



Development of Project-Based Learning Materials on Heat and Temperature to Train Student's Scientific Skills

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Abstract

This research aims to produce project-based learning materials on temperature and heat, which are suitable for use in improving scientific skills and learning outcomes in cognitive aspects. The research and development method is carried out in seven steps: a preliminary study, planning, product draft development, limited trial, product draft revision, wider trial and initial product revision. Products are rated by seven validators. Limited trials were carried out on eight subjects, and more extensive trials were carried out on 32 subjects at Madrasah Aliyah Negeri Yogyakarta III using a one-group pretest-posttest design. The results of the study have shown that the product development Education Unit Level Curriculum version lesson plans, 2013 Curriculum version lesson plans, Project-Based Student Books and project appraisal sheets) are feasible. This use can improve scientific skills in learning but cannot significantly improve the test subjects' cognitive aspects' learning outcomes. Thus, Project-Based Student Books can be used as a learning medium by the teacher. However, it needs further improvement and research in order to improve scientific skills in learning.

Keywords: cognitive aspects of learning outcomes; project-based learning; scientific skills

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INTRODUCTION

Students of Senior High Schools and Madrasah Aliyah need to be facilitated to develop knowledge and skills as provisions for them to continue to higher education and achieve career success in the 21st century. Students must learn to work in teams with different cultures and backgrounds, also be able to manage time, solve problems, do multiple tasks and access information (Santyasa, 2013).

Students can especially obtain this knowledge and scientific skills through learning activities at school. In Government Regulation Number 19 of

2005, it is stated that learning is held in an interactive, inspirational, fun, challenging manner, motivates students to participate actively, and provides sufficient space for initiative, creativity, and independence. Meanwhile, the 2013 curriculum document explains that science learning uses a scientific approach that emphasizes process skills rather than learning outcomes in cognitive aspects. Scientific learning adopts scientific steps in building knowledge through scientific methods (Nursyamsudin & Suwito, 2013). Thus, both the curriculum KTSP and the 2013 Curriculum have been arranged to be



more oriented towards students' activeness in obtaining knowledge and skills to influence individual students' scientific attitudes.

One of the learning models that facilitate students to actively work in groups, manage time, process information, carry out investigations to solve problems to develop meaningful knowledge and skills is project-based learning. Project-based learning as "a model that organizes learning around projects". Project-based learning is a student-centred learning approach by giving assignments in the form of investigations based on problems from the real world during a predetermined time, which can be done individually or in groups. Project-based learning is a complicated assignment by asking questions in the form of challenges or problems that involve students actively to design, solve problems and carry out investigative activities (Aiedah & Audrey, 2012). The assigned project can be in the form of investigative activities or product manufacturing. So, project-based learning can be defined as a learning model that adopts a constructivist paradigm and active learning, where students actively build and develop their knowledge and skills through project activities to solve problems from daily life.

The teacher's role in project-based learning is as a learning resource, guide and facilitator (Bender, 2012; S. Guo & Yang, 2012; Kubiak & Vaculová, 2011). In other words, the teacher provides clarification about concepts that are not understood and guides students in carrying out the steps of the scientific method to complete their project assignments. Also, the teacher assesses and observes the process of completing project assignments to ensure that students do it with their own hands.

The implementation of project-based learning follows the syntax set out

in the 2013 Curriculum guidelines with six steps, namely: (1) essential question; (2) designing project plan; (3) creating schedule; (4) monitor the progress; (5) assess the outcome; (6) evaluate the experience. Project-based learning activities begin with determining essential questions from the real world, which are then appointed as the project assignment's theme. The next stage is planning the project, collecting references from various sources, determining the project title, determining the variables to be investigated, determining the tools and materials needed, and planning the project experimental procedure to answer the questions determined at an early stage. The schedule and deadlines for completing project assignments are agreed upon by the teacher and students at the third stage. In the fourth stage, students carry out an experimental project, make a written report of the project results and submit the progress of implementing project activities while the teacher provides input. In the fifth stage, students present their projects orally and in writing, then they are assessed by the teacher. The final stage of implementing project-based learning is evaluation and reflection on a series of activities that have been carried out.

Projects can be focused on one subject or interdisciplinary (Bender, 2012). The selection of the coverage of the theme in the project task is considered by looking at the readiness of students and teachers. Projects can be assigned in groups or individually, depending on the complexity of the project task, students' abilities, and the competencies expected to be achieved in learning. Individual projects require students to apply and integrate abilities and knowledge that cover many things to complete their tasks (Nitko & Brookhart, 2011). Previous researchers who have suggested group project assignments include (S. Guo & Yang,

2012; Mureşan, 2014). Determining the number of students in a group determines the effectiveness of implementing project-based learning because the greater the number of individuals in a group, the less active role in project completion. Meanwhile, Larmer (Bender, 2012) recommends four students in one group. In this study, students in one group numbered three to four because the project assignments were quite simple.

In terms of the skills needed in the 21st century, project-based learning has the advantage of being able to help students develop collaborative skills, make decisions, solve complex problems, communicate and organize themselves. Another advantage is that it can develop teacher professionalism and improve student learning outcomes (S. Guo & Yang, 2012). Also, based on relevant research, it is found that project-based learning can facilitate students to solve problems in the surrounding environment using the knowledge they have (Mureşan, 2014). The teacher's lack of knowledge about students' projects, the habits of students doing learning that lead to passive learning make them less skilled when carrying out project activities, and in implementing and designing project-based learning activities can take a relatively long time. With these various strengths and challenges, teachers should be able to apply project-based learning in science (physics) subjects to optimize students' competency achievements, but the fact is based on initial observations in the field, teachers still rarely apply project-based learning.

Performance appraisals can measure the achievement of learners' competencies in project-based learning. Performance assessment is an assessment integrated with learning, focused on observing the performance and achievement of student competencies following predetermined

learning objectives. A distinctive feature of conducting performance appraisals is assessed performance competencies, assessment sheets and scoring rubrics (Nitko & Brookhart, 2011). Teachers often use written assessment techniques because it takes a relatively long time to assess performance, which is in line with relevant research results (Oladele, 2011). Assessment in project-based learning is included in performance appraisal techniques (Nitko & Brookhart, 2011).

Guidelines for implementing project-based learning and project performance appraisals can be made as a project-based learning tool. According to Ibrahim (Trianto, 2014), learning tools can be in the form of a syllabus, a Learning Implementation Plan, student activity sheets, evaluation instruments, learning media, and student textbooks. In this study, the syllabus, instructional media, and students' textbooks were not developed because the teacher provided them. The Learning Implementation Plan is developed on a project basis which contains the syntax for a project-based learning model. Student activity sheets are developed in project-based student books as a guide in completing project tasks. The evaluation instrument in this study was developed as a project appraisal sheet that can be used to assess student performance during project assignments.

Based on interviews with class X physics teachers at MAN Yogyakarta III, the teacher had conducted project-based learning and performance appraisals, but the learning tools were not equipped with project implementation manuals for students; a complete rubric did not accompany the performance appraisal tools.

Scientific skills include science process skills and psychomotor skills (manipulative skills). In this study, the acquisition of scientific skill scores was limited to measurement through a

written test with essay-shaped questions by not making sensory observations. The scientific skills in question are the skills to observe, classify, predict, formulate hypotheses, identify and control variables, conduct experiments, measure and use numbers, interpret data, analyze data, communicate, conclude, and the skills to use tools properly, correctly and safely.

Learning outcomes in cognitive aspects are based on Bloom's taxonomy revision (Munzenmaier & Rubin, 2013), consisting of remembering (C1), understanding (C2), applying (C3), analyzing (C4), evaluating (C5), and creating (C6). In this study, the assessment of learning outcomes in the cognitive aspects was carried out using a multiple-choice test with temperature and heat material questions that contained the ability to remember, understand, apply and analyze.

The choice of temperature and heat material in the development of project-based learning tools is because the characteristics of temperature and heat material are declarative, which requires verification through investigative/experimental activities, and close to everyday life, so they are suitable for project-based learning activities. So it is important to develop project-based learning tools on temperature and heat material that are suitable for use in learning physics, with the assumption that it can improve scientific skills and learning outcomes in students' cognitive aspects.

METHOD

This research and development use a model with seven stages of research, namely (Borg & Gall, 1989): (1) a preliminary study; (2) planning; (3) product draft development; (4) limited trial; (5) revision of the product draft; (6) more extensive trials; and (7) revision of the initial product to produce the final product of project-based

learning tools consisting of: Education Unit Level Curriculum version lesson plans, 2013 Curriculum version lesson plans, Project-Based Student Book and project assessment sheets.

In the preliminary study stage, a field survey and literature study was carried out. The field survey was conducted by observing physics learning in class XB MAN Yogyakarta III to analyze the need for project-based learning tools. A literature study is intended to collect references related to learning and project-based learning tools from journals, textbooks and law on education.

Basic Competency analysis is carried out at the planning stage, specification of learning objectives, and determination of competency criteria. At this stage, the product specifications are determined.

After determining the product specifications at the planning stage, the product draft's development is carried out, namely, draft I. Draft colleagues to review me for input and then revised (revision I) until draft II is validated by seven validators consisting of two lecturers. Experts, three physics teachers MAN Yogyakarta III and two physics teachers SMA NI Pematang. The validator assesses draft II and provides input for revision (revision II) so that draft III is produced, ready for limited testing.

The product draft was tried out on a limited basis to many students to determine the legibility of the Project-Based Student Book and project assignments. Revisions are made based on students' input (revision III) so that the initial product of project-based learning tools is produced that is ready to be tested more widely.

The initial product was tested in physics learning with more subjects to determine the product's effectiveness in improving scientific skills and learning outcomes of test subjects. Also, the test

subjects gave responses regarding the implementation of project-based learning.

The initial product that has been tested is more extensive, then revised (revision IV) is based on input of test subjects and evaluation of learning. Thus, the final product of project-based learning tools is produced.

Limited trials were conducted on many subjects without using an experimental design. The wider trial uses a pre-experimental design, namely one group pretest-posttest, which provides tests before (pretest) and after (posttest) project-based learning is carried out with products that have been developed.

The subjects involved in the limited trial were eight students in class XC MAN Yogyakarta III. In a broader trial, the test subjects involved were students of class XB MAN Yogyakarta III, totalling 32 participants.

The research data collection was carried out by using questionnaires and tests. The data collection instruments in this study included: (1) product validation instruments; (2) questionnaire on limited trials; (3) about the pretest-posttest scientific skills; (4) about the pretest-posttest cognitive aspects of learning outcomes; and (5) questionnaire in a broader trial. The validator's product validation instrument to assess project-based learning product products was validated through focus group discussions with 20 participants and validated by research instrument experts. Subjects in limited trials filled in questionnaires in limited trials to assess Project-Based Student Books' legibility, and project assignments were validated through focus group discussions with 20 participants and validated by research instrument experts. The pretest-posttest scientific skills that consisted of 10 essay items to determine the improvement of the subject's scientific skills in a broader

trial had been validated by research instrument experts and tested empirically on 29 students. The pretest-posttest questions on the cognitive aspects of learning outcomes, which consisted of 20 multiple choice questions to determine the improvement of learning outcomes in the subject's cognitive aspects in wider trials, have been validated by research instrument experts and tested empirically on 47 students. Test subjects filled in the wider trial questionnaire to explore responses regarding the implementation of project-based learning using development products have been validated through focus group discussions with 20 participants and validated by research instrument experts.

The feasibility analysis of project-based learning product products follows the steps outlined by (Sudijono, 2015). Data obtained from product validation sheets and questionnaire sheets on limited trials and wider trials are tabulated.

The mean score in the form of quantitative data is converted into qualitative data that states the quality of the product and the criteria for the test subjects' response on a scale of five with the provisions in Table 1.

Table 1 Product Quality Category and Test Subject Responses

Score Interval	Category
$\bar{X} > (M_i + 1.5 SB_i)$	Very good
$(M_i + 0.5 SB_i) < \bar{X} \leq (M_i + 1.5 SB_i)$	Good
$(M_i - 0.5 SB_i) < \bar{X} \leq (M_i + 0.5 SB_i)$	quite
$(M_i - 1.5 SB_i) < \bar{X} \leq (M_i - 0.5 SB_i)$	poor
$\bar{X} \leq (M_i - 0.5 SB_i)$	bad

Description:

Mi: ideal average

SBi: ideal standard deviation

The analysis of the validity and reliability of the pretest-posttest questions of scientific skills and learning outcomes in the cognitive aspects used the Rasch model. Each item's validity is

seen from the value of the outfit mean square, outfit Z-standard, and point measure correlation. The reliability of the questions regarding the value of person reliability, item reliability and alpha Cronbach (KR-20).

Analysis of the improvement of scientific skills and learning outcomes in the cognitive aspects using the t-test (paired sample t-test) by first confirming the normality test (one-sample Kolmogorov Smirnov) homogeneity that the data is normally distributed and has homogeneous variants. The following hypothesis is made to determine the increase in scientific skills and cognitive aspects of learning outcomes.

H_{o1} : the use of the product does not significantly improve the scientific skills of subjects in extensive trials.

H_{a1} : the use of the product can significantly improve the scientific skills of the subject in extensive trials.

H_{o2} : the use of the product can not significantly improve the learning outcomes of subjects' cognitive aspects in extensive trials.

H_{a2} : the use of the product can significantly improve the learning outcomes of the subject's cognitive aspects in extensive trials.

Decision making is carried out at a 95% confidence level with the following provisions: (1) if the significance value of the probability, $p > 0.05$, then H_o is accepted, which means that the use of project-based learning device products cannot significantly improve scientific skills and/or learning outcomes of students' cognitive aspects ; (2) if the significance value of the probability, $p < 0.05$, then H_o is rejected or H_a is accepted, which means that the application of project-based learning device products can significantly improve scientific skills and/or learning outcomes of students' cognitive aspects.

RESULT AND DISCUSSION

A preliminary study which includes field survey activities and literature study, was conducted to determine the importance of developing project-based learning tools. The field survey was conducted by observing physics learning activities, observing students' characteristics, and interviewing physics teachers related to learning and assessment for physics subjects in class XB MAN Yogyakarta III. From the results of the field survey, it is known that although the teacher facilitates students to be active in physics learning activities in class XB, learning tends to be more teacher-centred. The primary learning resources used in learning physics are student worksheets and printed books that have been provided. Besides, a library with a complete book collection accompanied by an adequate internet connection can be used by students to support learning. An adequate physics laboratory is a means for teachers to develop students' skills along with the knowledge material taught in the classroom. In learning activities, students have a high curiosity about the physics concepts described by the teacher. Based on interviews with class X physics teachers, the regular assessment of learning is a written test. However, teachers also assess the affective and psychomotor aspects of students. The psychomotor aspects of students are usually assessed through practicum activities in the laboratory. The teacher also carries out assessment activities through project assignment but has not been accompanied by a complete assessment rubric. The literature study was conducted to determine the implementation strategy and the positive and negative sides of project-based learning and assessment. It is also to determine which project assignments are suitable for senior high school level students, adjusted to the material coverage of temperature and heat.

Project-based learning is a learning model in which students carry out project tasks. Project-based learning syntax, namely: essential question, designing a project plan, creating a schedule, monitoring the progress, assess the outcome, and evaluate the experience. Project assignments can be either investigations or product manufacturing. Assessment can be carried out as long as students are completing project tasks, including the project planning stage, project implementation, and reporting project results. From the preliminary studies results, it is known that project-based learning tools for temperature and heat materials are important to be developed.

The planning stage consisting of basic competency analysis, specification of learning objectives and determination of competency criteria is needed to map learning activities and assessments that will be made into project-based learning product products. The basic competencies analyzed are in Education Unit Level Curriculum and Curriculum 2013 because currently, it is a transition period from Education Unit Level Curriculum to Curriculum 2013. Competency standards for temperature and heat material in KTSP apply the concept of heat and the principle of energy conservation to various energy changes. The competency standards are translated into three basic competencies, namely: (1) analyzing the effect of heat on temperature and changes in the shape of an object; (2) analyzing the method of heat transfer; (3) applying the Black principle in problem-solving. In the 2013 Curriculum, Core Competencies consist of Core-1 Competencies (spiritual attitudes), Core-2 Competencies (social attitudes), Core-3 Competencies (knowledge) and Core-4 Competencies (skills). The results of the analysis of Core-3 Competencies and Core Competencies 4 class X based on the Regulation of the Minister of

Education and Culture Number 64 of 2013 concerning Content Standards are as follows: (1) Core Competency 3: understand, apply and analyze factual, conceptual, procedural and factual knowledge. Metacognitive based on his curiosity about science, technology, arts, culture and humanities with insight into humanity, nationality, statehood and civilization related to the causes of phenomena and events, and applying procedural knowledge to specific fields of study according to his talents and interests to solve problems; (2) Core Competency 4: cultivating, reasoning and presenting in the realm of concrete and abstract related to the development of what they learn in school independently, acting effectively and creatively, and being able to use methods according to scientific principles. Basic Competency for Core Competency 3 is: analyzing the effects of heat and heat transfer on everyday life, and the basic competencies for Core Competency 4 are: planning and carrying out experiments to investigate the thermal characteristics of a material, especially the capacity and heat conductivity. The research result at the planning stage is the determination of the product specifications being developed.

The products developed to consist of: (1) Education Unit Level Curriculum version of the lesson plan; (2) the 2013 Curriculum version lesson plan; (3) Project-Based Student Book; and (4) project appraisal sheet. The Education Unit Level Curriculum P version of the lesson plan was made because the trial's research sample was limited, and the trial was more extensive in MAN Yogyakarta III, which still used Education Unit Level Curriculum. The lesson plan for the 2013 Curriculum version is made considering that in the upcoming 2014/2015 academic year, the 2013 Curriculum will apply to all primary and secondary education

throughout Indonesia. Project-Based Student Book is a book created to guide students to carry out project tasks and assess their performance while completing project assignments. The book was developed regarding the Education Unit Level Curriculum document, the 2013 curriculum and a guidebook for science fair project activities. The project appraisal sheet is used to assess students' performance during project activities starting from the planning, implementation and reporting stages of the project. For the Project-Based Student Book, eight project task themes were determined, namely thermometer, supercooled water, condensation, water freezing, water specific heat, thermal conductivity, convection rate, and radiation rate. In the Project-Based Student Book there is also a self-assessment sheet and peer-to-peer assessment sheets to assess their own performance and their friends' performance during project assignments.

The mean score of the validator's assessment for the draft lesson plan product Education Unit Level Curriculum version is 4.14 in the criteria for very good quality. The Education Unit Level Curriculum version of the lesson plan scores very well for the : thermometerrriteria (language, R-1; learning indicators, R-2; lwater-specificals, R-3; learning methods, R-4; learning activities, R-5 and learning assessments, R-6). So it can be seen that the Education Unit Level Curriculum version of the lesson plan is feasible to use in physics learning on project-based temperature and heat material and is ready to be tested. The Education Unit Level Curriculum version of the lesson plan validation is presented in the graph in Figure 1.

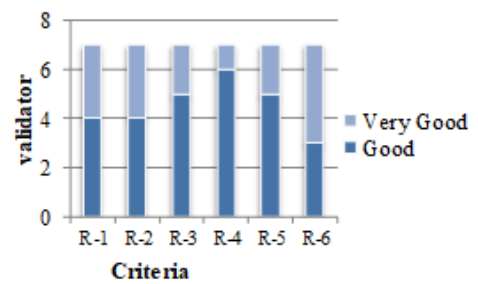


Figure 1 Validation Results for the lesson plan Education Unit Level Curriculum version

The mean score of the validator assessment for the draft lesson plan version of the 2013 Curriculum is 4.11 in the very good quality criteria. The lesson plan version of the 2013 Curriculum gets a very good average score for the overall assessment criteria (language, R-1; learning indicators, R-2; learning materials, R-3; learning methods, R-4; learning activities, R-5 and learning assessment, R-6). So it can be seen that the lesson plan version of the 2013 Curriculum is declared fit for use in learning physics on project-based temperature and heat material and is ready to be tested. The validation of the 2013 Curriculum version of the lesson plan is presented in the graph in Figure 2.

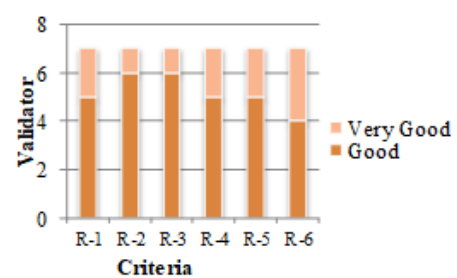


Figure 2 Validation Results for Lesson Plan 2013 Curriculum Version

The Project-Based Student Book product draft received a mean rating of 4.27, which was included in the very good score category, with a very good average score for each assessment criterion (project assignment, B-1; construction, B-2; self-assessment, B-

3). The Project-Based Student Book is declared suitable for use in project-based physics learning on temperature and heat material and is ready to be tested. The results of the Project-Based Student Book validation are presented in the graph in Figure 3.

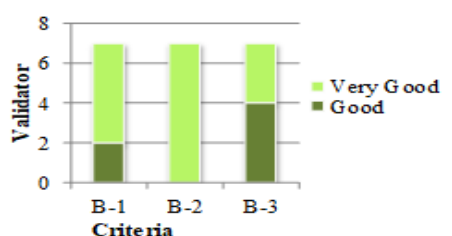


Figure 3 Results of the Project-Based Student Book Validation

The mean value of the project appraisal sheet product validation was 4.17 in the very good category, with a very good average score for each assessment criterion (construction, P-1 and performance competency, P-2). So that the project appraisal sheet product is feasible to use and ready to be tested. The results of the project appraisal sheet validation are presented in the graph in Figure 4.

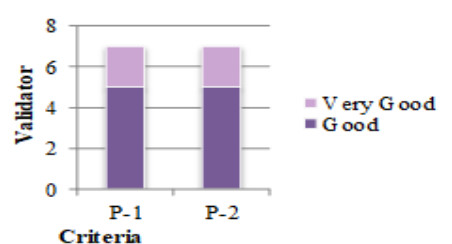


Figure 4 Validation Results of the Project Appraisal Sheet

Limited product trials were carried out in class XC MAN Yogyakarta III with 8 students as participants, each of whom received a project task theme that had to be done and responded to. Each test subject observes the Project-Based Student Book and carries out project tasks until the planning stage. The planning stage is determining the project title, making a list of tools and materials,

making a scheme of a series of tools and materials, and designing a project task experimental procedure. The teacher plays a role in explaining what students have to do and guides them to carry out project tasks at the planning stage. The teacher's activities are intended to test the draft lesson plan products. Also, the teacher assesses students' performance during project planning to test the product draft of the project appraisal sheet. After the learning activity is complete, the test subjects are given a questionnaire to review each project task theme in the Project-Based Student Book, and assess the readability of the Project-Based Student Book. The trial subjects were also allowed to provide input used as a guide in revising III.

The mean score of the validator assessment for the draft lesson plan version of the 2013 Curriculum is 4.11 in the very good quality criteria. The lesson plan version of the 2013 Curriculum gets a very good average score for the overall assessment criteria (language, R-1; learning indicators, R-2; learning materials, R-3; learning methods, R-4; learning activities, R-5 and learning assessment, R-6). So it can be seen that the lesson plan version of the 2013 Curriculum is declared fit for use in learning physics on project-based temperature and heat material and is ready to be tested. The validation of the 2013 Curriculum version of the lesson plan is presented in the graph in Figure 2.

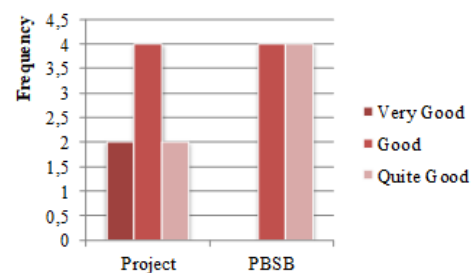


Figure 5 Subjects' Responses to Limited Trials

Apart from providing responses to project assignments and the Project-Based Student Book, subjects in the limited trial also carried out project assignments until the project planning stage based on previously acquired knowledge. The activities carried out by students in the limited trial were planning the project with the Project-Based Student Book guide, which included designing the project title, making a list of tools and materials and designing experimental project procedures. In general, the subject's performance in limited trials got good scores from the observer. One of the results of project planning made by the subject in a limited trial is presented in Figure 6.

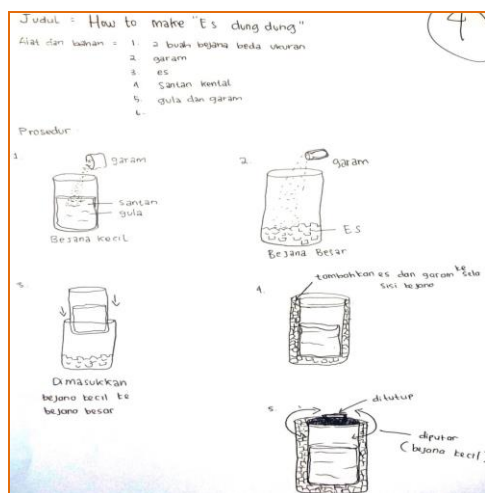


Figure 6 Project Planning by One of the Subjects in a Limited Trial

Subjects in limited trials provided input so that at the beginning of the lesson, it was explained in advance about the objectives of implementing project assignments so that students could know what they had to do. During the limited test, it was not explained in advance about the project activities' objectives because it was assumed that the Project-Based Student Book contained details of the objectives of the project assignments. These suggestions are implemented in learning in a wider trial class. Based on the results of

limited trials, the average student assessment of the Project-Based Student Book and project assignments is good, so it can be said that the Project-Based Student Book product can be read and understood by the test subjects well. Therefore, the initial product is ready to go through a broader trial phase.

After the limited trial was completed, the project-based learning device product development stage was a more extensive trial conducted in class XB MAN Yogyakarta III with 32 students as participants. The number of male 12, the number of female 20, divided by the physics teacher class X into 8 groups. 29 students took the pretest-posttest learning outcomes in cognitive aspects, 28 students took the pretest-posttest scientific skills, 31 students filled out the questionnaire responses. The wider trial design used the one-group pretest-posttest. The pretest and posttest were given included questions about scientific skills and questions about learning outcomes in cognitive aspects. The pretest and posttest values were analyzed to determine the meaning of learning and project assessment in improving scientific skills and learning outcomes in the cognitive aspects of the test subjects. Project-based learning activities carried out by students in a wider trial (including the project's planning, implementation, and reporting stages).

At the project planning stage, teachers and students determine the deadlines for each stage of the project together, and students learn the material about the themes they get. Students consult with the teacher about things they do not know and based on the procedure guide and the list of tools and materials presented in the Project-Based Student Book, students make procedural designs and write down the necessary tools and materials. The next activity in the planning stage is completed outside the school, where students look for

reference sources from books or the internet regarding material related to the theme of project assignments and more detailed project task implementation procedures. The next thing done at the planning stage is to determine the project title, set goals, identify variables and formulate hypotheses guided by the teacher. When students carry out the project planning stage at school, the teacher assesses their performance. Students assess their performance using self-assessment sheets. In assessing themselves, students are encouraged by the teacher to judge honestly and objectively, following the activities that have been carried out. Students' project performance during project planning activities is good, and they are actively involved in project planning, based on assessments by observers and students' self-assessments.

At the project implementation stage, students carry out experimental activities and make posters. Experimental activities for all project tasks were carried out and completed in the physics laboratory, except for project 4 (lowering the freezing point of water) and project 1 (thermometer), which had to be completed outside the school because it was not possible to complete it in the time available, which was two lessons. During the experimental activity, the observer assessed by using the project appraisal sheet. The next student activity after the experiment was completed, and the results of the data were written in tables and graphs, namely making data analysis, compiling conclusions, compiling abstracts and making bibliography guided by the teacher. After all experimental activities and data analysis have been carried out, students assess their performance honestly by filling out self-assessment sheets. The next stage in project implementation activities is making posters completed outside of school because the learning schedule and

activities of students at school are hectic. Students assessed their involvement in making posters and assessed the posters' results using self-assessment sheets; meanwhile, the observer only assessed the posters' results because they could not directly observe the poster making activities. In general, the observer's assessment and self-assessment of students regarding students' performance during project implementation activities are good. The poster assessment results for groups 3, 4, 5, 6 and 8 were good; for groups 2 and 7 it was quite good, and for group 1 it was poor. One of the posters of the results of student projects is shown in Figure 7.

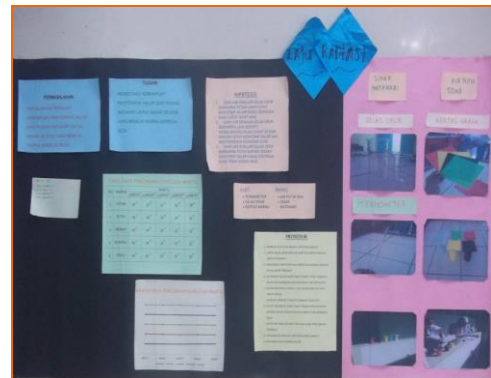


Figure 7 One of the Poster Results Made by Subjects in a Broader Trial

At the project reporting stage, students report their project results in group presentations and reports. Presentations are made with the media in the form of posters that have been made during project implementation activities. Based on the observer's assessment and self-assessment of students, the whole group can present the project results well, and all members in the group participate actively in explaining and answering questions from the teacher or other groups. The group report uses the Project-Based Student Book media in the sheet provided. Based on the observer's assessment and students' self-assessments, in general, the whole group can make a good report, and members of

the group play an active role in completing project reports.

Students' ability in the trial class is wider; in completing the project, tasks are not following expectations. Students are less able to collect initial information from available sources, so that at the planning stage, the teacher's role is more as a learning resource for students, while hopefully, they can find complete information about the theme of a given project assignment. At the time of the experiment, students were enthusiastic and skilled in using tools and materials and writing the experimental results, which could be categorized as good. However, 6 out of 8 groups experienced difficulties in analyzing experimental data. This is related to the collection of references that are not maximal so that students' knowledge cannot develop optimally. Subjects in the broader trial were given a pretest and posttest of scientific skills and cognitive aspects of learning outcomes to determine the improvement between before and after carrying out the overall learning and project assessment. Based on empirical validation results, each item of scientific skills and cognitive aspects of learning outcomes has met the validity and reliability criteria. It can measure scientific skills and learning outcomes of cognitive aspects of the experimental subject more widely. A summary of the results of the analysis of the questions is presented in Table 2.

Table 2. Summary of the Validity and Reliability of Pretest-Posttest Questions

Criteria	Scientific Skills	Learning Outcomes for Cognitive Aspects
The validity of each item	Valid	Valid
Person-reliability	0.63 (Weak)	0.80 (Enough)
Item reliability	0.85 (Good)	0.90 (Good)
Alpha-Cronbach	0.75 (Good)	0.81 (Very Good)

Twenty-nine students took the pretest-posttest learning outcomes in the cognitive aspects; 28 students took the pretest-posttest scientific skills. The pretest for scientific skills and cognitive aspects of learning outcomes was carried out at two different meetings, while the posttest for scientific skills and learning outcomes cognitive aspects were carried out at the same meeting within two hours of lessons, approximately 2×45 minutes. So, the number of respondents who analyzed the increase in learning outcomes in cognitive aspects and scientific skills was 21 students because, at the time of posttest scientific skills, some students left answers for 3-4 question numbers. With an assessment scale of 100 and the minimum completeness criterion value of physics is 75, a summary of the pretest-posttest scores of scientific skills and subjects' learning outcomes in the broader trial is presented in Table 3.

Table 3 Pretest-Posttest Value of Scientific Skills and Subject Learning Outcomes in Extensive Trials

Criteria	Scientific Skills		Learning Outcomes for Cognitive Aspects	
	Pretest	Posttest	Pretest	Posttest
The highest score	88.00	90.00	100.00	95.00
Lowest-score	56.00	66.00	30.00	30.00
Average	73.95	78.76	66.90	64.05

Standard- deviation	8.19	5.59	19.46	16.92
Subject-achieving-minimum completeness criteria	9	17	6	6
Number-subject	21	21	21	21

From Table 3, it appears that there is an increase between the mean pretest and posttest scores in the aspect of scientific skills. The mean value of learning outcomes in the cognitive aspects shows an increase between the mean pretest and posttest scores of cognitive aspects of learning outcomes.

The pretest-posttest data on scientific skills and cognitive aspects of learning outcomes have met the normality and homogeneity requirements to be analyzed by t-test. A summary of the results of the t-test is presented in Table 4.

Table 4 Summary of t-test results

Result	Scientific Skills	Learning Outcomes for Cognitive Aspects
p	0.022	0.319
df	20	20
T _{count}	-2.479	-1.023
t _{table}	2.093	2.093

From Table 4, it appears that based on the results of t-test analysis with paired sample t-test for the pretest-posttest data pair of scientific skills at the 95% confidence level, H_{01} is rejected. This means that applying project-based learning product products can improve the trial subject's scientific skills, namely students of class XB MAN Yogyakarta III, significantly. For the pair of pretest-posttest data on the cognitive aspects of learning outcomes at the 95% confidence level, H_{02} was accepted. The application of project-based learning product products cannot improve the learning outcomes of the trial subjects' cognitive aspects, namely students of class XB MAN Yogyakarta III, significantly.

The improvement of scientific skills and cognitive aspects of learning outcomes is discussed in the following sections. The increase in the mean posttest score compared to the pretest score, both for the value of scientific skills and the learning outcomes of the cognitive aspects, was quite small due to the implementation of the posttest in two hours of lessons (one meeting), while

the problems of learning outcomes in the cognitive aspects and scientific skills were designed to be solved in time - 60 minutes minimum each. Because students are not given enough time so that some posttest questions are not filled; what is clear is that scientific skill essay questions are left blank, while multiple-choice questions tend to be all filled because they can only put a cross mark on the available answer choices. Also, most of the test subjects who filled incomplete answers to the cognitive aspects of learning outcomes questions and scientific skills questions only had a slight increase in scores, and even the posttest scores were as large or slightly smaller than their pretest scores. Also, based on the analysis of the behaviour obtained when giving students questions during the pretest implementation. The students had not received the temperature and heat material and were still unfamiliar with the term scientific method; they worked happily and enthusiastically. On the other hand, at the posttest, students felt reluctant to solve the questions because they thought

there were too many to do in two hours of lessons.

After completing learning activities and project assessment, students respond by filling out questionnaires. The number of participants who filled out the questionnaire was 31. Students' responses in general regarding the Project-Based Student Book, learning and project assessment were in good categories. The results of these responses are presented in a graph in Figure 8.

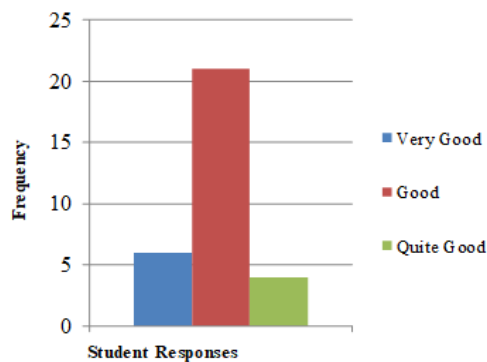


Figure 8 Subjects' Responses to Broader Trials

Thus, based on the assessment of the broader trial subjects who gave a good average response to the Project-Based Student Book product and a series of project activities, it can be concluded that the product developed in the form of the Project-Based Student Book can be read well and is suitable for use in learning.

This is following relevant research, which shows that students were more excited, happy, and comfortable in learning physics (Purwaningsih et al., 2020). Students have a positive response to learning. Relevant research states that project-based learning increases student motivation (Safaruddin, Ibrahim, Juhaeni, Harmilawati, & Qadrianti, 2020). Project-based learning (PjBL) is understood to be a promising approach that improves student learning in higher

education (P. Guo, Saab, Post, & Admiraal, 2020).

Although students were enthusiastic and gave favourable responses about the project assignments given, three participants gave input that project tasks should be carried out quickly so that it did not take up much time for learning. Based on this input, it is better if the project assignment can be carried out as a final project with an expanded theme covering physics, chemistry and biology subjects, then exhibited in an open school, so that it will be more challenging for students to do it, and is not constrained by limited time. The solution that can be done is to use time outside of class hours effectively and more intensive teacher assistance so that students can be well monitored at each stage of project completion.

CONCLUSION

Project-based learning product products consisting of Education Unit Level Curriculum version of lesson plans, 2013 Curriculum version lesson plans, Project-Based Student Book and project assessment sheets received very good assessments from the validators. Students' responses regarding the Project-Based Student Book, learning and project assessment on limited trials and wider trials are in good categories so that project-based learning product products are feasible for use in physics learning on temperature and heat material.

Physics learning on temperature and heat material using project-based learning tools is significant in improving scientific skills but not significant in improving learning outcomes in the test subjects' cognitive aspects.

Suggestions for using the product so that it can be maximally achieved in achieving predetermined learning objectives are as follows: at the beginning of the lesson, it is necessary to explain the objectives of implementing

project-based learning to students; students are given examples of project reports and products or project results in order better to understand the sequence of steps in scientific procedures; Project assignments in the Project-Based Student Book should be targeted to be completed within a maximum of two weeks, so as not to interfere with student learning, and can also train students to be able to use time effectively and efficiently.

Suggestions for further dissemination and development are as follows: dissemination should be carried out in schools with adequate physics laboratory facilities, making it easier for students to get the tools and materials needed to complete project assignments. For further development, it is necessary to develop project assignments that cover subject matter in science clusters, namely physics, chemistry and biology, and are exhibited openly in schools so that it is more challenging and provides much knowledge for students who carry out projects, as well as students who witness project exhibition.

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