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Development of Project Based Science Learning Module to Improve Students' Critical Thinking Skill

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Abstract
Project based learning (PjBL) is a learning model which can encourage students to be more involved in their learning and to think critically. The purpose of this study is to produce project based science learning module for grade 5 *Sekolah Dasar* (*SD*)/*Madrasah Ibtidaiyah* (*MI*) as a product of this research. This research was a Research and Development (R&D) which was utilized the 4D model. The result showed that the module validation by material experts obtain a percentage of 75%, by linguists the percentage was 83.9%, and by media experts the percentage was 85, 5% so that the module made are declared feasible to be used in the classroom. Individual trials on 5 students the result was 88%. In the small group trial of 10 students the result was 92.8% and in the large group trial of 20 students the result was 96.7%. The results of initial observations and final observations showed an increase in students' critical thinking skills with an average difference in individual trials of 21.80000, an average difference in small group trials of 21.40000 and average difference in large group trials of 21.55000. Apart from looking at the average differences in individual trials, small group trials, and large group trials, the average difference was also found in the experimental class which was treated with the control class which was not given treatment during the large group test, which was 10.60000. In conclusion, project based science learning module is effective in improving critical thinking skills of elementary students.

Keywords: module, science learning, project based learning, critical thinking

INTRODUCTION

The Freedom to learn policy was developed by the Ministry of Education and Culture for Indonesian quality in education. Independent Curriculum is the application of Free Learning policy. The independent curriculum is a learning method that refers to the interests and talents of students. To make curriculum development courses easier for students to comprehend, teachers require an appropriate learning model while implementing lessons. One of learning models employed in the curriculum is Project based learning (PjBL) (Hattarina et al., 2022). The PjBL can encourage students to be more involved in their learning and to think critically. According to the 21st century skills, there are four skills that must be acquired as well as the 4C, which are creativity, critical thinking, communication, and collaboration (Nurmala et al., 2021; Abbas & Fathira, 2022). From the experts above, it can be concluded that PjBL is very important to be developed in order to make some decisions and solving the problem as part of the critical thinking process.

When making decisions and dealing with problems, critical thinking is the ability to think carefully and reflectively in order to analyze circumstances, evaluate arguments, and achieve appropriate conclusions. People who can think critically are those who can draw conclusions from what they know, know how to use the information to solve issues, and can locate appropriate sources of information to help with problem solving. PjBL module can help students enhance their critical thinking abilities (Wahyuni et al., 2022). From the experts above, it is possible to figure out that by PjBL the students' ability in develop their critical thinking will achieve the learning objective. The learning technique is employed as a strategy for accomplishing learning objectives, operationalizing learning strategies in dealing with individual student differences, enhancing learning outcomes, boosting student learning acquisition, and having a direct effect on achieving objectives. A range of learning approaches can assist students in improving their learning abilities and learning outcomes. One of the learning techniques that can improve students critical thinking skill is project based learning.

Critical thinking is used to explain thinking with clear and goal-directed intentions (Saputra, 2023). The eight markers of critical thinking skills include recognizing questions, expressing hypotheses, deciding on an action, contemplating the use of acceptable processes, documenting observations, interpreting questions, detecting and dealing with irrelevance, and offering definition (Susilawati et al., 2020). From the experts above, it can be concluded that every students have their involvement in doing this learning model, PjBL, so this is as learning model will think critically in the process of learning. PjBL is a paradigm in instruction that focuses to the complicated challenges faced by students required to conduct investigations. This learning model, PjBL intends to guide through a project collaboratively that combines several curriculum disciplines, allows students to examine knowledge in a variety of ways that are important to them, and perform experiments collaboratively.

Efforts to explore students' ability to think critically is to choose a learning approach that can arouse students' interest in critical thinking. The PjBL approach can be a solution to develop students' critical thinking skills. PjBL is interpreted as a learning model that prioritizes student involvement, or what is known as a student-centered learning approach (Halimah & Marwati, 2022). Because it may play an active role directly in the learning environment, this PjBL technique can also assist readily grasp knowledge.

PjBL, as defined by Barus et al. (2022), is a learning strategy that allows students to create learning activities, work cooperatively on project, and eventually produce work products that may be shared to others. Using PjBL as its foundation, PjBL is a teaching methodology. To develop different types of learning, students engage in investigation, evaluation, and synthesis interpretation. PjBL is a thorough examination of a real-world problem (Masti et al., 2022). A benefit of PjBL, according to Fathurrohman (Cyndiani et al., 2022), is that students get more involved in problem-solving, which helps them learn new information and skills. They may also practise cooperation or collaboration, and PjBL gives them the chance to plan project.

Implementation of PjBL as learning model can provide many benefits for both teachers and students (Melinda & Zainil, 2020). They are: (1) students gain new knowledge and abilities in learning, (2) develop students' skills to solve the problem, (3) making students more enthusiastic in the learning process, (4) advancing and growing students' abilities in processing resources, (5) fostering collaboration between students, (6) students can make their own decisions and can create project assignment frameworks, (7) there are problems whose solutions have not been predetermined, (8) students can design processes to achieve results, (9) students must be obliged to obtain and organize information, (10) students make assessments on an ongoing basis, (11) students periodically check back on work that has been done, (12) the final result of this learning model is a product and its superiority is assessed, (13) the class has an atmosphere that can provide tolerance for errors and changes.

In addition to having a PjBL approach as a template for delivering material of science learning module of project based learning, there is also a need for PjBL teaching materials. To develop learning that can assist students develop their critical thinking abilities, researchers in this study used modules as teaching materials. The module is a teaching tool that is methodically simply organized for students to understand in accordance with their level of knowledge and age so that they may study on their own (independently) with little help or direction from teachers (Prastowo, 2015). As a result, this learning module will become instructional material that incorporates PjBL into scientific study for helping students improve their critical thinking skills.

Whereas a module, according to Imran et al. (2021), is a collection of individual learning experiences meant to assist students in achieving a set of predetermined goals. Meanwhile, according to Hadiyanti (2021) a module is a learning material systematically arranged based on the level of knowledge and age of students in a language that is easy to understand so that they can learn independently without the help of a teacher. In this research, science learning module of project based learning is very suitable since it is arranged systematically by matching to the students' knowledge and the age, so that students can improve critical thingking skills and independent learning.

In this study, the PjBL model and the selection of module teaching materials were selected based on problem analysis at SDIT Al-Madinah, including: 1) in learning the teacher has not developed teaching materials that can develop students' critical thinking skills, 2) the learning model used is still centered on teacher, 3) the main learning source is only student books and thematic teacher books.

METHOD

In this research, the researchers used Research and Development (R&D) as research design because this research aims to find, develop, and validate a product and test its effectiveness (Hamzah, 2020). In this research, the researchers developed project based science learning module. This research model used the 4D development model of project based science learning module, which was proposed by Thiagarajan et al. (1974) as an extension of Define, Design, Development, and Dissemination. Product development trials through the 4D model have several development stages as follows.

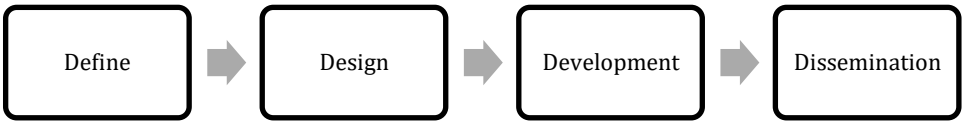

Figure 1. Model Development Stage 4 D

From the Figure 1 about Model Development Stage 4D, each stage can be given an explanation as follows. Starting from define, design, development, and dissemination. To see a brief explanation it is seen in the following. (1) Define. It contains activities to determine what products will be developed, along with their specifications. This stage is a needs analysis activity carried out through research and literature studies. (2) Design. It contains activities to create a design for a predetermined product of science learning module of project based learning. (3) Development. It contains the activities of making a design into a product science learning module of project based learning and testing the validity of the product repeatedly until a product is produced according to the specifications set. (4) Dissemination. It contains the activity of disseminating product science learning module of project based learning that have been tested for the benefit of others. This last point was not be part of this research.

This research was conducted in grade 5 SDIT Al-Madinah, Cibinong District, Bogor Regency, and West Java. In this research, the subject of this research and development of science learning module of project based learning consisted of two subjects. The first subject is the validator, which consists of three lecturers who are experts on material, language, and media. The second subject is a grade 5 student at SDIT Al-Madinah semester II of the 2022/2023 academic year. In this research, the data collection techniques were carried out by means of questionnaires, interviews, and observations. This research was conducted in 2 periods. The first was carried out in January and April, namely a preliminary study to find out problems in the learning process at SDIT Al-Madinah, the second stage of PjBL science learning module product development was carried out in May 2023. Development of science learning module of project based learning through the validation stage by material expert, media expert, and linguist. The next stage is through individual trials, small groups, and large groups. To find out the results of the development of science learning module of project based learning of students' critical thinking, in this research, the researcher used descriptive and quantitative analysis was carried out using Statistical Package for the Social Sciences (SPSS) 26 for Windows from the results of observations in observing students' critical thinking.

FINDINGS AND DISCUSSION

In this findings, the researchers noted some points that based on the research development of science learning module of project based learning. For the scientific learning module product with a successful test, the PjBL has a considerable influence. It has been done that can be explained by the outcomes of data analysis using SPSS and the t-test, and then by comparing the results of the first and final observations, which yielded an average number of significant increases. The experimental class receives an average improvement of 21.8 on the individual group exam. The experimental class's small group trials obtain a score of 21.4. The experimental class's large group trials experience an average rise of 21.55. The findings show that the application of project based science learning module on students' capacity for critical thought is thought to be successful and can enhance student learning outcomes.

Define

It contains activities to determine what products will be developed, along with their specifications. This stage is a needs analysis activity carried out through research and literature studies. Through analysis, objectives and limitations will be formed on teaching materials or materials that will be developed later. This definition stage has 5 steps, namely: (a) Front-end analysis, direct observation and interviews used in this point with homeroom teachers of class 5A and 5B Al-Madinah. From the observations and interviews that have been done by researchers, the results show that the project based science learning module has never been used during the learning process, the teacher only uses textbooks for class delivery and still uses audio delivery, meaning that students only listen to the material delivered by the teacher. In general, there is no variation in the use of instructional media to build students' critical thinking. After the interview, it was found that the teacher was not familiar with PjBL. Based on this analysis, it can be overcome by developing project based science learning module with an attractive design and adding a relevant theoretical base equipped with several questions and steps to create a project. So that it can build students to think critically by creating a project by working in groups. (b) Student analysis, from the results of observations made by researchers, it can be seen that the general characteristics of students in grades 5A and 5B have not developed the ability to think critically in the learning process. Meanwhile, from the results of interviews, the problems that arose among students were that the learning process using the lecture method made students easily bored during learning. So, based on the analysis of students, a project based science learning module can be developed which is expected to trigger students to think critically in the learning process.

This stage aims to conduct an analysis of the characteristics of students that are appropriate and relevant to the design of learning media development. The characteristics of the students analyzed included: knowledge, individual and social skills of students related to learning, media, and language. (c) Task analysis, from the results of interviews and observations, researchers analyzed the tasks that students needed to have in order to achieve minimal competence, namely critical thinking. So based on the task analysis, project based science learning module can be developed that can improve critical thinking skills. (d) Concept analysis, in this stage, the researchers have formulated the material concept that will be presented in the designed module. The concept of material presented is single substance material and mixtures. The material is adapted to the PjBL model so that the modules created relate to the project design. (e) Formulate Objectives (Specifying instructional objectives), at this point, the activity carried out is to formulate the

competency achievement indicators and objectives in learning. The competency achievement indicators that have been formulated are as follows: 3.9.1 Categorizing objects around into groups of single substances and mixtures. 3.9.2 Determine the composition of single substances and mixtures. 4.9.1 Making analysis tables for single substances and surrounding mixtures. 4.9.2 Conduct experiments by mixing several substances/objects. While the learning objectives that have been formulated are as follows: (a) Students are able to understand and identify material in everyday life based on its constituent components (single and mixed substances), (b) Students are able to make decisions when solving problems in everyday life, (c) Students are able to carry out experiments mixing several substances/objects that exist in everyday life, (d) Students are able to report the results of mixed experiments and their constituent components in everyday life.

Design

In designing, the researchers had been creating criteria (Constructing criterion-referenced test). The instruments designed were PjBL for science learning module to improve students' critical thinking skills and research instruments to develop products in the form of material validation questionnaires addressed to material validators, media validation questionnaires addressed to media validators, and design validation questionnaires addressed to design validators. (b) Selecting media (Media selection), The learning media that was developed based on problem analysis and needs analysis from the results of observations and interviews with homeroom teachers for classes 5A and 5B was a lack of varied learning media so the researchers decided to develop a project based science learning module as a means to improve students' critical thinking skills. (c) Selecting the format (Format selection), The format used in the project based science learning module on single and mixed substance material is adjusted between the material and the PjBL model and is designed in such a way that it looks attractive and conforms to the rules of the module. PjBL for science learning module on single and mixed substance materials are made using the Canva application from the front cover to the back cover. The selection of various color formats is also adjusted to the basic color, namely blue. (d) Initial design. At this stage, the initial design of the module is designed. The initial design of this module is made based on the results of the analysis in the definition phase and adapted to the selected format. The end result of this initial design created an initial prototype of the module which was validated by the validators, which consists of: 1) the initial part of the module has a front cover display made based on the selected learning material, namely theme I "Objects around Us". The title of the module is "Science learning module of PjBL" which is placed on the top left of the module cover. In the upper right corner there is the logo of the Universitas Ibn Khaldun Bogor which means the constituent campus and the Merdeka Campus logo. It is also equipped with the name of the project based science learning module. Furthermore, the display of the preface, table of contents, instructions for using the module, *Kompetensi Inti* (*KI*), *Kompetensi Dasar* (*KD*), learning indicators, and learning objectives. 2) The module content section contains material that uses steps from the PjBL model, the single and mixed substance content section is divided into 6 PjBL steps, namely determining the project, designing project planning, compiling the project schedule, implementing the project, reporting project results, and evaluating a project. 3) The closing part of the module contains a bibliography, glossary, author bio, and the back cover.

Development

Development, (a) Assessment by experts (Expert appraisal), before the product test is carried out with students, they must pass a validation test of three experts, namely a design expert, a language expert, and a material expert. Expert validation is carried out to measure the feasibility of the module in developing critical thinking skills. The appropriate criterion used in this expert validation test is validity in revising the product with the following validity percentage criteria guidelines.

Table 1 Validity Interpretation Criteria

Percentage (%)	Validity Level	Eligibility Criteria
81 - 100	Very Valid	No Revision
61 - 80	Valid	No Revision
41–60	Valid Enough	Need Revision
21–40	Invalid	Revision
0 - 20	Invalid	Total revision

Based on the percentage qualifications above, it can be seen that if the validator results show the number ≥60 % then this project based science learning module is declared valid and can be used for the next stage. Based on the results of the media expert's assessment, the result of 85.5 % indicated that it was included in the very valid criteria. Furthermore, media experts of project based science learning module provide comments and suggestions for module development, namely the letters for the author's name are heightened by painting the wax picture a lighter color.

Figure 2. Module before Revision

Figure 3. Module after Revision

The findings of the linguist's assessment of project based science learning module obtained a result of 83.9 % indicating the "very valid" criterion. Furthermore, linguists provide suggestions and comments for module development, explanation of the material is simplified and accompanied by concrete examples. The module has changed for the

language validation for the science learning module of project based learning that can be seen in Figure 4 that the module before revision and the module after revision.

Figure 4. Language before Revision

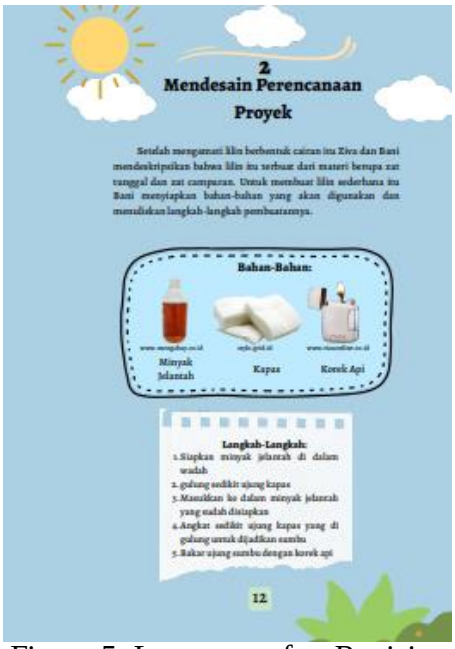

Figure 5. Language after Revision

The results of the material expert's assessment of project based science learning module obtained 75 results % indicating valid criteria. Material experts provide an assessment that for the development of project based science learning module this is in accordance with developments, so that the project based science learning module is suitable for use without revision. (b) Development trials (Developmental testing), After the project based science learning module product has been validated by experts and declared fit for use, the next step is to conduct a trial run. This try-out was conducted to find out students' responses to project based science learning module and it was divided into three stages, namely, individual test, small group test, and large group test. The assessment results obtained from individual test student responses consisting of 5 respondents amounted to 88% with a very valid category, small group test results consisted of 10 respondents 92.8% with a very valid category, and large group test results consisted of 20 respondents amounting to 96 .7% with a very valid category.

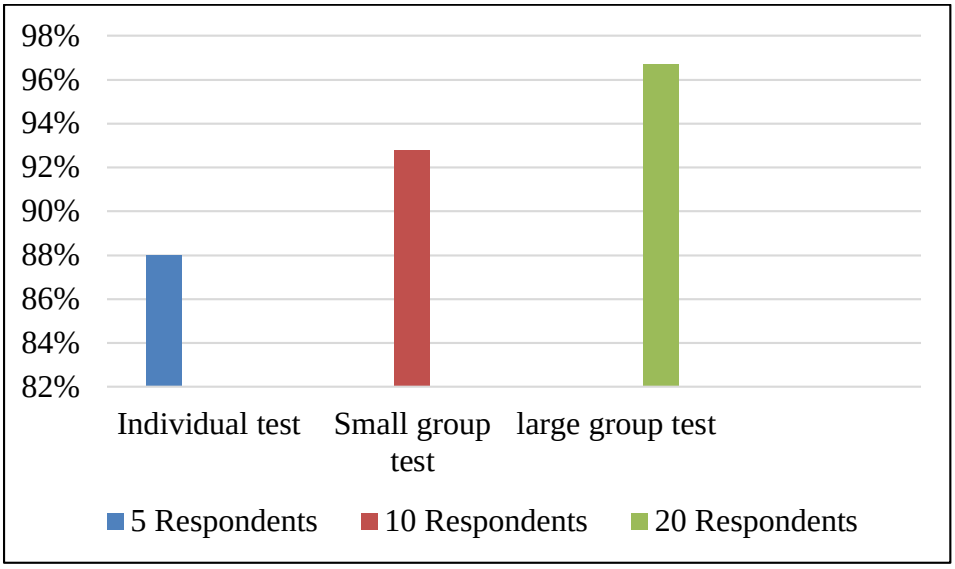

Figure 6, Test Results

From the Figure 6, it can be seen that the effectiveness of project based science learning module is carried out by conducting individual test stages, small group tests, and large group tests. This was done to measure the effectiveness of project based science learning module in developing students' critical thinking. In the trial phase the researcher made direct observations of students in the learning process to observe students' critical thinking in two situations, namely before and after using the project based science learning module. This data was obtained from the experimental class from the initial and final observations. The individual test was carried out on 5 respondents, the small group test was carried out on 10 respondents, and the large group test was carried out on 20 respondents.

In the results of initial and final observations of individual tests, small group tests, and large group tests, it can be seen that there was an increase after using the project based science learning module in improving students' critical thinking skill, in the individual test the initial observation results were 18.8 and the final observation was 40. 6 and an average acquisition of 21.8. In the small group test, the initial observation results were 17.4 and the final observation was 38.8, there was an average difference of 21.4. In the large control group test, the average initial observation value was 14.55 and the final observation was 25.15 with a difference between the two of 10.6. In the large group test, the experimental class obtained an average initial observation value of 17.1 and the second observation final of 38.65 with the difference between the two of 21.55. So from these data, it can be inferred the project based science learning module is effective to develop students' critical thinking. This shows that there is an increase in students' critical thinking after using project based science learning module. However, greater average results were obtained by the experimental class, because the experimental class was the class that was given treatment using the project based science learning module.

Furthermore, the quantitative descriptive data analysis stage uses SPSS 26 for Windows to determine whether there is an increase in students' critical thinking after using the project based science learning module. Previously, normality and homogeneity tests were carried out first. If the results show that they are normally distributed, a t-test is carried out to determine the development of project based science learning module of

students' critical thinking based on the results of initial and final observations in the control class and the experimental class.

Table 2. Results of the Paired Sample Test Control Class Test

Paired Samples Test

		Paired Differences							
					95% Confidence Interval of the Difference				
		Means	std. Deviation	std. Error Means	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	pretest - posttest	-10.60000	2.79850	,62576	-11.90974	-9.29026	-16,939	19	,000

Based on the results of the paired sample t-test in Table 2, the average value of the difference between the initial and final observations was -10.60000. The min value (-) means that the final observation value is greater than the initial observation value so that which means that there is an increase in the initial observation and final observation. The "t" value was obtained at 16.939 with significant value (2-tailed) of 0.000. It means the initial and final observations had a significant influence on decision making, namely Ha was accepted and Ho was rejected.

Table 2. The Result of Paired Sample Test Experimental Class Test

Paired Samples Test

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	pretest - posttest	-21,55000	3,15353	,70515	-23,02590	-20,07410	-30,561	19	,000

Based on Table 2, the presentation of the difference data obtained a result of -21.55000, the min sign (-) means that the final observation result was -21.55000 greater than the initial observation result. This means that there is an increase in the results of initial observations and final observations. The result of the "t" value is -30.561 with a sig (2-tailed) of 0.000, which means that Ha is accepted and Ho is rejected, meaning that the results of the initial and final observations have a significant effect on improving students' critical thinking. To find out the results of the final observation of the achievement of students' critical thinking in the experimental class and the control class, it is necessary to do an independent sample test as seen in Table 3.

Table 3. Independent Sample Test

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Pencapaian Berpikir Kritis	Equal variances assumed	4,870	,033	16,349	38	,000	13,50000	,82574	11,82838	15,17162
	Equal variances not assumed			16,349	29,981	,000	13,50000	,82574	11,81357	15,18643

Based on Table 3, the average difference between the control class and the experimental class is 4.870 with a sig (2-tailed) of 0.000, which means that Ha is accepted and Ho is rejected. From the presentation of the data it was concluded that there was an increase in learning outcomes after using project based science learning module. The development stage is the stage where the project based science learning module on static fluid material that has been developed and revised is disseminated to the intended research sites. However, researchers did not carry out this stage because researchers were constrained by the large number of funds required to disseminate the project based science learning module that were developed.

CONCLUSION

Based on the results of project based science learning module development, it can be concluded that in the validation of material experts, a percentage of 75% is valid, linguists are 83.9% in a very valid category, and media experts are 85.5% in a very valid category. Based on these results, the project based science learning module is categorized as feasible and valid. There is a significant influence from the project based science learning module with an effective test that has been carried out which can be explained through the results of data analysis using SPSS using the t-test, then getting the results of initial observations and final observations obtained an average number of significant increases, namely in the individual group test the experimental class obtain an average increase of 21.8, the small group trials of the experimental class obtain a result of 21.4, the large group trials of the experimental class obtain an average increase of 21.55. The results of these data indicate that the use of product of project based science learning module on students' ability to think critically is considered effective and can improve student learning outcomes. Furthermore, a field trial was carried out by giving student response questionnaires to assess project based science learning module, obtaining student response assessment results in individual tests of 88%, small group tests of 92.8%, and large group tests obtaining results of 96.7%. Based on the percentage results, the module obtain a very valid category and it is suitable for elementary students.

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