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Development of Inquiry Student Worksheet to Train High Order Thinking Skills on Chemical Equilibrium Material

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Abstract:Development of Inquiry Student Worksheet to Train High Order Thinking Skills on Chemical Equilibrium Material. The purpose of this study is to describe the feasibility of inquiry student worksheet to practice high order thinking skills on chemical equilibrium material. The research method used is the 4-D model including Define, Design, Develop and Dissiminate. This research was limited to the develop stage with limited trial stage. The research instrument used was a review sheet, a validation sheet, a student response questionnaire, a test sheet for learning outcomes in the domain of knowledge and a prestest-posttest question sheet for high order thinking skills. The results obtained showed that the feasibility of student worksheet in terms of content, language, presentation, and graphic criteria got percentage of 85%, 89%, 91% and 91% with very valid categories. Based on this percentage, the developed students worksheet is suitable for use in the learning process. The feasibility of the students worksheet was also supported by a very positive response from students with a percentage of 88.5%. There was an increase in the high order thinking skills test of students with an n-gain score of 0.707 which is in the high category. The percentage of results of each component of high order thinking skills includes analyzing (C4) of 84.3%, evaluating (C5) of 83% and creating (C6) of 87.5% in the high category and declared effective.

Keywords: Student Worksheet, Inquiry, High Order Thinking Skills, Chemical Equilibrium Material.

Abstrak:Pengembangan LKPD Inkuiri untuk Melatihkan Keterampilan Berpikir Tingkat Tinggi Pada Materi Kesetimbangan Kimia. Tujuan penelitian ini ialah untuk mendeskripsikan kelayakan dari LKPD berbasis inkuiri untuk melatihkan keterampilan berpikir tingkat tinggi pada materi kesetimbangan kimia. Metode penelitian yang digunakan yaitu model 4-D meliputi Define, Design, Develop, Dissiminate. Penelitian ini dibatasi hingga tahap develop dengan dilakukan uji coba terbatas. Instrumen penelitian yang digunakan adalah lembar telaah, lembar validasi, lembar angket respon peserta didik, lembar tes hasil belajar ranah pengetahuan dan lembar soal prestest-posttest keterampilan berpikir tingkat tinggi. Hasil penelitian yang diperoleh menunjukkan bahwa kelayakan LKPD ditinjau dari kriteria isi, kebahasaan, penyajian, dan kegrafisan mendapatkan presentase sebesar 85%, 89%, 91% dan 91% dengan kategori sangat valid. Berdasarkan presentase tersebut, maka LKPD yang dikembangkan telah layak untuk digunakan dalam proses pembelajaran. Kelayakan LKPD tersebut juga didukung dengan respon yang sangat positif dari peserta didik dengan presentase sebesar 88,5%. Terdapat peningkatan pada tes keterampilan berpikir tingkat tinggi peserta didik dengan n-gain score sebesar 0,707 yang termasuk kategori tinggi. Presentase hasil setiap komponen berpikir tingkat tinggi meliputi menganalisis (C4) sebesar 84,3%, mengevaluasi (C5) sebesar 83% dan mencipta (C6) sebesar 87,5% dengan kategori tinggi dan dinyatakan efektif.

Kata kunci: LKPD, Inkuiri, Keterampilan Berpikir Tingkat Tinggi, Kesetimbangan Kimia.

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INTRODUCTION

The development of science and technology plays an important role in social structure of everyday life, thus in the field of education. Education is a basic need to create quality of human resources. Students are expected to have an active role in developing their potential in the fields of religion, personality, intelligence, self-control, and skills needed in the life of society, nation and state. This can be realized with quality education in a learning process (Permendikbud, 2014).

The curriculum used in educational units in Indonesia is the 2013 curriculum. The 2013 curriculum develops the attitudes, knowledge and skills of students to be applied at various levels of education and in the community environment. In addition, the 2013 curriculum was also developed by refining the mindset, namely from passive learning patterns to active learning seeking and perfecting thinking patterns, from passive learning patterns to critical learning. This critical learning requires high school graduates to have high order thinking skills (Permendikbud, 2014).

High order thinking skills include critical, creative, logical, metacognitive and reflective thinking (Singh et al., 2018). High-order thinking skills facilitate students to find new knowledge through observation of phenomena in the environment (Verdina et al., 2018). Based on the revised Bloom's taxonomy, high order thinking skills are the most abstract skills in the cognitive domain. The ability of students to formulate problems, identify variables and analyze data is included in the skills to analyze or are in the C4 realm. Then the ability of students to identify problems, design experiments and make conclusions is included in evaluating skills or the C5 domain. Meanwhile, the ability to make hypotheses and express ideas / ideas is included in creative skills in the C6 realm (Nurkholik & Yonata, 2020).

Chemistry learning process requires skills in thinking and making reasoning. It is not only in that phase but also in its implementation there several materials that require proof obtained through the experiments carried out. One of the chemical materials in which it requires proof through experiments to be able to understand the concept as a whole, namely chemical equilibrium material. Basic competence in the material of chemical equilibrium that must be achieved by students is basic competencies 3.9 which states that students are required to analyze the factors that influence the shift in the direction of equilibrium and its application in industry, as well as basic competencies 4.9, namely designing, conducting, and concluding and presenting the results of the experiment. There are some factors that influence the shift in the direction of equilibrium (Permendikbud, 2018).

Based on this, students need to be trained in high order thinking skills in order to find and build concepts independently. Thus, students will find it easier to understand, interpret and solve problems in chemical materials, especially chemical equilibrium (Fassenda & Yonata, 2016). Inquiry learning model can be used to practice high order thinking skills. The characteristic of the inquiry learning model is the existence of a critical and analytical thinking process, so that students can seek or find a solution to a problem (Sanjaya, 2013). Qureshi (2017) states in his research that the inquiry learning model can be implemented to improve chemistry learning outcomes accompanied by increased self-confidence of students. In addition, learning using an inquiry model can also improve student learning outcomes (Almuntasheri et al., 2016).

The use of inquiry learning models to improve high order thinking skills is strengthened by the results of research conducted by Lukitasari & Yonata (2019) which explains that almost all students are trained in high-order thinking skills after applying the inquiry learning model to the reaction rate material as evidenced by the classical completeness of the participant's posttest. The students gain 83%. The use of inquiry learning models to practice high order thinking skills is also supported by research previously conducted by Syafitri & Yonata (2020) which succeeded in making students' high order thinking skills increase in chemical equilibrium material by implementing a guided inquiry learning model.

In the learning process, appropriate teaching materials are also needed to support the success of learning activities. One of the teaching materials that can be used in the learning process is student worksheet. Student worksheet serve to help teachers as well as students. Students can find the concepts through activities carried out independently or in a work group by following directions or directions from the student worksheet used. Through this process, process skills and students' scientific attitudes can be developed and are useful in increasing student success in achieving learning targets (Sagita, 2016). Based on the results of research conducted by Tyas et al. (2019), teachers need teaching materials that support the implementation of high order thinking skills in them. Another relevant research was conducted by Kurniyaningsih & Yonata (2019) who developed a student worksheet to improve students' creative thinking skills on chemical equilibrium material.

Based on the results of pre-research at Senior High School 1 Krian as many as 83.3% of students stated that during the learning process they had used students' worksheet. Students' worksheet can facilitate the learning process and understanding of the material. Meanwhile, based on an interview with a chemistry teacher at Senior High School 1 Krian, she stated that in the implementation of the learning process still using the teacher center method or teacher centered. This causes students to be less active and independent. In addition, students have never been given inquiry-based students' worksheet and trained in high order thinking skills during the chemistry learning process.

Based on this description, the researcher wants to develop inquiry-based student worksheet that can train students' high order thinking skills in chemical equilibrium material. The purpose of this development research is to describe the feasibility of the student worksheet which includes validity, effectiveness and practicality.

METHOD

The development design in this study is a 4-D model which consists of the stages of defining, designing, developing and disseminating. This research is only carried out until the develop stage and will be conducted a limited trial of 12 students of Senior High School 1 Krian who were randomly selected. The student worksheet developed was tested for its feasibility which included validity, practicality and effectiveness (Nieveen et al., 2010). The research instruments used include review sheets, validation sheets, pretest and posttest sheets for high order thinking skills, test sheets for learning outcomes in the domain of knowledge, and student response questionnaires.

Suggestions and inputs obtained from the analysis were qualitatively analyzed descriptively which was then used as a reference for the improvement of the Students' Worksheet. The validation process was carried out by two UNESA's chemistry lecturers and one chemistry teacher of Senior High School 1 Krian. The results of the validation were then analyzed using a quantitative descriptive method through percentages. The percentage of validation results is obtained from the score of the assessment results, guided by the Likert scale presented in table 1.

Table 1. Likert scale	
Scale value	Criteria
5	Very good
4	Good
3	Pretty good
2	Quite good
1	Not good
(Riduwan & Sunarto, 2017)	

Furthermore, the score obtained from the assessment results is calculated using the following formula (Suyono & Hariyanto, 2015) :

(%) =
$$\frac{\text{Score obtained}}{\text{maximal score}} \times 100\%$$

Furthermore, the validation results obtained are interpreted using the criteria in Table 2.

Table 2. Interpretation Criteria	
Percentage (%)	Criteria
0-20	Invalid
21-40	Less valid
41-60	Quite valid
61-80	Valid
81-100	Very valid
(Suyono & Hariyanto, 2015)	

The students worksheet developed is classified as valid and very valid if the percentage is $\geq 61\%$. The student response questionnaire that had been obtained was then analyzed and measured using the Guttman scale according to Table 3.

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Question	Answer	Score
Positive	Yes	1
	Not	0
Negative	Yes	0
	Not	1

After being analyzed using the Guttman scale, the percentage is calculated using the following formula:

(%) =
$$\frac{\text{Score obtained}}{\text{maximal score}} \times 100\%$$

The percentage obtained from the formula above is interpreted in Table 4.

Table 4. Interpretation of Response Scores		
Percentage (%)	Criteria	
0-20	Very unresponsive	
21-40	Not responding	
41-60	Less respond	
61-80	Respond	
81-100	Very responding	
81-100 Very responding (Riduwan & Suparto 2017)		

The results of the student response questionnaire analysis were used to determine the practicality of the student worksheet being developed. If the student's response reaches a percentage of $\geq 61\%$, then the student worksheet is categorized as practical. The score of the learning outcomes in the domain of knowledge is calculated using the formula:

Hasil belajar =
$$\frac{\text{Score obtained}}{\text{maximal score}} \times 100$$

Students are said to have mastered knowledge if the value of the learning outcomes obtained is equal to or more than the minimum learning completeness (KKM), which is \geq 75..

Analysis of the high order thinking skills test of students using quantitative descriptive analysis of the aspects of thinking in the realm of C4 (analyzing), C5 (evaluating) and C6 (creating). Each of these aspects is calculated using the following formula:

(%) =
$$\frac{\text{Score obtained}}{\text{maximal score}} \times 100 \%$$

The percentage obtained is then interpreted in Table 5.

Table 5. Score Interpretation Criteria	
Percentage (%)	Criteria
0-30	Very low
31-54	low
55-74	Normal
75-89	high
90-100	Very high
(Agustini	2014)

The pretest and posttest results are then analyzed by calculating the n-gain score <g> using the following formula:

 $\langle g \rangle = {posttest score - pretest score \over maximal score - pretest score}$

The n-gain-score value obtained is then interpreted in Table 6.

Score	Criteria
$g \ge 0,7$	High
$0,3 \le g \le 0,7$	Moderate
$g \le 0,3$	Low

Students are said to be high order thinking skills trained if the n-gain score obtained ≥ 0.7 and gets a learning result value ≥ 75 according to the Minimum Learning Completeness.

RESULT AND DISCUSSION

This development aims to develop proper student worksheet. After obtaining suitable student worksheet, they will then be tested limited to 12 students to obtain data on high-order thinking skills and student responses to the developed student worksheet.

Define Stage (Defining)

At the define stage, an analysis of the objectives and limitations of learning material is carried out on device development. Analysis of needs, competencies, students, assignments, and concepts is carried out at the definition stage (Ibrahim & Wahyusukartiningsih, 2014).

Design Stage (Planning)

In the design or planning stage, the activities carried out are designing and selecting the students worksheet format to be developed. Furthermore, the overall design process of the student worksheet is carried out. At the design stage, a prototype or initial design of the student worksheet is produced (Ibrahim & Wahyusukartiningsih, 2014). The student worksheet that was developed consisted of 3 student worksheet, each of which contains 1 factor that affects chemical equilibrium. Students worksheet are developed by following the inquiry stage according to Arrend (2012).



Figure 1. Cover Students worksheet view, Main Cover (left) and Students Worksheet Cover Sub-title 1 (Right)

Develop Stage (Development)

The development stage aims to get student worksheet that are feasible in terms of the validity, practicality, and effectiveness of the student worksheet being developed. The developing or development stage consists of several stages, namely review, validation and limited trials. The review process was carried out by 1 Chemistry lecturer in Unesa, while the validation process was carried out by 2 Chemistry lecturers from Unesa and 1 chemistry teacher from Senior High School 1 Krian who acted as validators. After going through the review and validation process, the students' worksheet will then be tested on a limited basis on 12 students of class XI Senior High School 1 Krian.

Study

The review process was carried out by the supervisor from the Department of Chemistry, Faculty of Mathematics and Natural Sciences Unesa to examine the tools that were being developed. Suggestions and comments from the supervisor, namely regarding the sentence structure used should be in accordance with the SPOK pattern. The use of sentences in accordance with the SPOK needs to be considered because the learning process is one of the communication processes between teachers and students. In the communication process, a mastery of the structure and pattern of sentences used is required. This is done so that the delivery of ideas or opinions conveyed by teachers to students, in this case stated in the student worksheet, can be well received (Krissandi & Nugraha, 2017).

The use of good and correct sentences will also make it easier for students to understand the contents of the student worksheet being developed, as well as make it easier to understand the concepts presented.

Validation

The validation process was carried out by two chemistry lecturers from Unesa and 1 chemistry teacher from Senior High School 1 Krian. In the validation process, the validity of the students worksheet was generated in terms of the content and construct validity criteria. Construct validity consists of aspects of language, presentation, and graphics. If the percentage results obtained for each criterion are $\geq 61\%$, then the students worksheet can be declared valid (Riduwan & Sunarto, 2017).

Table 7. Validation Results		
Assessed criteria	Average percentage	Category
Contents	85%	Very valid
Language	89%	Very valid
Presentation	91%	Very valid
Graphics	91%	Very valid

Based on Table 7, the student worksheet developed in terms of content criteria got a percentage of $\geq 61\%$, which is 85%. With these results, it means that there is a conformity between the material with Competency Standards, Basic Competencies and learning objectives in accordance with the content eligibility criteria according to BSNP (BSNP, 2010).

So that the student worksheet developed can be said to have met the criteria, namely the compatibility between the Basic Competencies and the indicators to be achieved with the 2013 Curriculum, the chemical equilibrium material with indicators and learning objectives are appropriate, the phenomena and material are correct, the contents of the students worksheet are in accordance with Guided inquiry learning model, the contents of the students worksheet also match the criteria for high order thinking skills.

The results of construct validation on the linguistic criteria get a percentage of \geq 61%, which is 89% which indicates a very valid category. Language criteria include grammatical correctness, writing students 'worksheet using short and easy-to-understand language, writing student worksheet using communicative language, and clarity of instructions or directions. So that student worksheet being developed can be said that they have met the criteria, namely using language that is short, easy to understand, communicative, and clear instructions. Language is an important aspect because when language can be loaded properly, students aged 16-18 years will find it easier to understand information and learning material because knowledge is built and constructed collectively (Santrock, 2008).

The presentation criteria get a percentage of $\geq 61\%$, which is 91%, which indicates a very valid category. The presentation criteria include the objectives of presenting student worksheet that are clear, the order of the material in the students worksheet has been systematic, the presentation of images is appropriate with references, presentation of student worksheet can generate motivation and curiosity of students, presentation of material in student worksheet encourages learners to be actively involved, presenting students' worksheet interesting or fun. So it can be said that the students worksheet developed has met all of the above criteria.

The graphic criteria get a percentage of $\geq 61\%$ which is 91% which indicates a very valid category. Graphic criteria include an attractive cover and describe the contents of the student worksheet, using a font type and size that makes it easy for readers to use students' worksheet, the harmony of text and image layouts on student worksheet, illustrations, pictures, graphics and photos. So it can be stated that the students' worksheet being developed have met the criteria, namely having an attractive cover, the type and size of the fonts used have made it easier for readers to use the students' worksheet, the layout of the text and images on the student worksheet is compatible, as well as illustrations, pictures, graphics, and clear photos.

Practically

Practicality for student worksheet developed in terms of student response questionnaires. The results of the student response questionnaire are presented in table 8.

Table 8. Student Response Questionnaire Results		
Assessed	Average	Category
criteria	Percentage	
Contents	94%	Very
		responding
Language	92%	Very
		responding
Presentation	78%	Respond
Graphics	90%	Very
		responding

Based on table 8, it can be seen that the respondent agrees with all aspects of the assessment contained in the students worksheet developed and has met the criteria for practicality because in every aspect the percentage of results is $\geq 61\%$ with the category of responding and very responding. Based on Table 8, it can be seen that the presentation criteria have the lowest percentage value. This is because there are some students who think that the questions contained in the student worksheet are difficult to understand.

Effectiveness

The effectiveness of the developed student worksheet can be seen from the completeness of the test results of learning in the realm of knowledge and the improvement of students' high order thinking skills. The test of learning outcomes in the domain of knowledge was given after the study was carried out using the students worksheet that had been developed. If the value obtained is \geq 75, the student is said to be complete in the material. The results obtained were 10 of the 12 students scored above 75 and classical completeness was 83.33%. This shows that most of the students have completed the learning process.

The test method used to see the improvement of students' high order thinking skills is through the pretest and posttest. With this test, researchers can find out the high order thinking skills of students before and after using the student worksheet developed. The pretest and posttest are in the form of a written test with 8 descriptive questions that cover all indicators of high order thinking skills, namely the cognitive domains C4, C5, and C6. Students are said to be trained in high level thinking skills if the n-gain score is ≥ 0.7 or high category.

The result obtained was that the average n-gain score of the 12 students was ≥ 0.7 , namely 0.70784 in the high category. This shows that the high order thinking skills of students have been trained after learning using student' worksheet developed with an inquiry learning model..

The average percentage obtained from each indicator is 84.3% for the cognitive realm of analyzing (C4), 84% for the cognitive-evaluating domain (C5) and 87.5% for the cognitive domain of creating (C6). This shows that the developed LKPD is effective in improving the high order thinking skills of students. This result is in accordance with previous research conducted by Aulia & Ismono (2015) which states that inquiry-oriented worksheet can train students' HOTS on chemical bonding material with an n-gain score 0.66 or in a sufficient category.

CONCLUSION

Based on the discussion of the results of the research that has been carried out, it can be concluded that the student worksheet developed are suitable for use in learning in terms of the results of the student worksheet developed on the criteria for content, language, practicality and graphics as 85%, 89%, 91% and 91% with very valid category. The practicality of the student worksheet has fulfilled in terms of the results of the student response questionnaire to the student worksheet developed by an average 88.5% with a very responsive category. Furthermore, the student worksheet had met the effectiveness criteria in terms of the cognitive realm learning achievement test of 83.33% classical completeness, and the results of the pretest and posttest high order thinking skills students got an n-gain score 0.70784 in the high category. Each component of high order thinking skills includes analyzing (C4) 84.3%, evaluating (C5) 84% and creating (C6) 87.5% with high category.

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