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Development of Student Worksheet Integrated by Differentiated-PjBL Model to Train Student Science Process Skills on Renewable Energy Material

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Abstract

This study is a research and development (R&D) to produce student worksheets that integrate the project-based learning model and a differentiated approach to train students' science process skills on renewable energy material. The development model used in this study is the ADDIE development model, namely analysis, design, development, implementation, and evaluation. This study aims to determine the feasibility and practicality of student worksheet products. Five expert validators conducted the product feasibility test, resulting in a score of 0.88 with valid criteria. Teachers and students carried out the product practicality test as users of student worksheets. The teacher's practicality test obtained an average score of 92.08% with very practical criteria, while the student's assessment obtained an average score of 86.95% with very practical criteria. Based on the feasibility and practical test results, the student worksheet products are feasible and practical for use in learning to train students' science process skills.

Keywords: student worksheet, project based learning, differentiated approach, science process skills

INTRODUCTION

Education is an essential aspect for a country. A high-quality educational program can produce competent and qualified human resources (Choi & Min, 2024). To achieve this, it is necessary to implement change and renewal in educational policies to align them with the conditions in the present era (Der & Els, 2024). The curriculum represents one of the most dynamic elements within the education field that constantly changes (Wallenius & Janne, 2024). The curriculum is a plan for implementing education that determines the direction, content, and process of education at the school, regional, and national levels (Marzuqi & Ahid, 2023). This is the reason behind the recurrent modifications to the Indonesian education curriculum.

The Indonesian education system implements several types of curriculum, including *Kurikulum* 2003, *Kurikulum* 2006, *Kurikulum* 2013, and *Kurikulum Merdeka*. Currently, the latest curriculum implemented in Indonesian education is the *Kurikulum Merdeka*. *Kurikulum Merdeka* was developed in response to the learning loss due to distance learning during the COVID-19 pandemic (Astutik, 2023). *Kurikulum Merdeka* allows students to learn according to their readiness, interests, and learning

profiles. This approach to learning is known as the differentiated approach. A differentiated approach facilitates the creation of an inclusive learning environment for students, defined as an engaging, supportive, and respectful learning atmosphere that acknowledges and appreciates each individual's unique characteristics and needs (Sutrisno et al., 2023).

The differentiated approach is designed to accommodate the diverse learning needs of students to create coherence between the curriculum and each student's learning needs and abilities (Mahara, Fajriyani & Sriwahyuni, 2023). The differentiated approach has several objectives, including: (1) to facilitate optimal growth by each student's abilities, (2) to enable students to comprehend their growth, and (3) to provide students with the opportunity to develop their talents and interests (Marantika, Tomasouw & Wenno, 2023). In designing learning, teachers must consider at least four components of a differentiated approach, including content, process, product, and learning environment, to accommodate different students' learning needs.

The content differentiation component is related to the material that will be taught to students. Teachers modify content or learning materials according to students' learning styles and conditions (Marlina, 2019). There are three types of learning styles based on the modality used by students in processing information (perceptual modality), namely visual, auditory, and kinesthetic (VAK) learning styles (Mudah, 2023). The process differentiation component relates to the student's processing of ideas or information. In this differentiation component, teachers facilitate students to understand the learning presented according to their learning styles (Hassan & Ajmain, 2022). The product differentiation component relates to the output produced by students after learning (Derici & Susanti, 2023). The learning environment differentiation component includes factors that affect students' comfort and engagement in the learning process, such as students' physical and social conditions (Azizah et al., 2023).

A differentiated approach allows teachers to make it easier for students to understand the material so the learning objectives are more accessible to achieve. The learning objectives defined in the *Kurikulum Merdeka*, especially physics subjects, include two elements, namely science concepts and science process skills. Teachers must design lessons that can accommodate these two aspects while still considering the diverse learning needs of their students. However, the learning in the classroom prioritizes the development of science concepts, with less emphasis on training science process skills. This is evidenced by the relatively low scores of Indonesian students in the Program for International Student Assessment (PISA), particularly in the science category, which is significantly below the average of Organization for Economic Co-operation and Development (OECD) countries.

Science process skills are those abilities to discover and develop concepts and facts independently (Rahayu et al., 2021). Science process skills are essential for students as the objective of science learning concerns more than merely understanding concepts (Yalçınkaya-Önder et al., 2022). It is very importance for teachers to develop learning activities that can effectively train students science process skills. These skills can be achieved by implementing learning activities that actively engage students in investigative processes (Herwinarso et al., 2023). Teachers can implement student-centered learning models that facilitate inquiry activities like project-based learning.

The project-based learning model facilitates student engagement through inquiry-based learning activities and making projects (Putra et al., 2021). Project-based learning activities direct students to design a solution in the project format, which answers the problem given. Student participation in project-based learning can facilitate the development of science process skills. According to the findings of the research conducted by Yuniasih et al. (2022), implementing project-based learning can improve students' science process skills. In implementing project-based learning, there are six syntaxes that students and teachers must complete during the learning process. These include identifying key questions, designing the project, making a schedule, tracking the project's progress, assessing the experience, and evaluating the results (Setiawan, Wahidin & Arif, 2023).

Integrating the syntax of the project-based learning model and the differentiated approach makes it easier for teachers to train students in science process skills. Appropriate learning media must complement The strategic learning method (Andreansyah, Rachman & Putri, 2020). Teachers are encouraged to consider using learning media to integrate project-based learning models and differentiated approaches effectively. Student worksheets are learning media containing instructions for activities organized based on competencies and learning objectives (Anggraini, Siahaan &

Fathurohman, 2024). The application of student worksheets has been demonstrated to enhance student engagement and activity during the learning process Halim & Melawati (2022), thus facilitating the science process skills. This finding is supported by the research of Jannah et al. (2024), which indicates that using student worksheets can improve students' science process skills.

Based on the problems that have been described, it is evident that the development of student worksheets that integrate the syntax of project-based learning models and differentiated approaches, referred as D-PjBL, to train student science process skills. The development of this student worksheet is designed to facilitate students conducting investigations that lead to the discovery and development of a concept independently while still considering students' different learning needs by the paradigm in the *Kurikulum Merdeka*. Integrating the four components of the differentiated approach in this student worksheet is expected to accommodate student learning needs that were less of a focus for teachers.

METHODS

In this study, the research method employed is research and development (R&D), which is used to develop and test a product to make it suitable for implementation in education (Maydiantoro, 2021). The development model used is the ADDIE model, which consists of five stages: analysis, design, development, implementation, and evaluation (Sugiyono, 2015). This research was only conducted up to the development stage; thus, the student worksheet products were not implemented on a large scale in learning environments. The analysis stage aims to explore and find information related to existing problems. The design stage aims to produce product designs including concepts and content in product development. The development stage contains activities to realize the product design made previously into a product ready to be implemented. The implementation of each stage is shown in TABLE 1.

TABLE 1. Implementation scheme of ADDIE stages

ADDIE Stages	Implementation
Analysis	Start
	Problem and potential analysis
	Case study
	Determine development of student worksheets integrated by D-PjBL
Design	Determine student worksheets content based on project based learning model and differentiated approach
	Designing the studente worksheets
Development	Create a studente worksheet based on project based learning model and differentiated approach
	Feasibility test of the student worksheets by expert validators
	Product revision
	Practicality test of student worksheets by teachers and students
	Product revision

At the development stage, an instrument is needed to measure product performance. This instrument is the basis for making revisions to the product before it is implemented. Instruments to measure product performance include validity instruments and the practicality of student worksheets made by a Likert scale. The validity instrument aims to describe the feasibility of student worksheets. The student worksheet validity instrument was prepared according to the assessment criteria from Badan Standar Nasional Pendidikan (BSNP), which included presentation techniques, content, language, and grammar. These criteria were tested on both material and media expert validators (Meiningsih, Alimah & Anggraito, 2019).

The validity of the student worksheets was assessed by five expert validators, consisting of two physics education study program lecturers and three physics subject teachers. The results of the assessment by expert validators are then analyzed using the Aiken V formula which can be seen in EQUATION (1).

$$V = \frac{\sum s}{\left[n(c-1)\right]} \quad (1)$$

Information:

$s = r - l_o$

n : number of validators

c : highest scoring number (in this case = 5)

l_o : lowest scoring number (in this case = 1)

r : the score given by the validators

Based on the V-TABLE value on Aikens V by looking at the number of validators and the number of categories, the student worksheet is considered valid if the V-count obtained is. The results of the product feasibility assessment by expert validators are then used as a reference for product improvement or revision before implementation. Products that have been revised according to the suggestions and input of expert validators then to be tested for practicality.

The practicality test aims to describe the practicality or ease of the student worksheets used in learning. In developing learning media, a practicality test is necessary to determine if the product developed is practical and easy to use during learning (Annisa, Putra & Dharmono, 2020). The practicality test of student worksheets is directed at product users, such as teachers and students. By the opinion of Aldi et al. (2022) valid student worksheets need to be tested for practicality on teachers and students. The practicality test by teachers was carried out on three physics subject teachers by completing a product practicality questionnaire which contained three aspects of assessment, namely didactic, construction, and technical aspects, which are the three requirements that must be met in the preparation for student worksheets (Purnamasari et al., 2020).

The results of the product practicality assessment by the teacher were then analyzed following EQUATION (2) from Akbar (2013) as quoted by Irawan & Hakim (2021) as follows:

$$V - au = \frac{TS_e}{TS_h} \times 100\% \quad (2)$$

Information:

$V - au$: individual validation (audience)

TS_e : total empirical score achieved

TS_h : total expected score

Student worksheets that are considered practical and have been revised according to the teacher's assessment are then assessed by students. The assessment of product practicality by students was directed at 30 students of class XI MIPA 5 SMA Negeri 6 Semarang who had studied renewable energy material. The student worksheet practicality questionnaire contains two assessment aspects: readability and appearance. After completing the questionnaire, students were asked to provide comments, responses, and input on the developed product. This aims to obtain suggestions for improving the development of student worksheets from students. The results of the LKS practicality assessment were then analyzed following EQUATION (3) from Oktafiana et al. (2020) as follows:

$$\text{Percentage of Practicality (P)} = \frac{\sum \text{score given by students}}{\sum \text{maximum score}} \times 100\% \quad (3)$$

Furthermore, the data on the practicality of the products that have been analyzed from teacher and student assessments are classified according to the criteria for product practicality according to Prasetya, Rohana & Fuadiah (2023) as in TABLE 2.

TABLE 2. Product practicality criteria

Criteria (%)	Practicality Level
$0 \leq P \leq 21$	Not Practical
$21 \leq P \leq 41$	Less Practical
$41 \leq P \leq 61$	Practical Enough
$61 \leq P \leq 81$	Practical
$81 \leq P \leq 100$	Very Practical

RESULTS AND DISCUSSION

Kurikulum Merdeka, born due to a learning loss caused by the Covid-19 pandemic, only focuses on delivering essential material. Different from the previously implemented curriculum, *Kurikulum* 2013 has too much material that teachers must deliver to students (Qurrota et al., 2023). Based on the results of interviews conducted with teachers, the implementation of *Kurikulum Merdeka* in schools, especially in physics subjects, is progressing quite well. The learning is designed to be student-centered, but students have not been able to conduct investigations independently and still depend on the instructions given by the teacher. In addition, the learning activities carried out have not accommodated the different learning needs of students in accordance with the paradigm in the *Kurikulum Merdeka*. As a result of further analysis, it is known that the cause of this problem is student worksheets used have not integrated the syntax of the student-centered learning model. Student worksheets only contain a set of material and questions. This causes students to have difficulty in carried out learning activities independently and it is difficult to develop their science process skills.

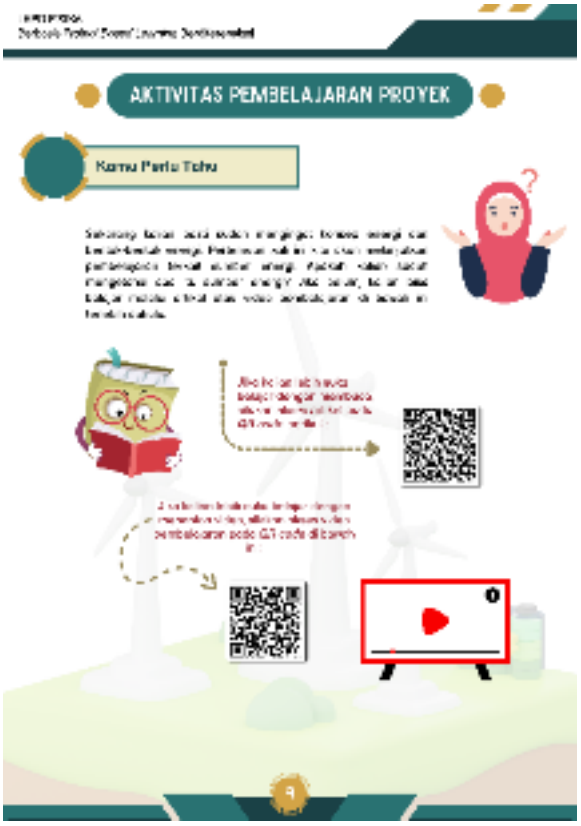
The results obtained at the analysis stage demonstrated that schools need learning media in the form of student worksheets that can direct students to conduct investigations independently to train students in science process skills. In developing student worksheets, it is necessary to integrate strategic learning methods. The method integrated into the development of student worksheets combines the syntax of the project-based learning model with the components of a differentiated approach. The next stage is design after finding out the product to be developed according to the analysis of school requirements. The first step in designing student worksheets is analyzing learning outcomes and objectives on renewable energy material. Based on this analysis's results, the student worksheet's content is also designed. Content development needs to consider the syntax of the project-based learning model, differentiated approach, and indicators of science process skills that must be achieved by grade X students (phase E). The design of student worksheets integrated by D-PjBL to train students' science process skills on renewable energy material can be seen in TABLE 3.

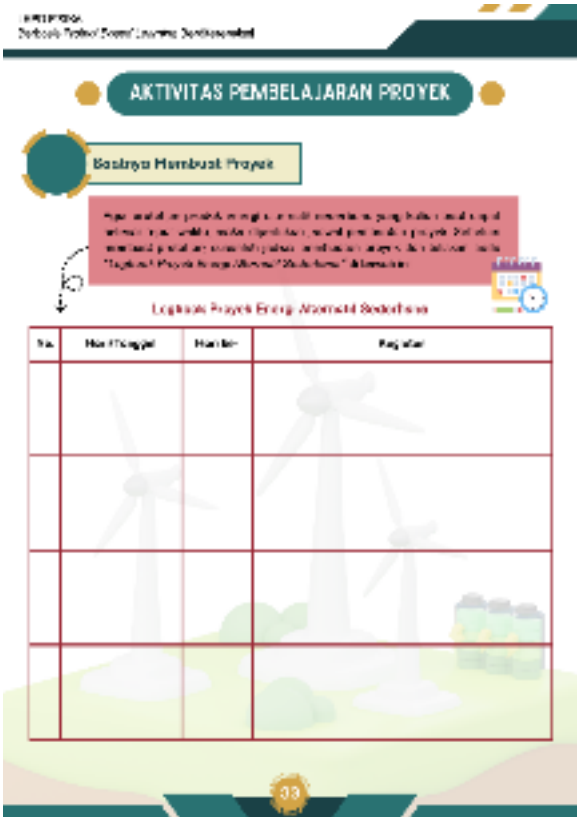
TABLE 3. Design of students worksheet integrated by D-PjBL

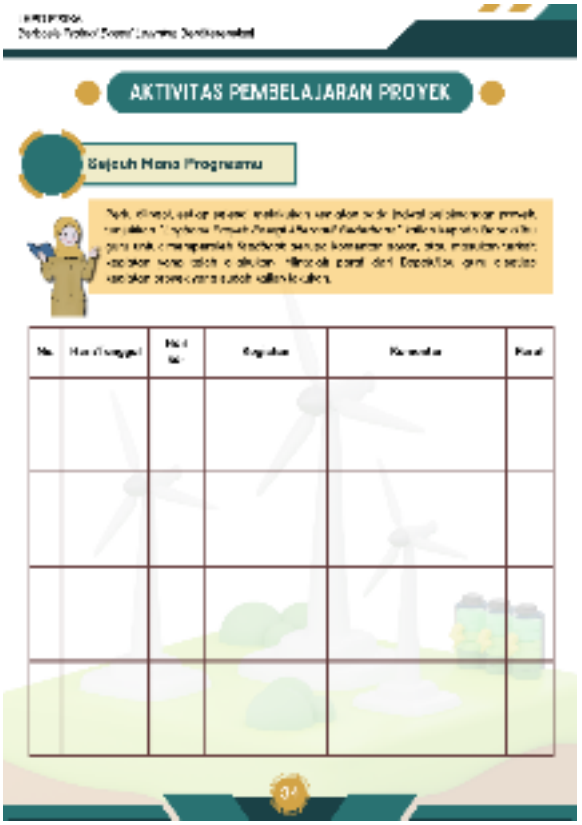
Content	Description
Cover	This section contains information about the student worksheet Home Page.
Preface	This section contains the authors general views on the student worksheet.
TABLE of Contents	This section contains information about the pages in the student worksheet.
Description of Student Worksheet	This section contains the purpose of making student worksheet in learning.
Instructions for use Student Worksheet	This section contains a series of steps that students and teachers need to take when using students worksheet as a learning tool.
Content Standards	This section contains learning outcomes and objectives for students in Grade X (phase E)
Project Learning Activities	This section contains the activities learning that integrated with the syntax of project based learning model and differentiated approach. These activities must be carried out by students in groups.
Info Seputar Energi (Insegi)	This section includes information about energy sources that can broaden students horizons. The *Insegi* content is integrated into the project-based learning syntax.
Glossary	This section contains terms used in the student worksheet and related to renewable energy materials.
Bibliography	This section contains of reference sources used by the author in the creation of the student worksheet.

Based on TABLE 3. The integration of project-based learning syntax, differentiated approach components, and science process skills indicators is contained in the "Project Learning Activities" section. Project learning activities consist of six parts in accordance with the syntax of the project-based learning model, namely: (1) *Kamu Perlu Tahu*, (2) *Tentukan Proyekmu Sekarang*, (3) *Saatnya Membuat Proyek*, (4) *Sejauh Mana Progresmu*, (5) *Saatnya Menilai Proyekmu*, dan (6) *Utarakan Perasaanmu* which are explained specifically in TABLE 4.

TABLE 4. Project learning activities in student worksheet

Project Learning Activities	Activity Description	Design of Student Worksheet
Kamu Perlu Tahu	This activities integrate the syntax of the project based learning model, namely the identifying key questions. In this section, issues regarding the availability of petroleum energy sources are presented through articles and videos. Students are given the opportunity to choose their preferred learning content, thus facilitating content differentiation in learning. This problem serves as a basis or guide for students in project creation. Students are required to answer questions after studying the learning content. This activity is conducted in groups, with students grouped according to their learning style to create a differentiated learning environment.	

Project Learning Activities	Activity Description	Design of Student Worksheet
Tentukan Proyekmu Sekarang	This activity integrates the syntax of the project based learning model, namely designing the project. Students are directed to identify the potential for renewable energy around the home environment before determining and planning projects. This identification is done through observation and interview activities. Students are given the freedom to determine the learning activities they want so as to create a different process. At the project design stage, students are assigned to design renewable energy prototypes based on the results of observations or interviews. Students can choose the type of prototype to be made (poster, video, or miniature) according to their learning style to facilitating product differentiation in learning.	
Saatnya Membuat Proyek	This activity integrates the syntax of the project based learning model, namely making a schedule. Students are asked to develop a schedule for making projects before they begin to make them. The purpose of this activity is to ensure that the project given to students can be completed on time. Students compile a prototyping schedule and write it down in the project logbook. Students arrange the prototyping schedule from the planning stage to the project presentation.	

Project Learning Activities	Activity Description	Design of Student Worksheet
Sejauh Mana Progresmu	This activity integrates the syntax of the project-based learning model, namely track the progress of the project. Students start the activity by making a simple alternative energy prototype according to the design and schedule that has been prepared. During the prototyping process, the teacher acts as a supervisor or monitor of the project implementation. Project monitoring aims to ensure that the project is carried out in accordance with the design, all group members participate in prototyping, there are comments, suggestions, and input given during the prototyping process, and all activities contained in the logbook are carried out by students. Teachers can record students achievements at each meeting in the TABLE contained in the student worksheet after monitoring.	
Saatnya Menilai Proyekmu	This activity employs the syntax of project based learning model, namely assessing the experience. The completed prototype is then presented to the class. At this stage, the teacher also assesses the results of the simple energy prototype.	

Project Learning Activities	Activity Description	Design of Student Worksheet
Utarakan Perasaanmu	This activity employs the syntax of project based learning model, nameley evaluating the results. Its objective is to ascertain the sentiments and experiences of students engaged in project-based learning. This evaluation activity serves as a reflection for the teacher on the learning achieved and as a means of identifying areas for improvement in the next lesson.	

Student worksheet integrated by D-PjBL cannot be implemented directly in the learning process. It needs an assessment from an expert regarding the feasibility and practicality of the product carried out at the development stage. The results of the feasibility assessment of the student worksheets integrated by D-PjBL by five expert validators are shown in TABLE 5.

TABLE 5. The results of student worksheet validity test on each aspect

No.	Assessment Aspect	V-Count	V-TABLE	Criteria
1.	Contents	0.91	0.80	Valid
2.	Presentation	0.89		Valid
3.	Linguistics	0.85		Valid
4.	Graphics	0.86		Valid
	Average	**0.88**	**0.80**	**Valid**

Based on the validation test results of two expert lecturers and three physics subject teachers, the student worksheets developed include valid criteria. They are feasible to use with a validity score of 0.88. To the results of the research, Yulkifli, Ningrum & Indrasari (2019) found that student worksheets with valid criteria can be used in high school physics learning. The highest assessment score is contained in the content feasibility aspect. The assessment indicators in this aspect include the suitability of the material, the accuracy of the material, the integration of the project-based learning model, and the integration of the differentiated approach.

Learning activities on student worksheets direct students to understand and find the concept of renewable energy material independently through the process of investigation and project creation. To complete this project, students need science process skills during the investigation (Andriyani, Shimizu & Widiyatmoko, 2019). This shows that science process skills can be trained by implementing project-

based learning model. The preparation of learning activities takes into consideration and accommodates the different learning needs of students in terms of content, process, product, and learning environment so that learning more effectively (Fitriana et al., 2024).

The presentation feasibility aspect consists of three indicators: presentation techniques, learning presentation, and presentation completeness. The achievement of the presentation feasibility score shows that the student worksheets are presented and arranged systematically to make it easier for teachers and students to achieve learning objectives. Student worksheets are considered valid when containing instructions that can facilitate students learning (Jeliyah, Putri & Satri, 2024). The arrangement of systematic and appropriate student worksheets can help students achieve the competency standards of the taught material (Wiranata & Sujana 2021). Learning activities are student-centered can make them active during learning activities. Student worksheets that contain activities that involve students can help them to be active in learning and make it easier to interact with the material presented (Aulina et al., 2022).

The linguistic feasibility aspect consists of two assessment indicators: readability and suitability for Indonesian language rules that are both appropriate and accurate. Student worksheets are an indirect communication tool between teachers and students, so this aspect is essential in developing student worksheets. Instructions for using student worksheets must be clear and coherent to make it easier for students to carry out learning activities independently without asking many questions to the teacher (Hanifah & Antasari, 2022). The assessment results on the linguistic aspect showed the validity of the student worksheets as an indirect communication tool for teachers and students. Students can follow the instructions and carry out the learning activities in the student worksheet independently.

The last student worksheet feasibility assessment is a graphic aspect, consisting of three indicators: size/format, cover design, and content design. In developing student worksheets, besides considering the content, observing the graphical aspects, especially those related to design and appearance, is also necessary. Students are more excited and motivated to learn if the learning media has an interesting design (Jeliyah, Putri & Satri, 2024). Using interesting combinations of colors, images, text, and graphics motivates students to learn (Widiastuti & Priantini, 2022). The graphic feasibility score obtained shows that the student worksheets developed have a size/format that is by The International Organization for Standardization (ISO) standards and an interesting design. The selection of background color, font type, layout, and elements on the student worksheet creates a harmonious impression and can increase students' enthusiasm for learning.

The results of the feasibility assessment by expert validators showed that the student worksheets obtained valid criteria in each aspect of the assessment. Furthermore, the practicality or ease of student worksheet products was assessed by teachers and students as practical users. The results of the practicality assessment conducted by three physics subject teachers are presented in TABLE 6.

TABLE 6. The results of student worksheet practicality test by the teachers

No.	Assesment Aspect	Percentage (%)	Criteria
1.	Didactics	92.92	Very practical
2.	Construction	93.33	Very practical
3.	Technical	90.00	Very practical
	Average	**92.08**	**Very practical**

The average practicality score in TABLE 6 shows that the student worksheets integrated by D-PjBL includes very practical criteria and makes it easier for teachers to implement learning activities. The practicality of student worksheets can be achieved when teachers are able to use learning media easily (Riawan, Suyatna & Herlina, 2019). Learning activities on student worksheets make it easy for teachers to direct students to conduct investigations independently. This can be seen from the percentage score of practicality in the didactic aspect which includes very practical criteria. Krisgiyanti & Pratama (2023) suggested that in the didactic aspect, student worksheets have a very important function because their use can help teachers in directing students to find concepts independently.

The construction aspect relates to the use of language, sentence structure, vocabulary selection, and the level of difficulty and clarity in student worksheets (Labib & Puspitawati, 2018). The percentage score of practicality in this aspect shows that the language used in the student worksheet is easy to understand and the learning activities are arranged clarity and coherence. The use of student worksheets

integrated by D-PjBL can direct students to carry out learning activities independently. This can minimize the teachers activity in writing or explaining the material so that they have more time for asking questions and monitoring students.

The technical assessment aspect concerns the appearance and images included in the student worksheets. The percentage score obtained in this aspect shows that the appearance and images of student worksheets are interesting, making it easier for teachers to increase students' enthusiasm and motivation to learn. The appearance of less attractive student worksheets makes students bored and unenthusiastic in participating in learning (Numa et al., 2023). Assessment of the practicality of student worksheets by students was carried out during the small-scale product test. The results of the assessment of the practicality student worksheet by students are shown in TABLE 7.

TABLE 7. the results of student worksheet practicality test by students

No.	Assessment Aspect	Percentage(%)	Criteria
1.	Readability	85.80	Very Practical
2.	Appearance	88.10	Very Practical
	Average	**86.95**	**Very Practical**

The aspect of practicality assessment by teachers focuses on the ease of student worksheets in helping teachers carry out learning. The practicality assessment by students is seen from the ease of student worksheets in delivering information and learning instructions (Riawan, Suyatna & Herlina, 2019). The practicality assessment by students consists of two aspects, namely readability and appearance. The average percentage score of practicality by students in TABLE 7. shows that student worksheets are very practical to use in learning.

The percentage assessment on the readability aspect shows that students easily understand the commands, instructions, and questions and can follow the learning activities presented in the student worksheet. The student worksheet integrated by D-PjBL is completed with pictures, illustrations, and videos that can be accessed via a QR code. The percentage score of practicality in appearance shows that the images and illustrations on the student worksheet can be seen clearly, and the QR code to access the video can be scanned easily. The selection of font types, elements, backgrounds, and color combinations on the appearance of the cover and content of the student worksheet is interesting and can increase student learning motivation. Sariani & Suarjana (2022) suggest that selecting interesting student worksheet components can increase student enthusiasm and increase their learning motivation.

CONCLUSION

The results of the feasibility assessment of the student worksheet integrated by D-PjBL by five expert validators showed that the student worksheet was feasible to use in learning with a score of 0.88. The valid student worksheets further assessed the practicality of the teachers and students by filling out the product practicality questionnaire. The results of the practicality test by the teacher resulted in a practicality score of 92.08%, and the assessment by students obtained a score of 86.95%. The practicality assessment by teachers and students both obtained very practical criteria, which means that the student worksheet integrated by D-PjBL is practical and easy to use in learning. The implication for the educational environment from this study's results is that students can carry out learning activities according to their learning style. Teachers need to realize that every student has learning needs and abilities, so the learning media used must be able to facilitate these differences. This study has limitations because the integration of differentiated approach components is only conducted based on learning styles. Suggestions for future research can consider aspects of students' readiness and different learning abilities in developing student worksheets.

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