, D. (2021). Meta Analysis: The Effect of Edmodo Assisted Physics Learning Media on Student Learning Outcomes. *Jurnal Penelitian Pendidikan IPA (JPPIPA)*, *7*, 231–237. https://doi.org/10.29303/jppipa.v7iSpecialIssue.822

Nurhayati, P., Emilzoli, M., & Fu'adiah, D. (2022). Peningkatan Keterampilan Penyusunan Modul Ajar Dan Modul Proyek Penguatan Profil Pelajar Pancasila Kurikulum Merdeka Pada Guru Madrasah Ibtidaiyah. *JMM (Jurnal Masyarakat Mandiri)*, *6*(5). https://doi.org/10.31764/jmm.v6i5.10047

Nurmahasih, U., & Jumadi, J. (2023). The Effect of Utilizing the PBL Model in Physics Learning on Student Learning Outcomes: A Systematic Literature Review. *Jurnal Penelitian Pendidikan IPA*, *9*(6), 81–88. https://doi.org/10.29303/jppipa.v9i6.2741

Panis, I. C., Mukin, M. U. J., & Uran, Y. L. (2023). Pengembangan Modul Pembelajaran Fisika Berbasis Kearifan Lokal Pada Alat Musik

Tradisional Untuk Meningkatan Pemahaman Konsep. *JKTP J. Kaji. Teknol. Pendidik*, *6*(1), 050. http://dx.doi.org/10.17977/um038v6i12023p050

Rahma, A. A. (2021). Efektivitas penggunaan virtual lab phet sebagai media pembelajaran fisika terhadap hasil belajar siswa. *Pedagogy: Jurnal Ilmiah Ilmu Pendidikan*, *8*(2), 47–51. https://ejournal.upm.ac.id/index.php/pedagogy/article/view/808/741

Rasyid, A. N. (2023). Pengembangan Modul Ajar Berbasis Kurikulum Merdeka Belajar Pada Mata Pelajaran Proyek IPA Sosial Terintegrasi Kearifan Lokal Batik Bondowoso Di SMKN 1 Tamanan Bondowoso: Universitas Islam Negeri KIAI Haji Achmad Siddiq (Tesis). *Universitas Islam Negeri Kiai Haji Achmad Siddiq Jember*.

Retnawati, H. (2016). *Analisis kuantitatif instrumen penelitian (panduan peneliti, mahasiswa, dan psikometrian)*. Yogyakarta: Parama publishing.

Riduwan, M. B. A. (2022). *Skala pengukuran variabel-variabel penelitian*. Bandung: Alfabeta.

Sapriyah, S. (2019). Media pembelajaran dalam proses belajar mengajar. *Prosiding Seminar Nasional Pendidikan FKIP*, *2*(1), 470–477. Retrieved from https://jurnal.untirta.ac.id/index.php/psnp/article/view/5798/4151

Saputri, R., Wilujeng, I., Jumadi, J., Nurohman, S., & Purnama, A. Y. (2023). Development of PBL Modul-El to Improve Problem Solving Students of Physics Education Program. *Jurnal Penelitian Pendidikan IPA*, *9*(10), 8376–8382. https://doi.org/10.29303/jppipa.v9i10.4092

Saragih, O., & Marpaung, R. (2024). Tantangan dan Peluang: Studi Kasus Penerapan Kurikulum Merdeka di Sekolah Mandiri Berubah Kabupaten Tapanuli Utara. *Jurnal Pendidikan Dan Pembelajaran Indonesia (JPPI)*, *4*(3), 888–903. https://doi.org/10.53299/jppi.v4i3.632

Sugiyono. (2019). Metode *Penelitian Pendidikan: Pendekatan Kuantitatif, Kualitatif dan R&D*. Bandung: Alfabeta.

Sumanti, V., Firman, F., & Ahmad, R. (2022). Peran Guru dalam Kebijakan Kurikulum Merdeka di Sekolah. *Keguruan*, *10*(2), 49–52. Retrieved from http://jurnal.uisu.ac.id/index.php/Keguruan/article/view/6434/4751

Swandana, H., Tindangen, M., & Herliani, H. (2023). High School Studentsâ€™ Perceptions about Implementation of the Merdeka Curriculum in Biology Lessons in Samarinda. *Jurnal Penelitian Pendidikan IPA*, *9*(10), 8235–8244. https://doi.org/10.29303/jppipa.v9i10.4585

Trianto, & Tabany, A. (2017) *Mendesain Model Pembelajaran Inovatif, Progresif, dan Kontekstual*. Jakarta: Kencana.

Wahyuni, B., Zainuddin, Z., Misbah, M., & Murshed, M. B. (2024). Character-based physics learning module through generative learning model: Student conceptual understanding. *Journal of Environment and Sustainability Education*, *2*(1), 31–39. https://doi.org/10.62672/joease.v2i1.15

Widiasih, W., Sukmayadi, D., Aprianti, R., & Nadiyyah, K. (2023). A New Pattern to Improving Student Physics Learning Outcomes. *Jurnal Penelitian Pendidikan IPA*, *9*(9), 7439–7444. https://doi.org/10.29303/jppipa.v9i9.3324

Wulandari, A. S., & Widiyatmoko, A. (2023). Penerapan alur merdeka belajar dalam meningkatkan kemampuan berpikir kreatif dan hasil belajar peserta didik. *Proceeding Seminar Nasional IPA*. Retrieved from https://proceeding.unnes.ac.id/snipa/article/view/2307/1790

Yolanda, Y. (2023). Penerapan Alur Merdeka pada Mata Kuliah Telaah Kurikulum Buku Teks Fisika untuk Meningkatkan Keterampilan Kolaborasi dan Kreatif Mahasiswa. *PASCAL (Journal of Physics and Science Learning)*, *7*(1), 6–19. Retrieved from https://jurnal.uisu.ac.id/index.php/PASCAL/article/view/7269/5404

Yolanda, Y., & Fathurohman, A. (2023). Analysis Of Student Collaboration Skills Using The Independent Flow Of Basic Physics Course Material Of Capacitors. *Al-Khazini: Jurnal Pendidikan Fisika*, *3*(1), 32–42. https://doi.org/10.24252/al-khazini.v3i1.36701