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Development of Basic Chemistry E-Module Based on Problem-Based Learning for Chemistry Education Students

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Abstract: This research was motivated by the lack of educational material on Basic Chemistry with math problems and the use of digital technology. The aim of this study is to create a problem-based learning-based fundamental chemistry (PBL) module for students of chemistry education at Tanjungpura University. Research form is research and development (R&D) with 4 D model. Research process includes: 1) Define, 2) Design, 3) Develop, 4) Dissemination. The sample for this study included second-semester students of Tanjungpura University's chemistry education degree program who had taken basic chemistry courses. The data collection technique used is an indirect communication technique. The data collection tool used a feasibility questionnaire on the physical, media and linguistic aspects, each of which was validated by two validators. Data analysis technique is done by qualitative descriptions. Based on the results of data analysis, the average feasibility of the content aspect reached 95.00% (very feasible criterion), 97.50% of the communication aspect (very feasible criterion) and 95.00% of the language (a very feasible criterion). The Problem-Based Learning-Based Electronic Basic Chemistry (PBL) module is very suitable to use for basic chemistry learning with a feasibility of 95.625% (very doable) and feedback of students have a feasibility level of 78.03% (good), it can be concluded that the basic electronic chemistry module under the problem-solving learning method is very feasible to use in learning.

Keywords: Basic chemistry; E-module; Problem based learning.

Introduction

The Minister of Education and Culture issued a new policy, Freedom of Learning and Free Campus, in 2020. This policy aims to improve graduates' soft and hard skills so that they are more prepared and relevant to the needs of the times (Ishak, 2021). The main policy is the right to study outside of the study program for three semesters in the forms of Internships/work practices, village projects, school teaching, student exchanges, research, entrepreneurial activities, and humanitarian projects are all examples of activities. All of these activities expose students to the world of work and as a result, the student learning should be contextualized and familiarize students with problem solving so that they can solve a variety of problems later in their lives.

The Problem Based Learning model focuses on specific topics with the goal of studying the content, process ability, problem solving, and real-world issues (Uliyandari et al., 2021). Students are exposed to real-world problems through the Problem Based Learning model. The more problems students face, the more their thinking skills will improve and they will be able to solve them more effectively. Students' attitudes and activities will improve if they become accustomed to these conditions (Alfiantara et al., 2016).

Learning using PBL, according to Khotim et al. (2015), can increase students' conceptual understanding of learning materials and make students' scientific concepts will have real-world applications (Imaningtyas et al., 2016). In addition to learning strategies, teaching materials constitute an important learning tool. Students will benefit greatly from engaging with efficient teaching materials. Presently, educational materials

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must keep up with technological advances. Interactive multimedia-based teaching materials, such as e-modules, are one type of teaching material that can facilitate the learning characteristics of today's digital generation (Fadieny & Fauzi, 2021). E-modules are teaching materials in the form of modules that are displayed electronically and are intended to increase students' interests and motivation to learn (Suarsana, 2013).

Students can use information and communication technology tools to effectively and efficiently explore, analyze, and exchange information (Primasari et al., 2019). Smartphones can now display e-modules thanks to technological advances. The benefits of using e-modules include a reduction in the use of paper in the learning process where E-modules are organized systematically in a language appropriate with the students' abilities. Therefore, the developed electronic module can be used anytime, anywhere by smartphone, for ordinary students in the age of technology (Laili et al., 2019). The online module will help students understand, reason, try and apply these teaching materials for a smooth learning process (Abdullah et al., 2021).

Some previous research on developing problem-based learning-based electronics modules has been done including a study by Pamularsih & Haryanto (2020) entitled "Development of electrical modules exploratory learning-based chemistry electronics on colloids" that obtained the results of colloidal chemistry lessons from students taught with the discovery learning-based colloidal chemistry electronics module (real group) experiment has outperformed normal learning with test results t, tcount = 6.277 < ttable = -1,66691, so that it can be concluded that there is a significant difference in the experimental class compared to the controlled class. Other related research by Zhafirah et al. (2021) has shown that e-modules based on hydrocarbon problem-based learning (PPL) are reported to be effective in enhancing students' problem-solving ability. At the same time, the improvement of students' math solving ability after using the electronic math-solving learning module on hydrocarbon materials based on the N-Gain test reached a value of 0.575 with the average level.

Core and PBL-based electronic chemistry modules are not currently available in the Chemistry Education program. Therefore, it is essential to create digital educational resources that students can use anytime, anywhere. The researchers recognized the need for a study on the creation of didactic materials in the form of electronic modules following the explanation provided above. The development of the electronic fundamental chemistry module of problem-based learning for students of chemistry education is the focus of the researchers' study entitled "Basic Chemistry E- module Development Based Problem Based Learning for Chemistry Education Student". Students completing this basic electronic chemistry module will gain a better understanding of concepts such as stoichiometry, thermochemistry, and chemical bonding. In addition, students will be able to create their own concepts and incorporate them into real-life situations upon completion of this online module.

Method

The method used in this study is research and development (R&D). The research process using Four-D research and development according to Thiagarajan (1974) includes 4 stages, namely definition phase, design phase, development phase and dissemination phase. The steps are as follows:

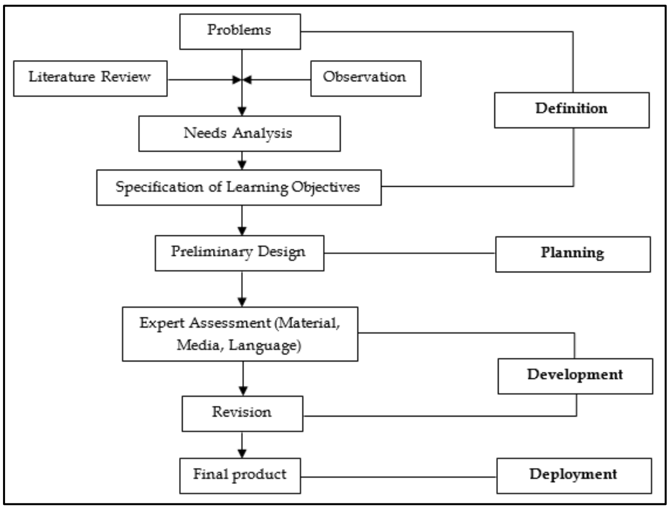

Figure 1. Problem Based Learning Basic Chemistry E-Module

The first step is definition. Definitions are used to identify and define needs in the learning process. In this case, the researcher conducted interviews and analyzed teaching materials used by students of the Chemistry Education study program at Tanjungpura University.

The second step is the design phase. The purpose of the design phase is to design the learning devices. The steps to be carried out at this stage are: (1) preparation of test standards (elaboration of test criteria), (2) selection of media in accordance with the characteristics of the document and learning goals. materials, (3) format selection, including reviewing existing learning material formats to determine the format of learning materials to be generated, (4) initial design in the selected format.

The development phase is the third step. The development phase corresponds to the creation of a new product. It consists of two phases: (1) expert evaluation and (2) developmental testing. The goal of this development phase is to create the final version of the learning device after going through adjustments based on feedback from experts and practitioners. The purpose of this development phase is to create the final form of the learning device after undergoing modifications based on expert/practitioner input and data from the test results.

The Dissemination phase is the final step to be carried out through national and international scientific publications to obtain wider input and suggestions for improving the resulting e-module. The technique used in this research is an indirect communication technique. Indirect communication techniques are data collection techniques using questionnaires as a tool.

Analysis of the Problem Based Learning (PBL) feasibility questionnaire for Basic Chemistry E-Module. The steps for processing the Problem Based Learning (PBL) E-Module Basic Chemistry assessment questionnaire data are as follows: First is calculating the frequency of scoring scores for each item/statement. Second is Calculating the total score of each item/statement. Third is calculating the percentage of scores per item with the formula:

$$P = \frac{\sum x}{\sum xi} \times 100\ \% \quad (1)$$

With:
P = percentage of score acquisition
$\sum x$ = total score (total score) for each item
$\sum xi$ = total ideal score (highest score)

Last is calculating the average percentage of eligibility as a whole with the formula:

$$V = \frac{\sum P}{n} \quad (2)$$

With:
V = average percentage validity
$\sum P$ = the average number of percentage scores for each aspect
N = number of aspects assessed

Determine the eligibility criteria for the Problem Based Learning (PBL) Basic Chemistry E-Module with the following interpretation criteria:

Tabel 1. E-Module Eligibility Criteria

Percentage (%)	Category
0-20	Very unworthy
20-40	Not Worthy
40-60	Fairly Worthy
60-80	Worthy
80-100	Very Worthy

(Riduwan, 2008).

Result and Discussion

The findings of the research, as well as a discussion of each stage of this research and development are as follows:

Define

At this stage an analysis of existing Basic Chemistry teaching materials and interviews with students were carried out. The result is that the existing teaching materials are not as yet based on Problem Based Learning and have not included video media in learning. During the Covid 19 pandemic, it was necessary to have electronic materials but the lecturers who support this course have not provided electronic teaching materials. The results of interviews with students show that teaching materials based on Problem Based Learning can develop students' thinking skills in solving problems related to the learning in progress and linking it with Basic Chemistry knowledge makes learning more meaningful. Thus, we need teaching materials based on Problem Based Learning. It is essential to provide some dynamic and communicative teaching materials as the students enrolled in this course are mature learners who will quickly get bored if the course is purely based on document. Therefore, in this module, videos related to children's life are included while in the homework section, there are exercises that require students to analyze the duly watched videos and to create new videos. There is a two-way learning that is entertaining.

Then runs an analysis of the concepts contained in the Basic Chemistry book that has been used as a learning resource so far. As a result, there are 3 chapters that will be developed, namely the first about chemical bonds, the second about stoichiometry and the third about thermochemistry. These three chapters will be connected with the Problem Based Learning model.

Design

Presentation of material using PBL syntax in which Chapter 1 discusses Stoichiometry problems related to the content of an ingredient, in this case vinegar, and is accompanied by a video on vinegar making. In the video, vinegar is made from kepok banana peels. Kepok bananas are a local ingredient that is easily available. Chapter 2 on thermodynamics is equipped with a very actual discourse on heat produced from kerosene and LPG. Furthermore, in the last chapter discusses the problem of chemical bonds that exist in various compounds.

Development

The development stage is the stage of creating a development product that can be achieved through verification. The Electronic Problem-Based Learning Basic Chemistry module has been expertly validated for its feasibility in terms of physical elements (content and presentation), media and language. The table below shows the conclusions of our due diligence.

Tabel 2. Due Diligence Test Results for Basic Chemistry E-Module Based on Problem Based Learning

Aspects Assessed	Assessment Results		
	Validation I (%)	Validation II (%)	Criteria
Content	95	94	Very Worthy
Presentation	89	93	Very Worthy
Language	92	94	Very Worthy
Media	97	96	Very Worthy
Average	93.25	94.25	Very Worthy

The feasibility test of the Problem Based Learning Basic Chemistry E-Module was carried out by expert validation twice with one revision. In Table 2 it can be seen that the average validation of the validators is 93.75% which is termed as very feasible criteria for use, in spite of that the media and material validators provide some suggestions and input. Based on the suggestions of these experts, the researchers have made revisions to improve the Basic Chemistry E-module.

Material Aspect

The sentence in the initial PBL syntax stating that "you noticed and comprehended the discourse given" was removed and replaced with "Pay close attention to the discussion below to make it easier to comprehend" in accordance with the comments from the material validator. The comparisons between the prior and subsequent improvements are shown in Figure 2.

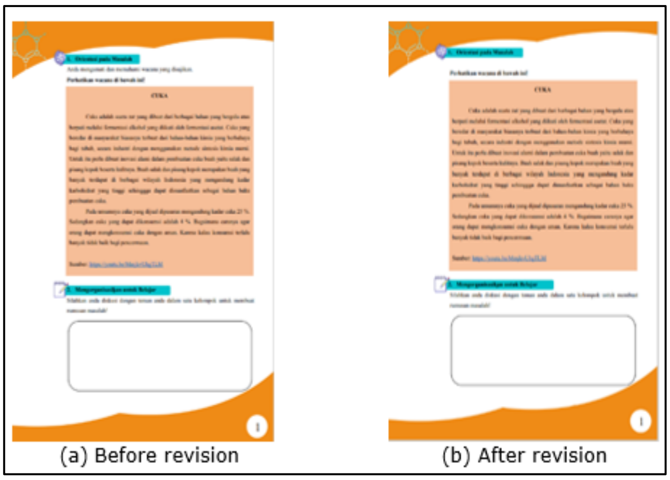

Figure 2. Improvements on material aspects

Media Aspect

After being validated, the media expert gave several suggestions for improvement, namely on the cover of the E-Module, the disproportionate layout image, inharmonious size and type of letters, it is necessary to make improvements to the cover of the E-Module and obtain a comparison before and after the revision which can be seen in Figure 3.

Figure 3. Revision of the Cover

In the template section, media experts also recommend adjusting the template design with regard to the color theme used in the template, from previously using a combination of blue and orange components to orange only. Accordingly, the template design must be revised and a comparison before and after the revision can therefore be applied.

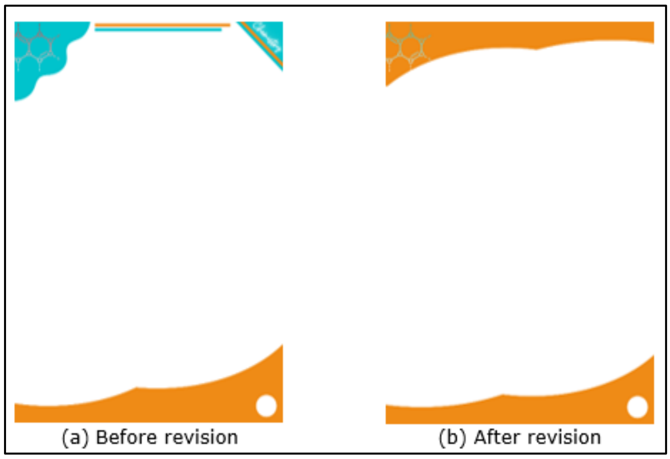

Figure 4. Template design improvements

This instructional material is packaged into an E-Module using the Flip PDF Professional Application after revisions are made in accordance with the advice and feedback from professionals. After that, upload it to Google Drive using the URL https://bit.ly/E-Modul_KimDas_PBL and evaluate how Untan FKIP Chemistry Education students respond to the E-Module product. The response tests carried out included one-to-one response test, limited response test and extensive response test.

One-to-one response test

The one-to-one response test was carried out on to the 1st semester students who had taken Basic Chemistry courses. Three students who reflected the traits of the target group, namely high, average, and low abilities, were used in this trial. A link to the Basic Chemistry E-Module Based on Problem-Based Learning, which has been updated based on professional advice on due diligence, is subsequently provided to the selected students. The results of the student response test in the one-to-one response test are presented in Figure 5.

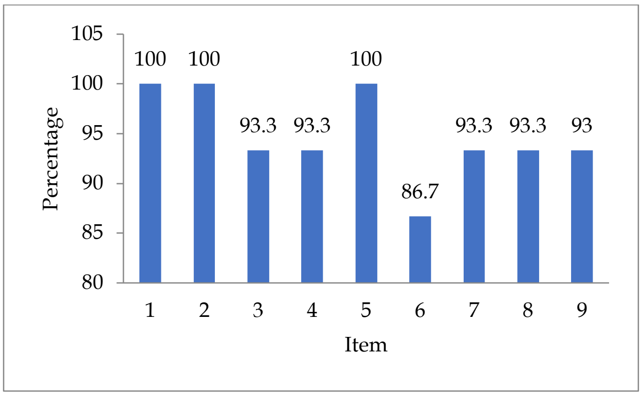

Figure 5. Graph of One-to-One Response Test for Problem Based Learning Basic Chemistry E-Modules

According to the figure 5 the explain about that chart (1) Display of the Basic Chemistry E-Module Based on Problem Based Learning cover. (2) Display of the Basic Chemistry E-Module Content Design Based on Problem Based Learning. (3) The ease with which the material/content in Problem Based Learning can be understood E-Module in Basic Chemistry. (4) The clarity of the illustrations in Problem Based Learning E-Module in Basic Chemistry. (5) Information clarity in providing insight into the Problem Based Learning Basic Chemistry E-Module. (6) The clarity of the letters used in the Problem Based Learning Basic Chemistry E-Module. (7) The ease with which language and sentences are understood in each reading of the Problem Based Learning Basic Chemistry E-Module. (8) The video clarity in the Problem Based Learning Basic Chemistry E-Module. (9) Clarity of Video Sound in the Problem Based Learning Basic Chemistry E-Module. According to the graph above, the average response from these three students was 95% (very good), because the e-module content design was very good, and they felt they were getting clear information and insights. Following that, a limited response test was performed.

Limited response test

The limited response test was given to students in their seventh semester who had taken Basic Chemistry courses. Each class was attended by three students with good, medium, and low abilities, who were then provided with a link to the Basic Chemistry E-Module Based on Problem Based Learning, which had been revised based on expert advice on due diligence.

Based on the analysis of limited test's student response data, item 3 receives the highest percentage of 95.56%, indicating that the Problem Based Learning Basic Chemistry E-Module has a very appealing cover display and design, and the videos contained in the Chemistry E-Module Basic Problem Based Learning are very clear (91.11%). While item 4 receives the lowest response of 82.22% which indicates that the images used are clear to them. As can be seen from the questionnaire responses, the font size should be increased. The letters were then revised in the module's images.

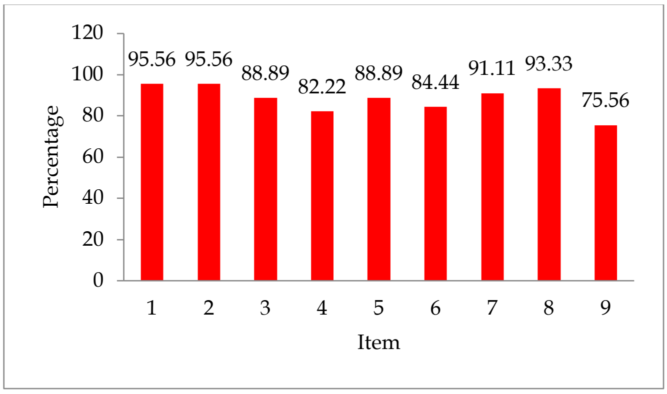

Figure 6. Depicts the graph of the limited response test for the Problem Based Learning Basic Chemistry E-Module.

Based on Figure 6, the average response from students is 88.39% (very good). Next, an extensive response test was then carried out. After revising the size of the letters in the pictures of the e-module, then an extensive response test was carried out on to 28 students.

Extensive response test

The response results show that all items have increased. Based on Figure 7, the average student response is 78.03% (good), but the lowest response was found for item No.9 due to the poor audio clarity of the video. For this reason, we interviewed several students to get more specific information. According to the information obtained, when playing the video, the signal was unstable and the sound where the students were was interrupted.

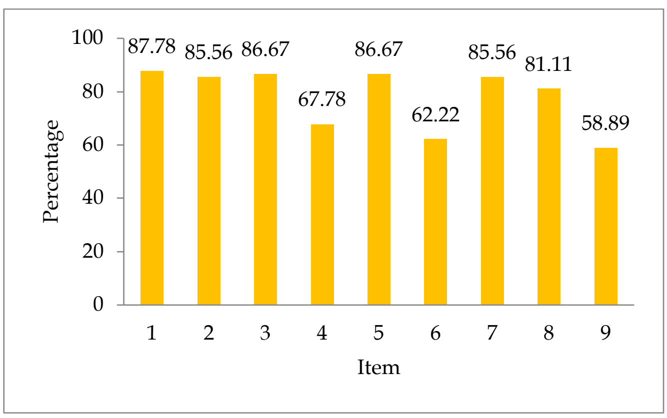

Figure 7. Limited Response Test Graph of Problem Based Learning Basic Chemistry E-Module

Conclusion

The Basic Chemistry E-module based on Problem Based Learning (PBL) is very suitable for use in Basic Chemistry learning with a feasibility level of 95.625% (very feasible), and student responses to the Problem Based Learning Basic Chemistry E-Module have a feasibility level of 78. 03% (good).

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