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Development of Guided Inquiry-Based Chemical Handout in Buffer Solution Materials for Senior High School

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ABSTRACT

This research is motivated by the still limited teaching materials or learning tools that facilitate students in enriching experiences, developing knowledge and activeness of students, and supporting students to formulate their own discoveries. The limitations of these learning tools will certainly affect the quality of learning, especially in chemistry learning. The purpose of this study is to develop a guided inquiry-based chemical handout on a valid buffer solution based on aspects of content suitability, language worthiness, presentation worthiness and graphic worthiness. The research design used research and development design with a 4-D development model. The 4-D development model has four stages: Define, Design, Develop, and Disseminate. This research was carried out until the development stage and followed by limited trials. Data collection techniques was in the form of validation sheets and questionnaire responses of teachers and students. Data analysis technique used descriptive analysis. The results show an average percentage rating of three experts at 93% with a valid category. The results of trials to teachers and students each obtained an average percentage score of 94% and 86%. From the results of the study it can be concluded that the guided inquiry-based chemical handout on buffer solution material for SMA is valid and good for a learning handout.

1. Introduction

One of the educational activities is organizing the learning process. The learning process that develops in the classroom is generally determined by the role of the teacher and students as individuals who are directly involved in the learning

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process. How to teach is a key and a requirement for students to be able to learn well (Trianto, 2012). In order to maximize the achievement of learning achievement is to increase the involvement or activities of students in the learning process. Therefore, teachers are required to be more innovative and productive in learning in class, so that maximum learning outcomes are obtained in all subjects including chemistry.

Slameto (2005) reported that the teaching and learning process in schools will run well if the learning system or model is selected carefully. One of the factors that influence learning activities are in selecting and implementing the right strategy. And then how it is implemented by teachers who are competent in the field of teaching and education (Gusmida et al., 2017). Chemistry lessons are often considered difficult for students to understand. This is because most chemical concepts are abstract. Therefore, in learning chemistry, proper representation is needed to make chemistry easier for students to understand.

Chemistry teaching material learned in Senior High School (SMA). One of them is a buffer solution which is a concept so that students are less motivated, feel bored, passive in learning, less interested, and quickly forget the subject of the buffer solution being taught. Material that is conceptual in nature is usually less understood by students if it is not accompanied by an understanding that can ultimately affect the learning outcomes of students. Therefore, the teacher needs to compile a teaching material that can invite students to make students actively learn. One of the teaching materials that can make active learning is to use handouts. The handout that the teacher designed is a guided inquiry model. With this model students will be guided by the teacher in learning according to the stages of guided inquiry. Mince (2011) inquiry learning model is one alternative to guide students in an investigation situation or scientific process that can develop scientific attitudes. According to Fitri et al. (2013) the application of the guided inquiry learning model can increase student activity by providing student motivation. This is very influential on increasing student activity from cycle I to cycle II.

Handouts are usually made for instructional purposes. Handouts make learning "portable and enduring" (easy to carry anywhere and lasting) and can load back information that students have obtained and develop tests for students. Handouts were originally made in handwriting. The teacher uses handouts as discussion material to accompany the lecture and as additional information that is not in the lecture (Mohammed Nazrul Islam, 2005). Taking notes in class will increase student focus and ultimately more understanding of the concepts achieved. Consequently it can improve student learning outcomes (Piolat, Olive et al. 2005). Active involvement with educational material, for example through recording has benefits for a deeper level of understanding (Bohay, Blakely et al. 2011).

The Indonesian government has tried to improve the quality of education by increasing teacher competence and developing a national curriculum (Sukasni et al., 2017). The 2013 curriculum is a national curriculum that has been applied to answer the challenges of education in the digital age. The 2013 curriculum is

designed to strengthen students' competencies such as knowledge, skills and attitudes as a whole (Rudy, 2015). Students who concentrate only on subject matter and teachers certainly need a learning environment that supports learning (Erwiza et al., 2019). Nurmaliza et al. (2018) concluded that there is a positive influence on the environment and interest in learning. Therefore, the better the non-physical environment, the interest in student learning will increase.

Furthermore, students may lose the visual modality of the presentation by focusing all the time on writing. In addition students' note-taking skills vary in terms of speed and accuracy. Most first-year students face challenges in making complete notes and in many cases they prefer to be given complete and comprehensive notes (van der Meer 2012).

One of the problems in the world of education in Indonesia is that there are still limited teaching materials or learning tools that facilitate students in enriching experiences, building students' knowledge and activeness, and supporting students to formulate their own discoveries. The limitations of these learning tools will certainly affect the quality of learning, especially chemistry learning. Teaching material is an important factor that also influences learning success. The main benefits of teaching materials that are arranged for the organization of learning and learning a topic, namely: (1) If given to students before learning and learning activities take place, students can study the material to be discussed first, (2) Classroom learning runs more effective and efficient because the time available can be used as much as possible for interactive learning and learning activities such as question and answer, discussion, and group work (Ginting, 2008).

With regard to teaching materials, teachers and students can utilize chemistry textbooks as teaching material. Many chemical textbooks from several publishers are circulating in the market, each publisher has its own characteristics and there are differences in each book. Based on the results of observations researchers have not found chemical teaching materials based on Guided Inquiry for high school / MA class XI even semester. Therefore it is necessary to arrange and develop a guided inquiry-based teaching material so as to facilitate them in learning chemistry.

Ergül et al. (2011) which says that guided inquiry engages students in the scientific learning process like a scientist, solves problems by observation, collects data accurately and accurately. Students who are trained with the guided inquiry model will be more rigorous to actively understand the concept as an attempt to satisfy their curiosity. Daniah (2015) who said that one of the steps in the inquiry learning process is collecting data. Students are trained not to manipulate data, not to be prejudiced, make decisions based on facts and not to mix facts with opinions because data collection is a mental process that is very important in developing intellectuals.

The selection and use of appropriate teaching materials in a learning process is important in directing students to gain learning experiences. The way teachers teach is closely related to the use of teaching materials and the preparation of

appropriate learning implementation plans and the way learners learn is closely related to the use of teaching materials. Teaching materials can be in the form of handouts, Student Worksheets (LKPD), modules, and others.

Therefore, teaching materials need to be developed in the form of handouts which are one form of teaching materials that are easily developed and can be utilized in learning (Belawati, 2003). The purpose of this study was to develop a guided inquiry-based chemical handout on a valid and good buffer solution based on aspects of content suitability, language worthiness, presentation worthiness and graphic worthiness. Handouts are usually made for instructional purposes. Handouts make learning "portable and enduring" easy to carry everywhere and enduring and can load back information that has been obtained by students and develop tests for students.

2. Methodology

This research used the Research and Development (R&D) method which refers to the 4-D model as developed by Thiagarajan et al. in 1974. This model consists of 4 stages of development, namely Define, Design, Develop, and Disseminate or adapted into a 4D model, which is Defining, Designing, Developing, and Disseminating (Trianto, 2009). In this research only reached the development stage according to the researchers' needs and for the dissemination stage is carried out in further research. Figure 1 and Figure 2 show a flowchart of 4-D development procedures. However, this research was used until the development stage because the time was adjusted to and the research needs.

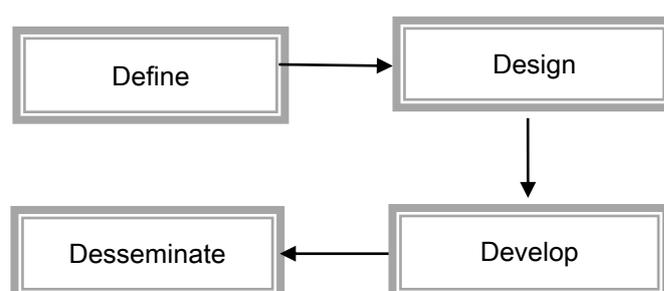


Figure 1. Flowchart of 4D development procedures

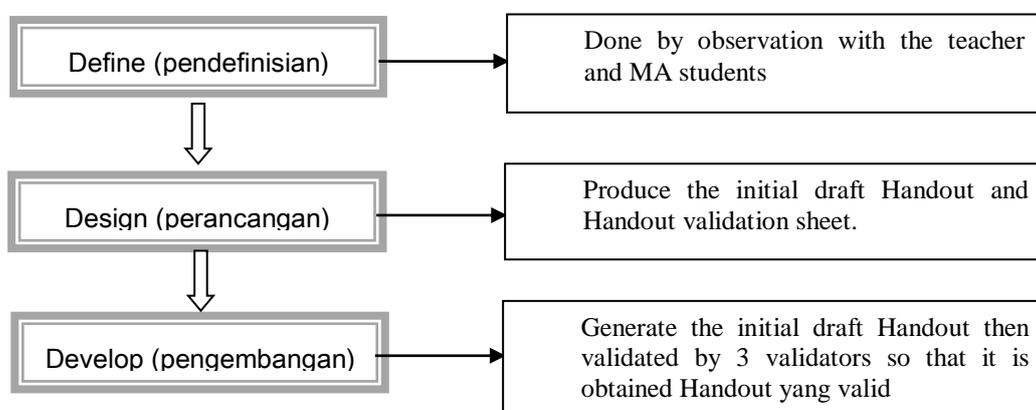


Figure 2. The flow chart of research development procedures

The development phase was to produce teaching materials in the form of revised handouts based on the input from experts. In this stage, three steps were carried out, namely:

Validation Sheet

Handouts used by teachers and students in the learning process were first validated. The validation was carried out by education experts in accordance with their fields of study. They are lecturers at Riau University. Validated aspects are the appropriateness of content, linguistics, presentation, component completeness, inquiry model, and physical form.

All the suggestions from the validator were used to revise the developed handouts. The revision phase aims to improve the guided inquiry-based chemical handout section which was considered inappropriate by the validator before the product was tested. The improved chemistry learning handout was then given back to the validator for further discussion before testing. The revision was stopped when the validator had stated that the guided inquiry-based chemistry learning handout that was designed could already be piloted at school.

Teacher response questionnaire and student questionnaire responses

Teacher response questionnaire and student questionnaire responses are handout trial activities to determine teacher responses and student responses to the developed the handouts. The handout used was a validated handout. The teacher's response to the chemical solution handout consists of three chemistry subject teachers.

Limited Test

At this stage, a limited test was carried out to see learners' responses to the chemical buffer Handout. The limited test was carried out in class XI3 IPA MAN 2 Kampar.

The data analysis technique used in the study was descriptive statistical analysis. The level of product feasibility of the results of research development is identified with the percentage score. The greater the percentage of scores from the data analysis results, the better the level of product feasibility of the research results of the Handout development. The criteria for the level of feasibility analysis of the percentage of products resulting from the development of learning tools are presented in Table 1. Similar to the analysis of the validation sheet, the feasibility assessment of the handout is obtained from the teacher questionnaire and student response questionnaire.

Table 1. Criteria for Eligibility of Percentage Analysis (Riduwan, 2012)

| Percentage (%) | Information |
|----------------|--|
| 80,00 – 100 | Good / Valid / Eligible |
| 60,00 – 79,99 | Fairly Good / Fairly Valid / Fair enough |
| 50,00 – 59,99 | Poor / Invalid / Inadequate |
| 0 - 49,99 | Not Good (Replaced) |

3. Results and Discussion

The product was produced from this development research is a chemical handout of a buffer solution that is valid and suitable for use in the study of chemistry in the buffer solution material. The stages of development research include the defining stage, the design stage and the development stage.

The define phase includes 3 main steps, namely front end analysis, student analysis, and task analysis. The results of the front end analysis are still limited to the Guided inquiry-based Handouts that can facilitate students in understanding the concepts and material counts of buffer solutions. Task analysis produces several analyzes, including content structure analysis, concept analysis, procedural analysis, information processing analysis, and formulation of learning outcomes. Content structure analysis is the analysis of curriculum content based on the material developed. Development of buffer solution materials was based on core competencies and basic competencies. Concept analysis produced a concept map. While the results of procedural analysis were the stages of completing the task used in the Handout namely the guided inquiry stage which includes orientation, formulating the problem, formulating a hypothesis, formulating data, testing the hypothesis, and formulating conclusions.

The analysis of information processing results in an analysis of the need for a handout developed for topics such as the concept of a suitable buffer solution. The explanation of the topic is still a macroscopic explanation of the concept, but for explanation of the concept with a microscopic approach has not yet appeared. The

microscopic explanations was through pictures or illustrations which was attached to the Handout in order to make it easier for students to understand the concept of buffer solution correctly. While the formulation of objectives produces learning outcomes that are formulated based on basic competencies and learning indicators that refer to the syllabus.

The Design Stage produces the initial design of the Handout and the Handout validation sheet. The Handout design developed contains the Handout structure in accordance with the Teaching Materials Development Guide which includes the title of the Handout, Handout instructions, Handout material, Handout practice questions, and homework. The Development Phase produced an initial Handout design, namely a guided inquiry-based Handout. The syntax of guided inquiry learning can be seen in table 2.

Tabel 2. Syntax of guided inquiry learning (Wina Sanjaya, 2011)

| No | Phases | Teacher Behavior |
|----|------------------------|--|
| 1 | Orientation | The teacher explains the topics, objectives and expected learning outcomes in learning |
| 2 | Formulate the problem | The teacher guides students to identify problems in the form of questions |
| 3 | Formulate a hypothesis | The teacher gives students the opportunity to provide temporary answers to the problems that have been identified |
| 4 | Formulate data | The teacher gives students the opportunity to get information about the problem identified |
| 5 | Test the hypothesis | After collecting data, the teacher guides students to prove the answers while students go through hypothesis testing |
| 6 | Formulate conclusions | The teacher guides students in formulating conclusions |

The handout validation aims to determine the feasibility of the Handout that will be used in learning activities. The validation of the Handout was carried out by 3 validators, which were two lecturers of Chemistry Education at Riau University and one of lecturer at FMIPA. The handout validation covers 4 aspects, namely the aspects of content eligibility, language, presentation and graphics.

Handout Validation

Before the guided inquiry-based handout designed or developed is used, validation is first performed by the validator. Validation is carried out by 3 validators, each validator provides ratings, comments and suggestions. The validator assessment data is described and analyzed qualitatively and quantitatively by determining percentages and calculations using a Likert scale.

The result of the validation of the guided inquiry-based handout shows that each component has an average of 93%. The validator team assessed the Handout from four aspects was in accordance with the characteristics of the guided inquiry-based Handout characteristic. The average score recap of the four assessment aspects of the feasibility of the Handout (Table 3). The handout aspect assessment

diagram obtained from 3 validators, which is 93% and can be declared as valid categories.

Table 3. Average Scores of the Fourth Aspect of Handout Eligibility

| No | Indikator Penilaian | Skor Validator | | | | Remark |
|---------|--------------------------|----------------|-----|----|------|--------|
| | | 1 | 2 | 3 | Mean | |
| 1 | Content eligibility | 92,5 | 93 | 95 | 93 | Valid |
| 2 | Language Worthiness | 95 | 100 | 90 | 95 | Valid |
| 3 | Presentation Feasibility | 95 | 90 | 95 | 93 | Valid |
| 4 | Feasibility of Graphics | 94 | 88 | 88 | 90 | Valid |
| Average | | 75 | 74 | 74 | 93 | Valid |

Teacher's response

A questionnaire was given to the chemistry teacher to see the teacher's response to the guided inquiry-based chemical handout. The results of questionnaire data is given in table 4.

Table 4. Teacher responses to guided inquiry-based chemical handouts

| No | Statement | Average rating (%) | Category |
|-----|---|--------------------|----------|
| 1. | The material presented in the handout is in accordance with basic competencies. | 100 | Good |
| 2. | The material presented in the handout uses the concept correctly and correctly. | 92 | Good |
| 3. | The material presented in the handout has a coherent and whole mindset. | 92 | Good |
| 4. | The material presented in the handout is easy for students to understand. | 92 | Good |
| 5. | The material presented is contextual. | 92 | Good |
| 6. | The time allocation provided is in accordance with the depth of the material. | 100 | Good |
| 7. | Presentation of material in the handout encourages students to be active in the learning process. | 83 | Good |
| 8. | Handouts can help students in building / constructing knowledge about the material being studied. | 100 | Good |
| 9. | The sentences used in the handout are clear, easy to understand and communicative. | 83 | Good |
| 10. | Use Indonesian according to the improved spelling rules (EYD). | 100 | Good |
| 11. | The suitability of the image with the text used. | 92 | Good |
| 12. | The pictures and examples presented in the handout are easy to understand. | 92 | Good |

| | | | |
|----------------|--|-----------|-------------|
| 13. | The pictures and examples presented in the handout help in understanding the material. | 100 | Good |
| 14. | The questions in this handout are relevant to the material and easy to understand. | 100 | Good |
| 15. | Presentation of handouts increases student enthusiasm for learning. | 100 | Good |
| 16. | Presentation of handouts can lead students to explore new information or knowledge. | 83 | Good |
| 17. | Presentation of handouts can guide students in drawing conclusions. | 92 | Good |
| 18. | Cover and page design handouts are organized and attractive. | 83 | Good |
| 19. | The text or writing in this handout is easy to read. | 100 | Good |
| 20. | Bad letters. | 92 | Good |
| 21. | The image presented is clear or not | 100 | Good |
| 22. | There is a description on each picture presented | 92 | Good |
| 23. | The images presented are interesting and in accordance with the material. | 100 | Good |
| 24. | Color matching and attractive. | 100 | Good |
| Average | | 94 | Good |

Table 4 shows that overall this guided inquiry-based chemical handout was considered feasible by the teacher, with an average rating of 94%. So that the handout is good applied to the learning process at school.

Student Responses

From the questionnaire given to students to see students responses to the guided inquiry-based chemical handout, the results obtained as shown in Table 5.

Table 5. Student response data to the guided inquiry-based Chemical Handout

| No | Statement | Average rating (%) | Category |
|----|---|--------------------|-------------|
| 1. | Learning with this handout makes me enthusiastic in learning | 100 | Good |
| 2. | Chemistry learning activities that have been carried out help me more easily understand the hydrocarbon material being taught | 81 | Good |
| 3. | I sure can understand the entire contents of this handout well | 85 | Good |
| 4. | This learning makes me happy to discuss with friends to solve problems by exchanging the results of answers | 76 | Pretty Good |
| 5. | I always check the results of my answers | 98 | Good |
| 6. | The student activities and practice questions in this handout helped me to build my chemical knowledge | 86 | Good |

| | | | |
|----------------|--|-----------|-------------|
| 7. | From each activity in this handout, I can conclude and draw important ideas about hydrocarbon material | 91 | Good |
| 8. | I always try to work out the problems in this handout in my own way | 93 | Good |
| 9. | I can relate the contents of this handout to the things that I have seen, done or thought about in my daily life | 93 | Good |
| 10. | I enjoy studying chemistry, especially hydrocarbon materials by using this handout | 80 | Good |
| 11. | With this learning I find it easy to draw conclusions from a problem solving | 79 | Pretty Good |
| 12. | After attending this lesson, my understanding of the material improved | 73 | Pretty Good |
| 13. | I gained new knowledge by participating in a series of activities in this handout | 74 | Pretty Good |
| 14. | I experienced the ease of studying this handout | 89 | Good |
| 15. | The language used in this handout is communicative and easy to understand. | 85 | Good |
| 16. | The material presented in the handout is easy to understand. | 90 | Good |
| 17. | Every example and picture in this handout helped me understand the material. | 80 | Good |
| 18. | The questions in this handout are easy to understand. | 93 | Good |
| 19. | The typeface in this handout is interesting and easy to read | 86 | Good |
| 20. | The appearance of this handout is fun | 98 | Good |
| Average | | 86 | Good |

Based on Table 5, it can be seen that in general students rate the developed handouts with an average rating of 86% with a good category to use.

Results of Implementation of Guided Inquiry Model Stages with chemical solution handouts

The level of implementation of the stages of the guided inquiry model and the students' creative thinking ability during and after learning is carried out as follows:

- 1) The results of observations of the feasibility of the stages of the guided inquiry model

The results of this observation were obtained from observers' observations during the learning activities using guided inquiry-based chemical handouts. This observation sheet was observed by an observer of 26 students by filling out the observation instruments provided. Complete observers' observations can be seen in Table 6 and Table 7.

Tables 6 and 7 show the observational data of 26 students who have participated in the learning process using guided inquiry-based chemical solution handouts. Overall it can be concluded that students are actively involved in the learning

process. This means that the developed handouts are categorized as effective and 'good' are used in the study of chemistry especially on buffer material.

Table 6. Results of observations of stage I (Meeting 2) of the implementation of the guided inquiry syntax with the chemical handout of the buffer solution

| No | Stages of Guided Inquiry Model | Percentage | Assessment criteria |
|------------------------|----------------------------------|------------|---------------------|
| 1 | Formulate the problem | 81% | Good |
| 2 | Formulate Hypothesis | 80% | Good |
| 3 | Designing Experiments | 79% | Good |
| 4 | Record the Results of Experiment | 81% | Good |
| 5 | Analyzing Data | 78% | Good |
| 6 | Make conclusions | 78% | Good |
| Overall average | | 80% | Good |

Table 7. Results of observation in phase II (Meeting 3) of the implementation of the guided inquiry syntax with the chemical solution handout

| No | Stages of the Guided Inquiry Model | Percentage | Assessment criteria |
|------------------------|------------------------------------|------------|---------------------|
| 1 | Formulate the problem | 85% | Good |
| 2 | Formulate Hypothesis | 78% | Good |
| 3 | Designing Experiments | 82% | Good |
| 4 | Record the Results of Experiment | 82% | Good |
| 5 | Analyzing Data | 81% | Good |
| 6 | Make conclusions | 81% | Good |
| Overall average | | 81% | Good |

4. Conclusion

Based on the analysis of the data that has been presented on the results of the study, the conclusions from this study can be drawn, including: Development research conducted has resulted in a product in the form of chemical handout based on a guided inquiry-based buffer solution for an even semester of class XI in senior high school is valid. The validity of the developed handouts is in the valid category. Teachers and students responses to the guided inquiry-based chemical handout that was developed produced an assessment is with a good category. The chemical hanout of buffer solution is made to produce students who actively participate in the learning process using guided inquiry solution chemical buffer handouts. Overall it can be concluded that students are actively involved in the learning process. This means that handouts developed in the category of valid, effective and good categories are used in the study of chemistry, especially in the buffer solution material.

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