

THE DEVELOPMENT OF STUDENT WORKSHEET IN COLLIGATIVE PROPERTIES OF SOLUTION TO TRAIN CREATIVE THINKING SKILLS

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Abstract

The study aims to produce student worksheet in colligative properties of solution that are valid, practical, and effective. The method of student worksheet development uses R&D method but only reached the limited trial of development stage. The developed student worksheet were tested on limited trial to twelve 12th grade students who had received colligative properties of solution material. Based on the results of the research, the percentage of validity in content criteria is 80.22%, language criteria is 80.67%, presentation criteria is 80.00%, and graphics criteria is 83,33%. The percentage of practicality in content criteria is 93.33%, language criteria is 91.67%, presentation criteria is 91.67%, and graphics criteria is 97.92%. The effectiveness of student worksheet based on knowledge has an average score of 85 and based on creative thinking skills, it has average percentage of characteristic of creative thinking on fluency is 82.64%, flexibility is 84.45%, elaboration is 88.89%, and originality is 90.28%. Thus the results of this research indicate that the developed student worksheet is valid, practical, and effective.

Keywords: Student worksheet, creative thinking, validity, practicality, effectiveness

INTRODUCTION

Education in the 21st century is in the age of knowledge (knowledge age). In this period, education requires students to have skills, be able to innovate, master technology, and be able to develop survival skills [1]. Based on Ministry of Education and Culture Regulation No.20 of 2016 concerning graduate competency standards for primary and secondary education, graduates for high school/equivalent students must have competence in the dimensions of attitude, knowledge, and skills. In the dimension of skills, high school students/equivalent must have creative, productive, critical, independent, collaborative, and communicative thinking and acting skills [2].

Creative thinking is an original and complex way of thinking to produce complex products [3]. Creative thinking is often referred to as divergent thinking, because it only starts from one problem, but the solution is done widely and has many possibilities [4]. Creative thinking can be defined as the entire set of cognitive activities used by individuals according to a specific object, problem and condition, or a type of effort toward a particular event and the problem based on the capacity of the individuals. In addition, they try to suggest an authentic and new design, generate different hypotheses, solve the problem with the

help of discovering and finding new applications [5]. There are 4 characteristic of creative thinking skills, they are fluency, flexibility, elaboration, and originality [6].

During this time the learning delivered by the class is only to understand what is taught by the teacher, but do not understand why they have to learn the material so that it makes students' thinking skills weak [7]. Based on graduation standards set forth in Ministry of Education and Culture Regulation No.20 of 2016, of course there needs to be an effort to improve students' creative thinking skills. One effort that can be done is the presence of media or learning resources during the learning process. Media or learning resources during the learning process one of which is a student worksheet.

Student worksheet is one of the visual teaching material in printed form [8]. Based on the rules of the 2013 curriculum, student worksheet must be made by applying a scientific approach to improving the quality of student learning, especially skills because the 2013 curriculum student worksheet tends to lead to practicum activities [9].

Chemistry is a branch of science in which the study of matter build up and the changes experienced by this material in natural processes and in planned experiments [10]. Chemistry learning basically does not only focus on

theoretical knowledge, but must be followed by the ability to apply the concept. One material that can be used by conducting an investigation is the colligative properties of the solution. The colligative properties of the solution can be presented experimentally or non-experimentally. So that students not only learn to understand concepts and avoid rote learning, students are also directly involved in the process of finding knowledge so that learning is more meaningful. This is based on basic competencies in the material.

From the basic competence of the colligative properties of the solution, then indicators competency achievement are made. Based on indicators of competency achievement, it turns out that in teaching material the colligative properties of the solution cannot only use 1 learning model, so we need some learning models that are relevant to the desired competency achievement indicators. The model is used so that a learning that has been designed can make students actively involved so that students can have direct experience and make the learning meaningful for students. This is in accordance with the demands of the 2013 curriculum where chemistry learning should be carried out using a scientific process/performance skills approach where it can use discovery learning (inquiry/learning) models [11].

Learning models that can be used to actively involve students in the search for knowledge are inquiry and discovery learning models. Inquiry and discovery learning models can be divided into several levels, one of which is guided inquiry and guided discovery. The application of guided inquiry learning models is the activities of students as researchers with the guidance of teachers, who train students to be able to act as problem solvers [12]. The inquiry learning model is suitable for studying science in secondary schools because science learning is related to finding systematic order. Thus, science is not only about mastering knowledge in facts, concepts, or principles, but also about the process of discovery [13].

Discovery learning can increase student's creativity, especially on the courage and ability of

students to show different report or opinion with their classmates, students start accustomed to suggest new experiments and decompose new conclusions the observations they have made [14]. In addition to discovery learning, there is another model that can be used, namely PjBL (Project Based Learning). In this PjBL students can bring out student creativity because it is based on the principle of PjBL that is autonomous, or get freedom in implementing the learning process, choosing project content, and bringing up creative solutions [15,16]. The project-based learning model can bridge students to develop student's creativity through project-based problem-solving activities. The project based learning model is one of the excellent learning models in developing the basic skills students must possess, such as decision-making skills, creativity skills, and problem-solving skills [17].

Based on this background, the researcher will conduct a study entitled "The Development of Student Worksheet in Colligative Properties of Solution to Train Creative Thinking Skills".

METHOD

This type of research conducted in this study is a development research that is the development of student worksheets on the material properties of colligative properties to practice creative thinking skills of twelfth grade students. This research is guided by the method of research and development (R&D). This research is only limited to the stage of development studies which reach the product trial phase on a limited basis [18].

Sources of research data related to the validity of worksheet were obtained from the judgement of 3 chemist, related to practicality and effectiveness obtained from 12 high school students of twelfth grade MAN Sidoarjo students.

The steps of development are review of student worksheets, providing suggestions by filling out the study sheet. Then 3 validators who are chemist, give an assessment score in the range 1-5 according to the Likert scale on the validation sheet. The assessment of worksheet validity developed is seen from the content validity and

construct validity. The validity of worksheets is calculated using the formula:

$$\text{Validity (\%)} = \frac{\sum \text{data collection score}}{\sum \text{criteria score}} \times 100\%$$

Σ criteria score = highest item score x number of validators x number of aspects.

The results of the assessment of the validity scores that have been obtained are interpreted using the validity criteria as in Table 1 with the following score criteria.

Table 1. Criteria for Interpretation of Scores of Validity

Percentage	Criteria
1%–20%	Not Decent
21%–40%	Less Decent
41%–60%	Pretty Decent
61%–80%	Decent
81%–100%	Very Decent

[19]

Based on the score interpretation criteria table of validity, the worksheet developed can be said to be valid if in every aspect $\geq 61\%$.

After validation of the worksheets have been carried out, then the worksheets that were developed were tried out on a limited basis to 12 of MAN Sidoarjo students in twelfth grade.

Practicality data was obtained from student response questionnaire. Questionnaire responses of students using the Guttman scale assessment criteria. The Guttman scale consists of two intervals namely yes and no. On positive questions, if the answer is "yes" then the score is "1" and "no" has "0" score. As for negative questions, if the answer "yes" has a value of "0" and "no" has "1" score. The practicality of worksheet is calculated using the following formula.

Positive question:

$$\% \text{ response} = \frac{\text{number of yes answers}}{\text{number of students}} \times 100\%$$

Negative question:

$$\% \text{ response} = \frac{\text{number of no answers}}{\text{number of students}} \times 100\%$$

The results of the assessment questionnaire response scores that have been obtained are interpreted using the score criteria as in Table 2 below.

Table 2. Criteria for Interpretation of Scores

Percentage	Criteria
0%–20%	Not Good/Very Low
21%–40%	Less Good/Low

Percentage	Criteria
41%–60%	Pretty Good/Average
61%–80%	Good/High
81%–100%	Very Good/Very High

[19]

Based on the score interpretation criteria table of practicality, the worksheet developed can be said to be practical if in every aspect $\geq 61\%$.

The effectiveness data was obtained from tests of creative thinking skills and knowledge tests. Creative thinking skills tests include originality, flexibility, fluency, and elaboration. Each component of creative thinking is calculated using the following formula

$$\text{Score} = \frac{\text{score obtained}}{\text{total score}} \times 100\%$$

The percentage of each component of creative thinking is then interpreted in accordance with the following Table 2.

Based on those criteria, each component of creative thinking can be said to be successful if a percentage of $\geq 61\%$ is obtained or in the high category.

As for the analysis of individual test results, then the pretest and posttest results are analyzed through the calculation of n-gain scores with the following formula.

$$G = \frac{\text{posttest score} - \text{pretest score}}{\text{maximum score} - \text{pretest score}}$$

The normalized gain score level is categorized in three categories according to the Hake [20]. The student creative thinking skills are successful if the n-gain score is ≥ 0.3 or in average criteria.

Analysis of student knowledge test data in accordance with the rubric created. The results obtained by students are then calculated using the following formula.

$$\text{Score} = \frac{\text{score obtained}}{\text{total score}} \times 100$$

From these learning outcomes, students are said to master knowledge if learning outcomes of ≥ 77 are in accordance with the completeness criteria of the school.

As for the analysis of individual test results, then the pretest and posttest results were analyzed through the calculation of n-gain scores.

The normalized gain score level is categorized in three categories according to the Hake [20]. The student learning outcomes for knowledge are successful if the n-gain score is ≥ 0.3 or in average criteria.

RESEARCH RESULTS AND DISCUSSION

Validity of Worksheets

Development of worksheet in this material of colligative properties consists of 5 worksheets, namely first worksheet concerning decrease in vapor pressure, second worksheet increase in boiling point, third worksheet decrease in freezing point, fourth worksheet in osmotic pressure, and fifth worksheet in colligative properties of electrolyte and non-electrolyte solutions. All worksheets have a component of creative thinking. In the development of this worksheet, several different learning models were applied that were adjusted to the indicators of competency achievement after curriculum analysis and task analysis. First worksheet and fifth worksheet use the guided discovery learning model, second worksheet and third worksheet use guided inquiry, and fourth worksheet uses project based learning. From the results of the assessment conducted by three validators were categorized valid if the criteria reached $\geq 61\%$. The average validation data from the five developed worksheets are presented in Table 3.

Table 3. The Result of Worksheet Validation

No	Aspects of Criteria	P(%)	Criteria
1	Content	80.22%	Decent
2	Language	80.67%	Decent
3	Presentation	80.00%	Decent
4	Graphic	83.33%	Very Decent

The results of the validation in the table above show that the worksheet in the colligative material developed has fulfilled the validity of the content and objectives with the results obtained 80.22% with a decent category, the suitability of basic competences and indicators to be approved in the worksheet with 2013 curriculum, the suitability of the colligative properties material, in accordance with indicators, the truth of phenomena and materials that are in accordance with the worksheets, the suitability of the contents of the worksheets with the criteria for creative

skills, and worksheets are able to improve students' scientific attitudes.

The developed worksheets have also fulfilled the constructional validity based on linguistic criteria with the results obtained 80.67% in the decent category. The student worksheets use terms that are understandable, the student worksheets use clear and concise language, the student worksheet use appropriate English and Indonesian language, and the student worksheets use effective and efficient language.

The criteria for presentation with the results obtained 80.00% in the decent category, contain clarity of purpose, systematic material order, the image presentation is appropriate and accompanied by a reference, the presentation of student worksheets arouses student motivation and curiosity, encourages students to be actively involved, and is interesting.

The criteria for graphics with the results obtained 83.33% in the very decent category, interesting covers and present the contents of student worksheets, the use of font types and text sizes used to facilitate the reader using student worksheets, the harmony of the layout of text and images, as well as the use of illustrations, images, graphics, and photographs.

Practicality of Worksheets

The practicality of student worksheets was analyzed using student response questionnaire data. The student response questionnaire data for the developed worksheet has been presented in Table 4.

Table 4. Student Questionnaire Results

No	Aspects of Criteria	P(%)	Criteria
1	Content	93.33	Very Good
2	Language	91.67	Very Good
3	Presentation	91.67	Very Good
4	Graphic	97.92	Very Good

The results of the validation in the table above show that the worksheet in the colligative properties of the solution developed has fulfilled the worksheet eligibility in terms of practicality. The content criteria has 93.33% percentage, that is in very good category. The questions on content criteria questionnaire are the simplicity of worksheet material to understand, the

appropriateness of questions in student worksheet with the characteristics of creative thinking skills taught, activities in student worksheet in accordance with the material taught, student worksheet activities enhance scientific attitudes, and student worksheets provide space for students to channel ideas or ideas in solving problems based on phenomena.

Both of linguistic and presentation criteria are 91.67%, that is in very good category. The questions on linguistic criteria questionnaire are whether student worksheets use understandable terms or not and whether the student worksheets language is clear or not. The questions on presentation criteria questionnaire are the question on student worksheet are understandable, systematic material order, the student worksheets are interesting, and the student worksheets arouse students motivation and curiosity.

Graphic criteria has 97.92% percentage in very good category. The questions on graphic criteria questionnaire are interesting covers and present the contents of student worksheets, the use of font types and text sizes used to facilitate the reader using student worksheets, the harmony of the layout of text and images, and the illustrations and images of student worksheets help students to understand the concept.

The results for the content, linguistic, presentation, and graphic criteria based on the results of the validation and student questionnaire responses show that the worksheets developed are feasible to use.

Effectiveness of Student Worksheets

The effectiveness of student worksheets is evaluated from the tests of knowledge and creative thinking skills. Data on the results of knowledge during the post-test can be seen in the Table 5 below.

Table 5. Students Knowledge Test Results

No	Name	Pre-test	Post-test	n-Gain	Category
1	S1	30	80	0.7	High
2	S2	20	80	0.8	High
3	S3	50	90	0.8	High
4	S4	20	80	0.8	High
5	S5	40	90	0.8	High
6	S6	30	90	0.9	High
7	S7	30	80	0.7	High

No	Name	Pre-test	Post-test	n-Gain	Category
8	S8	30	90	0.9	High
9	S9	20	90	0.9	High
10	S10	20	90	0.9	High
11	S11	20	80	0.8	High
12	S12	20	80	0.8	High

*S = Student

Based on the results of the posttest, students have completed because the scores obtained have exceeded the completeness criteria score of ≥ 77 . Table 5 shows that the n-gain score is in 0.7-0.9, which is high category. Whereas the creative thinking skills test is presented in Table 6 below.

Table 6. Creative Thinking Skills Result

No	Aspect of Criteria	Pretest	Posttest
1	Fluency	41.67	82.64
2	Flexibility	42.22	84.45
3	Elaboration	47.22	88.89
4	Originality	47.22	90.28

Skill test assessments on the pretest and posttest use the rubric criteria. Assessment of fluency using a score of 0-3 with the provisions if the student is able to give 3 answers then he gets a score of 3, if not answering then gets a score of 0. Assessment of flexibility using a score of 0-3 with the provision if students are able to give 3 different answers then he gets a score of 3, if he doesn't answer then gets a score of 0. Assessment of elaboration uses a score of 0-3 with the provisions if the student is able to answer all questions completely and in accordance with the desired keywords then gets a score of 3, if he doesn't answer gets a score of 0. Assessment of originality uses a score of 0-3 with the provision that if a student is able to connect between variables and between experimental results with hypotheses and develop it, he gets a score of 3, if he doesn't answer then he gets a score of 0.

All of the result of pretest students are in average categories, which is in 41%–60% interval. The results of the students' creative thinking skills posttest had a percentage of the characteristics of fluency has 82.64% and were in the very high category. The percentage of the characteristics of flexibility has 84.45% and was in the very high category. The percentage of the elaboration characteristics was 88.89% and it was in the high

category. The percentage of originality characteristics was 90.28% with a very high category. Based on these results, the worksheets on the colligative properties of solution to train students' creative thinking skills that are developed reaches the effectiveness criteria.

The student worksheets on the material of the solution's colligative properties to train the creative thinking skills developed has fulfilled the feasibility in terms of validity, practicality, and effectiveness.

CLOSING

Conclusion

Based on the results and discussion related to the student worksheets on the colligative properties of the solution to train creative thinking skills can be said to be feasible because they are valid, practical, and effective. The student worksheets are valid because all of the criteria are above 61%. The average percentage of validity in content criteria is 80.22%, language criteria is 80.67%, presentation criteria is 80.00%, and graphics criteria is 83,33%. The student worksheets are practical because all of the criteria on students responses questionnaire are above 61%. The percentage of practicality in content criteria is 93.33%, language criteria is 91.67%, presentation criteria is 91.67%, and graphics criteria is 97.92%. The student worksheets are practical because the knowledge test has an average score of 85 (above minimum criteria ≥ 77) and all of creative thinking skills test result are above 61%, they have average percentage of characteristic of creative thinking on fluency is 82.64%, flexibility is 84.45%, elaboration is 88.89%, and originality is 90.28%. Thus the results of this research indicate that the developed student worksheet is valid, practical, and effective.

Suggestion

Based on the results and grading related to the student worksheet on the colligative properties of solution to train students' creative thinking skills be given the following suggestions:

1. This student worksheet were developed only at the limited product trial stage. Therefore, it

is necessary to further research up to the stage of trial use by applying the worksheets developed in classrooms or schools with more samples.

2. There is a calculation to find the value of the degree of ionization in this student worksheets. However, it is better if there are worksheets that discuss the calculation of the colligative properties of the solution developed separately.
3. Students selection for product trials of student worksheet development that uses inquiry and discovery learning models are expected for students who have not yet recieved the colligative properties of solution material, instead of finding a concept, the students might be recalling the concept already taught.

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