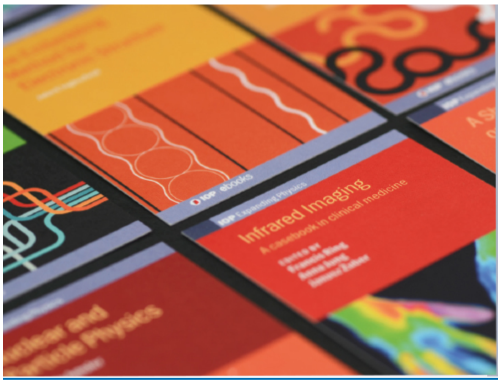
Journal of Physics: Conference Series

PAPER • OPEN ACCESS

Construction of High School Chemistry Module, Based on Problem-based Learning (PBL) on Salt Hydrolysis Material for Gifted Students

To cite this article: R G T Kusumah *et al* 2020 *J. Phys.: Conf. Ser.* **1467** 012047



Construction of High School Chemistry Module, Based on Problem-based Learning (PBL) on Salt Hydrolysis Material for Gifted Students

R G T Kusumah[1*], A Walid[1], I Sugiharta[2], E P Putra[1], I Wicaksono[3], M Erfan[4]

[1]Institut Agama Islam Negeri Bengkulu, Bengkulu, Indonesia
[2]Universitas Islam NegeriRaden Intan Lampung, Lampung, Indonesia
[3] SMA Negeri 51 Jakarta, Jakarta, Indonesia
[4]UniversitasMataram, West Nusa Tenggara, Indonesia

***raden@iainbengkulu.ac.id**

Abstract. This research aims to develop a Problem-based Learning Module for Hydrolysis Material considering the characteristics, feasibility, and effectiveness to accommodate gifted students. The tests were conducted to material experts, media experts, and students. The model used as the basis for the development of Problem-Based Learning (PBL) chemistry module is the 4-D model (Define, Design, Development and Disseminate). Data analysis techniques are observation and questionnaire. Based on the test, it shows that the Problem-based Learning Module received a good category and is worth it to use. Cognitive learning outcomes of students in the experimental class after using the Problem-Based Learning Module is better than the control class that uses conventional learning. It can be seen from the comparison of the average score of improvement in the learning outcomes of experimental class students who use Problem-Based Learning modules. So, it can be concluded that the learning outcomes using the Problem-Based Learning chemistry learning module are better than conventional learning.

1. Introduction

Science is one of the requirements in mastering science and technology. Chemistry as one of the basic sciences in science has a crucial role in the progress of science and technology [1]. This is marked by the development of technology in all fields that apply chemistry concepts.

The 2013 curriculum currently employed has been instructed by the Indonesian governmentto use the Scientific Approach. Based on the Minister of Education and Culture Regulation No. 69 of 2013 concerning the Basic Framework and Structure of High School Curriculum states that the 2013 curriculum was developed by perfecting the mind-set including: teacher-centered learning becomes student-centered, Passive learning becomes active learning seeking. There are five main activities in the learning process using scientific, namely observing, asking, trying, associating, and communicating. The use of learning models is also a frame of applying an approach, method, and learning technique. There are many learning models, and some suggested in the 2013 curriculum, including Inquiry-Based Learning, Discovery-Based Learning, Project-Based Learning and Problem-Based Learning [2-4]. By applying the application of a scientific approach or scientific approach is expected in learning science including chemistry, students can have scientific abilities to identify problems, formulate hypotheses, conduct experiments, analyse results, conclude, communicate and

IOP Conf. Series: Journal of Physics: Conf. Series **1467** (2020) 012047 doi:10.1088/1742-6596/1467/1/012047

science literacy. By using Problem-Based Learning (PBL), students are expected to be able to know and analyze the problems that occur in their daily lives and apply theories and concepts that have been learned in chemistry to overcome these problems.

Chemistry is one branch of science that is mostly abstract and complex. In addition to being abstract, chemistry also studies numerical or numerical questions. Most concepts in chemistry as a whole are concepts or material that is abstract, so students are required to understand these concepts correctly and deeply [5–9]. In Chemistry, it also cannot be separated from mathematical calculations, where students are required to be skilled in solving problems mathematically. The results in the learning process of chemistry in schools becoming more complex. Therefore, a more comprehensive understanding is needed in studying Chemistry.

Chemistry learning that has been taught in schools only emphasizes the provision of material content (products) from chemistry itself, so as the abilities possessed by students are limited to the cognitive aspects. Chemistry learning that is taught should start from observing the phenomenon, conceptualizing, then symbolizing. The characteristics of chemistry learning that focuses on science process skills as proclaimed in the National Education Standards Agency/BSNP (2006) as one of them is problem-based learning. Many criticisms aimed at the teacher's way of teaching emphasize too much information or concepts. But it cannot be denied, that the concept is a significantly essential aspect, but it does not lie in the concept itself, but lies in how students understand the concept. The importance of understanding concepts in the teaching and learning process greatly influences attitudes, decisions, and ways of solving problems in learning [10, 11].

Problem-based learning is a learning condition that requires students to work on authentic problems with a view to compiling their own knowledge [12]. Also, it provides active learning conditions for students [13].The ability to solve problems also needs to be possessed by students in learning Chemistry, because Chemistry is developed through critical thinking, analytical, inductive and deductive to solve problems related to the material in the environment or to solve problems related to chemistry that students learn in school.

Proficiency in solving problems will ease them to overcome life's problems, so they can survive the onslaught of problems that confront them. The skills, expertise and human reason are carried out subject to the prevailing norms [14]. The ability of students to solve a problem will certainly also affect the success of students in learning. One important factor in problem solving is students' ability to think in understanding concepts, because the problem-solving requires thinking abilities according to logical thinking frameworks, based on mathematical logic. The ability to solve a problem can help students make the right decisions, careful, systematic, logical, and consider various points of view. The ability to solve a basic problem can be trained through constructivism learning, namely through direct and independent learning experiences [11].

The results of the needs analysis at the PublicSenior High School 1 Bengkulu City and the Public Senior High School2 Bengkulu City through observations based on the National Education Standards (SNP) show that the process standard has the most significant gap compared to other standards. Process standards are directly related to the learning process in the classroom, learning instruments, teaching materials, and learning media that influence on graduate competency standards and assessment standards, so it is necessary to make improvements to the process standards.

One of the causes of the high gap in the standard process can also be known from the results of observations in class which show that during learning in class, the teacher still uses the lecture method which is only in the form of transfer of material from teacher to student, so learning becomes less meaningful. The learning activities carried out are still not dominantly student-centered and lack of guiding students to learn to solve problems either solving chemistry problems or solving problems through investigations or other scientific activities. This condition causes teaching and learning activities to be less than optimal.

Based on the results of interviews with chemistry teachers at the School, the problem that is often experienced by students, especially in the matter of salt hydrolysis is that it is difficult for students to solve problems in solving given problems, because to solve these problems students are also required

IOP Conf. Series: Journal of Physics: Conf. Series **1467** (2020) 012047 doi:10.1088/1742-6596/1467/1/012047

to be able to react the compound/element formula clam first and also caused by the ability of students to understand the concept of Chemistry is still lacking, students tend to memorize more without being accompanied by a deep understanding of concepts. Sometimes students find it challenging to determine the right steps to solve the given problem. You could say the ability to solve problems is still lacking. Dominant students only accept concepts from teachers without anyone taking the initiative to find out more on their own. Students are not sharpened enough to find their own material concepts in learning, students have so far only received material from the teacher, so learning becomes less active. Facts in the field based on direct observations made when the teacher is carrying out learning, the results obtained are that in the average learning process, students are still less active in answering questions raised by the teacher, lack of student initiative to ask questions, submit ideas or ideas. Students rarely appreciate ideas, ask important things related to chemistry concepts that exist in everyday life when learning takes place,so in the process off teaching and learning, the role of the teacher is still dominant compared to students, so learning becomes less active, and also influenced by the learning methods applied by teachers so far in schools that provide more material content or lecture methods. Indeed, the existing problems will affect the learning outcomes achieved by students.

Based on the analysis of the absorption of the results of the National Examination in 2012/2013 and 2013/2014 in Public Senior High School 1 Bengkulu City and Public Senior High School2 Bengkulu City, the mastery of the material in the study of salt and Ksp hydrolysis is still below 50%. Students' mastery of salt and Ksp hydrolysis material is still lacking compared to the national average. Based on the explanation of chemistry teacher at 11th grade that salt hydrolysis material is one of the material that is difficult to understand because in this material besides theory also requires a lot of mathematical calculations, determine the formula for different types of salt solutions, determine the pH of the solution, so students must-really must understand the concept of this salt hydrolysis material. Difficulties of students are especially seen when students determine the pH value of a solution.

Students are required to understand the concept so that later they can solve a given problem. In the matter of salt hydrolysis discussed about the definition of hydrolysis solution, the nature and type of salt solution, determination or calculation of pH, and its application in everyday life. Difficulties experienced by students, especially in salt hydrolysis material is where students still do not understand the concept in depth, so that in solving the given problem it still feels difficult to solve the answer.

Analysis of the low average value of the UN Chemistry Science natural sciences Public Senior High School 1 Bengkulu City and Public Senior High School 2 Bengkulu City especially on the Salt Hydrolysis material caused by the following problems 1) lecture method is still dominant in teaching and learning activities so that it causes boredom in students; 2) students' lack of understanding of the concept of salt hydrolysis, 3) students are less active in exploring chemical information so that their knowledge of chemistry only comes from the teacher; 4) The teacher's dominance is still greater than the students 'activeness in learning, 5) the lecture method and the assignments have not completely overcome the students' difficulties, 6) students still have difficulty solving questions that require high analysis 7) salt hydrolysis material is still difficult for students to understand especially in determining the ionization reaction and the pH of the solution which requires understanding of concepts and calculations.

Problems in schools are also influenced by the teaching materials used. Based on the results of observations and interviews with chemistry teachers at school, the teaching materials used so far are teacher-made chemistry modules. In terms of material, the module used contains a summary of 1 semester material for chemistry with sample questions and practice exercises. The module material used is mostly taken from existing school chemistry books and then summarized again. When viewed in terms of design, the modules used are colourless and without animated icons. According to the teacher, the module is used as a student activity sheet in learning chemistry. The contents of the module also do not yet have components that encourage students to develop their concepts, structured steps are not yet available to facilitate students in solving problems. In the context of developing teaching materials, the data collection stage has been summarized in the analysis of the needs of students and teachers in the form of a questionnaire. Based on the results of a questionnaire that was conducted on 30 students of Public Senior High School 1 Bengkulu City, 100% of students still wanted teaching materials in the form of modules in chemistry learning. Students want modules that are interesting, easily understood by students, have a lot of pictures, and their applications in everyday life. Contains complete material so that students can study independently at school or at home. Therefore, the need for the development of existing modules is very necessary, namely modules that are more attractive both in terms of content, design, drawing, and suitability with the material being taught [15, 16]. It can also be seen in research that this millennial generation is very fond of things that are interesting and different [17].

2. Methods

Theresearch conducted is research and development,which aimsdeveloping Problem-Based Learning chemistry modules. The model that will be used as a basis for the development of Problem-Based Learning chemistrymodules is the 4-D model (four-D model) proposed by Thiagarajan [18]. The procedure for developing Problem-Based Learning chemistry modules uses the 4-D model. The 4-D model includes define, design, development, and disseminate. The research and development procedures used in the development of Problem-Based Learning chemistry modules are based on the 4-D model

2.1. Questionnaire

The questionnaire used is a module assessment questionnaire. The module assessment questionnaire was adapted from the BNSP module assessment questionnaire so that it could be used immediately. The questionnaire will assess the appropriateness of content, presentation and language. The questionnaire was also used to determine the response of chemistry students and teachers to the problem-based learning module.

2.2. Observation Sheet

The observation sheet is used for affective and psychomotor assessments. Observation sheet is a sheet to observe the appearance of the observed aspects. The observation sheet used is in the form of a checklist in the form of a list of questions for which the answer remains to check (check). The observation sheet contains the assessment guidelines called rubrics or criteria to be assessed. This step is the same as the one done byWalid, Sajidan, Ramli, &Kusumah and Khoirudin [19, 20].

2.3. Test of Learning Outcome

The tests used in this study were the initial test (pretest) and the final test (posttest). This test takes the form of multiple choice which is used to measure learning outcomes before and after using a problem-based learning based chemistry module. This test data is used to determine whether or not there is an increase in student learning outcomes. Before an instrument is used in a sample, a good instrument must fullfill as good test criteria. A good test must be tested for validity, reliability, and analyzing the items of the instrument using a test of distinguishing power and difficulty levels. Data analysis techniques used in this study were questionnaire analysis and analysis of learning outcomes.

3. Results and Discussions

3.1. Discussion of Defining Results

At this stage of definition aims to identify the problems that exist in the learning process and become the basis for designing products in the form of modules that are made. At this stage, field studies, material analysis and curriculum analysis are carried out.

3.1.1. Field Study

At this stage, classroom observations were conducted, interviews and questionnaires were distributed to students and teachers about learning chemistry in schools. The dissemination of this questionnaire

IOP Conf. Series: Journal of Physics: Conf. Series **1467** (2020) 012047 doi:10.1088/1742-6596/1467/1/012047

aims to determine the learning process and the needs of schools in learning. Questionnaires for teacher needs were given to 4 high school teachers in Bengkulu City, namely 2 teachers from Public High School 1 Bengkulu City and 2 teachers from Public Senior High School 2Bengkulu City. While the questionnaire revealing the needs of students was given to 15 students in each school, namely in Public Senior High School1 Bengkulu City and Public Senior High School 2 Bengkulu City. Question questionnaire needs of students consists of 14 questions. The results of the questionnaire revealing the needs of students are students need printed teaching materials that are in accordance with the 2013 curriculum. Students have not used the Problem-Based Learning model. Students need teaching materials with complete material. Students agree if module teaching materials are developed Problem-Based Learning to improve student learning outcomes.

Based on observations and interviews with Chemistry teachers at Public Senior High School 1 Bengkulu City and Public Senior High School 2 Bengkulu City it is known that the learning methods used by teachers are still conventional and rarely use a learning model, which means students are not accustomed to learning using learning models such as problem-based learning. Another problem is the ability of students to solve problems is still relatively low, both in solving problems that require mathematical analysis or reacting compounds with abstract material. During this time learning is only in the form of transfer of material from teacher to student, so that students' understanding of concepts only comes from giving content material by the teacher without anyone developing the concept in depth by finding their own solutions to the problems given. Classroom learning is still dominated by teachers, students still lack an active role in teaching and learning activities.

With these problems so the researchers decided to use the learning model Problem-based learning. The problem-based learning model requires students to identify, formulate and solve problems, so that students' concepts will be more honed in solving existing problems. Researchers hope that by choosing this method of problem-based learningwill be more effective as indicated by the completeness of individual student learning outcomes.

3.1.2. Material Analysis

The lesson material to be developed is salt hydrolysis material, which in the syllabus is mentioned in Basic Competence (KD) 3.1 and 4.1. The development of this chemistry module raises the theme of salt hydrolysis, arguing that there are many applications in daily life that are close to students on salt hydrolysis material and students' UN scores on salt hydrolysis material are still below the provincial and national average. So that the existence of problem-based learning chemistry modules is expected to make it easier for students to learn the modules and materials that will be presented. The teacher stated that there are still many students who find it difficult to understand abstract material. In addition to being abstract, salt hydrolysis material is also numerical or numbers that require mathematical analysis to calculate, for example, to calculate the pH of the solution. The teacher also has not found teaching materials and learning methods that are suitable with material that is abstract and requires mathematical calculations such as salt hydrolysis.

With the problem of the analysis of the material, the researchers try to develop teaching materials, which are modules based on problem-based learning. With a module based on problem-based learning will help students to find their own problems, identify, formulate and solve problems contained in the module. The Problem-Based Learning module is also equipped with an explanation of the application of salt hydrolysis material in everyday life. So, the material that is abstract in salt hydrolysis in being understood by students is accompanied by a deepening of the concepts they have.

Bruner states that learning is an active process that allows humans to discover new things beyond the information provided to him. The concept is learning by Discovery Learning. The teacher must give flexibility to students to be problem solvers. Students are encouraged to learn on their own through activities and experiences. This is reinforced by Dahar which states that trying alone to find solutions to problems and the accompanying knowledge will produce knowledge that is truly meaningful.

3.1.3. Curriculum Analysis

Learning strategies are needed to support the realization of all competencies contained in the 2013 Curriculum. In the sense that the curriculum contains what should be taught to students, while learning is a way of what is taught can be mastered by students. The 2013 curriculum was implemented in stages starting in the 2013/2014 school year. The most important component of curriculum implementation is the implementation of the learning process that is held inside or outside the classroom to help students achieve competency attitudes, knowledge and skills. Minister of Education and Culture Regulation number 65 of 2013 concerning Process Standards states that the learning process uses approaches or learning methods that are appropriate to the characteristics of students and subjects. Among the approaches and methods recommended in the Process Standard are a scientific approach, to strengthen the scientific approach (scientific), integrated thematic (thematic inter-subject matter), and thematic (in a subject) need to be applied disclosure-based learning/research (discovery/inquiry) learning).

3.1.4. Purpose of Module Development

Development of Chemistry modules based on problem-based learning is arranged based on the learning steps which include first, namely the presentation of phenomenain everyday life related to the material and then orient students to the problems found, students determine the problem and utilize their knowledge to study, detail and analyze problems so that a clear, specific and solvable formulation appears. Then organize students to learn by helping students in analyzing problems. The third is to help individual or group investigations, namely to help students solve problems or conduct experiments. Fourth, namely presenting the work by displaying the results in the form of data or tables of investigations or experiments; and the last to analyze and evaluate the problem-solving process. These steps are adjusted to the syntax of the problem-based learning model which is integrated in the chemistry learning module which aims to improve student learning outcomes.

3.2. The Designe Stage

3.2.1. Format Selection Based on Module Criteria

The format of the module criteria that was developed was adapted from the opinion of Sanjaya using module elements including, (1) module title, general guidelines, (3) objectives to be achieved, (4) success criteria, (5) concept maps, (6) learning material, (7) material summary, (8) assignments and exercises, evaluation questions, (10) answer keys, (11) glossary and (12) bibliography [21, 22].

The module is also organized based on the Problem-Based Learning step. The purpose is aiming to improve student learning outcomes and can improve attitudes. It is suitable with research from Walker stated thatProblem-Based Learningtechnology learning will increase understanding,experience, and confidence for the teacher in developing student activities [23].

The Problem-Based Learning based learning model is also supported by the research of Hakkarainenwhich suggests that using the Problem-Based Learning model can assist students in overcoming existing problems with the demands and complexities in the field and the problems to be faced in the future rather than using learning conventional [24].

3.2.2. Initial Module Design

At the planning stage an analysis of the basic competencies relating to the material to be selected was carried out. So that the material in the module does not deviate from the goal, so that a quality module is produced. Standard Competence and Basic Competence analysis is very useful for producing quality teaching materials [25–27]. The selected material is adjusted to the results of the analysis of the absorption of the National Examination for the 2012/2012 and 2013/2014 Academic Year which shows that the results of the absorption of the National Examination for school-level students in Public Senior High School 1 Bengkulu City and Public Senior High School 2 Bengkulu City are still below the provincial average and national.

IOP Conf. Series: Journal of Physics: Conf. Series **1467** (2020) 012047 doi:10.1088/1742-6596/1467/1/012047

The developed module is a chemistry learning module based on Problem-Based Learning, the first step taken is to analyze the concept of salt hydrolysis. The initial design of the module developed was consulted with the supervisor. After the lecturer agrees with the initial design, the material is collected from various sources, such as reference books, educational sites, papers, supporting images. The materials are then compiled and written on the module, this stage is supported by Microsoft Word 2007 and Corel Draw 5. The initial design of the module developed consists of: (1)module title, (2) Module description, (3) objectives to be achieved, (4) instructions for using the module, concept maps, (6) learning material, (7) material summary, (8) understanding comprehension, (9) competency test, (10) glossary and (11) bibliography. The cover on the A4-sized module contains the University logo, module title, the purpose of making the module for the even semester XI, supporting drawings and compilers. On the French page, there is the University logo, the main title of the module, the purpose of the module is made for even semester XI classes. After the French page there is an introduction, table of contents, introduction that contains a description of the module, core competencies and basic competencies, learning indicators, module usage instructions, module anatomy and a concept map that describes salt hydrolysis material.

The concept map page contains an explanation of the material that will be discussed in the module. Then in the learning activities, load the material taught which is equipped with a learning activity sheet that is prepared based on the steps of the Problem-Based Learning model. Contextual problems that must be formulated and solved by students. Experiments must be carried out to explain the problem presented. The material is presented to strengthen the knowledge gained through experiments. Summary that contains the essence of the module. Understanding test contains about practice questions that students use to further deepen knowledge about the material, Competency test to test the knowledge that has been obtained. Glossary used to write difficult words. Summary contains the essence of the module Then the cover and bibliography.

According to research conducted by Endah, Suyadi, & Budi, Liquid fertilizers with high productivity can be made or developed with 3 methods [28].

3.3. Development Phase

3.3.1. Draft I

After the first draft of the Chemistry module based on problem-based learning has been completed, the module is then validated by the lecturer and teacher. This validation is to see the feasibility of the content, presentation, language, of the developed module. Based onAmri and Widyaningty'sopinion that validation is a process to test the suitability of modules with competencies that are the target of learning [9, 29]. If the contents of the module are appropriate, meaning that it is effective for learning competencies that are the target of learning, then the module is declared valid. However, if the validation result states that it is invalid then the module is repaired so that it becomes valid.

The validity used in the module evaluation item is aiken validity which is based on the evaluation of 7 validators which are then calculated and the average rating of the validators is calculated, and the results of the validation aiken show the valid value which is more than or equal to 0.76 on average the value for rating grading, the number of items in the value there are 33 grading items. So, for the aiken validity test with an overall average score of 0.83 which means it meets the requirements for validity.

To learn problem-based learning based modules for students, learning tools are also arranged, namely syllabus, lesson plans, and learning outcomes test grids which are then arranged into learning outcomes tests. For lesson plans and the learning outcomes grating is validated from a lecturer and a teacher and the results of the validity are relevant between the indicators on the grid and the questions that will be used as a test of learning outcomes.

3.3.2. Revision I

After being validated by lecturers and teachers, draft I is a problem-based modulelearning on salt hydrolysis material was revised based on suggestions from lecturers and teachers presented in Table 1

Table 1. Results of Module Validation and Revision by Validator

Validation Source	Before revision	After Revision
Lecturer	For writing the title on the cover modules should be proportional, i.e. fontsbigger hydro hydrolysis title than the module based titles problem-based learning and for Other fonts that are on the cover adjust to the rules	Change the font size on cover to be more proportionate and according to the rules writing the title on the cover
	The drawing on the module should be giveninformation and sources.	Give information to image inside the module
	Learning activities 1, 2, and so on to be replaced and named accordingly with sub material taught.	Give the name of the activity study according to the material, for example "let's learn the charateristics ofsalt, let's study determine the price of pH ".
	For litmus images on the page 5 to be soldered	Draw litmus on page 5 soldered.
	Where to write answers on the module to be given a line.	Add lines to student answer sheet in module
	In the end it should be on add module competency test which is not equipped with a key answers so students can practice work on the problem deeper and without the help of an answer key	Add competency test module at the end module that includes all indicators to be achieved after learning
Chemistry Teacher	View sentences constantly repeatedly	Repair the module section with sentences that are repeated.
	Check writing Ka and Kb to be consistent	Writing Ka and Kb consistent
	Writing (+) on H + and OH does not consistent, there is a large and small	Improve writing H + and OH

3.3.3. Draft II
The second draft was the result of the revised draft I based on the input of the validators. The second draft was then trialled to 5 students at Public Senior High School 1 Bengkulu City and Public Senior High School 1 Bengkulu City.

3.3.4. Small Trial
A small trial was conducted on 5 students in Public Senior High School 1 Bengkulu City and Public Senior High School 2 Bengkulu City. This small trial aims to see the readability of problem-based learning chemistry modules on salt hydrolysis material before being tested in experimental classes in each school. A small trial was also conducted on 1 teacher for each school. Small trials are also used to gather information that can be used as material to improve the product in subsequent revisions. The results of small trials can be seen in Tables 2 and 3.

Table 2. Readability Questionnaire Results And Student Responses To The Small Group Try Out

	No	Aspect	Percentage (%)	Criteria
Respondence 10 students	1	Content	76,6	Good
	2	Languange	81,6	Very Good
	3	Presentation	81,0	Very Good
	4	Graphic	80,0	Good

Table 3. The Results of The Readability Questionnaire And The Teacher's Response To A Small Group Trial

	No	Aspect	Percentage (%)	Criteria
Respondence 2 teachers	1	Content	79,1	Good
	2	Languange	75,0	Good
	3	Presentation	75,0	Good
	4	Graphic	79,1	Good

3.3.5. Revision II
Ten students during the small trial gave advice on the questionnaire given. The results of small trials are in Tables 2 and 3. Based on the readability questionnaire filling, there needs to be some improvements to the draft module II. In the graphic aspect of the module, there was 1 student who stated that the columns for the student worksheets were given a line to be neater. Then in the language aspect of the module, there were 2 students who stated writing is wrong and must be corrected. And there were 3 students who commented that there was the same problem in the example problem on page 33.

3.3.6. Draft III
Draft III is the revised result that was revised based on the results of a small trial. The draft III was then tested in a large scale namely in 1 class for each school and to 2 teachers of Public Senior High School 1 Bengkulu City and 2 teachers at Public Senior High School 1 Bengkulu City.

3.3.7. Revision III
Forty-nine students responded to the problem-based learning Chemistry learning module, for the results of the questionnaire the responses can be seen in Tables 4 and 5 are the results of the responses of 4 teachers in 2 schools tested.

Table 4. Readability Questionnaire Results and Student Responses in Large Group Trials

	No	Aspect	Persentage (%)	Criteria
Respond of 49 Students	1	Content	79,2	Good
	2	Language	84,5	Very Good
	3	Presentation	81,0	Very Good
	4	Graphic	81,2	Very Good

Table 5. Readability Questionnaire Results and Teacher Response to Large Group Trials

	No	Aspect	Persentage (%)	Criteria
Respond of 4Teachers	1	Content	87,5	Very Good
	2	Languange	85,4	Very Good
	3	Presentation	87,5	Very Good
	4	Graphic	87,5	Very Good

Based on the large group trial received input from the respondents used for improvement suggestions, there were some students who wrote that the colors on the core competency sheet were too conspicuous so the impression was less interesting to look at and there were also students who gave suggestions to change the background color on the introduction so that it was more in sync with the dominant module color green. While there are teachers who give suggestions for adding semester writing to the cover and adding problem-based learning chemistry module writing to the cover to make it clearer when students read the cover that the module is a chemistry module and is clearly used by the class and the intended semester.

3.3.8. Draft IV

Draft IV is a revised module based on suggestions from respondents in a large trial conducted in 2 schools with 49 students and 4 teachers, then the revised results of this module are used for the next stage of the field trials and at this stage learning effectiveness is carried out using Problem-Based Learning chemistry learning modules with the aim to improve student learning outcomes. From figure 1 shows the revision from expert judgement.

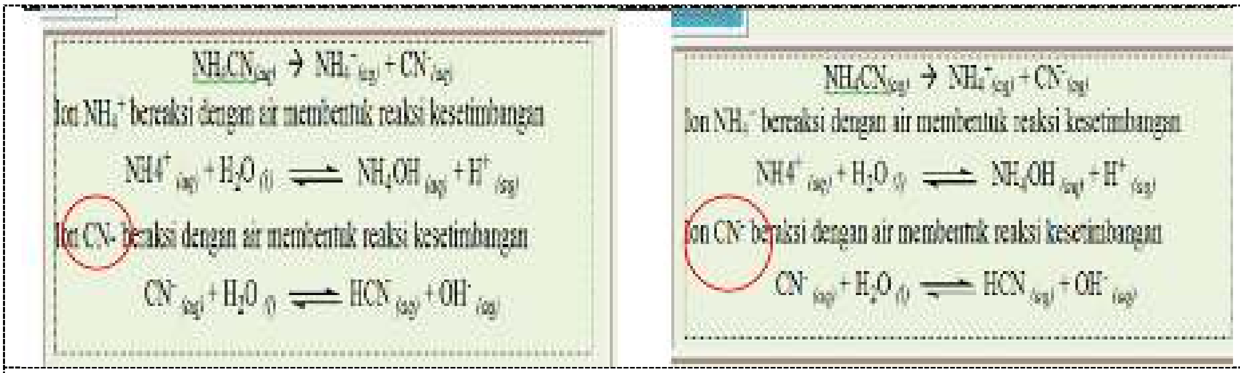


Figure 1 Module Revision from Expert Judgement

3.3.9. Module Implementation

At this stage, the module is implemented in 1 experimental class in each school, in the experimental class students learn the salt hydrolysis material using the module development results, while for the control class using learning as usual provided by the teacher, each class is given a pre-test before learning is carried out to determine the initial abilities of students before receiving treatment. After learning each class is given a post-tests both the experimental class and the control class, this is done to see the final results of learning and to find out the difference between the experimental class learning using the Problem-Based Learning chemistry learning module and the control class using the usual learning methods done by the teacher. For learning outcomes between the experimental class and the control class for each school can be seen in Table 6 and 7.

This problem-based learning module was developed through a series of steps. This research uses the 4D model developed by Thiagarajan[18]. In addition, media development has also been carried out by Rusnilawati, Sulistyowati, and Syawahid by using the same steps. The implication for students is that learning outcomes are in the good category [30]–[32].

Table 6. Student Learning Outcomes at Public Senior High School 1 Bengkulu City

	No	Aspect	Percentage (%)	Criteria
Respond of 5 Teachers	1	Content	86,6	Very Good
	2	Languange	83,3	Very Good
	3	Presentation	88,0	Very Good
	4	Graphic	85,0	Very Good

Table 7. Student Learning Outcomes at Public Senior High School 2 Bengkulu City

Learning Outcome	Eksperiment Class		Control Class	
	Average Score		Average Score	
	Pretest	Postest	Pretest	Postest
Knowledge	34,38	71,88	31,43	64,64
Attitude	3,13	3,20	3,05	3,14
Skill	3,11	3,23	3,06	3,14

After learning students are also given a questionnaire response to provide responses to the modules used in learning, at this stage the number of students who gave responses amounted to 60 students and 5 teachers, for the results of the questionnaire responses given by students and the teacher can be seen in Table 8 and Table 9.

Tale 8. The Results Of The Readability Questionnaire And Student Responses In Field Trials

Learning Outcome	Eksperiment Class		Control Class	
	Average Score		Average Score	
	Pretest	Postest	Pretest	Postest
Knowledge	34,40	71,00	33,80	65,00
Attitude	3,17	3,29	3,13	3,17
Skill	3,19	3,21	3,10	3,17

Table 9. The Results Of The Teacher's Readability And Response Questionnaire In The Field Trials

	No	Aspect	Percentage (%)	Criteria
Respond of 60Students	1	Content	83,8	Very Good
	2	Languange	90,2	Very Good
	3	Presentation	87,0	Very Good
	4	Graphic	84,3	Very Good

3.3.10. Revision IV

At this stage, extensive trials and the effectiveness of the module in learning were completed for 49 students in 2 schools and 4 teachers. But there are still input and suggestions for the module before proceeding to the stages of dissemination or dissemination to several schools. For suggestions given the incompatibility of sheets on a module with a table of contents, there is one page that does not match the table of contents, based on these suggestions the module is repaired before it is used at a later stage.

3.4. Dissemination

After a revision in the extensive trial phase and module effectiveness, the next stage is the disseminate stage or wider product distribution. At this stage, the researchers distributed Problem-Based Learning chemistry modules to schools in the city of Bengkulu. Because of limited manpower and time, researchers can only distribute the Problem-Based Learning chemistry modules to 2 schools in Bengkulu City.

This distribution phase aims to further refine the Problem-Based Learning chemistry module, so that at this stage a questionnaire is given to each teacher at the school visited. The questionnaire distributed with the module is also given a suggestion column to provide suggestions or suggestions. From the results of the distribution of questionnaires in 2 high schools in the city of Bengkulu, an average percentage of 82.50% was obtained or with very good criteria.

Prastowo states that, "a module is defined as a notebook with the aim that students can learning independently without or with the guidance of the teacher "[33]. This opinion is in accordance with the positive response given by the teachers because the teacher needs a book that still works well when students study independently at home.

4. Conclusion

Problem-Based Learning modules have been through the stages of define, design, develop and disseminate. This model has a step that orienting the students to the problems, organizing students in groups, making their independent or group inquiry, developing and presenting their work and analyzing and evaluating problem solving. The trial results show that the Problem-Based Learning chemistry module is rated as "Very Good", so this module is suitable for use in the learning process. Cognitive learning outcomes of students in the experimental class after using the Problem-Based Learning chemistry module is better than the control class that uses conventional learning, it can be seen from the comparison of the average score of improvement in the learning outcomes of experimental class students who use Problem-Based Learning chemistry modules , for Public Senior High School 1 Bengkulu City that is 37.50 higher than the average increase compared to the control class that does not use the development results module that is 33.21. forPublic Senior High School 2 Bengkulu Cityin the experimental class the average increase in learning outcomes was 37.60 while the control classamounted to 31.19. Statistical test results show that the significance value is lower than the significance level $\alpha = 0.05$ so that it can be concluded that the learning outcomes using the Problem-Based Learning chemistry learning module are better than conventional learning.

References

[1] F. G. Winarno. 2008 *Kimia Pangan dan Gizi*. Bogor: M-Brio Press

[2] R. R. T. Wasonowati, T. Redjeki, and S. R. D. Ariani. 2014 Penerapan Model Problem Based Learning (PBL) pada Pembelajaran Hukum-Hukum Dasar Kimia Ditinjau dari Aktivitas dan Hasil Belajar Siswa Kelas X IPA SMA Negeri 2 Surakarta Tahun Pelajaran 2013/2014. *J. Pendidik. Kim* **3** 3 66–75

[3] H. Sofyan and K. Komariah. 2016 Pembelajaran Problem Based Learning dalam Implementasi Kurikulum 2013 Di SMK. *J. Pendidik. Vokasi* **6** 3 260–271

[4] K. Kayacan and I. S. Ektem. 2019 The Effects of Biology Laboratory Practices Supported with Self-regulated Learning Strategies on Students' Self-directed Learning Readiness and Their

Attitudes towards Science Experiments. *Eur. J. Educ. Res* **8** 1 313–323
[5] N. Z. N. Kar and S. Saleh. 2012 Kesan pendekatan Inkuiri Penemuan Terhadap Pencapaian Pelajar dalam Mata Pelajaran kimia. *Asia Pacific J. Educ. Educ* **27** 159–174
[6] E. Ristiyani and E. S. Bahriah. 2016 Analisis Kesulitan Belajar Kimia Siswa Di Sman X Kota Tangerang Selatan. *J. Penelit. dan Pembelajaran IPA* **2** 1 18
[7] K. I. Supardi and I. R. Putri. 2011 Pengaruh Penggunaan Artikel Kimia Dari Internet Pada Model Pembelajaran Creative Problem Solving Terhadap Hasil Belajar Kimia Siswa SMA. *J. Inov. Pendidik. Kim* **4** 1 574–581
[8] Z. Tatli and A. Ayas. 2010 Virtual laboratory applications in chemistry education. in *Procedia - Social and Behavioral Sciences* **9** 938–942
[9] T. Widiyaningtyas and A. Widiatmoko. 2014 Media Pembelajaran Berbasis Web Pada Mata Pelajaran Kimia. *J. Teknol* **2**1 47–51
[10] S. Gao, Y. Wang, B. Jiang, and Y. Fu. 2018 Application of problem-based learning in instrumental analysis teaching at Northeast Agricultural University. *Anal. Bioanal. Chem* **410** 16 3621–3627
[11] Rusmansyah, L. Yuanita, M. Ibrahim, Isnawati, and B. K. Prahani. 2019 Innovative chemistry learning model: Improving the critical thinking skill and self-efficacy of pre-service chemistry teachers. *J. Technol. Sci. Educ* **9** 1 59–76
[12] R. I. Arends. 2008 *Learning to Teach: Belajar untuk Mengajar*. Yogyakarta: Pustaka Pelajar
[13] N. Rerung, I. L. . Sinon, and S. W. Widyaningsih. 2017 Penerapan Model Pembelajaran Problem Based Learning (PBL) untuk Meningkatkan Hasil Belajar Peserta Didik SMA pada Materi Usaha dan Energi. *J. Ilm. Pendidik. Fis. Al-Biruni* **6** 1 47
[14] M. Rosyid. 2019 Polemik Manusia Perdana Antara Islam dan Barat. *Anal. J. Stud. Keislam* **19** 1 129–154
[15] R. G. T. Kusumah and A. Munandar. 2017 Analysis Of The Relationship Between Self Efficacy And Healthy Living Conciousness Toward Science Learning Outcome. *EDUSAINS* **9** 2 132–138
[16] H. Sofyan, E. Anggereini, and J. Saadiah. 2019 Development of E-Modules Based on Local Wisdom in Central Learning Model at Kindergartens in Jambi City. *Eur. J. Educ. Res* **8** 4 1138
[17] M. F. Rozaq. 2019 Pengaruh Meme Terhadap Identitas Pemuda Muslim Nusantara : Telaah Respons Konten Instagram. *Anal. J. Stud. Keislam* **19** 1 193–210
[18] S. Thiagarajan. 1974 *Instructional Development for Training Teachers of Exceptional Children: A sourcebook*. Bloomington, Indiana: ERIC
[19] A. Walid, S. Sajidan, M. Ramli, and R. G. T. Kusumah. 2019 Construction of The Assessment Concept to Measure Students' High Order Thinking Skills. *J. Educ. Gift. Young Sci* **7** 2 237–251
[20] M. Khoirudin. 2019 Pengembangan Modul Pembelajaran IPA Biologi Berbasis Scientific Approach Terintegrasi Nilai Keislaman Pada Materi Interaksi Antar Makhluk Hidup Dengan Lingkungan. *IJIS Edu Indones. J. Integr. Sci. Educ* **1** 1 33–42
[21] W. Sanjaya. 2011 *Perencanaan dan Desain Sistem Pembelajaran*, 4th ed. Jakarta: Kencana
[22] A. G. Pangastuty, U. Cahyana, and A. Purwanto. 2017 Pengembangan Media Lecturemaker Dalam Pembelajaran Kimia Sma Pokok Bahasan Ikatan Kimia Melalui Penerapan Professional Learning Community. *JRPK J. Ris. Pendidik. Kim*
[23] A. Walker *et al.* 2011 Integrating Technology and Problem-Based Learning: A Mixed Methods Study of Two Teacher Professional Development Designs. *Interdiscip. J. Probl. Learn* **5** 2 7
[24] P. Hakkarainen. 2011 Promoting Meaningful Learning through Video Production-Supported PBL. *Interdiscip. J. Probl. Learn* **5** 1
[25] A. Alidawati. 2019 Meningkatkan Hasil Belajar Siswa Dengan Menggunakan Media Gambar Berupa Rumah Adat Tentang Keragaman Budaya Di Indonesia Pada Pelajaran IPS Di Kelas V SD Negeri 03 Kota Mukomuko. *Indones. J. Soc. Sci. Educ* **1** 1 78–84

[26] I. B. Minarti, S. M. E. Susilowati, and D. R. Indriyanti. 2012 Perangkat Pembelajaran Ipa Terpadu Bervisi Sets Berbasis Edutainment Pada Tema Pencernaan. *J. Innov. Sci. Educ* **1** 2 7
[27] V. P. Indria, S. Sumarsih, and N. Agustriana. 2017 Meningkatkan kemampuan Membaca Permulaan pada Anak Kelompok A PAUD Sambela Kota Bengkulu. *J. Ilm. POTENSIA* **2** 2 95–100
[28] A. Endah, A. Suyadi, and G. Budi. 2015 Pengujian Beberapa Metode Pembuatan Bioaktivator Guna Peningkatan Kualitas Pupuk Organik Cair. *Agritech J. Fak. Pertan. Univ. Muhammadiyah Purwokerto* **17** 2
[29] A. Amri and A. J. Tharihk. 2018 Pengembangan Perangkat Asesmen Pembelajaran Proyek Pada Materi Pencemaran Dan Kerusakan Lingkungan. *Didakt. Biol. J. Penelit. Pendidik. Biol* **2** 2 103–112
[30] R. Rusnilawati. 2016. Pengembangan perangkat pembelajaran matematika bercirikan active knowledge sharing dengan pendekatan saintifik kelas VIII," *J. Ris. Pendidik. Mat* **3** 2 245
[31] M. Syawahid and H. Retnawati. 2014 Pengembangan Perangkat Pembelajaran Matematika Terintegrasi Dengan Pengembangan Kecerdasan Emosional Dan Spiritual. *J. Ris. Pendidik. Mat* **1** 1 12
[32] Y. Sulistyowati and S. Sugiman. 2014 Pengembangan Perangkat Pembelajaran Bangun Ruang di SMP dengan Pendekatan Creative Problem Solving. *Pythagoras J. Pendidik. Mat* **9** 2 219–232
[33] A. Prastowo. 2013 *Panduan Kreatif Membuat Bahan Ajar Inovatif*. Yogyakarta: DIVA Press