Development of Chemistry Teaching Materials Based on STEM Problem Based Learning on Solution Chemistry Materials for Students of Chemistry Education Study Program

Winda Regita Pratiwi, Hartono, Tatang Suhery*

Chemistry Education Study Program, FKIP Universitas Sriwijaya
**Corresponding author. Email: tatangsuhery_ta@yahoo.com*

ABSTRACT
This research is development research that aimed to produce an the chemistry teaching material of solution chemistry based *STEM-Problem Based Learning* approach by Amy Abbot that the valid and practice. The development model used is model *ADDIE* with Tessmer evaluation. The steps of *ADDIE* model were used is analysis, design, and development. The steps of Tessmer formative evaluation in this research are expert review, one-to-one and small group. The results obtained at the experts review for validation design score of validity is 0,933 with high category, the validation pedagogic score of validity is 0,976 with high category, and validation material score of validity is 0,833 with high category. The results of practicality test using qualitative data from the walkthrough and the practicality avarage in the one to one stage obtained a scrore of 87,47% with a very high category, while the small group stage got a score 90,98% with a very high category. Based on the evaluation result, it indicate that chemistry teaching material of solution chemistry based *STEM-Problem Based Learning* has valid and practice.

Keywords: *Development research, Teaching materials, STEM-problem based learning, Solution chemistry.*

1. INTRODUCTION

Education is very important in human life. Along with the times, especially in the 21st century, the demands of human life are getting higher. Of course, high quality human resources are needed to compete in facing the challenges of the 21st century. Critical thinking and problem solving, creativity and innovation, collaboration and communication are skills that must be mastered in the 21st century. Agustina, et al., (2018) stated that the ability of creativity can be increased through learning science and to foster the creativity of students it needs to be conditioned with situations that provide opportunities for these students to find solutions in explaining scientific phenomena, making predictions, solving problems, stating what is not known, and preparing appropriate learning strategies.

Septiani (2016) suggests that one of the obstacles in the lack of Indonesian students' ability to achieve competence is the learning strategy used. Where learning is carried out in schools today there are still many who use conventional learning strategies that are still teacher-centered. Therefore learning reforms that shift from educator-centered learning to learner-centered learning are answers to efforts to develop the 21st century in learners. The presence of educators in learning is only as facilitators who facilitate learning activities, namely by choosing learning strategies, learning methods, providing learning resources such as sufficient teaching materials to produce independent teaching and learning activities (Redhana, 2019)

Based on a questionnaire given to students of the 2018 class of chemistry education study program, it shows that 88.4% of students still need additional teaching materials to support the basic chemistry

learning process of solutions. This is because the teaching materials they have are difficult to understand. And based on interviews conducted with lecturers in basic chemistry courses in the chemistry education study program of the Teacher Training and Education Faculty of Sriwijaya University, learning activities still have a high dependence on the presence of lecturers and the lack of teaching materials causes students to experience difficulties in carrying out learning activities.

Teaching material is one of the components that must be in learning, because teaching material is a component that must be studied, studied, examined and used as material that will be mastered by students and at the same time can provide guidelines for learning it. Teaching materials can act as independent teaching materials, if this learning material is equipped with learning objectives or competencies to be achieved, learning materials described in learning activities, media illustrations, learning procedures, exercises that must be done are equipped with answer signs and formative tests are equipped with keys answers, feedback and a bibliography (Hernawan, et al., 2012).

Teaching materials are very important for educators and students. According to Sungkono (2009) educators will experience difficulties in increasing the effectiveness of their learning if they are not accompanied by teaching materials. Likewise for students, without teaching materials students will experience difficulties in learning. Therefore, teaching materials are very important to be developed in an effort to improve the quality of learning.

According to Thibaut, L et al., (2018) in PBL learning students can develop problem-solving skills through a self-directed problem solving process. The teacher does not provide specific guidance, but serves as a resource that students can use to achieve goals. STEM Problem Based Learning is a learning approach that is suitable to be applied to meet the 21st century skill criteria (Abbot, 2016). This is because in the STEM Problem Based Learning approach, students are not only taught in theory, but also in practice in the form of projects, so that students experience the learning process firsthand. which encourages students to be independent in the learning process and directs students to solve various problems in everyday life (Negara, et al., 2017). Based on research conducted by Fikri, et al., (2019) STEM-based learning (Science, Technology, Engineering and Mathematics) can increase the creativity of students based on solving problems in everyday life, This is in line with research conducted by Rini (2009) that the creativity and motivation to learn in students can be started from the preparation of the learning process, the use of learning techniques and learning aids media. Where the learning aid media can be in the form of teaching materials that are used to attract students' interest in learning. The development of teaching materials in the form of modules based on STEM Problem Based Learning conducted by Rachmawati, et al., (2017) has also met valid and practical criteria that can help students to learn independently.

The basic solution chemistry course is a course in the FKIP chemistry education study program that studies the proof and application of various basic concepts and principles related to chemistry materials, one of which is solution chemistry. Based on the RPS of basic chemistry of solution, solution chemistry material has a relationship with everyday life that can be raised through the STEM problem-based learning approach so that students are expected to be creative in accordance with the profiles of chemistry education graduates and the demands of the 21st century.

Based on the background described above, the research problems studied were (1) How to develop basic chemistry teaching materials for solutions based on STEM Problem Based Learning on chemistry solutions for chemistry education students who meet valid criteria? (2) How to develop basic chemistry teaching materials for solutions based on STEM Problem Based Learning on chemistry solutions for chemistry education students that meet practical criteria?

2. RESEARCH METHODS

2.1 Types of Research

This research is a development research with the ADDIE model combined with Tessmer's (1998) formative evaluation.

2.2 Research Subjects

The subjects in this study were 6 validators (expert lecturers) and 4th semester student of 2018 class who has taken the Basic Chemistry Solution course of the Sriwijaya University Chemistry Education Study Program.

2.3 Research Procedures

ADDIE development model The researchers used only the development stage, while the implementation and evaluation stages were carried out by the next researcher. So to evaluate the product at the development stage combined using the Tessmer formative evaluation method to the small group stage, and the final result of the development stage is the teaching material Basic Chemistry Chemistry material

solution based on STEM-Problem based Learning for students of chemistry education study programs.

2.3.1 Analysis

At this stage the researcher analyzes the need for the development of teaching materials through several stages, namely analyzing student needs, analyzing student characteristics and analyzing curriculum.

2.3.2 Design

At this stage the researcher designs the teaching materials according to the needs, namely by designing the concept, content and appearance of the teaching materials, the results of this design are in the form of a specific prototype. will be evaluated by the researcher with the help of a supervisor called self evaluation.

2.3.3 Development

At this stage, product development is carried out in the form of teaching materials Basic Chemistry STEM-based Solutions Problem Based Learning on Solution Chemistry for Chemistry Education Study Program students using Tessmer's formative evaluations are expert reviews, one to one and small group.

2.4 Data Collection Techniques

This research data collection technique uses:

2.4.1 Interview

The interview was carried out by giving a number of questions to the respondent namely the lecturer of basic chemistry solution who teaches in the chemistry education study program FKIP Sriwijaya University. Interviews were conducted to find out the problem analysis and needs analysis as initial data of the study.

2.4.2 Questionnaire

The questionnaire is distributed by researchers during pre-research and at the development stage. Pre-research questionnaire sheets were given to students of the 2018 FKIP Sriwijaya University chemistry education study program Indralaya class and Palembang class. The questionnaire contains questions that have been filled out by students. The data obtained are used as initial research data. At the product development stage, questionnaires will be distributed at the one-to-one and small group stages for product practicality data.

2.4.3 Walkthrough

Walkthrough used in the one to one and small group stages by asking guided questions related to the practicality of the product to students. Each sheet of the product will be asked regarding the legibility aspect of the product to meet practical criteria.

2.4.4 Expert Validity

At this stage the validity test will be carried out on the initial product design by the validator. This stage involved 6 validators consisting of two pedagogical experts, two material experts and two design experts. The data collected in the form of a validation sheet *containing* the validator's assessment of pedagogic validation, material and design. The assessment scale of the validation sheet uses a 4-item Likert scale (Likert, 1932), which is very good (SB) with a value of 4, good (B) with a value of 3, not good (TB) with a value of 2, very bad (STB) with a value of 1 (Sugiyono, 2018) .

2.5 Data Analysis Techniques

The data analysis technique used to determine the validity of the product in this study uses the Aiken V formula as follows:

$$V = \frac{\Sigma s}{[n(c-1)]}$$

(Aiken, 1985)

The Aiken's V coefficient ranges from 0-1. Here is an interpretation of the Aiken's V coefficient.

Table 1. Category V Aiken Score

No.	Aiken's V Coefficient Value Range	Category
1.	0.68 - 1.00	High
2.	0.34 - 0.67	Moderate
3.	0 - 0.33	Low

Meanwhile, to analyze the practicality using qualitative data from the walkthrough results and the average practicality of the Likert scale questionnaire using the following practicality technique formula:

$$P = \frac{X}{Y} \text{ x } 100\%$$

with the criteria of practicality as follows:

Table 2. Practicality Value Criteria

Interval (%)	Category
0-20	Very low
20-40	Low
40-60	Enough
60-80	High
80-100	Very high

(Riduwan, 2009)

3. RESULTS AND DISCUSSION

This research is a development research with the ADDIE model combined with Tessmer's formative evaluation. The research stages used in the ADDIE development model include analysis, design and development. The reason for choosing this development model is because the learning design model involves the basic stages of an effective and efficient learning system and the process is interactive, where the results of each stage can bring the development of learning to the previous stage. The final result of one stage is the initial product for the next stage (Syahroni&Nurfitriyanti, 2017).

Tessmer's formative evaluation was limited to the small group stage. The evaluation stage includes an expert review, one-to-one and small group stage. The use of Tessmer's formative evaluation is because at each stage of this development model an evaluation is immediately carried out, to find product weaknesses so that it can be revised, this is more effective than using the evaluation stage of the ADDIE model.

3.1 Analysis

Analysis stage conducted to find out what teaching materials should be developedby researchers. The analysis carried out is to analyze the needs of students, student characteristics and analysis of curriculum to the development of teaching materials.

As for the analysis phase of need, the researcher spreads the questionnaire Chemistry study program students in semester 3. The results of the distribution of questionnaires with Chemistry Education study program students, obtained information that the teaching materials used by students were in the form of books in the form of soft files facilitated by professors who lectured on basic chemistry courses of solution, the book was a thick book in language English, which causes students difficulty learning. Apart from the books in English, there are students who have books from the library, but only a few students because the books in the library are also limited. A total of 75, 45% of students stated that the teaching materials used by these previous students also lacked relevant problems related to daily life so they had difficulty finding solutions to problems that existed in learning chemistry. Therefore 88.4% students need additional teaching materials to make it easier to understand the basic chemistry of the solution.

In the analysis of student characteristics, based on a questionnaire it was found that 85.5% of students were enthusiastic about learning basic chemistry of solutions, especially if the learning was related to problems of daily life. And as much as 92.8% student too Prefer collaboration with classmates in carrying out basic chemistry solutions. Researchers also conducted interviews with lecturers who taught basic chemistry courses in solutions, from the results of the interview shows that student learning activities still have a high dependence on the presence of lecturers. In learning activities, lecturers usually explain phenomena in everyday life but the lack of teaching materials causes students to experience difficulty understanding and carrying out learning activities, therefore additional teaching materials are needed which are expected to bring out student creativity.

The curriculum used by the 2017 Unsri FKIP chemistry education students to 2019 is the revised 2017 curriculum. The basic chemistry course of solution is a new course in the 2017 revised curriculum, as a substitute for the basic chemistry course 2. Based on the Lecture Unit (SAP) and the RPS (Semester Program Plan) basic chemistry of solutions found that one of the materials studied by students in semester 2 is chemistry solution. Solution chemistry is a chemistry material that is closely related to STEM elements, this is because in solution chemistry there are scientific elements that explain the concepts of nature as a chemistry subject that involves observation and many chemistry variables that are interrelated. .

The application of STEM in learning is very suitable to use problem-based learning models, so that the STEM elements are more visible and learning outcomes can be realized (Farwati, et al., 2017). Based on the learning indicators on the chemistry of this solution is related to everyday life so that real problems that can be raised suitable for the STEM-Problem

Based Learning approach can be raised. In this solution chemistry material there are also no STEM-Based Problem Based Learning teaching materials, therefore researchers develop teaching materials to be able to bring out student creativity in accordance with the profiles of 21st century chemistry education graduates and skills.

3.2 Design

At this design stage, researchers began to develop conceptual designs, both in terms of the content of the teaching materials and in their appearance such as the rules for fonts for teaching materials, namely fonts that should be used in writing teaching materials, namely times new romance, calibration and arial (LKPP, 2015). Revise the font for teaching materials from comic sans MS to arial, black to 12pt in size.

At this stage the researcher also conducted a literature study from the journal Chemistry Connection a Problem Based Learning STEM Experience as a reference in understanding the STEM-Problem Based Learning syntax which will be a characteristic of teaching materials, and through books such as the text book General Chemistry: Principles, Patterns and Application that are commonly used by lecturers in learning, University of Asas & Structure Chemistry books, Basic Chemistry books Core Concepts Third Edition Volume 2, Chemistry books for universities, Chemistry books for Dummies, Basic Chemistry books 2 Current Chemistry Principles and Chemistry books Basic: Principles and Applications of Modern Fourth Edition Volume 1 to obtain supporting material and questions to be included in Basic Chemistry teaching materials Chemistry material solutions Solution based on STEM-Problem Based Learning. This product design then becomes a specific prototype which is then evaluated by the researcher (self-evaluation) with input from the supervisor.

3.3 Development

3.3.1 Expert Review

Products that have been designed revised self-evaluation results are validated by design validators, pedagogic validators and material validators. The results of the validator's assessment can be seen in Table 3.

Table 3. Overall Validation Average Score Results

Validator	Aiken Coefficient Value	Category
Design	0.934	High
Pedagogic	0.976	High
Theory	0.833	High

In the design aspect trial, the value for basic chemistry teaching materials for solution chemistry solutions based on STEM-Problem Based Learning was 0.934 which was classified as high. Trial of the pedagogical aspect obtained the value for basic chemistry teaching materials for solution chemistry materials based on STEM-Problem Based Learning of 0.976 which is classified as the high category and the test for the material aspects obtained the value for basic chemistry teaching materials for solution chemistry materials based on STEM-Problem Based Learning of 0.833 which is classified as high category. Based on the design aspects, pedagogical aspects and material aspects, the basic chemistry teaching materials for solution chemistry materials based on STEM-Problem Based Learning are declared valid.

The comments of the design validator, pedagogic and material can be seen in Table 4

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Table 4. Expert Lecturer Comments and Suggestions

Validator	Comments and Suggestions
Design	- Improve the color composition and image on the cover page - Improve the design and shape spacing on the contents of the teaching material to make it tidier - Adjust the font size and type based on the guidelines for making teaching materials - Adjust the size of the illustration image, for easy reading
Pedagogic	- Correct writing on the table of contents page
Theory	- Improve the systematic sequence of learning indicators and the order of material on teaching materials based on the level of the material

3.3.2 One to One

The initial product of the revised self-evaluation, besides the one being validated by the validator, was also tested through one to one trials with the aim of seeing the initial practicality of the product being tested on 3 students based on one characteristic, namely the ability with the high, medium and low categories. The three students gave answers on the walkthrough sheet, filled out a practicality questionnaire and provided comments / suggestions. Based on the results of the walkthrough that has been carried out, it can be concluded that the presentation of the material and the use of language in teaching materials is good, but there are still improvements in the clarity of images and writing on teaching materials. The comments / suggestions from ZS students, namely the pictures on the teaching materials on pages 10 and 11 are too striking. Comments / suggestions from BW students were that there were errors in writing pH marks on teaching materials. Comments / suggestions from DFS are regarding the image on the cover page that is unclear and blurry and there is an error in writing the title mark of the supervisor. After getting the results from the three students, the researchers improved the teaching materials and analyzed the practicality of the teaching materials based on the results of the walkthrough and using practicality calculations so that an average score of 87.47% was obtained with the very high category. Products developed at the expert review stage which are declared valid and one to one which are declared practical are called prototypes 1. The recapitulation of the analysis of the one to one test results can be seen in Table 5.

Table 5. Analysis of the One to One Test Results Recapitulation

Indicator	Practicality	Category
Cover page	75%	High
Clarity of tables / illustrations /Picture	91,7%	Very High
Language and sentences	91,7%	Very High
Clarity of writing	91,7%	Very High
Color Composition	91,7%	Very High
Content / content of teaching materials	91,7%	Very High
Average Score	87,47%	VeryHigh

Figure 1. One to One Stage

Figure 2. Small Group Stage

3.3.3 Small Group

Prototype 1 was then tested again through the small group stage to see the practicality of small groups of the teaching materials developed. This trial was conducted with a larger scope than the one to one stage, where 9 students were selected based on two characteristics. The ability characteristics consist of 2 high categories, 5 medium categories and 2 low categories, and the characteristics of the gender differences are 6 female students and 3 male students.

Based on the results of the walkthrough that had been carried out, it was concluded that almost all students agreed that the teaching materials developed had met the criteria both in clarity of pictures and writing, presentation of material and use of language. However, there are some comments / suggestions from students that need to be corrected, namely the lack of brackets in writing the concentrations of H + and OH-. The researcher corrected the comments / suggestions, then analyzed the practicality of teaching materials using practicality calculations and obtained an average value of 90.98% with a high category and the product was declared practical which was called prototype 2. The recapitulation of the analysis of the small group test results can be seen in the Table 6.

Table 6. Analysis Recapitulation of Small Group Test Results

Indicator	Practicality	Category
Cover page	94%	Very High
Clarity of tables / illustrations / figures	94%	Very High
Language and sentences	91,7%	Very High
Clarity of writing	83,3%	Very High
Color Composition	88,89%	Very High
Content / content of teaching materials	94%	Very High
Average Score	90,98%	Very High

The development product in the form of teaching materials developed by researchers has a characteristic where the material in teaching materials is presented that is relevant to everyday life, besides that the teaching material also contains STEM-Problem Based Learning syntax which facilitates students to be creative through products that will be engineered by students that are in line with Herak & Lamanepa's (2019) research that the STEM approach can increase creativity.

But the research development stage conducted by researchers only reaches the development stage which produces valid and practical products. The product in the form of valid teaching materials here means that it is suitable for use based on the validity of the design, pedagogic validity and validity of the material and practical teaching materials, meaning that its implementation on a small scale is easy to implement based on the legibility aspect of the teaching material itself. This is in line with relevant research conducted by Negara, et al., (2017) that the products they develop are also declared valid and practical.

The next stage of ADDIE research, namely the implementation stage, was not carried out by researchers because the actual classroom environment was needed to see the achievement of learning objectives and the evaluation stage was also not carried out because the evaluation at this stage was the overall evaluation of each stage in a summative and formative manner. Therefore, the effectiveness of the product has not been obtained, it is expected that the effectiveness of the product will be tested by further researchers.

4. CONCLUSION

Based on the results of the research and development carried out, it can be concluded that:

1. Basic chemistry teaching materials chemistry material solutions The STEM-PBL-based solutions developed have met valid and practical criteria. The validity at the expert review stage was based on the Aiken coefficient with a design validation value of 0.934, a pedagogic validation value of 0.976 and a material validation value of 0.833. From the quantitative data, the resulting teaching material is in the high category so that this teaching material is declared valid.
2. Based on the qualitative walkthrough data and practicality calculations at the one to one stage, a practicality value was obtained of 87.47% with a very high category and at the small group stage a practicality value of 90.98% was obtained with a very high category so that this teaching material was declared practical.

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