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Research Article

Engaging every learner: Differentiated educational materials for renewable energy

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Abstract: The learning approach in the classroom is often centered on the role of the teacher, so the development of teaching materials based on differentiated learning is important to meet diverse learning needs. Therefore, this study aims to describe the validity and student responses to teaching materials based on differentiated learning on renewable energy materials. The research method used is Research and Development (R&D) with the ADDIE model. Data collection was done through observation, questionnaires, and interviews. Data analysis techniques include learning style analysis, feasibility and validity of teaching materials, and student responses to questionnaires. The subjects of this study were 35 students of class X-11 of State High School in Samarinda City and the object of research was teaching materials based on differentiated learning on renewable energy material. The results showed that the teaching materials were in the highly valid category, with a percentage score of 88% in the material aspect and 89% in the media aspect. The results of student responses showed a percentage score of 81%. Trials on a wider sample need to be carried out to ensure the effectiveness of this approach if students have the same circumstances, especially learning styles.

Keywords: ADDIE; differentiated learning; learning styles; renewable energy; teaching materials

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1. Introduction

Each student has a different background and learning style during the learning process (Bendriyanti et al., 2021). Learning styles become students' learning habits that have an impact on the achievement of learning outcomes (Wibowo et al., 2023). Not all students in the classroom can capture learning material from teachers with one particular learning style (Lestari & Djuhan, 2021). If students are routinely asked to learn material with inappropriate or unpopular methods, they will have difficulty focusing their attention when seeking information (Marpaung, 2015).

Adaptation of learning methods that suit students' learning styles needs to be done (Hanggara & Suhardi, 2016). One of the steps that can be taken is to implement differentiated learning as a learning approach that can meet all the diverse learning needs of students (Sada et al., 2023). Differentiated learning is used so that teachers do not generalize all students (Himmah & Nugraheni, 2023). The implementation of differentiated learning can involve a combination of various learning models while still considering the individual needs of each student (Fitra, 2022). However, many teachers are not used to visualizing how to apply different learning methods (Herwina, 2021).

The availability of teaching materials is an important element in organizing an effective learning process (Sanjaya et al., 2023). Teaching materials are learning materials that are compiled in a comprehensive and structured manner, following the principles of learning applied by teachers and students in the teaching and learning process (Magdalena et al., 2020). Teaching materials refer to various media aids, methods,

instructions, and guidelines that are systematically arranged, attractive, safe, and according to the needs of students (Setiawan et al., 2022). Teaching materials function centrally in providing support to teachers in lesson planning (Salsabilla et al., 2023).

However, until now, teaching materials that are in accordance with the Merdeka Curriculum are still limited (Madani et al., 2023). In addition, many teachers do not understand how to compile and develop teaching materials as part of learning materials (Kamila et al., 2023). The development of differentiated teaching materials cannot be ignored because the main essence of learning is to provide facilities that suit students' needs (Ndiung et al., 2023).

Research on the development of teaching materials based on differentiated learning has been done. In the research of Fianti & Neratania (2024), the development of ethnoscience integrated physics teaching materials was carried out where the teaching materials developed had accommodated learning styles as a whole, but the teaching materials did not contain worksheets based on learning styles. While.'s Madani et al., (2023) research developed teaching modules only focused on the feasibility of teaching modules that were not implemented directly to students. In addition, research conducted by Yuanisyak et al., (2023) teaching materials developed focus more on visual and auditory learning styles which can be seen from the content presented. Meanwhile, Nurhayati (2023) stated that the development of teaching materials is still quite lacking, especially in Physics subjects. This is also reinforced when researchers found that physics textbooks used by students have not accommodated students' learning styles.

From some of the above studies, the researcher developed a differentiated learning-based teaching material on renewable energy material that contains detailed physics material, accommodates the three learning styles (visual, auditory, and kinetic), contains worksheets based on learning styles, competency tests, and appendices of recommended learning activities that have been implemented directly to students. The benefits or contributions in this study are to assist teachers in delivering renewable energy materials according to student needs, make learning more interesting for students, provide innovation for schools in improving the effectiveness and quality of education, and become a reference for other researchers in developing similar teaching materials.

Teaching materials that are prepared must meet the validity criteria so that they can be used effectively by students (Wati et al., 2022). Validity testing is carried out to assess whether teaching materials are suitable for use or not, based on the valid status of the experts (Irman & Waskito, 2020). Validity can be seen from the consistency and effectiveness of teaching materials in supporting learning (Nurhayati, 2023). Student response is different from the evaluation of learning outcomes, but rather student responses to the teaching materials developed (Gola et al., 2022). Student responses were given in the form of questionnaires to students who were limited trial subjects (Tania & Susilowibowo, 2017).

Therefore, it is at this point that the urgency of this research is felt. The objectives of this study are (1) to describe the validity of teaching materials based on differentiated learning on renewable energy materials; and (2) to describe student responses to teaching materials based on differentiated learning on renewable energy materials.

2. Materials and Methods

2.1 Types of research

This research uses a type of R&D (Research and Development) research. This research aims to develop and test the validity level of a product. The product to be developed and tested for its feasibility level is in the form of teaching materials based on differentiated learning on renewable energy material. This research uses the ADDIE model which consists of five development stages, namely the analysis stage, design stage, development stage, implementation stage, and evaluation stage.

2.2 Research Subjects and Objects

The subjects in this study were 35 students of class X-11 High School 10 Samarinda and the object of the research was teaching materials based on differentiated learning on renewable energy material developed.

2.3 Data Collection Techniques

The data that has been collected is then analyzed. The steps taken to analyze and interpret the research data are:

1) Learning style analysis

In the initial stage of the trial, students' learning styles were analyzed by processing data obtained from the results of filling out the learning style questionnaire by students as respondents. The learning style questionnaire consists of three learning styles, namely visual, auditorial, and kinesthetic (VAK). Data collection was done quantitatively through a closed questionnaire using a Likert scale as a measuring tool. The Likert scale used uses a scale of 1 - 4 which can be seen in Table 1.

Table 1. Likert Scale with 4 Alternative Answers and Rating

Positive Statemen	Score	Negative Statemen	Score
Always	4	Always	1
Often	3	Often	2
Rarely	2	Rarely	3
Never	1	Never	4

(Isnanto & Hamu, 2022)

After collecting data and calculating according to Table 1 above, the classification of students' learning style tendencies is done by calculating the number of students for each learning style. After that, the results are compared with the total number of students to calculate the percentage of each learning style, can see Formula 1.

$$\text{Persentage} = \frac{\text{Number of students by learning style tendency}}{\text{Total students}} \times 100\% \quad (1)$$

2) Feasibility and validity analysis of teaching materials

The feasibility of teaching materials was analyzed by processing data obtained from the results of feasibility and validity test questionnaires by expert lecturers and physics teachers as respondents. The feasibility and validity test questionnaire consists of several aspects, namely material content, language, presentation, and graphics. Data collection was done quantitatively through a closed questionnaire with a Likert scale which can be seen in Table 2.

Table 2. Likert Scale of Feasibility and Validity of Teaching Materials

Score	Category
5	Very good
4	Good
3	Fair
2	Not Good
1	Not Good

(Fraenkel et al., 2012)

After that, the percentage of feasibility of the teaching materials developed using Formula 2 is calculated.

$$\boldsymbol{P = \frac{\sum TSe}{\sum TSh} \times 100\%} \quad (2)$$

Description:
P = Percentage of feasibility of teaching materials
$\sum \boldsymbol{TSe}$ = Total number of respondents' answers
$\sum \boldsymbol{TSh}$ = Maximum score of the respondent
(Nesri & Kristanto, 2020)

After the percentage results are obtained, the next step is to interpret them into qualitative values with a scale of five according to the assessment aspects in Table 3.

Table 3. Interpretation of Percentage of Feasibility and Validity of Teaching Materials

Percentage	Category
$P < 21$ %	Very Inappropriate/Very Invalid
$21\% \leq P < 41$ %	Not Feasible/Invalid
$41\ \% \leq P < 61$ %	Reasonably Feasible / Reasonably Valid
$61\ \% \leq P < 81$ %	Decent/Valid
$P \geq 81\%$	Very Feasible/Very Valid

(Sudaryono et al., 2013)

3) Student response analysis

Student response questionnaires were analyzed by processing data obtained from the results of student response questionnaires after using the teaching materials that had been developed. Data collection was done quantitatively through a closed questionnaire using a Likert scale as an assessment measurement tool. The Likert scale used uses a scale of 1-5. The Likert scale used for the student response questionnaire is shown in Table 4 and the percentage interpretation into student response categories is shown in Table 5.

Table 4. Likert Scale for Student Response Questionnaire

Skor	Kategori
5	Strongly Agree
4	Agree
3	Neutral
2	Disagree
1	Strongly Disagree

(Fraenkel et al., 2012)

The percentage of student response was calculated using Formula 3.

$$\text{Response Percentage} = \frac{\text{Total score}}{\text{Maximum total}} \quad (3)$$

The percentage of student responses is then interpreted as in Table 5.

Table 5. Interpretation of Percentage of Student Response Questionnaire Results

Percentage	Category
$P < 21$ %	Very Not Good
$21\% \leq P < 41$ %	Not good
$41\ \% \leq P < 61$ %	Pretty good
$61\ \% \leq P < 81$ %	Good
$P \geq 81\%$	Very good

(Riduwan, 2015)

2.4 ADDIE Stages

The analysis stage is used to formulate the concepts that will be used in developing teaching materials. The analysis carried out is an analysis of the general situation, analysis

of student characteristics, and needs analysis. Analysis of the general situation aims to analyze the basic problems faced in learning. Analysis of student characteristics aims to find out the level of diverse abilities of students, students' knowledge and skills that have been owned, and individual learning styles of students. Analysis of student characteristics, namely learning style indicators adapted from the book Quantum Learning: Making Learning Comfortable and Fun (Deporter & Hernacki, 2013). The needs analysis consists of curriculum analysis and content analysis. Curriculum analysis aims to gain an in-depth understanding of the content of the curriculum and identify the competencies that students need to master. This determination was made based on the Merdeka Curriculum on the subject matter of renewable energy for High School class X semester 2. The indicators used as a reference are derived from predetermined Learning Outcomes. Meanwhile, content analysis aims to obtain an overview of the characteristics and depth of material or concepts that will be presented through teaching materials by previously determined competency standards and indicators. The results of the analysis then become the basis for designing and developing teaching materials effectively.

The design stage begins with the preparation of material, designing the presentation format, flowchart design, and initial design of teaching materials. At this stage, the concept design of the product to be developed is obtained, namely teaching materials focused on a differentiated learning approach. Furthermore, the implementation of the design was carried out to produce an initial product draft.

The development stage is in the form of validation activities for teaching materials based on differentiated learning on renewable energy materials that have been developed. Valid teaching materials are teaching materials that fulfill material validation instruments and media validation that have been carried out by expert validators (Irman & Waskito, 2020). Expert validators in this study were 2 expert lecturers who were divided into material expert lecturers and media expert lecturers, and 1 professional teacher. Suggestions and criticisms from validators will be used to revise teaching materials so that teaching materials can be declared valid and suitable for use. The feasibility test is carried out to assess the feasibility of the product and produce products that meet quality standards and can be used effectively by students in the learning process.

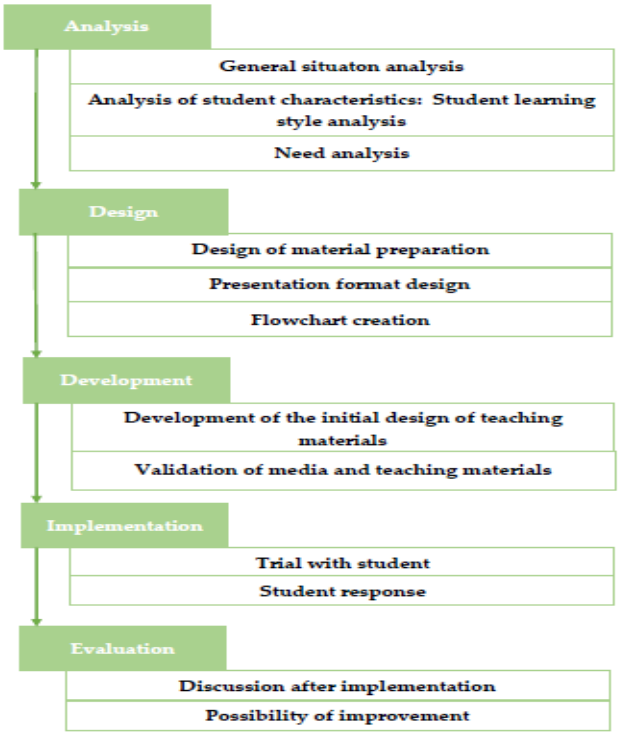


Figure 1. ADDIE Stages

The implementation stage is carried out on a limited basis to test the effectiveness of teaching materials based on differentiated learning on renewable energy material at High School 10 Samarinda. Implementation was carried out on students in class X-11. After studying teaching materials based on differentiated learning, students gave their responses using a student response questionnaire.

The evaluation stage is a stage to measure the success of using teaching materials based on differentiated learning. At this stage, data obtained during the implementation at school is analyzed using instruments and data tests that have been developed. ADDIE's stages are shown in Figure 1.

3. Results

The results showed that the differentiated learning-based teaching materials developed have gone through a series of ADDIE stages and have been validated by experts in their fields and have been tested. Teaching materials have three parts, namely the initial part, the content part and the final part. The initial part consists of the front cover of the teaching material, preface, table of contents, list of images, about the book and the book presentation system. The content section consists of section 1, namely the introduction of learning styles, section 2, namely differentiated learning, section 3, namely renewable energy, section 4, namely competency tests. The front cover of the book can be seen in the Figure 2.

Figure 2. Front cover of teaching material

In section 1, namely the introduction of learning styles, there is a front cover, concept map, information about visual, auditory and kinesthetic learning styles consisting of an introduction to learning styles, benefits, characteristics, signs, advantages, disadvantages, as well as additional information in the form of learning videos made in the form of barcodes, as well as learning style tests in the form of learning style questionnaires that can be accessed by students by scanning the barcode on the mobile device used. In part 2,

namely differentiated learning, there is a front cover, concept map, information about the definition of differentiated learning, objectives, characteristics, components, advantages, disadvantages and references to differentiated learning presented in the form of barcodes. In section 1 and section 2 in this teaching material can be used as a reference by the teacher if the learning process will use a differentiated learning approach with a customized learning model. In section 3, namely renewable energy, consists of a front cover, concept map, learning outcomes, Pancasila student profile, learning objectives, and four sub-materials, namely learning activity 1: understanding and types of energy; learning activity 2: problems and impacts of energy sources, and alternative energy solutions; learning activity 3: transformation of renewable energy in technological products; learning activity 4: designing creative products in the field of renewable energy. In the learning activities there are materials, posters, activities, physics concepts, science literacy, interactive videos in the form of barcodes, inventors/originators, summaries, reflections and worksheet for visual, auditory and kinesthetic learning styles. In section 4, the competency test presents multiple choice questions and essays to determine students' abilities regarding the material studied. At the end, the appendix consists of teaching module recommendations and assessment rubrics. This appendix is used as a reference for teachers when using a differentiated learning approach based on students' learning styles in the learning process. The Infographic of the contents of this book can be seen in Figure 3.

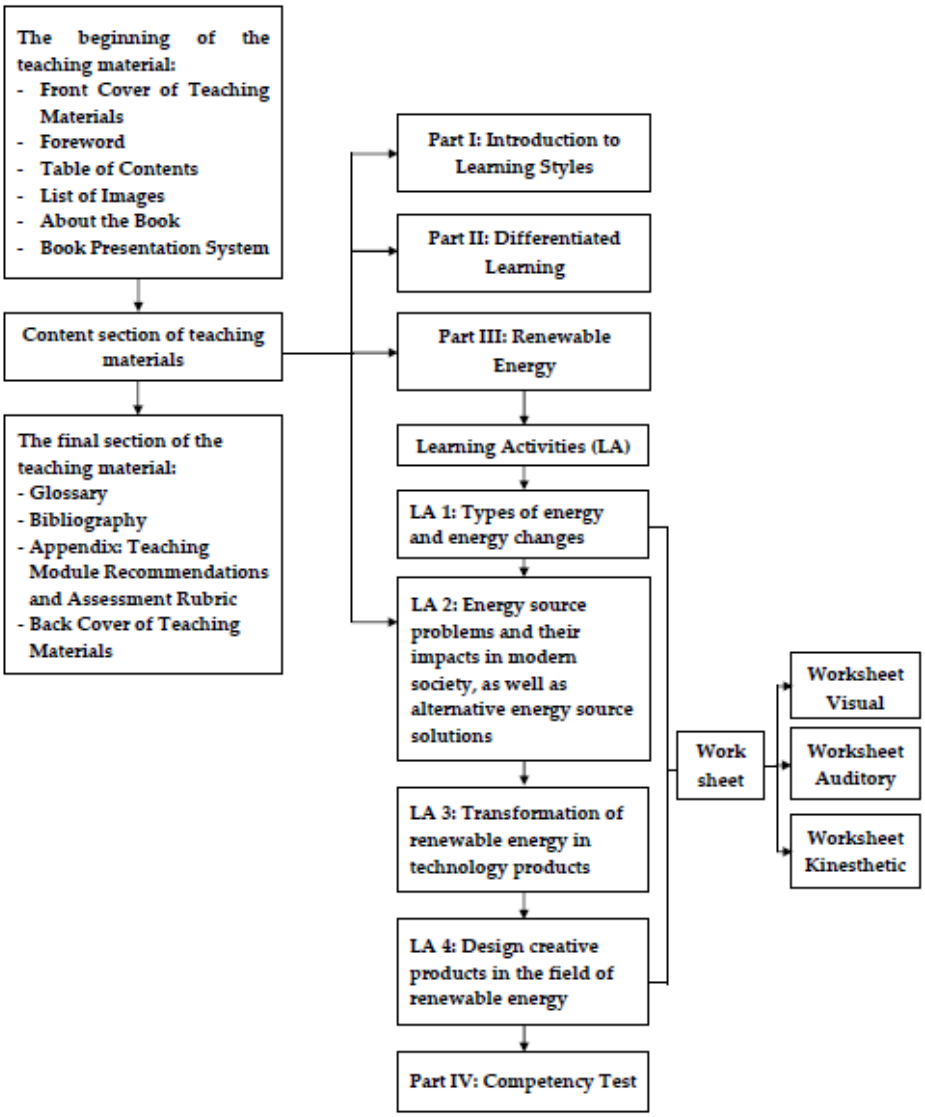


Figure 3. Infographic of the book content

Validation of teaching material products is carried out not only to ensure that the product is feasible and valid, but also to identify deficiencies and weaknesses based on input from validators, resulting in a final product that can be used effectively by students (Masithah et al., 2022). Validators on material aspects and media aspects, with a total of 3 validators. Based on the validity test using the validity assessment sheet instrument, the results are shown in the Table 6.

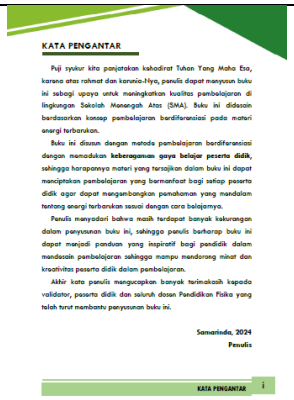
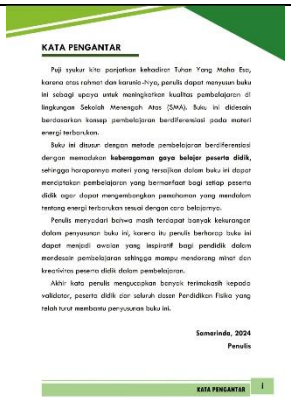
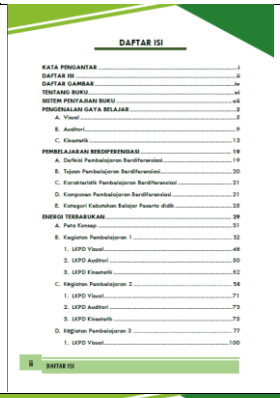
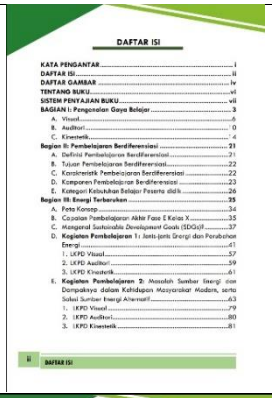
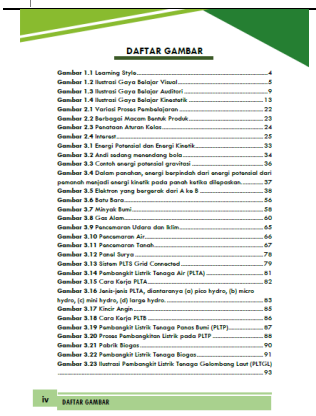
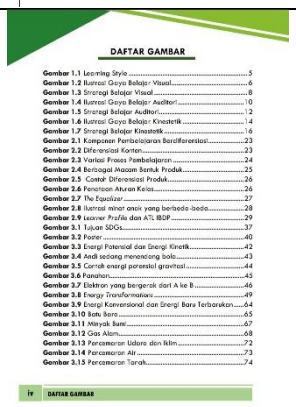
Table 6. Validity Results of Media and Material

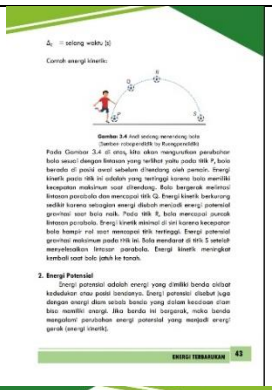
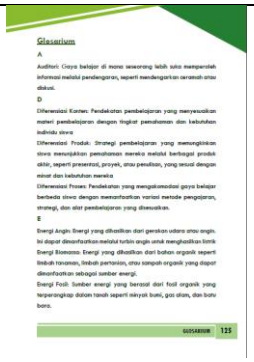
Aspect	Componen Aspect	Average Percentages (%)	Category
Material Validity	Content Feasibility	90%	Very Feasible
	Presentation Feasibility	87%	Very Feasible
Average Material Validity		88%	Very Valid
Media Validity	Language Feasibility	92%	Very Feasible
	Graphic Feasibility	86%	Very Feasible
Average Media Validity		89%	Very Valid

Table 6 is the result of the validation of teaching materials which shows an average score of 88% in terms of material aspects and an average score of 89% in terms of media aspects on a maximum score of 100%. Based on the criteria for the validity of teaching materials, teaching materials based on differentiated learning on renewable energy material are included in the category of very valid or very feasible in both aspects. So that the teaching materials that have been developed are valid and feasible to use and can be tested in learning High School. This shows that the textbooks developed in this study are valid. Both components of content suitability, presentation of material, language, and graphics. Revisions were made in accordance with the responses and suggestions given by each expert. The following are the results of the display of the content of teaching materials before revision and after revision which are presented in Table 7.

Table 7. Display of Teaching Materials Before and After Revision

Display of Teaching Materials Before Revision	Display of Teaching Materials Before Revision	Display of Teaching Materials Before Revision
		• Improve the front cover by changing the animated graphics that reflect differentiated learning and renewable energy, adding information on school level, grade, semester, etc.

		• Improve the writing in the preface
		• Improve the writing in the table of contents section
		• Improved the writing in the image list section
		• Added brief information on SDGs and the relationship between SDGs and Energy

 	• Add image caption description
 	• Replace the picture with a picture that is in the student's environment
 	• Improving Glossary
 	• Change the back cover background

Before conducting the implementation stage, the results of the learning style questionnaire distributed to students in class X-11 were taken to obtain further data on their learning preferences. The questionnaire results showed that there were 11 students with visual learning styles, 15 students with auditory learning styles and 9 students with kinesthetic learning styles. Thus, the questionnaire results show significant variation in learning style preferences among the students in the sample. The distribution of learning styles of students in class X-11 can be seen in Table 8.

Table 8. Distribution of Learning Styles of Students in Class X-11

Learning Style	Total	Percentage
Visual	11	31%
Auditory	15	43%
Kinesthetic	9	26%
Total	35	100%

The implementation stage was carried out by taking student response questionnaires. In the student response questionnaire, there are several aspects that are analyzed, namely aspects of material, language, interest and learning style. Based on the results of the analysis of the student response questionnaire data, a score of 81% was obtained in the very good category. The percentage score on each aspect is 80%, 83%, 81%, and 81% respectively. The language aspect received the highest percentage score compared to other aspects with a percentage score of 83%. Then, the interest and learning style aspect obtained a percentage score of 81%. Then, the last aspect, namely the material, received a percentage score of 80%. This can be seen in the Table 9.

Table 9. Student Response Questionnaire Results

Assessment Aspect	Average Percentages (%)	Category
Material	80%	Good
Language	83%	Very good
Engagement	81%	Very good
Learning Style	81%	Very good
Student Response	81%	Very good

4. Discussion

The learning style questionnaire distributed aims to obtain further data on student learning preferences. The questionnaire results show that students with auditory learning styles dominate compared to students with visual and kinesthetic learning styles. This can be seen from the percentage of students with a visual learning style of 31%, students with an auditory learning style of 43% and students with a kinesthetic learning style of 26%. The results of the learning style questionnaire analysis resulted in 7 groups with a distribution of 2 visual groups, 3 auditory groups and 2 kinesthetic groups.

The results of the validation of teaching materials showed an average score of 88% in terms of material aspects and an average score of 89% in terms of media aspects at the maximum score of 100%. Based on the criteria for the validity of teaching materials, teaching materials based on differentiated learning on renewable energy material are included in the category of very valid or very feasible in both aspects. The teaching materials that have been developed are valid and feasible to use and can be tested in High School Physics learning (Wibowo et al., 2023).

The assessment of the validity of teaching material products in the material aspect consists of 2 components, namely content and presentation feasibility. The content feasibility component aims to assess the content components in teaching materials in accordance with the curriculum standards used, namely the Merdeka Curriculum (Himmah & Nugraheni, 2023). The average score on the content feasibility component is 90% with a very valid or very feasible category. Furthermore, the presentation feasibility component aims to assess the presentation component of the material and the completeness of the teaching materials. The average score of the presentation feasibility component is 87% with a very valid or very feasible category. The assessment of the validity of teaching material products in the media aspect consists of 2 components, namely linguistic and graphical feasibility. The linguistic component aims to assess the use of language and the level of ease of reading in teaching materials. The average score on the

language feasibility component is 92% with a very valid or very feasible category. Furthermore, the graphic component aims to assess the level of visual satisfaction related to the size of the teaching chart, cover design and layout of the teaching material content. The average score on the grammatical feasibility component is 86% with a very valid/very feasible category.

This teaching material has the advantage of meeting the needs of visual, auditory, and kinesthetic learning styles through images, illustrations, audio, interactive videos, and PhET simulations. In addition, the included worksheets adapt the differentiated learning approach in process and product differentiation, making it easier for students to learn independently. This teaching material is also equipped with an explanation of visual, auditory, and kinesthetic learning styles, thus helping students understand the advantages, disadvantages, and appropriate learning methods. In addition, this teaching material is equipped with teaching module recommendations and assessment rubrics that make it easier for teachers in the learning process (Irman & Waskito, 2020). However, this teaching material also has shortcomings, including the material presented still uses language that is difficult to understand, and the lack of worksheets with a combination of learning styles, as well as measuring instruments used during learning style tests do not present results directly but need data processing first.

The results of this study are similar to research conducted by Widiastuti et al., (2023) by developing differentiated teaching materials on writing opinion articles for high school students which have the advantage that the material is presented in a varied manner according to the student's learning profile, including video, audio, text, images, animations, and videos that are made interesting for class XII students. This learning material is designed with communicative language so that it can be used independently by students. Purmadi & Surjono (2016) by developing web-based teaching materials based on student learning styles for Physics subjects have the advantage of adapting to student learning styles, facilitating communication between teachers and allowing students to learn independently in a more organized manner, as well as providing materials that are varied and easy to understand.

In the student response questionnaire, there are several aspects analyzed, namely aspects of material, language, interest and learning style. Based on the results of the data analysis, the student response questionnaire obtained a score of 81% with a very good category. The percentage score on each aspect is 80%, 83%, 81%, and 81% respectively. The language aspect gets the highest percentage score compared to other aspects with a percentage score of 83%. Based on the results of several student responses given in the comments and suggestions section, it states that the language used is easy to understand and understand. Then, the interest and learning style aspect obtained a percentage score of 81%. In the aspect of interest and learning styles, some students like the illustrations displayed, the use of colors in teaching materials that attract students' learning interests, and have advantages in grouping based on students' learning styles. Then, the last aspect, namely the material, received a percentage score of 80%. The material aspect gets a low percentage score compared to other aspects because the physics material contained is still difficult for students to understand (Sanjaya et al., 2023).

Evaluation of student responses is not only obtained from the student response questionnaire, but also from the results of semi-structured interviews conducted on each representative of visual, auditory and kinesthetic learning styles. The following are the statements of student representatives with visual, auditory, and kinesthetic learning styles.

The visual learning style representative, SNA, stated that:

"Renewable energy teaching materials are quite easy to understand the material, because the illustrations and images listed on the teaching materials are in accordance with the theme and can be understood and in accordance with the visual learning style. In addition, renewable energy teaching materials are quite helpful in self-study and the teaching materials developed are quite interesting in learning Physics."

The auditory learning style representative, AZW stated that

"The teaching materials used are in accordance with the learning style, making it easier to do the tasks given. In addition, the content in the teaching materials attracts attention and thinking in self-study, and the questions given are related to everyday life so it is easier to answer. As a student with an auditory learning style, these teaching materials facilitate more flexible, attention-grabbing, and fun learning."

Kinesthetic learning style representative, ILB stated that

"This teaching material makes it easier to grasp the material and helps in the self-learning process because it is in accordance with the kinesthetic learning style."

Based on the validation results from validators, student responses and improvements, it can be concluded that the teaching materials based on differentiated learning on renewable energy material developed have met the valid criteria and are suitable for use.

5. Conclusion

Based on the results of the research that has been conducted, it can be concluded as follows (1) The validity of teaching materials based on differentiated learning on renewable energy materials is in the very good category; (2) Student responses at the implementation stage to teaching materials based on differentiated learning on renewable energy materials developed are in the very good category. The suggestions that can be given based on the research that has been done are as follows (1) There is a need for improvement of teaching materials from the graphical aspect by adding more illustrations, images and varied colors; (2) For further researchers, in order to be able to test this teaching material product into the effectiveness test of teaching materials on student learning outcomes as a whole because this research is only limited to measuring the validity and student response to teaching materials, as well as trials conducted only limited to one sub-material on teaching materials. (3) For future researchers, in order to be able to test student worksheets that include all three learning style preferences without dividing worksheets based on learning style groups; (4) At the implementation stage, it can be further developed to several school samples because in this study the implementation stage is still limited to one school.

Authors Contribution: All authors have the same duties and roles in the research until the publication of this article.

Conflict of Interest: Authors declare there are no conflicts of interest.

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