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THE DEVELOPMENT OF STUDENT WORKSHEET WITH MULTIPLE REPRESENTATIONS ORIENTED BY OPEN-ENDED PROBLEM SOLVING IN CHEMICAL EQUILIBRIUM MATTER

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Abstrak

Tujuan penelitian ini untuk mengetahui kelayakan Lembar Kegiatan Siswa (LKS) pada materi Kesetimbangan Kimia dan respon siswa SMA. Sumber data diperoleh dari tim ahli meliputi dosen dan guru kimia sebagai penelaah dan validator. Rancangan penelitian ini adalah *Research and Development* (R&D), tetapi hanya dibatasi sampai tahap uji coba terbatas. Uji coba terbatas dilakukan terhadap 15 siswa kelas XI IPA 6 SMA Negeri 15 Surabaya. Instrumen penelitian yang digunakan berupa lembar telaah, lembar validasi, dan lembar angket. Analisis data dilakukan secara deskriptif kualitatif untuk hasil telaah dan deskriptif kuantiatif untuk hasil validasi terhadap kelayakan LKS serta respon siswa. Hasil penelitian menunjukkan bahwa LKS yang dikembangkan telah layak digunakan karena memenuhi kelayakan berdasarkan hasil validasi kriteria kesesuaian terhadap komponen *Open-Ended Problem Solving* dengan persentase 83,33%; kriteria kesesuaian dengan *multiple representations* dengan persentase 89,59%; kriteria isi dengan sebesar 88,92%; kriteria penyajian dengan persentase 92,32%; kriteria kebahasaan dengan persentase 87,50%; dan kriteria kegrafisan dengan persentase 89,72%. Persentase respon siswa untuk kriteria kesesuaian terhadap komponen *Open-Ended Problem Solving* dengan persentase 89,33%; kriteria kesesuaian dengan *multiple representations* dengan persentase 82,22%; kriteria isi dengan persentase 80%; kriteria penyajian dengan persentase 83,33%; kriteria kebahasaan dengan persentase 80%; dan kriteria kegrafisan dengan persentase 88,33%.

Kata Kunci: LKS, multiple representation, open-ended, problem solving, kesetimbangan kimia, kelayakan

Abstract

The aims of this research are to know the feasibility of student worksheet in Chemical Equilibrium matter and response of Senior High School students. The sources of data are resulted by lecturer and teacher of chemistry as reviewer and validator. Research design uses Research and Development (R&D) method but limited until limited trial step. The limited trial is conducted by 15 students of XI IPA 6 SMA Negeri 15 Surabaya. Research instruments are review sheet, validation sheet, and questionnaire sheet. Data analysis was done by qualitative descriptive for the result of student worksheet review and quantitative descriptive for the percentages of assessment result from validator and also from response of students. The result has showed that the student worksheet fulfilled the feasibility criteria for suitability with component of Open-Ended Problem Solving with percentage 83.33%; suitability with multiple representations with percentage 89.59%; content with percentage 88.92%; presentation with percentage 92.32%; language with percentage 87.50%; and graph with percentage 89.72%. The percentages of student response have fulfilled the feasibility criteria for suitability with component of Open-Ended Problem Solving with percentage 89.33%; for suitability with multiple representations with percentage 82.22%; content with percentage 80%; presentation with percentage 83.33%; language with percentage 80%; and graph with percentage 88.33%

Keywords: student worksheet, multiple representation, open-ended, problem solving, chemical equilibrium, feasibility

INTRODUCTION

The globalization era has many challenges. Improving the quality in education is one way to overcome these challenges because education can create the qualified human resources.

Education in Indonesia evolves over time toward a better direction. Learn from the development of education in developed countries, Indonesia is also doing similar developments, such as curriculum development in Indonesia that has changed from the curriculum of Active Student Study Method/ Cara Belajar Siswa Aktif (CBSA) to Competency Based Curriculum/ *Kurikulum Berbasis Kompetensi* (KBK) and now Educational Level Unit of Curriculum/ *Kurikulum Tingkat Satuan Pendidikan* (KTSP). Goverment has implemented KTSP in an effort to improve the quality of human resources since 2006. KTSP recommended that all activities expect student-centered learning, so that students are expected to construct knowledge / understanding by their own.

Chemistry as part of the natural sciences is always related to how to find out about the systematic nature, so the chemistry is not only the mastery of knowledge in the form of a collection of facts, concepts, or principles, but also is a process of discovery. One of the subject matter in chemistry is chemical equilibrium. Chemical equilibrium matter involves complicated concepts. Based on the questionnaire of preliminary study that has been conducted by 30 students in SMA Negeri 15 Surabaya, as many as 53,33% of students stated that the chemical equilibrium was a difficult matter. It was happened because the linkage between the sections of these materials is very high, requiring a higher level of thinking to be able to understand the concepts they learned it.

Based on the characteristics of the subject matter, the understanding of the concept can be done through the discovery process. This discovery process is done through the thinking process until students are able to find the right concept. On a person's thought processes are influenced by cognitive development. According to Piaget's theory of cognitive development, factors that influence a person's cognitive development are the age and active manipulation and interaction with the child's environment[1].

Problems in chemistry or other discipline knowledge are various. Johnstone (in Overton, Tina and Potter, Nicholas, 2008)[2] categorized the problems based on three factors whereas the data was given, the method was familiar, and the outcome of problem was well-definite. The factors were described in the Table 1 as follows:

Table 1. Types of Problems

Type	Data	Method	Outcome	Skills
1	Given	Familiar	Given	Recall of algorithms
2	Given	Unfamiliar	Given	Looking for parallels to known methods
3	Incomplete	Familiar	Given	Analysis of problems to decide what further data are required
4	Incomplete	Unfamiliar	Given	Weighing up possible methods and deciding on data required
5	Given	Familiar	Open	Decision making about appropriate goals. Exploration of knowledge networks
6	Given	Unfamiliar	Open	Decisions about goals and choices of appropriate methods. Explorations of knowledge and technique networks.
7	Incomplete	Familiar	Open	Once goals have been specified, the data are seen to be incomplete
8	Incomplete	Unfamiliar	Open	Suggestion of goals, methods, consequent need for additional data. All of the above skills.

Source: [2]

Based on the table above, normal problems usually were type 1 and 2. Type 3 until 8 represented more skills which needed investigation. Type 5 until 8 was the open-ended problems. The outcomes had not to be clear stated absolutely on the early and the method could be uncommon. The data could be uncompleted and then the students must finish through experiment and/ or through literature research.

Various theories and concepts in science, especially chemistry are reflected with macro, submicro, and symbolic representations. Johnstone described these three equivalent levels using an equilateral triangle, each vertex of which corresponds to a chemistry level, and accordingly, chemical representations can be

categorized in three equivalent types as follows:

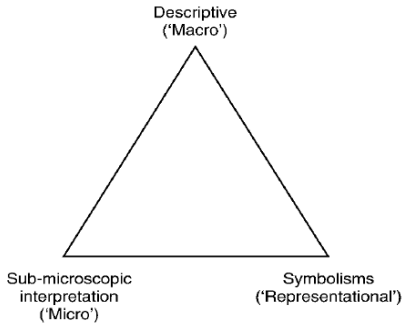

Figure 1. Representation in Chemistry
Source: [2]

Johnstone stated that chemistry existed in three forms which could be thought of as corners of a triangle and each form complements the others. These forms of the subject are the macro, that was what could be seen, touched and smelt; the submicro that was atoms, molecules, ions and structures; and the representational that was symbols, formulae, equations, etc. The macro level chemistry is what students do in the laboratory or experience in real life. However, chemistry, to be more fully understood, had to move to the submicro situation where the behavior of substances is interpreted in terms of the unseen. and molecular, and recorded in some representational language and notation. Chemistry could be taught almost entirely from the submicro and representational forms, with the macro, or real life aspects often being divorced from the rest of the subject. Where this approach has been changed to set learning and problem solving within a real life context, evidence has demonstrated that students engage much more enthusiastically with their learning.

According to the statement, the representation was the language for science, especially chemistry. Chemist used them for communicating and developing thinking skills, process skills, or scientific method. Three aspects of chemical representations contained information about related concepts. By correlating these representations in explaining chemistry knowledge would give contribution to the students' understanding which created in the individual mental image about chemical phenomenon.

Based on the questionnaire of preliminary study, as many as 6,67% of students stated that they confused in understanding macro level, as many as 50% of students stated that they confused in understanding submicro level, as many as 23,33% of students stated that they confused in understanding symbolic level, and as many as 6,67% of students stated that they confused in understanding submicro and symbolic level. I. Devetak, M. et al (2004)[3] explained that to solve the above problem well, students must had basic knowledge of chemistry and the ability to correlate macro, submicro, and symbolic from relevant chemistry concepts. They also must showed the skill needed to solve the problems which related to the particle well.

In addition, many researches about misconception were experienced in the student and teacher on the chemical equilibrium matter. One of them was uncovered by Arzu, et al (2000)[4]. He stated that phenomenon reached chemical equilibrium looked naturally macro as stable and static system. Meanwhile, at submicro level, system was dynamic not only because of molecular movement but also because of breaking and forming bond that has zero net. According to the statement, in relating macro to submicro level produced misconception in understanding the concept of chemical equilibrium.

Nazriati and Fauziatul Fajaroh (2007)[5] stated that misconceptions could be reduced or could be prevented if the learning process in class was conducted with appropriate approach and teaching material and also with reasoning the potential and condition of students.

Sri Untari (2008)[6] added that the substantial message of learning on teaching material all this time still not yet facilitated the students on developing their thinking skills.

Based on observations, the learning of chemistry in this school was performed using the device in the form of student book and student worksheet, and supported by the use of presentation media. Based on questionnaire of preliminary study, as many as 66.67% of students stated that the student worksheet had not been able to assist them in understanding the material in the learning of chemistry. Thus,

so we need to develop the student worksheet which appropriate to the needs of students. Based on the learning needs and competencies which must be achieved, then the researcher need to develop student worksheet in chemical equilibrium matter. Issues focused in this research include feasibility of student worksheet and student responses. Criteria for assessing the feasibility of teaching materials used in the development of this student worksheet refers to Guidance of Teaching Material Development[7]. Such criteria include criteria of content, presentation, language, and graphical. In addition, based on the characteristic of matter, the feasibility was added with feasibility criteria for suitability with component of Open-Ended Problem Solving, and suitability with multiple representations

Based on the above, we conducted a study to determine the feasibility of student worksheet has been developed in terms of suitability with component of Open-Ended Problem Solving, suitability with multiple representations, content, presentation, language, and graph. The benefits of research-oriented development of student worksheet oriented by Open-Ended Problem Solving is for teachers are (1) As an alternative to increasing professionalism in developing learning tools that can be used as a tool used to train the students' thinking skills in teaching and learning at the chemical equilibrium matter. (2) Help students to better understand the concepts through problem solving.

METHOD

This type of study is a development research with the aim of research to develop student worksheet. Sources of data in this study were the expert team includes chemistry lecturer and chemistry teacher as expert of content, linguists, and media as reviewers and validators, and also 15 students class grade XI Senior High School. The development design of the student worksheet refers to the model of Research and Development (R & D). The development was done in this research only to determine the feasibility of student worksheet. The development design is presented in Figure 2.

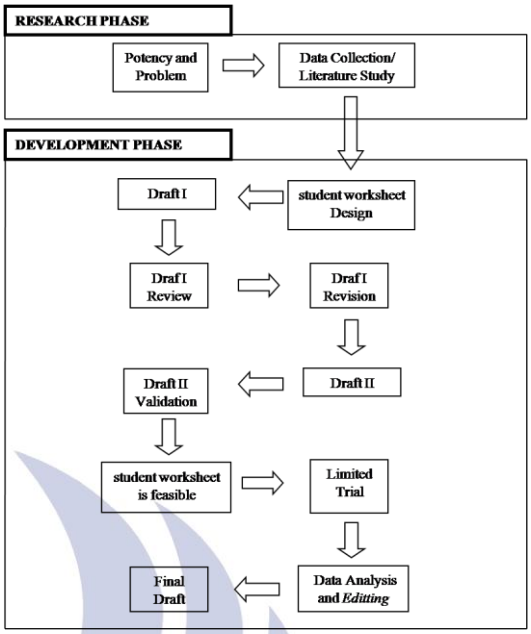

Figure 2. Design of Research and Development (R&D)

This study used instruments include review, validation, and questionnaire sheets. Data collection techniques in research and development use a questionnaire to determine the student responses to the student worksheet. Student worksheet in this study is said to be feasible if the percentage of each of the feasibility criteria achieved ≥ 61%[8]. Data of review sheets of the student worksheet and then analyzed to provide a qualitative descriptive overview of the advice has been given a team of experts. While the results of validation were analyzed by using quantitative descriptive.

The analysis was performed on each criterion of the validation sheet. The percentage of the data was obtained by the calculation based on Likert scale as in Table 2 as follows:

Table 2. Likert Scale

Assessment	Scale Value
Very Less	0
Less	1
Enough	2
Good	3
Very Good	4

Source:[8]

Calculating the percentage of feasibility on each criteria used the following formula:

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$$P(\%) = \frac{\sum \text{Score result of data collection}}{\text{Score of criteria}} x100\%$$

Score of criteria= highest score x number of aspect x number of respondents

The results of the validation sheet analysis were used to determine the feasibility of student worksheet. The scores interpretation of feasibility percentage is presented as follows:

Table 3. Scores Interpretation

Percentage	Category
0% - 20%	Very Less
21% - 40%	Less
40% - 60%	Enough
61% - 80%	Good
81% - 100%	Very Good

Source: [8]

The results of student responses were obtained by filling a questionnaire. Students provide an assessment on each criterion based on the scores in Table 3.

Table 4. Guttmann Scale

Answer	Score
Yes	1
No	0

Source: [8]

Calculating the percentage on each criteria used the following formula:

$$P(\%) = \frac{\sum \text{Score result of data collection}}{\text{Score of criteria}} x100\%$$

Score of criteria= highest score x number of aspect x number of respondents

Based on that percentage has been calculated, then the response criteria can be determined based on Table .

RESULT AND DISCUSSION

Validation Result

Validation was performed respectively by three experts of content, language, and media consisting of chemistry lecturer and chemistry teacher to use the validation sheet. Validation sheet used to collect data based on an assessment of the feasibility of suitability with the Open-Ended Problem Solving components, suitability with multiple representations, content, presentation, language, and graph of student worksheet. Validation result can be seen from the following data:

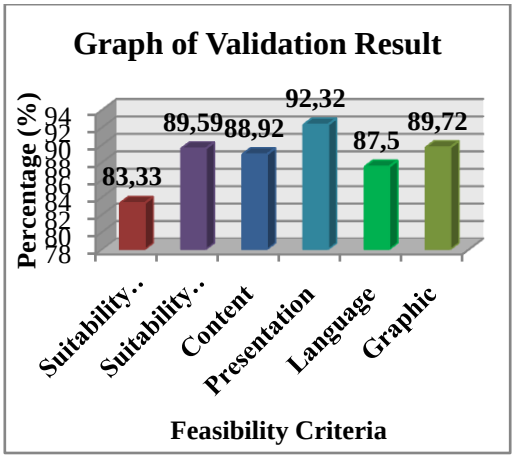

Figure 3. Validation Result of the Student worksheet

According to the Riduwan[8], student worksheet is feasible based on the criteria if the aspects obtained the percentage of ≥ 61% according to the Likert scale.

Based on the validation of content experts in Figure 3, student worksheet which developed fulfilled the feasibility criteria of suitability with Open-Ended Problem Solving component with the average percentage of 83,33% and in the category of very good because it was in the interval 81% -100%.

Piaget (in Dahar, 1989)[1] stated that the formulation of the questions is one of the most important parts. In solving the problem actually depends on the creation and submission of questions so that constructivism is an important part in the construction of the question.

Step through the open-ended problem solving was helped with multiple representation that has been developed in this student worksheet. Students could be trained not only to be able to solve the problem in stages, but also trained students to construct knowledge, as well as making students interact freely with each other so as to make learning more meaningful.

Based on the validation of content experts in Figure 3, student worksheet fulfilled the feasibility criteria of suitability with multiple representation criteria with the average percentage of 89.59% and in the category of very good because it was in the interval 81% - 100%.

Josep, J and Sanjose, V. (2007)[9] stated that the use of multiple representations when

solving problems is very beneficial for students. Format representation of issues affecting the performance of students and the use of representation as a learning strategy can result in an increase in resolving the problem.

Based on this theory, student worksheets can be said to be feasible if student worksheet can train students to solve a problem using the steps of open-ended problem solving and assisted with formatting problems using multiple representations representation appropriately so that students are expected to understand the problem to be resolved correctly.

Based on the validation of content experts in Figure 3, student worksheet fulfilled the feasibility of content criteria with the average percentage of 88,92% and in the category of very good because was in the interval 81% - 100%.

These results showed that student worksheet fulfill the feasibility of content criteria based on Guidance of Teaching Material Development[7]. Such criteria include: suitability with KTSP curriculum, suitability with the Standards of Competence, and the Basic Competence that is needed to be achieved; the matter was relevant to the indicators of learning outcomes; summary of the material composing the key concepts, the evaluation questions in the student worksheet was understood easily and in accordance with indicators and learning outcomes; activity experiments in the student worksheet according to the materials and basic competencies that has been developed; presentation of the book in accordance with the level of thinking and reading skills of students; facts, concepts, and illustrations were presented accurately; materials that support learning has been presented (features and examples) in accordance with the development of science and technology; presentation of material in the student worksheet was logical and systematic based on the need of knowledge that will be given.

Based on the validation of content experts in Figure 3, student worksheet fulfilled the feasibility of presentation criteria with the percentage of 92.32% and in the category of very good because it was in the interval 81% - 100%.

These results showed that the student worksheet fulfill the feasibility of presentation criteria based on Guidance of Teaching Material Development[7]. Such criteria include: cover presented the content of the student worksheet; clear indicators of learning outcomes; presentation student worksheet was intriguing; concept that was presented coherent and balanced among sub chapter from beginning until ending; suitability of illustrations with the subject matter; illustrations or figures helped in understanding the concept; presentation was completed by a reference image; matter presentation based on student-centered; bibliography writing in accordance with applicable rules; presentation of the student worksheet was interesting or exciting; presented information was complete; and completeness of the presentation.

Based on the validation of linguist in Figure 3, student worksheet fulfilled the feasibility of language criteria with the percentage of 87.50% and in the category of very good because it was in the interval 81% - 100%.

These results showed that the student worksheet fulfill the feasibility of language criteria based on Guidance of Teaching Material Development[7]. Such criteria include: student worksheet writing used the appropriate language to the level of student progress; student worksheet writing used good English and used correct interconnected language in inter-chapters, sub-chapters, paragraphs, and sentences; student worksheet writing used terms that was understood easily; and term or symbol or sign was used steadily.

Based on the validation of media experts in Figure 3, student worksheet fulfilled the feasibility of graphical criteria with the percentage of 89.72% and in the category of very good because it was in the interval 81% - 100%.

These results showed that the student worksheet fulfill the feasibility of graphical criteria based on Guidance of Teaching Material Development[7]. Such criteria include: the use of the font (type and size);

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display design; layout of text, images, tables, and graphs were presented in a harmonious; illustrations, graphics, images; print quality: quality of paper; as well as terms, formulas, and the symbol that were clearly stated in italics/ bold/ underlined.

Limited Trial Result

The result of limited trial is presented in the following figure:

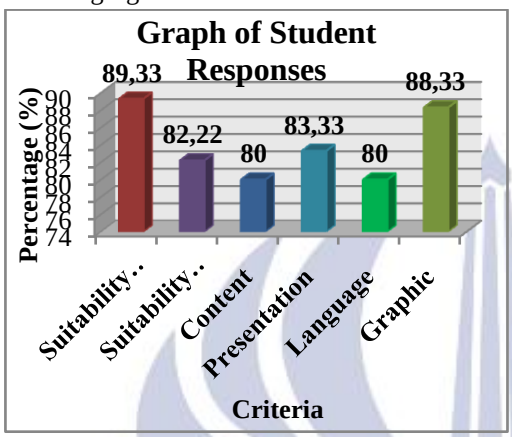

Figure 4. Student Responses to the Student Worksheet

Based on Figure 4, the percentage of suitability with Open-Ended Problem Solving component criteria of student worksheet was obtained by students' responses as many as 89.33% with very good category.

These results showed that the student worksheet help students during problem solving process through open-ended problem

Based on Figure 4, the percentage of suitability with multiple representation criteria of student worksheet was obtained by students' responses as many as 82.22% with very good category.

These results showed that the multiple representations can be understood well by the students.

Based on Figure 4, the percentage of contents criteria of student worksheet was obtained by students' responses as many as 80% with good category.

These results showed that the student worksheet help students with an excellent understanding of matter. This is because they thought that these questions and a description or explanation of the student worksheet could assist students in learning.

Based on Figure 4, the percentage of presentation criteria of student worksheet was obtained by students' responses as many as 83.33% with very good category.

These results showed that the student worksheet help students with an excellent understanding of the subject matter. This is because they argued that the student worksheet could raise their motivation to learn and ask, either the teacher or friend. In addition, students also argued that student worksheet was interesting and entertaining as well as illustrations or figures that was presented could assist them in understanding the concepts that made them more active in teaching and learning activities, both individually and as they worked in groups.

Based on Figure 4, the percentage of language criteria of student worksheet was obtained by students' responses as many as 80% with good category.

These results showed that the English language and terms which is used in the student worksheet are easily understood by students.

Based on Figure 4, the percentage of graphical criteria of student worksheet was obtained by students' responses as many as 88.33% with very good category.

These results showed that the color of text in student worksheet can support a good illustration or image. Students also argued that the font and size of paper made them comfortable when reading the subject matter of student worksheet.

Overall, the results of students' responses data support the assessment by the experts.

CLOSURE

Conclusion

Based on result of this research and discussion can be concluded that student worksheet fulfill the feasibility criteria for suitability with component of Open-Ended Problem Solving with percentage 83.33%; criteria for suitability with multiple representations with percentage 89.59%; criteria of content with percentage 88.92%; criteria of presentation with percentage 92.32%; criteria of language with percentage

87.,50%; and criteria of graph with percentage 89.72%. Students' responses was obtained through the questionnaire of students responses positively to student worksheet. The percentages showed that the response on criteria for suitability with component of Open-Ended Problem Solving with percentage 89.33%; criteria for suitability with multiple representations with percentage 82.22%; criteria of content with percentage 80%; criteria of presentation with percentage 83.33%; criteria of language with percentage 80%; and criteria of graph with percentage 88.33%.

Suggestion

It is necessary to know the efectivity of student worksheet further by implicating with more students.

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