

**DEVELOPMENT OF STUDENT WORKSHEET WITH OPEN ENDED
PROBLEM SOLVING ORIENTED ON ENTHALPY CHANGES OF
CHEMICAL REACTION SUBJECT MATTER TO TRAIN
STUDENT CRITICAL THINKING SKILL**

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Abstrak

Penelitian ini memiliki tujuan untuk mengetahui kelayakan dari LKS berorientasi *open ended problem solving* pada submateri perubahan entalpi reaksi kimia untuk melatih keterampilan berpikir kritis siswa yang dikembangkan baik secara teoritis maupun empiris. Kelayakan teoritis ditinjau berdasarkan hasil validasi, sedangkan kelayakan empiris ditinjau berdasarkan respon siswa terhadap LKS yang dikembangkan. Penelitian dan pengembangan ini mengacu pada metode pengembangan 4-D (*four-D method*). Pelaksanaan pengembangan pada penelitian ini hanya sampai pada tahap pengembangan (*Develop*), karena penelitian ini dilakukan hanya untuk mengetahui kelayakan LKS yang dikembangkan. Instrumen penelitian yang digunakan adalah lembar telaah, lembar validasi, dan angket respon siswa. LKS yang dikembangkan ditelaah untuk mendapat saran, kemudian divalidasi untuk mendapatkan penilaian, dan diujicobakan kepada 20 siswa kelas XI MIA 2 SMAN 19 Surabaya untuk mengetahui respon siswa. Berdasarkan hasil penelitian dapat disimpulkan LKS yang dikembangkan layak untuk digunakan secara teoritis dan empiris. Hal tersebut karena kelayakan teoritis dari hasil validasi mendapatkan persentase kriteria isi sebesar 90,56%; kriteria penyajian sebesar 86,11%; dan kriteria bahasa sebesar 87,5%. Selain itu kelayakan empiris dari respon siswa menunjukkan bahwa siswa sangat merespon kriteria isi dengan persentase 86,58%; kriteria penyajian 85%; dan kriteria bahasa 88% .

Kata Kunci: Lembar Kerja Siswa, *open ended problem solving*, perubahan entalpi

Abstract

The study was aimed to know the feasibility of student worksheet with open ended problem solving oriented on enthalpy changes of chemical reaction subject matter to train student critical thinking skill that had been develop according to theoretically and empirically feasibility. The theoretical feasibility is reviewed based validation result, while empirical feasibility is reviewed based on student responses to student worksheets. This research and development refer to four-D model. This study is limited on develop stage, because the study was conducted only to know the feasibility of student worksheet. The instrument of this study consists of review sheet, validation sheet, and response Student worksheet that developed was reviewed to get advice, then validated to get an assessment, and tested on 20 students of class XI MIA 2 SMAN 19 Surabaya to know the students responses. Based on the result of study can conclude that the student worksheet is feasible to be use theoretically and empirically. It has because the theoretical feasibility get percentage of content is 90.56%; presentation is 86.11%; and language criteria from validation result is 87.5%. Furthermore, the empirical feasibility from students response shown that student response on good category to the some criteria, content with percentage 86.58%; presentation 85%; and language criteria 88%.

Keywords: Student worksheet, open-ended problem solving, enthalpy changes

INTRODUCTION

The development of science and technology resulting in the more developed efforts to develop human resources into a society that has a sensitivity, independently, being responsible, and can educate themselves throughout life, and be able to solve the problem. On the other side, the National Education System (Sisdiknas) [1] explained that the national education works to improve and develop the skills and character development as well as the civilization which prestige with the aim to develop students' potentials to become a man of faith and piety. Based on the functions of the national education is also the responsibility of teachers to achieve quality learning process and quality, but knowledge cannot simply be transferred to the student but must interpreted himself by each individual, so student must have critical thinking skill. Therefore, the need for a strategy or method of learning so that students can be actively involved in learning activities, so that students are able to build their own knowledge.

In the world of education variety of approaches and strategy has developed, and in this case it takes the approach that makes the students construct their own knowledge. One innovation that has been developed is the constructivism approach that can be applied by many methods, one of them is open-ended problem solving. According Hedden and Speer in Martunis (2010) model of open ended is a learning model that provides the opportunity freely to students for students to think actively and creatively in solving or solve a problem [2], while according to Gagne in Pait (2012) problem solving namely learning that will help students find merge of formulas or concepts being studied [3].

"The model presented in this paper was effective in increasing student's skill and confidence level in tackling Open Ended Problems". A study has been conducted by Nikos J. Mourtos obtain results by applying the open ended problem proved to increase students' ability to solve problems [4].

Pedagogy related to the Rutherford & Ahlgren (1990) states that there should be learning science subjects, one of which is chemistry can help students develop their thinking. In addition, the study should help students to develop their understanding for students to face life in the future. For that end, Rutherford & Ahlgren (1990) states "Student should be given problems-at levels appropriate to their maturity-that require them to decide what evidence is relevant and to offer their own interpretations of what the evidence means. This puts a premium, just as science does, on careful observation and thoughtful collecting. Students need guidance, encouragement, and practice in collecting, sorting, and analyzing evidence, and in building arguments base on it. However, if such activities are not to be destructively boring, they must lead to some intellectually satisfying payoff that students care about." The essence of Rutherford & Ahlgren sight is students need to be taught authentic learning experiences and problem solving skills. In addition, students are given the experience to face the problems open ended. Experience in learning will give students opportunities to acquire problem-solving skills. To assist students in solving problems now developed a model of learning problem solving [5].

Learning open ended problem solving that is learning to apply open ended problem further solve it problems by using

the problem solving process gradually. Components or stages - stage on the model of problem solving include: (1) students understand the problem correctly (understanding the problem), (2) students plan completion (device a plan), (3) the students carry out the settlement (carry out the plan), (4) students to re-examine the completion of the steps that have been made (look back) [6]. Thus, open-ended problem solving models used as problem solving stage to solve the open ended problem. Means to help realize the model of open ended problem solving through the student worksheet.

Based on the fact in SMAN 19 Surabaya shows student worksheet used felt no innovation, student worksheet only contains material and exercises, so it felt useless if delivered to the students. Because of it, now class of XI SMAN 19 Surabaya do not use the worksheet, although in fact student worksheet is needed by students for student worksheet can be used for training and provision of information. This is consistent with the results of the analysis worksheets in the field. Student worksheet used in high school students currently only contains material and exercises, and several worksheets already contains practical activities that will help the understanding of the students, but the contents of student worksheet is still not connecting material with everyday life, where the connecting material with real life day will help the understanding of the students and help students to practice critical thinking skills, especially learning a chemical that has a lot of concepts to be learned.

Chemistry learning should be more emphasis on activities that many students have difficulty, for example, in understanding the concept of

thermochemistry because it is abstract and extent of thermochemistry material. Based on the results of the survey also said that in addition to the acid-base material, a material that is difficult thermochemistry understood by students, especially at enthalpy changes subject. Therefore, needs to study about, "Development of student worksheet with open ended problem solving oriented on enthalpy changes of chemical reaction subject matter to train student critical thinking skill"

METHOD

The research of development student worksheet with open ended problem solving oriented that had been developed refers to a four-D model. The stages are: define, design, develop, and the disseminate stage [7]. However, in this study is limited only to the stage of develop.

Source of data in this study came from three sources. First, the data was derived from the study of 2 chemistry lecture and 1 chemistry teacher. Second, the data validation results from one chemistry lecture and two chemistry teacher. Third, the data originated of tests on 20 students of class XI MIA SMAN 19 Surabaya. Thus, the research instrument in this study using review, validation, and student response sheet. Furthermore, the collected data will be descriptive quantitative analyzed.

Analysis validation sheet is performed against each criterion. Percentage of data obtained using a Likert scale [8], as seen in Table 1.

Table 1. Likert Scale

Criteria	Score
Not Good	0
Less Good	1

Criteria	Score
Good Enough	2
Good	3
Very Good	4

Calculation formula that used to obtain the score acquisition.

$$P (\%) = \frac{\text{total score of collecting data result}}{\text{Criteria score}} \times 100\%$$

with description:

Score Criteria = highest score x number of questions x number of respondents

Feasibility of student worksheet can known from the percentage that obtained, use Likert scale score interpretation [8], as seen in Table 2:

Table 2. Likert Scale Score Interpretation

Percentage (%)	Criteria
0,01 - 20,99	Very Invalid
21,00 - 40,99	Invalid
41,00 - 60,99	Less Valid
61,00 - 80,99	Valid
81,00 - 100,00	Very Valid

Based on the Likert scale score interpretation, student worksheet that had been develop can be categorized as feasible if the percentage $\geq 61\%$ or in valid category, so the student worksheet is feasible theoretically.

Analysis of student responses questionnaire is using a calculation Guttman scale criteria, which was given a score of 1 if yes and a score of 0 if not. Questionnaire for the students, made in the form of a "yes" or "no" [8].

Table 3. Guttman Scale

Answer	Score
Yes (Y)	1
No (N)	0

Then, the percentage calculation use formula as below:

$$P (\%) = \frac{F}{N} \times 100\%$$

Where:

P = response answer

F = total of "yes" answer

N = total of respondents

Based on data that obtained from student response questionnaire, after that do the analysis appropriate with Likert Scale score interpretation [8], as seen in Table 4.

Table 4. Likert Scale Score Interpretation

Percentage (%)	Criteria
0 - 20	Very unresponsive
21 - 40	Unresponsive
41 - 60	Less responsive
61 - 80	Responsive
81 - 100	Very responsive

Student worksheet is feasible empirically if the percentage that obtained $\geq 61\%$.

RESULT AND DISCUSSION

Theoretical feasibility

Data from the review result by two lecturers of chemistry and one chemistry teacher that used to get advice and suggestions on the draft I, which was subsequently revised to produce draft II to be validated and tested. Feasibility theoretically can be known base on the validation result that reviewed from content, presentation, and language criteria.

Validation do by a chemistry lecturer and two chemistry teachers. Result of validation of student worksheet with open ended problem solving oriented is presented in Table 5.

Table 5. Validity Result

No.	Criteria	Percentage	Category
1.	Content	90,56 %	Very Responsive
2.	Presentation	86,11 %	Very Responsive
3.	Language	87,5 %	Very Responsive

Based on validity result known the percentage content criteria of student worksheet with open ended problem solving oriented that had been developed get the percentage 90.56%. Based on the Likert scale scores interpretation in Table 2, content criteria of student worksheet has a very valid criteria, because the score entry in the interval 81% - 100%. These results indicate that the student worksheet with open ended problem solving oriented that developed has comply the eligibility content criteria based on guidelines for the development of teaching materials [9]. Content criteria include: the suitability of the material with core competencies (KI) and the Basic Competency (KD) to be achieved; student worksheet material relevant with indicators of learning and the learning objectives are presented clearly; the problem raised in accordance with the level of cognition, organization of material follows the systematic of science where the facts, concepts, principles, procedures and theories presented in accordance with applicable in the chemistry subject; as well as the relationship between the concepts and principles of chemistry with the properties of the material that had been observed. The content criteria also includes conformance of student worksheet with the stages of open ended problem solving model, It consists of: there is an problem of open ended; there is command to understood the problem, there

is a command that the students began to devise a plan, there is a command that the students carry out planning solution problems that have been created, and there is a command that the students look back their working [6]. The contents criteria also includes conformance of student worksheet with components of critical thinking skills by Ennis (1996) [10] comprising: providing simple explanation which is an activity focused on the problem; establish basic skills through observe and report the observation results; concluded results of the investigation; make further explanation by constructing argument; and set a strategies and tactics which students look back their work. Based on the information processing theory [11] that in study process there is processing, storage, and recalling knowledge. Student worksheets that had been developed contain phenomena in order to student focus on the phenomenon. It will make the stimulation is received then the stimulus is stored momentarily in the register sensing. Further components of critical thinking Ennis (1996) [10] students will observe and then take the conclusion of observation result, so will be occur preprocessed and transferred to short term memory. The next component of the construct arguments that the initial processing was processed again to be transferred into long term memory. The principle of association and grouping entered, stored, studied, analyzed, and recalled back through look back working.

Based on validity result known the percentage presentation criteria of student worksheet with open ended problem solving oriented were developed get the percentage 86.11%, the student worksheet with open ended problem solving orientation has a well very valid

categories, because the presentation criteria as a percentage falls within the interval 81% - 100%. These results indicate that the student worksheet with open ended problem solving oriented developed has comply the criteria presentation based on guidelines for the development of teaching materials [9]. Presentation criteria include: compliance with the concept of coherent, consistent, and well balanced between sub-chapter; presentation of illustrations or images that are relevant to the subject matter; variations in the general look interesting and not boring; provision of adequate space for the freedom of students give answers, and completeness of presentation such as: introduction, table of contents, references, concept maps, objective, instructions for use. Learning theory of Vygotsky's known about scaffolding which to help given peers or adults who are more competent then reduce the scaffolding and provide the opportunity for students to take responsibility [11]. Student worksheet developed containing phenomena with relevant image as scaffolding for students. Furthermore, to provide the opportunity for students worksheets were developed to provide sufficient space for the give the opportunity to students to answer the question. Based on the description, the presentation criteria of student worksheet with open ended problem solving orientation is feasible.

Based on validity result known that the percentage language criteria of student worksheet with open ended problem solving oriented were developed get the percentage 87.5%. Based on the validation results, the student worksheet with open ended problem solving oriented has been very valid the criteria of language. That's

because the percentage falls within the interval 81% - 100%. These results indicate that the student worksheet with open ended problem solving oriented developed has comply the language criteria based on guidelines for the development of teaching materials [9]. Language criteria include: the use of language in accordance with EYD, the level of cognitive development of students, communicative, and use a clear sentence structure. According to Piaget's theory of cognitive development express the stage of development of children and adolescents, namely sensorymotor stage, preoperational, concrete operations, and formal operations [11]. Based on observations data of class XI students of SMAN 19 Surabaya aged 16-17 years. According to Piaget's theory of cognitive development, children in that age range are at formal operations stage. Based on the analysis developed worksheets that have been prepared using the language on the stage of formal operations so the student worksheet has developed easily to understood by each student.

Based on validity result that review to content, presentation, and language criteria, student worksheet were developed are feasible theoretically.

Empirical Feasibility

Empirical feasibility obtained based on the result of students responses to the student worksheets were developed. Data from student responses to the student worksheet with open ended problem solving oriented are presented in Table 6.

Table 6. Student Response Result

No	Criteria	Percentage	Category
1.	Content criteria	86,58 %	Very responsive
2.	Presentation criteria	85 %	Very responsive

No	Criteria	Percentage	Category
3.	Language criteria	88 %	Very responsive

Based on the results of students response to the content criteria of student worksheet with open ended problem solving oriented get a percentage 86.58%. It shows that the students have been very responsive to the contents criteria of student worksheet were developed. Students stated that the contents of student worksheet developed has been presented systematically so it is easy to understand.

In addition, the results of the students response to the presentation criteria of student worksheet has developed get the percentage 85%, it means that the student is responding to the presentation criteria of student worksheet were developed. Student worksheet developed has been used size that clearly readable, student worksheet developed equipped with pictures and illustrations as well as there is enough space to answer so as to make them interested in the student worksheet with open ended problem solving oriented.

Based on the result of student response, students very responsive to the student worksheet with open ended problem solving oriented and the percentage is 88%. Students show that student worksheet were developed already accordance to appropriate language to EYD, the level of cognitive development of students, communicative, and the use of sentence structure clearly uses it to make them easier to understand student worksheet.

Based on the result of validation and student response that obtained percentage 61% in each criterion, so student

worksheet that had been developed is feasible theoretically and empirically.

CLOSURE

Conclusion

Based on the data analyzing and discussion can be concluded is as follow:

1. Student worksheet with open ended problem solving oriented on enthalpy changes of chemical reaction subject matter is feasible theoretically. It proven by validity result of content criterion is 90.56%; presentation criterion is 86.11%; and language criterion is 87.5%.
2. Student worksheet with open ended problem solving oriented on enthalpy changes of chemical reaction subject matter is feasible empirically. It known from student response shown that student response to the some criteria, content get percentage 86.58%; presentation is 85%; and language criterion is 88%.

Suggestion

1. Development of student worksheet with open ended problem solving oriented on enthalpy change of chemical reaction subject matter in this study is limited on develop stage, so that the next research expected to be made until the disseminate stage.
2. Student worksheet with open ended problem solving oriented on enthalpy change of chemical reaction subject matter on the phenomenon of Hess's Law has not take into account the assumption of a human energy needed to reach the final state, so that in future studies expected to develop student worksheets with the phenomenon that takes account of all that related with Hess Law.

3. *Pretest* and *posttest* sheet that give before and after use the student worksheet oriented *open ended problem solving* on enthalpy changes of chemical reaction to train student critical thinking skill, it should has same indicator but with different question.

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