

Development of Science Process Skills-Based Student Worksheets on Renewable Energy Materials to Enhance Mutual Cooperation and Creative Character

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Article Info	Abstract
Article history: Received: August 14, 2024 Accepted: December 19, 2024 Published: March 1, 2025 Keywords: Creative Mutual cooperation Renewable energy Student worksheets This article is licensed under a creative commons attribution-share alike 4.0 international license © 2025 Jurnal ilmiah Pendidikan Fisika	Science process skills are an approach that should be used as a reference by educators in carrying out good physics learning in the classroom. This research aimed to produce valid and practical science process skills-based renewable energy material student worksheets to improve mutual cooperation and creative characters. The type of research conducted is 4D model development research. The research trial subjects were 33 students of class X MA. Data collection techniques used validation instruments for validity and student response questionnaires for practicality. The study results are: (1) student worksheets are categorized as very valid with an average score of 3.52; (2) student worksheets are categorized as practical with an average score of 2.64. Thus, the worksheet on renewable energy material based on science process skills is feasible to improve the character of mutual cooperation and creative and cognitive abilities of students in physics learning.
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INTRODUCTION

Physics is one of the branches of natural science that is important in shaping scientific attitudes and developing students' cognitive skills (Jannah et al., 2021; Laksana et al., 2020). Physics is considered a part of science that utilizes a conceptual approach, both abstract and concrete concepts, to explain various natural phenomena, as well as to develop scientific attitudes and master their applications in everyday life (Jannah et al., 2021; Suhardiman et al., 2022). Physics is a part of scientific knowledge and is the product of scientific research (Burgawanti et al., 2023; Yanti et al., 2020). Several components are needed to acquire a scientific attitude, such as lesson planning, which includes teaching materials (Burgawanti et al., 2023; Suhardiman et al., 2022).

Teaching materials refer to a set of learning materials presented sequentially and comprehensively and must be mastered by students during the learning process. Teaching materials are also beneficial for educators to facilitate active student participation, allowing students to study the content before the teaching-learning process begins (Burgawanti et al., 2023; Suhardiman et al., 2022). Therefore, when discussing a particular topic, if students are provided with enough information related to the topic, the available learning time will allow the educator to explain the material in detail or conduct discussions. Currently, physics education in schools faces challenges in enhancing students' critical

thinking, creativity, and scientific skills, which are crucial for dealing with advancements in science and technology in the global era. One way to overcome these challenges is using Student Worksheets designed to train students' science process skills ([Burgawanti et al., 2023](#); [Suhardiman et al., 2022](#)). Student worksheets are an example of teaching materials used ([Handayani et al., 2020](#); [Mahtari et al., 2020](#); [Misbah et al., 2018](#); [Suhardiman et al., 2022](#)).

Worksheets refer to printed materials containing an overview of the content and instructions students must follow when using them. Worksheets help support or facilitate learning, fostering a correlation between students and educators, thus enhancing learning outcomes ([Budi et al., 2021](#); [Dewantara et al., 2019](#); [Laksana et al., 2020](#); [Lestari et al., 2021](#); [Suhardiman et al., 2022](#)). The components of worksheets are simpler than modules but more complex than books. A good worksheet can be identified by its structure, which includes learning objectives, worksheet objectives, and student activities ([Pawestri & Zulfiati, 2020](#); [Setiyaningsih et al., 2022](#)). Worksheets that meet didactic, construction, and technical criteria are categorized as good worksheets ([Burgawanti et al., 2023](#)). The didactic criteria relate to the universal use of worksheets, concept discovery, and various media stimuli; construction criteria relate to clarity in worksheet content, sentence structure, and vocabulary; while technical criteria involve the visual presentation of the worksheets ([Pawestri & Zulfiati, 2020](#)).

Physics learning requires dual skills for students to compete in the global era. One of these skills is science process skills (SPS) ([Jannah et al., 2021](#); [Suhardiman et al., 2022](#)). SPS focuses on developing students' ability to acquire knowledge and communicate it. SPS is important for students as it helps improve critical thinking, reasoning, knowledge development, problem-solving, creative thinking, and scientific attitudes ([Elfeky et al., 2020](#); [Ginting et al., 2022](#); [Nadia et al., 2021](#); [Nurhuwaida et al., 2022](#); [Zainuddin et al., 2020](#)). SPS are divided into basic and integrated categories. Basic SPS includes observing, classifying, measuring, communicating, predicting, and making conclusions (focused on knowledge, with skills being supplementary) ([Elfeky et al., 2020](#); [Hodosyová et al., 2015](#)). Integrated SPS includes problem formulation, hypothesis development, variable identification and definition, investigation planning and execution, data acquisition and presentation, data analysis, and drawing conclusions ([Ekici & Erdem, 2020](#); [Kruea-In et al., 2015](#); [Purnamasari et al., 2021](#)).

Worksheets can be used for developing SPS ([Muhdhor et al., 2023](#)). Worksheets containing SPS have various benefits that enhance science process skills, creativity, ideas, critical thinking, communication, observation, classification, prediction, reasoning, logical, and creative thinking skills. Therefore, SPS-based worksheet can be a strategy to enhance students' SPS and character ([Wahyuni et al., 2022](#)). Teaching worksheets based on SPS require active student participation in learning ([Lindayani et al., 2023](#)). One of the goals of SPS-based worksheets is to train science process skills, covering various aspects, including collaboration and creativity ([Maisarah & Prasetya, 2023](#)).

The topic of renewable energy in physics is taught to students in grade X during the even semester of the independent curriculum ([Tatsar et al., 2023](#)). The main topics in this material include energy, renewable energy, the urgency of energy needs, and the potential of renewable energy in Indonesia. Renewable energy is closely related to students' lives, and energy needs are a global issue that has been widely discussed for decades ([Karira et al., 2023](#)). Renewable energy refers to energy sources from nature that do not harm the environment and provide sustainable energy supplies while mitigating climate change ([Cardona-Vasquez et al., 2024](#); [Igeland et al., 2024](#); [Laugs et al., 2024](#); [Loutfi, 2024](#)). However, there are obstacles in practical lessons due to limited teaching materials on

renewable energy in schools ([Delima et al., 2023](#)). Students' creative thinking ability in solving everyday problems can be enhanced through practical activities ([Sofia et al., 2022](#)).

Character education is the responsibility of various parties, including schools and society ([Damayanti & Nawawi, 2023](#)). The Pancasila Student Profile represents qualities instilled through school culture in each student ([Udin & Nawawi, 2023](#)). There are six dimensions of character in the Pancasila Student Profile: faith, devotion to God and noble character, mutual cooperation, global diversity, critical thinking, creativity, and independence ([Ulandari & Rapita, 2023](#)). In some schools, efforts for character education are minimal and often have little impact on students. In other words, the awareness of the importance of mutual cooperation in daily life has not fully reached the students ([Listyaningsih, 2022](#)). Similarly, creative character education remains limited due to several factors, such as teachers' understanding, the implementation of character education, and the national education system ([Sancaya & Arofah, 2022](#)). Mutual cooperation is helping each other or working together to solve problems, providing beneficial results due to its advantageous effects ([Delay & Piou, 2019](#); [Jeong et al., 2016](#); [Rejeki, 2020](#)). Collective problems can be solved easily and cheaply through mutual cooperation ([Evans et al., 2020](#); [Lukiyanto & Wijayaningtyas, 2020](#); [Rahayu et al., 2015](#)). Creativity is an individual's ability to create something new, such as ideas, actions, or products ([Novitasari et al., 2022](#)). Creativity is a beneficial change that brings new insights and enlightenment ([Kim et al., 2019](#); [Wahbeh et al., 2024](#)). Often, one creative act leads to another ([Katz et al., 2022](#); [Culpepper & Gauntlett, 2024](#)).

Preliminary studies conducted by the researchers found that students' SPS categories were still low because they were only trained in the material but were less practiced in formulating problems and hypotheses, identifying variables, defining variables, analyzing data, and drawing conclusions or summaries. Students were also inclined to be individualistic and less creative, indicating the need for SPS-based worksheets to improve mutual cooperation and creative character. SPS-based worksheet has various benefits that enhance science process skills, creativity, critical thinking, communication, observation, classification, prediction, reasoning, logical thinking, and creative thinking skills. Therefore, SPS-based worksheets can be used as a strategy to enhance SPS and student character ([Wahyuni et al., 2022](#)).

Although many studies have developed worksheets for physics learning, most existing worksheets have not been specifically designed to train science process skills, which are important for improving students' scientific thinking abilities. Previous research has shown that many worksheets are limited to delivering material without integrating practical skills training involving observation, experiments, and data analysis ([Muhdhor et al., 2020](#); [Pawestri & Zulfiati, 2020](#)). This indicates a gap in the approach used in many of the available worksheets in the education market.

Based on the study by [Tematan & Mago \(2021\)](#), worksheets that are highly valid and practical and able to train students' SPS have been well-received by students. Other research ([Handayani et al., 2020](#)) showed improvements in the character of grade X students using scientific-based history worksheets, which had high validity and led to character development. Another study by [Anggraini et al. \(2015\)](#) found that SPS-based worksheets on particle dynamics were quite valid, reliable, and suitable for use in learning.

The novelty of this research lies in the development of SPS-based worksheets on renewable energy materials, which aim to deliver physics knowledge and enhance mutual cooperation and creativity among students. These worksheets are designed to stimulate students to conduct observations and experiments and analyze results, thereby training them in critical and creative problem-solving. This research is expected to significantly contribute to developing more effective physics learning methods integrated with practical

skills and foster better scientific character among students. This research aims to produce valid and practical SPS-based worksheets to improve mutual cooperation and creative character as seen from their validity and practicality aspects.

METHODS

This research is a development research. The research subject is PPP-based worksheets on renewable energy materials to improve the character of mutual cooperation and creativity. The test subject is 33 students of class X of one of the MA in Banjarmasin. The research was conducted to describe the feasibility of PPP-based worksheets on renewable energy material to improve mutual cooperation and creative characters in terms of validity and practicality. This study used the 4D development model (define, design, develop, disseminate) ([Thiagarajan et al., 1974](#)). The 4D development model is a learning device development model ([Hidayatin et al., 2022](#)). The researchers chose the 4D model in the study because this model is systematically organized to solve learning problems and meets the characteristics and needs of students ([Suhardiman et al., 2022](#)). The 4D model development research chart is shown in Figure 1.



Figure 1 4D model development research chart

The validity analysis technique used is that the worksheets developed were validated by two academic experts and one practitioner expert using a validation sheet with a scale of 1-4. The scores obtained from the three validators were summed and averaged. Student worksheets are said to be valid, at least in the good category ($2.80 < X \leq 3.40$) ([Widoyoko, 2016](#)). Furthermore, the validity value of the three validators was calculated for reliability using the Cronbach alpha equation. While the practicality analysis uses a student response questionnaire with 20 statement items filled in at the last meeting by students. The worksheets are said to be practical, at least in the good category ($2.4 < X \leq 3.2$) ([Widoyoko, 2019](#)).

RESULTS AND DISCUSSION

The research conducted was research and development of SPS-based worksheets on renewable energy material for class X. This study aims to develop SPS-based worksheets on renewable energy material that meet valid and practical criteria to improve mutual cooperation and creative characters. In this study, the 4D model was used, which includes the stages of defining (define), designing (design), developing (develop), and disseminating (disseminate) ([Thiagarajan et al., 1974](#)). The 4D model allows researchers to systematically design, develop, and test worksheets that meet various eligibility criteria.

The first stage is define, which is divided into five parts, namely first, initial analysis is used to find out the problems of educators and students in physics learning at school. Researchers analyzed the teaching materials in the school and found that the learning model used by educators in class X of one of the MA in Banjarmasin is still conventional (only relying on worksheets) and still rarely does experimental activities in class. Second, we analyzed the interests and characteristics of students in learning. Students in class X of one of the MAs in Banjarmasin are in the formal operational stage. Third, task analysis is an activity to identify skills that students in learning then acquire. Fourth, concept analysis identifies the main concepts used for the related subject matter. Fifth, identifying the specifications of learning objectives in accordance with the basic competencies. In this

section, the formulation of learning outcomes and the flow of learning objectives for class X of one of the MAs in Banjarmasin is carried out.

The second stage, design, involves designing the initial draft of learning devices by constructing ATP based on the LO used. Furthermore, learning objectives were made from the ATP. Renewable energy material learning objectives are formulated for meetings 1-4.

The third stage, namely develop (development), included the validation of academics and practitioners and validation by academic experts carried out by lecturers, while practitioner experts were carried out by physics subject educators in class X, one of the MA in Banjarmasin, to assess its validity. Product deficiencies can be known through validation so that improvements can be made. After being validated, the worksheets that have been developed are simulated to fellow students. So that criticism and suggestions for device improvement are obtained. If necessary, revisions were made again. The worksheets were then ready to be tested in the field. The worksheet design results display is shown in Figure 2.

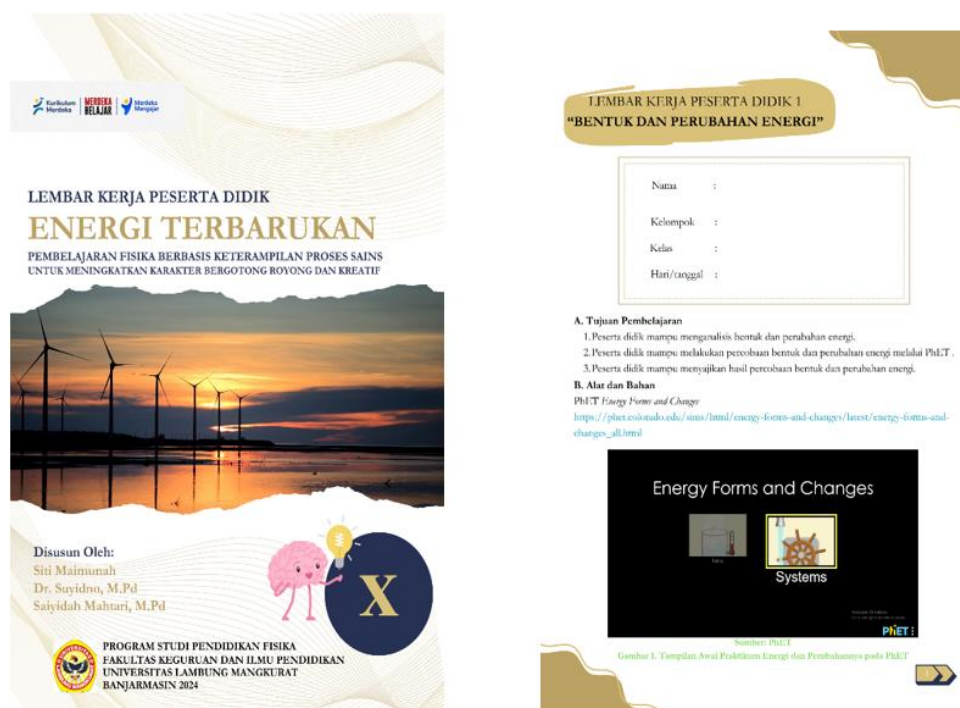


Figure 2 Display of worksheet design results

Product validation is carried out to determine the feasibility of the worksheets developed. The media (devices) developed by researchers were validated by two academic experts and one practitioner expert. The results of worksheet validation can be seen in Table 1, which shows the validity of worksheets in the aspects of format, content, language, presentation, and graphics.

Table 1 Results of worksheets validation

Criteria Aspect	Validity		Reliability	
	Value	Category	Value	Category
Format	3.64	Very good	1.03	Very High
Contents	3.50	Very good		
Linguistics	3.67	Very good		
Presentation	3.44	Very good		
Graphics	3.33	Good		

After validation by academic experts and practitioners, many significant improvements were made to the SPS-based worksheet tool to improve its quality and effectiveness. Before validation, the worksheet format was not well organized, especially in arranging sections and instructions for use. However, after receiving feedback, the structure of the device was improved with a clearer and more structured arrangement and more detailed instructions to make it easier for students to understand. In addition, the content of the worksheets was initially less relevant to students' daily lives, which could reduce their understanding of the material. Improvements were made by adding examples closer to students' daily experiences and linking physics concepts with practical issues. In terms of language, the previous tool used vocabulary that was quite technical and could confuse students. However, after revision, the language was refined and simplified with additional explanations of technical terms to make it easier to understand. The graphical presentation also received improvements, as the initial appearance was less attractive. Changes were made by adding more relevant and interesting illustrations and graphics that helped visualize important concepts in the material. Finally, the device's graphics, which were initially inconsistent, with irregular font sizes and spacing between elements, were improved by setting more consistent font sizes and clearer spacing between elements so that the device became easier for students to read and follow. These improvements ensure that the worksheets developed can be used effectively in learning, provide a better learning experience for students, and support achieving the desired learning objectives.

The results of the validation of PPP-based worksheets on renewable energy material to improve mutual cooperation and creative characters on renewable energy material in Table 1 shows that the worksheets developed include aspects of format, content feasibility components, language, and presentation in a very good category and good graphic category with very high reliability. PPP-based worksheets to improve mutual cooperation and creative characters on renewable energy material include a cover, preface, table of contents, general information, instructions for use, concept map, worksheet 1, worksheet 2, worksheet 3, which contains six SPS indicators, stabilization questions, answer keys, author's biodata, and reference sources (bibliography). This PPP-based worksheet consists of three activity topics: Worksheet 1, Energy and its Changes; Worksheet 2, Energy Needs Issues; and Worksheet 3, Wind Power Cars, which contain six PPP indicators.

In the first meeting, learners are given worksheet 1 to conduct an online practicum through the PhET Energy Forms and Changes page. In the second meeting, learners are given worksheet 2 in the form of energy demand issues. In the third and fourth meetings, students are given worksheet 3 to make wind power car projects. At each meeting, the PPP-based worksheet students do includes an analysis of six PPP indicators and stabilization questions. This is in accordance with the opinion of ([Diella et al., 2019](#) ; [Handayani et al., 2020](#)) where the cognitive abilities and science process skills of students will increase if they use worksheets integrated with SPS. Integrated SPS in worksheets will make students always use science skills in learning a concept which is in line with the nature of science, namely processes, products, and attitudes.

A good worksheet according to [Suhardiman et al. \(2022\)](#) and [Burgawanti et al. \(2023\)](#) has met the didactic, construction, and technical requirements. This is in line with the opinion of ([Pawestri & Zulfiati, 2020](#)) where the didactic requirements are related to its universal nature and have a variety of stimuli in the media; construction requirements related to language, vocabulary, and clarity of worksheets; and technical requirements related to writing, images, and worksheet display. SPS-based worksheets to improve mutual cooperation and creative characters are more easily understood by students because the illustrations of images and problems presented are in accordance with everyday life. This is in line with ([Muslimah, 2020](#) ; [Suhardiman et al., 2022](#)) that the overall content and

clear image messages are good images in worksheets. Validated worksheets are then revised based on input from validators to obtain better worksheets that can be used in learning. Their practicality is in Table 2.

Table 2 Practicality of worksheets

Criteria Aspect	Validity Per Aspect	Category
Ease of Use of Worksheets	2.46	Good
Benefits of Worksheets	2.86	Good
Time Efficiency	2.60	Good

The practicality of the worksheet is the ease of use of worksheets during learning. Figure 2 shows the results of the practicality test based on students' responses to the developed worksheets in terms of the ease of use of worksheets, the benefits of worksheets, and the efficiency of learning time using worksheets. The practicality of the worksheets obtained an overall score of 2.64 in the good category, so it can be classified as practical. The students' response questionnaire was distributed to 33 students of class X of one of the MAs in Banjarmasin after the learning process using the SPS-based worksheets for four meetings was completed. According to (Widiawati et al., 2022), data regarding the practicality of learning devices was obtained from students' questionnaire responses when learning using learning devices developed to determine the practicality from the student's point of view as the research subject. (Kriswati et al.;, 2020; Suhardiman et al., 2022) . states that a learning device is practical if it can be used flexibly, learning is well implemented, learner activity is in accordance with the expected scenario, and positive responses are obtained.

The ease of use of worksheets has a good category (practical) because the worksheets developed are easy to understand and use vocabulary appropriate for students. In line with (Handayani et al., 2020; Khodizah et al., 2022), worksheets that do not cause difficulties in the learning process, have clear instructions, are easy for students to understand, and use clear and effective writing will not confuse. The benefits of worksheets also have a good category (practical) because worksheets make students active, and their learning achievement increases (Alqhorina & Effendi, 2024). This is in accordance with learning theories that support learning using SPS-based worksheets, namely constructivism and behavioristic learning theories. Constructivism learning theory states the importance of contextual learning, where students connect the knowledge learned with their daily experiences. Meanwhile, behavioristic learning theory emphasizes the importance of experiential learning, where students learn through direct experience and reflection. PPP-based worksheets often include experimental tasks designed to help learners collect data and summarize the results that require learners to use scientific process skills to find their own solutions (Abidin, 2022) . In addition, the developed PPP-based worksheet is also done in groups by students so that they can collaborate and argue well in each activity presented in the worksheets. The time efficiency aspect of learning using worksheets has a good category (practical). This is because, in learning, students can complete the worksheet on time. In line with (Khodizah et al., 2022), which states that if the worksheet has a clear completion time, students can make the most of the time given and determine their time allocation. In addition, the concepts contained in the material and problems in the SPS-based worksheet can be understood more quickly by students. This means that, according to students, SPS-based worksheets to improve mutual cooperation and creative characters on renewable energy material can be feasible and easily used in the learning process.

CONCLUSIONS

The research concludes that the developed SPS-based worksheet is feasible for improving the character of mutual cooperation and creativity. This is supported by the researcher's findings as follows: a) The worksheet developed is classified as very valid because the

results of the validation of several aspects of the assessment, including aspects of format, content, language, and presentation, have very good categories and the graphic aspects are categorized as good. b) The developed worksheet is classified as practical because the results of students' responses have an average validity of all aspects 2.64 in the good category. For further researchers, learning tools developed in the form of SPS-based worksheets can be refined using more detailed sources using other Pancasila student profile characters because the research is only limited to the characters of mutual cooperation and creativity, using other physics materials besides renewable energy but still paying attention to the effectiveness of learning time, and analyzing the results of character improvement with more effective methods.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS STATEMENT

All authors have contributed to the conceptualization, methodology, formal analysis, investigation, and writing this article.

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