PE - 09

THE DEVELOPMENT OF PHYSICS MODULE BASED ON PROBLEM BASED LEARNING FOR GIFTED-TALENTED STUDENTS AT ISLAMIC SENIOR HIGH SCHOOL OF AMANATUL UMMAH GRADE XI

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Abstract

This research was aimed at designing and developing the PBL-based Physics module (Problem Based Learning) for the gifted-talented students. This research used modified 4-D Models from Thiagarajan, Semmel, & Semmel method. The development of the module begins by analyzing students' and teachers' need to the PBL-based physics module for the gifted-talented students and defining the developed teaching materials. The results of the definition of the curriculum and students' characteristics are used to develop the module for the gifted-talented students adapted with PBL syntax. Review and validation were conducted in three phases. The first phase was done by linguists and graphics and material experts, the second phase by a Physics lecturer who also assessed other research instruments, and the third by their peers (Physics teachers in accelerated classes) in order to make the final module ready to be tested to the students. A post test-only control study design was employed to test the use of the module. The results showed that the module was appropriate for use with good criteria (assessment of experts is at 3.22; assessment of lecturers at 3.45; assessment of teachers at 3.61 with a maximum scale of 4). Students' response to the module was very positive. Students were vastly interested in the use of the PBL-based Physics module and found it easy to use. Based on the statistical tests, the results showed that students with this module had learning achievements of cognitive, affective, and psychomotor better than those who merely used the school-book in the PBL learning environment. This indicates that the PBL-based Physics module can effectively be used to improve the learning achievements of cognitive, affective, and psychomotor of the students.

Key words: Development of Physics module, Problem Based Learning, gifted-talented students.

A. Introduction

The concept and idea of accelerated classes in Indonesia came from the Directorate of School Education, Director General Ministry of National Primary and Secondary Education, with the point that the talented children both hyperior (low intelligence) and superior (higher intelligence) need to be given special treatment. This refers to the 1945 Constitution (amendment) of Article 31 paragraph (1) which states, "Every citizen has the right to education". In addition, the 2003 National Education Law Article 5, paragraph 4 says, "Citizens who have the intelligence and special talents are entitled to special education". The condition is also reinforced by Decree No. 70 Year 2009 on Inclusive Education for students who have disorders and have the potential of intelligence and/or special talents. In the development of the concept, exceptionally superior children were accommodated in the accelerated classes. These children are often referred to as gifted-talented children.

The gifted-talented students have such characteristics as fast learners, excellent memory, problem-solvers and logic thinkers, high intellectual curiosity, the ability to see relationships, the ability to maintain concentration, responsibility and independence in work, initiator and innovator, flexible thinkers, observant and responsive to new ideas, able to communicate with adults using adult way, enjoying the intellectual challenge, delicate flavor, sometimes bizarre humor (Thomson, 2006). These characteristics do not appear as a whole, but depending on the school environment.

Based on the condition of the accelerated classes, there are some gifted-talented students who have difficulty in learning. The cause of the difficulties comes from the children themselves, curriculum, and the learning environment (Ahmadi, et al., 2011). Therefore, there must be a change in the curriculum that is suited to the needs of the students.

Gifted-talented students need depth of the learning materials more as well as opportunities and wider extension of the curriculum in order to develop their skills (Thomson, 2006). Therefore, the material for these students should be differentiated (distinguishable) from the ordinary students. Differentiations of curriculum include material differentiation, process differentiation, product differentiation, and learning environment differentiation (Davis and Rimm, 1998 cit. Directorate of Extraordinary School, 2009). Thus, the learning materials should be escalated according to the needs of the students, i.e. the use of high-level cognitive learning, the varied and complex materials, related to solving real-life problems, enabling in-depth research, and a flexible time limit. Introducing affective attitude was enhaced to characterize the domain of the students.

Watters & Diezmann (2003) considered that gifted-talented students were an important contributor toward the technology community in the future. Provision of support for them is often lacking. Rarely do science teachers provide opportunities for the gifted students to enrich the formal school. Education for the gifted students in science has paid little attention despite the great progress being designed for the future. Therefore, special attention for the gifted-talented students is needed in learning sciences.

The top-quality learning process of Amanatul Ummah is the *daurah* system. *Daurah* system is an activity to review materials and questions on a particular subject, i.e. the subject tested in the National Examination and the National Selection of State University. The advantage of this system is that students can get used to the problems with National Examination standard. The principle of repeating learning materials and problems is in line with the principles of behaviorism. However, based on the nature of Physics, learning undertaken must meet the component of product, affective, and psychomotor. Thus, the learning process does not only refer to the cognitive domain, but to the development of the affective and psychomotor skills for the students, especially in science.

Bruner cit. Dahar (1989) suggested that students learnt through active participation with the concepts and principles to gain experience and perform experiments that allowed them to discover the principles themselves. In the view of Dewey cit. Nur (2008), schools should reflect the greater community and the classroom should be a real-life laboratory for investigation and problem solving.

Piaget cit. Suparno (2007) examined how students built cognitive knowledge. The Students will form a scheme, develop it, and change it. They will construct their own and from their interaction with the experience and the objects encountered. In Physics learning, the students are free to learn by themselves. Physics is a physical science (Piaget cit. Suparno, 2007). This underlies the importance of the use of inquiry methods in Physics learning that gives the students the opportunity to observe, collect, analyze, and conclude the data.

Meanwhile, in reality of education, there are many teachers who still use conventional teaching materials. Conventional teaching materials are the teaching materials instantly, directly purchased, used, and effortless to prepare, plan, and organize (Prastowo, 2011).

Until recently, the packaging of Physics teaching materials is still linear, i.e. instructional materials only present concepts and principles, examples of problems and their solutions, as well as exercises. The teaching materials are less associated with the real-life issue of the students such as the problem of energy crisis, the greenhouse effect, the problems by lightning, building fire due to short circuit, the high voltage power lines, and so on. According to Liu cit. Sujanem (2009), this linear packaging of instructional materials provides fewer opportunities for the students to develop skills in formulating problems, solving them, reflect on their learning, and developing understanding. In fact, the interesting, effective and efficient learning process requires more attractive teaching materials than the conventional ones.

Just as in the selection of instructional materials that prefer instant teaching materials, Indonesian people also have the same mindset. As a result, most of them are more concerned with the product than the process itself, leading them to get frustrated and stressed. Oftentimes, the news in the media broadcast the case of suicidal, frustrated, and desperate people with the situation they face. Actually, people will not get stresses or even committed in suicide if they can face and solve their own problems.

The condition indicates that students are less trained in solving problems on the process of education. Consequently, their ability to solve the problems is still weak. Hence, the students need to get used to solving their own problem since their early age. In order that they can learn about their own thought, the cognitivists suggest that the best way is through problem-based learning. This type of learning will enable the students to solve their own problems through a structured process. Learning by problem or better known as PBL (Problem Based Learning) is the learning that is designed to help the students: (1) develop their thinking skills, problem solving, and intelligence, (2) learn adult roles by comprehending these roles through real-life or simulated situations, and (3) develop skills for independent learning (Nur, 2008).

The aforementioned description shows that in Physics learning for the gifted-talented students, it requires conceptual and contextual Physics teaching materials in a PBL environment. PBL refers to the learning process in which problems are presented as a stimulus for learning. The issues are complex and structured as well as related to the students' life (Nur, 2008).

Majid, et al. (2009) researched a series of activities in Math and Science Camp in Malaysia which taught ability to solve problems to the gifted-talented students with the finding that the gifted-talented students were more effective in developing their problem solving skills through PBL method. Tan, et al. (2009) also concluded that the effectiveness of PBL could develop the students' creativity. Therefore, the physics modules for the gifted-talented students should be developed based on PBL model.

The results of the study by Sujanem, et al. (2009) showed that the high school's physics module should be developed to explicitly contain the contextual learning materials. The Physics learning process in high schools should be conducted with the problem-based learning model. The result of the test showed that the developed Physics modules could be effectively used as a learning facility in learning physics. Kampen, et al. (2012) used a single Physics teaching module through PBL in the lecturing curriculum. This module was effective in improving the students' learning motivation so as to replace the lecturing method.

The constructivism learning model can influence the gifted-talented students in middle school science classroom. Singh (2013) found that the constructivism learning program was valuable for the advanced and gifted-talented students. The extracurricular science program is also valuable for the teachers who create peer groups due to communication and the resources that support it. Quasi-experimental study of short-term PBL web-based module, self-study, and a combination of both by Shen, et al. (2007) showed that the significant design was a PBL web-based pedagogical learning for short-term modules in the vocational college students in Taiwan.

Based on those descriptions, it is necessary to develop physics learning modules for the gifted-talented students based on Problem Based Learning (PBL) and test its practicability. The purpose of this study is to develop a PBL-based Physics module and describe its practicability and the gifted- talented students' response to the use of the module, in addition to describing the effectiveness of this module.

B. Research Method

Initial study to analyze the needs of students and teachers was conducted from May 2012 to September 2012. The research to develop the implemented modules was from October 2012 to June 2013. The research was conducted at the Sebelas Maret University of Surakarta and Islamic Senior High School of Amanatul Ummah Grade XI in Acceleration Program.

This study is a development research using modified 4-D model of Thiagarajan, et al. (1974) which consists of Define, Design, Develop, and Disseminate. The development of physics module based on PBL was carried out up to the Development phase.

The sample for needs analysis was determined using purposive sampling, and so was the class for testing the use of the module. However, the control and experimental classes were determined randomly. The effectiveness of the use of the module was determined using a posttest-only control group design.

The research instruments were the sheets of module-study, module-validation, validation of research instruments, questionnaire, observation, post-test, and interview guidance and researchers as research instruments.

Module-study sheets were used to analyze the weaknesses of the module that was developed and used as the basis of refining the module. Module-validation sheets were to determine the practicability of the module in terms of its content, language, and graphics. Validation sheets of research instruments were to obtain the content validity of the instrument used to test the effectiveness of the use of the module. Questionnaire sheets were to determine students' response to the use of the PBL-based Physics module. Observation sheets were to determine the students' affective and psychomotor value during the learning process. Test sheets were to measure cognitive learning achievements of students. Interview guidance sheets used for in-depth research related to needs analysis and in-depth data to support the data that have been obtained using other techniques. Researchers as research instruments were to determine the direction of the research while doing needs analysis and determining the sample.

The practicability of the PBL-based physics modules for the gifted-talented students was described based on the review and validation which were carried out, in addition to being supported by their response and its effectiveness in use. The students' response to the use of PBL-based physics module was described based on the analysis of the students' questionnaire responses. The determination of the effectiveness of the use of the PBL-based physics module used a statistical analysis of independent sample t-test for the data of cognitive and affective, and the Mann-Whitney U test for the psychomotor data.

C. Results and Discussion

The results of a preliminary study conducted to managers and teachers gained information that the implementation of accelerated classes in Islamic Senior High School of Amanatul Ummah is a system called *daurah*. The *Daurah* system is great for the students' development of productive cognition. However, some of them have difficulty in analyzing the problem due to lack of contextual learning. The learning process is delivered in a lecturing way. The students' abilities of productive cognition are trained from the exercises in a formal class or *daurah* class. However, the students' cognitive and psychomotor skills in science learning have not yet been measured, and so has their affective attitude for processing skills in any laboratory. Therefore, it is mandatory to renew the teaching methods in the accelerated classes of Amanatul Ummah. In this study, the learning model employed is a PBL model as recommended by the Directorate of School (2009).

Further preliminary study in 2012 found that the students used a textbook from a publisher which they thought less interesting due to their difficulties in understanding the language in the book. In addition, the appearance of the book was less contextual. The teacher and administrator took a solution to replace the book with the one from a different author in the same publisher. It was enough to merit students' attention. But for the contextual learning, the textbooks used were still less supportive for the laboratory activities. Therefore, the school needed another learning source that could support students' independent learning through constructivist learning. To answer these problems, researchers developed a PBL-based physics module in a fluid lesson. The fluid lesson was chosen due to its suitability to the used learning model and its close application to the students' daily life.

The other finding of a preliminary study was that the students were able to follow complex instructions given by the teachers during the learning activities. Also, the students were able to analyze a problem when given a phenomenon. The students liked to hypothesize. However, some claimed not to be able to test the truth of the hypothesis because the learning process was less supportive to do it. The students of the accelerated classes were able to think abstractly. Then, they did not have difficulties learning any abstract material. However, constructivist learning experiences which the students hoped needed to be realized within the expected source of learning.

The finding of interviews with the students showed that they agreed if there was a module for learning physics. They wanted a module which is communicative and concise, has pictures to clarify the boring materials, and has exercises and discussion.

Analysis of tasks was performed by analyzing the curriculum adjusted to the high-thinking stage based on the gifted-talented students' learning character. The Fluid lesson was chosen because it is closer to students' life and can be packaged in a contextual learning. Then, the students' learning activities in using the developed PBL-based Physics module were analyzed. The concepts that needed to be taught were formulated in the form of a concept map. The result of the student and the task analysis was used to formulate learning objectives.

The formulation of learning objectives based on the results of the analysis was made according to the indicators that have been adapted to the thinking stage of the gifted-talented students. Then, the PBL-based syllabus and lesson plan were prepared as the basis for the PBL-based physics modules for the gifted-talented students. In addition, the students' assessment was arranged in the form of the question-framework to measure their learning achievements after using the developed module.

The lessons were arranged by reviewing the basic lesson of Physics in the university level to get the depth of lessons more than the lesson in the regular classroom. Following the compilation of the lessons, the module was laid out. Then, the learning activities in the module adjustable to the PBL syntax were designed.

The syntaxes of PBL included (1) familiarizing students to the problem, (2) organizing them to learn, (3) assisting personal or group investigations, (4) developing and presenting the work as well as displaying it, and (5) analyzing and evaluating the process of solving problem (Nur, 2008). Then, learning modules were designed based on those syntaxes, consisting of: (1) initial motivation, (2) introduction of activity, (3) laboratory of physics, (4) let's understand the concept...!, (5) application of mathematics and applications of concept, and (6) formative test.

The module was arranged based on the finished designs completed with the module guidance and direction at the end of each learning activity. The module consisted of seven learning activities ranging from Pressure and Pascal's Principle, The influence of depth on the hydrostatic pressure, Archimedes Principle and Its Application, Surface Tension and Capilarity, Fluid Flow and Continuity, Bernoulli Equation and Its Application, as well as viscosity and Poiseuilles' Law.

Majid, et al. (2011) stated that the teaching materials for the gifted students should consider students' creativity and thinking ability. Consequently, the development of the Physics module applicable for the gifted-talented students was a module consisting of constructivist learning which could bring out the students' creativity through the challenges in the experiment. The cognitive domain used was developed up to stage C-6, while the assessment of students' affective aspects was developed to *characterize* aspects.

The module that has been made based on the preliminary design was then reviewed and validated by linguists and graphic experts as well as the lessons experts. Following the feedback, the module was revised. Afterward, the second phase of review and validation was carried out by a Physics lecturer. The feedback obtained was then used for further revision. A review and validation were then done by a peer, who is a Physics teacher in an accelerated program in Islamic Senior High School of Amanatul Ummah. The results of the review were used to revise further.

Table 1. Validation Result of the First Phase

No	Validated Element	Average	Category
1.	Eligibility of content	3,17	Good
2.	Delivery of lesson	3,44	Good
3.	Language and readability	3,08	Good
4.	Graphics	3,05	Good
5.	PBL aspect in module	3,40	Good
Average Value of Eligibility		3,22	Good

Table 1 shows the results of the first stage of validation. The developed module meets a good criterion. However, there is still a weak point in its language and readability as well as its graphic aspects.

Table 2. Validation Result of the Second Phase

No	Elemen Validated	Average	Category
1.	Eligibility of content	3,44	Good
2.	Delivery of lesson	3,63	Very Good
3.	Language and readability	3,33	Good
4.	Graphics	3,43	Good
5.	PBL Aspect in module	3,37	Good
Average Value of Eligibility		3,45	Good

Table 2 shows the results of the second stage of validation. After the revision of the first phase, there is an increase in the average value of practicability for the developed PBL-based Physics module. To meet the suitability of the module with the character of the students, further validation was done by a Physics teacher in an accelerated program who is considered to know the students' character more.

Table 3 shows the results of the third stage of validation. Those results indicate that the module is applicable for use with good criterion. Furthermore, the use of the module was tested by the eleventh graders of Acceleration Program at Islamic Senior High School of Amanatul Ummah in the second semester. Once students learnt the fluid lesson in the PBL environment with different media, they were given a post-test. The classes that used the PBL-based physics module were asked to provide feedback on the use of the module through the response questionnaire.

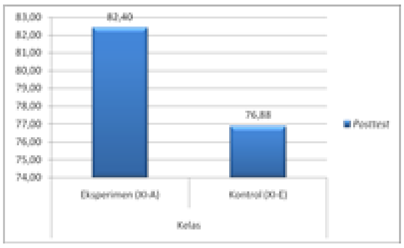
Table 3. Validation Result of the Third Phase

No	Elemen Validated	Average	Category
1.	Feasibility of content	3,83	Very Good
2.	Delivery of lesson	3,81	Very Good
3.	Language and Readability	3,42	Good
4.	Graphics	3,50	Good
5.	PBL aspect in module	3,50	Good
Average Value of Eligibility		3,61	Very Good

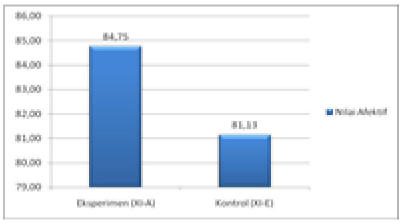
On the one hand, the results of the analysis of the closed questionnaire for students' response showed that the average response of the student's interest was around 93.75% for the content of the module, 92.71% for the learning model, and 91.67% for the module as a whole. It means that students were very interested in the content, learning models, and physics module as a whole. Furthermore, the average of students' ease in learning the module is 88.54% for the language, 89.56% for guidance, 83.33% for the content, and 83.33% for the Physics laboratory activities in the module. It means that the module is very easy to be understood by the gifted-talented students. On the other hand, in the open questionnaire, 100% of students stated that they could understand the language used in module and 100% of students were interested in its appearance.

Generally, Students are interested in using the PBL-based physics module. They are also easily able to understand the language, instructions, content, and laboratory activities in the module. Following the use of this module, students enjoyed learning physics using the PBL model whose subject matter was related to the phenomenon in their everyday life. They also find it easier to work on the test items after using the module during their learning. The findings of interviews for the content of the material in the module with some students who used this module showed a positive response. The same is also true for its use of language and graphics.

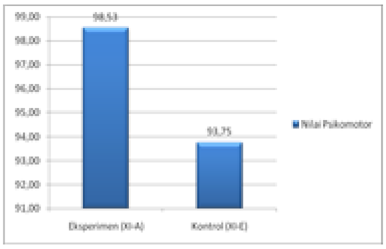
The data of students' learning achievements are in the form of cognitive, affective, and psychomotor. The average values of the students' cognitive are indicated by the post-test values shown in Figure 1. The affective values are indicated in Figure 2, and the psychomotor shown in Figure 3.



Picture 1. The Average of Students' Cognitive Value



Picture 2. The Average of Students' Affective Value



Picture 3. The Average of Students' Psychomotor Value

The cognitive and affective data are distributed normally and homogenously. As a result, the hypothesis testing to the effectiveness of the module employed independent sample t-test. Meanwhile, the psychomotor data was not distributed normally and homogenously. Therefore, the hypothesis testing to the effectiveness of the module employed Mann-Whitney U. The statistical data were processed using statistical software PASW Statistics 18.

Table 4 shows that the data of affective learning achievements is significant at 0.033<0.05, indicating that there are differences in learning achievements between the gifted-talented students using the PBL-based physics module and the gifted-talented students using school textbooks. Based on the average values of affective learning, it can be seen that the values of experimental class is better than those of the control class. Thus, it can be concluded that the affective learning achievements of the students who use PBL- based physics module are better than the students who use the textbook with a significant difference.

Table 4. The result of independent sample t-test two tailed

	t-test for the average similarity		
	T	df	Sig. (2-tailed)
Affective	2,202	42	,033
Post Test	2,435	42	,019

Meanwhile, the cognitive value of learning indicated by the posttest score has a significance of 0.019 <0.05, indicating that there are differences in the cognitive achievements of the gifted-talented students who used PBL-based physics module and the gifted-talented students who used school textbooks. Based on this average value, it can be seen that the cognitive achievements of the experimental class is better than the control class. Thus, it can be concluded that the cognitive achievement of students who use the PBL-based physics modules is better than students who use a printed book with a significant difference.

Table 5. The result of Mann-Whitney U test two tailed

	Psychomotor
Mann-Whitney U	153,500
Wilcoxon W	363,500
Z	-2,317
Asymp. Sig. (2-tailed)	,021

Table 5 shows that the significance of psychomotor achievements is 0.021 <0.05. it indicates that there are differences in psychomotor achievements between students who used the PBL-based Physics module and students who use school textbooks. Then, it can be seen that psychomotor achievement of the experimental class is better than that of the control class. It can be concluded that psychomotor achievement of students who used the PBL-based physics module is better than those who use textbooks with a significant difference.

Based on the statistical analysis of the achievement of learning physics using various media in the PBL environment, it can be concluded that the use of the PBL-based physics module can improve learning achievements of cognitive, affective, and psychomotor of gifted-talented students. This finding is in line with the findings of Suardana (2006) who argued that the application of problem-based learning can enhance students' ability to solve problems, increase the activity of students in learning, and improve students' learning achievements.

Most of the students in the study of Suardana (2006) gave a positive response and hoped that the problem-based learning with a module-assisted cooperative approach could be continued and developed in the study of Chemical Physics. It is also true for the result of this study. The gifted-talented students responded positively to the use of the PBL-based physics module. Referring to the interview findings, the students hoped that the PBL-based physics modules could be continuously used on other materials of physics. In addition, questionnaire results show that the gifted-talented students are very interested in PBL which provides a contextual learning.

Singh (2013) found that the constructivist learning is useful for the gifted-talented students as well as advanced students. This activity of learning in this study takes a form of a physics learning activity in PBL environment. Using the PBL modules is practical to students when they give a highly positive response to the use of the PBL-based physics module for the gifted-talented students.

Watters & Diezmann's (2003) research to the gifted-talented students in the science learning found that the practice of science in the form of solving the authentic problem can meet the gifted-talented students' intellectual needs. In this study, students' intellectual fulfillment can be seen through the positive response given after they learn how to use the PBL-based Physics module. In addition, the significant differences in learning achievements after using the module show that students can construct their knowledge through PBL and can solve the problems presented during the post-test.

The PBL-based Physics module can provide the real problems which are presented in the form of a module that can be used for the self-learning. The teaching materials in the module provide opportunities for the gifted-talented students to construct the meaning through Physics

Laboratory activities, Lets Understand the concept...!, and Concept Application that can facilitate students in understanding the concepts and improve their learning achievements. The gifted-talented students have different learning speeds from the ordinary students. Therefore, the flexibility of time is a key feature of the module for them. Each learning activity is given recommended time to learn even though it may not be too tight. The maximum time-limit to complete the learning activities is provided, but students can choose topics to learn according to their interest. To optimize the achievement of learning physics in the accelerated class, students should use the PBL-based physics module.

D. Conclusion and Suggestion

The conclusions of this research are: (1) the PBL-based Physics module for the gifted-talented students is practicable with a good value. Its practicability can be seen from the results of the expert's validation (3.22) and a lecturer of Physics (3.45), indicating that the overall components in the module are good. Based on the validation questionnaire of a Physics teacher in the accelerated classes, it was obtained that the result of validation was good (3.61). In addition, based on the students' questionnaire of responses and interviews, it can be seen that the developed module was in line with the learning characteristics of the gifted-talented students, (2) the gifted-talented students in Acceleration Program at Islamic Senior High School of Amanatul Ummah responded positively to the PBL-based physics module, (3) according to the statistical value, on the confidence interval of 95% (0.05 significance level), it can be concluded that the use of the PBL-based physics module is more effective to improve the learning achievements of cognitive, affective, and psychomotor of the gifted-talented students than the use of the textbook.

Recommendations for further research are to develop a similar study using different materials in accordance with the PBL learning model. A similar study can be further developed for other constructivist learning models that are appropiate for the learning characteristics of the gifted-talented students, such as the SAVI (Visual Auditory Somatic Intelligence), Quantum Learning, CTL (Contextual Teaching and Learning), and so on.

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