Scientific Reasoning Analysis on the Implementation of PjBL-Worksheet on Renewable Energy Topic in High School Physics Learning

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Abstract. Scientific reasoning skills (SR) is one of important skills in Content Standards for Elementary and Secondary Education as stated in the Minister of Education and Culture Regulation No. 21 of 2016. In fact, there are many students who found difficulties in developing scientific reasoning skills on the Physics learning process. Preliminary research lead to the finding that a learning media/worksheet for Renewable Energy topic that can facilitate various learning styles and levels of students' initial knowledge is needed as an effort to overcome the differences in scientific reasoning. As a follow-up to the previous development research, this research implemented PjBL worksheet on renewable energy to analyze students' scientific reasoning. This research is a quasi-experimental with one group pretest-posttest design. The population of this study were all of 12^{th} students in one of the SMA N in Pringsewu district. Purposive sampling technique were used in obtaining 29 students as research sample. The instrument of the study is test of scientific reasoning ability in the form of essay that was developed to meet content validity and high reliability. Research data were analyzed through descriptive and inferential statistical analysis (test of the dependent data for mean difference) at the 5% significance level. The results showed that the average SR of students before implementation was 41.17, which increased to 83.79 after the implementation of PjBL-worksheet. The results of the statistical test also confirm the conclusion that the stdent's SR ability after implementing PjBL-worksheet is better than the student's SR before implementation. It was also found that all students experienced an increase in SR with the category of at least moderate individual improvement and the average gain score of SR students was 0.72 which was in the high improvement category. So it can be concluded that the student's SR is categorized as good after the implementation of PjBL-worksheet.

Keywords: scientific reasoning · worksheet · project based learning · renewable energy

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1 Introduction

T Learning in the 21st century demands various skills that must be mastered by students, so that it is expected to prepare students to master these skills to become successful individuals in life. The skills that are important in the 21st century include: *learning to know, learning to do, learning to be, dan learning to live together* [1]. Each of these four principles contains specific skills that need to be empowered in learning activities, such as critical thinking skills, problem solving, communication, collaboration, innovation, creation, digital literacy, and various other skills. Achieving 21st century skills can improve the quality of learning, and help students develop participation.

US-based Partnership for 21st Century Skills (P21), identify the competencies needed in the 21st century, namely *"The 4Cs"- communication, collaboration, critical thinking, dan creativity* 21st century students need academic skills and technical savvy. According to a preliminary survey conducted via Google Forms by researchers from secondary schools in Lampung Province, 100% of teachers learned physics using student worksheets, but 100% of the student worksheets used by teachers were 30% are perceived as offensive and make students uncomfortable. 100% of teachers used relevant student worksheets and were active in learning. Up to 100% of teachers use technology to teach physics, but technologies such as LCDs are also used without images and videos, but her 70% of teachers still use spoken language to teach increase. As much as 20% of the student worksheets used have not accommodated the need for integration of projects or scientific experiments in learning. Other preliminary results show that 40% of students understand better when learning is accompanied by pictures or videos, 50% of students understand better when learning is accompanied by experiential activities, and 10% of students understand better by teachers. Understand learning better when explained orally and 40% of the students were unable to dare to express their opinions and opinions. Rebut other students' answers if the answers given don't fit the theory.

The results of the preliminary research also show that 70% of students find it difficult to understand renewable energy in everyday life, because the teacher only explains what it means, there are no learning activities that make students able to reason and argue about energy in everyday life. Students considered that learning physics was very boring, and renewable energy topic was considered unclear. Therefore, most students are not actively learning in physics class. Teachers therefore need a learning medium that includes renewable energy topics that encourages students to learn more actively. Media that can be developed to train students to be more active in learning is student worksheets.

Student worksheets are guides used to carry out research or problem-solving activities. This activity sheet can be in the form of a guide for the exercise of developing cognitive aspects or a guide for the development of all aspects of learning in the form of an experimental or demonstration guide. So that by using the media in the form of student worksheets, educators can measure the cognitive, affective, and psychomotor aspects of students directly.

Project based learning worksheets (PjBL-worksheet) are worksheets that are prepared by heed the steps and principles of project-based learning. This worksheet uses the project as a resource for students to find and acquire the knowledge they need. Worksheets are created in his PjBL. This learning model allows students to be directly involved in the learning process as projects are carried out both individually and in groups. PjBL

learning provides an opportunity for students to learn, collaborate to solve problems, and present their findings to an audience [2]. Many simple projects can be done by students, allowing them to learn more actively and solve everyday problems related to the topic [3].

Physics is introduced to Indonesian students in primary and secondary schools. The result of the research shows Physics learning activities cannot promote physical concepts. As a result, the level of scientific thinking of school students remains low. In the learning process, learning activities accompanied by experimental activities and group discussions can train students' scientific reasoning, so that students can express their respective opinions among group members. Students can work together creatively to develop an idea to create a product in project-based learning. The learning carried out in the project-based learning model is based on discovery, design and everything that can develop student activities in a mind-blowing manner [4]. On and hands-on so that it fosters students' efforts to build complex and experiential memories. The process of project-based learning can make it easier for students to understand the topic, because students immediately apply their knowledge to a project they are preparing.

The project will make it easier for students to remember the concepts that have been obtained. PjBL is an alternative learning that can be used not only to assess cognitive aspects, but also student performance [5]. Based on the explanation of several problems from the results of filling out the questionnaire on the needs of students, learning physics on Renewable Energy topic requires learning media that are able to accommodate the learning styles of students assisted by digital technology. One of the learning media that can be used to meet these needs is project-based worksheet. As a follow-up to the research, this research implemented PjBL-worksheet in renewable energy topic to see whether the implementation of PjBL-worksheet in renewable energy topic that had been developed had an impact on the development of students' scientific reasoning abilities.

2 Method

This study is a quasi-experimental design using a one-group pretest-posttest design, namely by using one class as an experimental class by measuring students' scientific reasoning before and after applying PjBL-worksheet on renewable energy topics. In the one-group pretest-posttest design, the sample used is one group, in which case the group is selected by purposive sampling and then the group is treated in the form of worksheet for renewable energy topics based on PjBL. So that the effect of the treatment can be seen from the values of O1 and O2 which are statistically analyzed by means of a mean difference test using a paired sample t-test. The hypothesis in this study is that the students' scientific reasoning ability after the implementation of the PjBL-worksheet on renewable energy topics was higher than the students' scientific reasoning ability before the application of the developed PjBL-worksheet on renewable energy.

The population in this study were all 12^{th} students at one of the SMA N in Pringsewu district. The sampling technique used is non-random sampling with purposive sampling type by looking at the average value of students' physics learning outcomes and problems of students' scientific reasoning abilities. The instrument of data collection in this study was in the form of a scientific reasoning test in the type of essay questions which were

compiled based on scientific reasoning indicators. The data collection technique at the research stage is through the test method by comparing scientific reasoning before and after the implementation of the worksheet on renewable energy topics based on PjBL. The question instruments used in this study were previously analyzed for the validity and reliability of the questions.

Data on students' scientific reasoning abilities consist of initial data and final data derived from the pretest and posttest results of scientific reasoning abilities. The data from the pretest and posttest were then analyzed descriptively, determined the N-gain value, then analyzed inferentially starting with the normality test and continued with the paired sample t-test at a 5% significance level. The level of scientific reasoning of students is seen based on the answers given at the pretest and posttest which are then analyzed based on the criteria of scientific reasoning. The normality test was conducted to determine whether the scientific reasoning score data came from a normally distributed population or not. The data tested were in the form of pretest and posttest results. The N-Gain value is used to determine the increase in students' scientific reasoning abilities. Paired sample t-test was used to test whether there were differences in students' scientific reasoning abilities before and after the implementation of PjBL-worksheet on renewable energy topic. This test was carried out using the SPSS program. In addition, students' scientific reasoning abilities were also studied in terms of gender with male and female categories. The analysis was carried out in a quantitative descriptive way.

3 Result and Discusion

Before and after the implementation of PjBL-worksheet on renewable energy topic, students' scientific reasoning abilities were measured with the results of descriptive statistical analysis as presented in Table 1.

Based on Table 1, both the highest score, the lowest score, and the average score of students' scientific reasoning after the implementation of the PjBL-worksheet is higher than the scientific reasoning score before the implementation of the PjBL-worksheet. This data shown an increase in students' scientific reasoning abilities as a result of the implementation of PjBL-worksheet. The deviation of the posttest score which is lower than the deviation of the pretest score indicates that the pretest data group is more diverse than the posttest data group, which also means that the average score in the posttest data group better describes the condition of the data group. PjBL-based worksheets with the

Table 1. Descriptive Statistics of Students' Scientific Reasoning Ability Before and After Implementation of PjBL-Worksheet on Renewable Energy topic

Descriptive Statistic	Pretest	Posttest
Maximum score	60	95
Minimum score	29	75
Average	41.17	83.79
Standard deviation	7.79	5.61

activity of revealing real-life phenomena, focusing on authentic (not simutive) questions or problems, and their solutions have the potential to bridge students developing their thinking creativity [6]. The use of PjBL-based worksheet also can improve synthesis, evaluation, prediction, and reflect that learners enjoy the learning process [7]. This means that efforts to train students to design processes to determine an outcome, train students in accountability and manage information carried out on a project have the potential to increase student reasoning activities.

The next data analysis focused on the inferential analysis of students' scientific reasoning, starting with the normality test using the Kolmogorov-Smirnov test from the SPSS program and producing the outputs which are summarized in Table 2.

Based on Table 2, the entire data group shows a significance value (sig value) $>$ 0.05. Because the value of sig $>$ 0.05, then is accepted, which means that both groups of data come from a normally distributed population. Because the assumption of normality is met, the next analysis is carried out using a paired sample t-test with the test results p-value $= 0.00 < 0.05$ then H_0 is rejected, which means that there is a significant difference between students' scientific reasoning abilities before and after the implementation of PjBL-worksheet. The average posttest score is higher than the average pretest score, based on Rusefendi, it can be concluded that students' scientific reasoning abilities after implementing PjBL-worksheets are better than students' scientific reasoning abilities before implementation.

These findings direct further analysis to the analysis of the acquisition of increasing students' scientific reasoning abilities based on the n-gain score which is analyzed in total and by gender. The results of the descriptive analysis are then presented in Table 3.

Based on Table 3, in total the average acquisition of students' scientific reasoning abilities is 0.72. n-gain $>$ 0.7 categorizes in the high category improvement. Judging from the highest score, both in total and assessed by gender, the maximum score is $>$ 0.9 which is also included in the high category. The minimum gain score is 0.5, both in

Table 2. Normality Test Results of Students' Scientific Reasoning Ability

Data Group	Sig.	Test decision
Pretest	0.121	Retain H_0
Postetst	0.086	Retain H_0

Table 3. Descriptive Statistics of Acquired Improvement of Students' Scientific Reasoning Ability

Descriptive Statistics	Total	Male	Female
Average	0.72 (High)	0.74 (High)	0.70 (High)
Maximum	0.93 (High)	0.93 (High)	0.93 (High)
Minimum	0.50 (Moderate)	0.51(Moderate)	0.50 (Moderate)
Standard Deviation	0.10	0.12	0.10

total and by gender, which means that each student experiences an increase in scientific reasoning ability with a minimum improvement category in the medium category. This finding shows a good improvement in students' scientific reasoning ability after the implementation of PjBL-worksheet.

Furthermore, an analysis of the percentage of categories of increasing students' scientific reasoning abilities based on gender was carried out, with the results as shown in the bar chart in Fig. 1.

Figure 1, reveals the information that 50% of female students had a high category improvement for their scientific reasoning abilities while the male students showed 55% improvement in the high category. This finding leads to a tendency that male students are more affected by the increase in their scientific reasoning abilities.

Furthermore, the study looked at the level of improvement experienced by students who were grouped into level 0 (category did not change), level 1 (increased category level 1), level 2 (increased level 2). Category) and level 3 (increased category level 3). The results of the descriptive analysis are presented in Fig. 2.

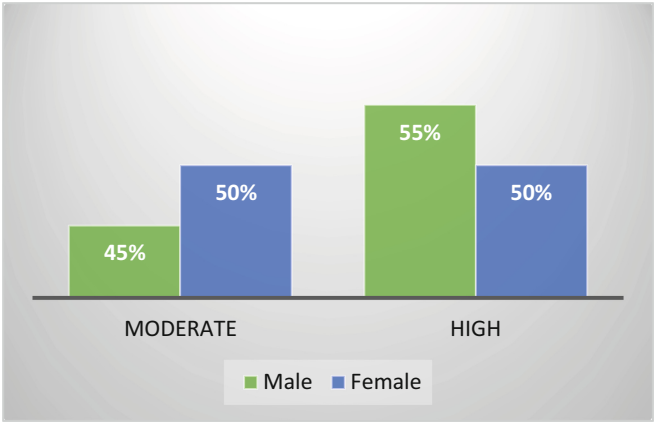

Fig. 1. Bar chart of the Percentage of Ability Improvement Category Student Scientific Reasoning Based on Gender

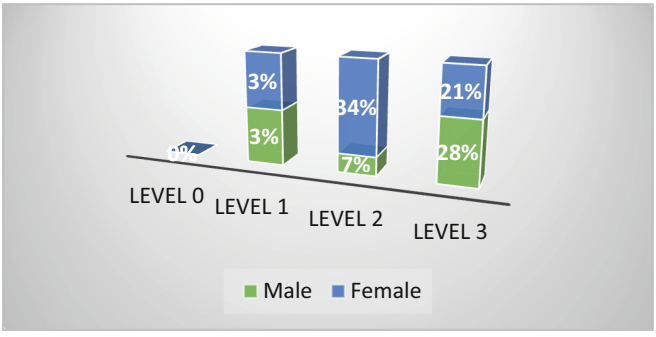

Fig. 2. Bar Chart of the Percentage of Student Improvement Levels

Based on Fig. 2, there are no students at level 0 which means that there are no students who do not experience an increase in the category of scientific reasoning abilities. Most of the students (49%) were in the improvement of level 3 which means most of the students were in the category of step three, for example students from the low category were affected by the implementation of PjBL-worksheet and occupied the very high category of scientific reasoning ability. It is very possible, since the importance of training scientific reasoning could manage through the learning process [8].

Based on gender, male students had a higher percentage of level 3 improvement, which was indicated by a better impact than female students on the changed scientific reasoning ability category. These findings indicate a tendency that male students get a better impact than female students. To validate this finding, whether it applies to the population, an inferential statistical analysis was performed with the results of the normality test as presented in Table 4.

Based on Table 4, both data groups have sig values. > 0.05 both through the Kolmogorov-Smirnov test and the Spahiro-Wilk test. This leads to a decision to accept H0 which means that both groups of data come from a normally distributed population. Next, an inferential analysis was performed using an independent sample t-test with the test output as presented in Table 5.

In Table 5, it is known that the value of sig. Levene's Test for Equality of Variances is $0.321 > 0.05$, which means that the two data populations have homogeneous variances. Therefore, the results of the t-test calculation studied are tcount $= 0.889$ which is in the H0 acceptance area. This means that there is no significant difference between the increase in the scientific reasoning ability of male and female students. This means that the implementation of PjBL-worksheet on renewable energy topic has an effect that is not significantly different for both female and male students.

The results of this study support the results of previous research that, men are superior in the fields of biology, science, and physics, but are not found in other subject

Table 4. Output Tests of Normality

	Kolmogorov-Smirnova			**Shapiro-Wilk**		
	Statistic	**Df**	**Sig.**	**Statistic**	**df**	**Sig.**
Gain_M	0.176	11	0.200*	0.950	11	0.644
Gain_F	0.176	11	0.200*	0.945	11	0.577

Table 5. Output Indepenedent Sample T-Test

	Levene's Test for Equality of Variances		**t-test for Equality of Means**	
	F	**Sig.**	**t**	**df**
Equal variances assumed	1.020	0.321	0.937	27
Equal variances not assumed			0.889	17.895

areas [9]. Other study revealed the result that women were more dominant in terms of reading and writing, but the two sexes did not differ in mathematics [10] and in the world of mathematical and science olympiads, men's achievements are more prominent than women's [11]. Based on data and expert research, it can be said that there is a need for efforts to focus students' abilities without paying attention to the differences in the identity of each student, such as gender. Related to this, it can apply PjBL-worksheets which is to ground students' Scientific Reasoning skills. This is crucial by reason of scientific reasoning is an important cornerstone of skepticism and evidence-based reasoning that is the basis of learner science [12] and scientific reasoning becomes important and is applied as a pedagogical framework in the learning process of students [13].

Implementation of the use of PjBL worksheets on the topic of renewable energy. It uses reflection, investigation, discovery, application, and communication of learning steps as syntax. Learning activities begin by explaining to students the learning process that is taking place. Then, students are given pretest questions. This pretest question is intended to find out the scientific reasoning of students before using the developed PjBL-worksheet. The next learning activity is the teacher starts learning by showing videos of phenomena related to energy in everyday life that will be studied including sun, water, wind, and biomass. Furthermore, students are asked to classify renewable and non-renewable energy. The teacher explains the learning objectives to be achieved then the teacher asks students to watch the second video about the use of renewable energy in everyday life.

The teacher asks students to form groups of 6–7 people to give project ideas by seeking information from various sources (Internet or books). The teacher then provides PjBL-worksheet to students as a guide for learning. The teacher as a facilitator, asks students to use the PjBL-worksheet individually by following the guidelines in the PjBL-worksheet from sketching simple tools according to the project idea of utilizing renewable energy. In the final stage of learning, students are asked to make a simple project regarding the use of renewable energy according to the sketch that has been made outside of classroom learning hours, then students analyze the results of the experiment with the help of the guide in the PjBL-worksheet.

At the second meeting, students were asked to present a simple project and conclude the results of experiments that have been carried out by students with each group. After all the topic has been taught by the teacher for 2 meetings, at the end of the lesson students are also given a posttest to determine the achievement of students' scientific reasoning after learning using PjBL-worksheet is carried out. The first phase before entering the core activities is the preliminary stage. At this stage the teacher displays a video about the energy resources that exist in the surrounding environment, so students classify which ones include renewable energy and which ones include non-renewable energy. In addition, students provide reasons for the answers given. Striving students to systematic learning that involves learning knowledge and skills through the preparation of complex questions, authentic questions and work design or estuary products of PjBL-based learning [14]. This activity bridges students in conserving reasoning and formulating claims. After that, the teacher asks students to join their respective groups consisting of 6–7 students.

In the Reflection phase, the teacher shows an illustration of energy that can be found in everyday life. The teacher asks students to watch the video and discuss project ideas to be made with their groups. This activity guided students in practicing observing skills as the best way of learning through visual displays such as written information/charts/diagrams/illustrations they could gathered through books or videos [15]. The activities that involve students in finding and gathering information, using media can enrich the experience of managing information, encourage the ability to observe various symptoms, catch signs that distinguish them from symptoms in other events [16]. Students' scientific reasoning abilities involve the whole process of inquiry [17]. This activity also mastery students in arguing against energy illustrations presented through conservation reasoning.

In the Research phase, the teacher distributes PjBL-worksheet according to the project ideas that have been discussed by students. In this phase, students and their groups collect information from various sources (internet) related to project ideas that will be made regarding wind energy or water energy as a solution to the problem of limited energy. Students write down the results of project ideas on the PjBL-worksheet that has been provided. In this phase, activities are carried out when students discuss with their groups to find information related to project ideas. Information acquisition activities emphasize the ability of students to be able to think critically, connect learning materials with relevant surrounding circumstances and master information technology, communication and collaboration [18]. This activity trains the ability to analyze, argue, and practice digital literacy, so that students have good scientific reasoning. If students' knowledge of scientific reasoning is low, then students will have difficulty solving physics problems [19].

In the Discovery phase, the teacher guides students with their groups to make sketches of the project ideas that have been made and express the relationship between the project ideas and the sketches that have been made. In this phase, students have made a sketch of the project idea and continued with making a simple project with their group regarding wind and water-power plants. Students also determine the formulation of the problem, determine the variables investigated, and make hypotheses. The activity of designing a project is made by writing down the tools and topics and the manufacturing steps discussed. Project-based learning has positive and significant effects for problem-based learning, such as on problem-solving skills, conceptual understanding, attitudes toward learning, and student performance that is comparable to or better in content knowledge tests [20]. Project-based learning involves students to produce something, such as a process, design, product, simulation, or product design, experimental design, data analysis and interpretation [21].

In the Application phase, students and their groups design simple tools according to the project ideas of each group, make research objectives, formulate problems from the tools made, determine the variables to be investigated, determine the relationship between variables, investigate the relationship between variables. In this phase, they mastery the science process skills and accommodate students' learning styles, namely kinesthetic. In this phase, it makes students more active and able to form argumentation skills that are supported by reason. Students then conclude the results of the experiment and provide rebuttals if the opinions and data obtained are not in accordance with the

theory or information used by the group. In this phase, you practice your analytical skills, and provide rebuttals to simple projects that have been made.

In the Communication phase, students present simple projects and explain the results of experiments that have been carried out with their groups. This presentation activity makes students do questions and answers with other groups and refute the opinions of other groups if there is an error in the theories and concepts of physics regarding renewable energy. Learning with presentations makes students participate actively as indicated by discussions, interactive questions and answers and motivates students [22]. This condition will make it easier for students to be more active and more creative in exploring their abilities in accepting the topic provided by the teacher.

Based on the results of the data analysis and description above, it shows that the overall achievement of learning activities using PjBL-worksheet received a positive response from students. Based on this, it can also be concluded that learning runs smoothly and in accordance with the learning scenario. This can be interpreted that the implementation of each activity and time management can be achieved properly so as to have an impact on increasing scientific reasoning abilities for each student.

4 Conclusion

Based on the results of research and data analysis, it can be said that the scientific thinking ability of students after implementation of PjBL worksheets is better than that of students before implementation. This is based on the average score of students' scientific reasoning abilities before implementation of 41.17 which increased to 83.79 after the implementation of PjBL-worksheet and was also validated by the results of statistical tests which also confirmed the findings. It was also found that all students experienced an increase in their scientific reasoning ability scores with a minimum "moderate" individual improvement category and an average score of 0.72 students' scientific reasoning ability improvement which was in the high improvement category. So, the implementation of PjBL-worksheet provide good effect on the student's SR.

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