Improving Students' Critical Thinking Skills Through Student Worksheet Colloid Systems Based On Discovery Learning and Multiple Representations at Senior High School

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Abstract. Expansion study with the Plomp method has been carried out to produce student worksheet colloid systems based on discovery study and multiple representations to increase learners' critical thinking skills. Sampling was done by apply the cluster purposive sampling technique. Study instruments apply is the problem sheet, a problem sheet in the form of sheet validity and practicalities, about objective and about the critically thinking skills. Outcome of the study showed that the resulting student worksheet shows the validity of which is very high (k = 0, 83). The outcome of the practicality of small group learner were very high k = 0.834. In the field test, the practicality of learner was very high (k = 0.815) while the practicality by the teacher was high (k = 0.74). Hypothesis test of study outcomes shows that there is a notable diverse between the study outcomes of experimental classroom learner and control classroom learner. The outcome of the critically thinking skills of hypothesis testing showed that there are notable diverse between the critically thinking skills of learners experimental and control classrooms. In addition, the study outcome show that student worksheet has met the criteria of being practical and impactive.

1. Introduction

One offshoot of science that has a notable role in life is chemistry. What is known is that this science studies matter and its properties, changes and accompanying energy [6]. Chemistry is obtained and developed according to experiments in order to get replay to the question of what, why, and how natural event related to the structure, possession, contexture, dynamics, transformation and lively of matter. Therefore, chemistry subjects in high school learn everything about matters regarding the contexture, structure and properties, changes in the dynamics and lively of matters which implicate expertise and analysis. Chemistry can explain micro (molecular) macro event on various aspects of matter. Additionally, the chemistry was very helpful and contribute to the control of other sciences, especially as the science of mining, the science of agriculture, science of health, science fisheries and technology [5].

The study process in the 2013 curriculum is student-centered which is implemented apply a scientifical approach. Study with this method is designed so that learner actively participate form theory, laws or belief with the phase of identifying problems, formulating problems, formulating hypotheses,
collecting data, analyzing data, drawing conclusions and communicating the theory, laws or belief found [10].

Discovery Learning is an instructional model that develops active learners how to discover, investigate, so the outcome are obtained is not easily oblivious learners [10]. Study with the discovery learning method requires learner to seek and discover their own theory and belief, from excitation with direction of the teacher, so that the critically thinking process of learner can be honed. Discovery Learning models can increase scientifical skills [1], and have a notable impact on critically thinking skills of learner [11].

Discovery Learning is a study model to develop study participants practice active to discover and investigate itself, so that the outcome get will last long in the retention and not with ease oblivious learners [10]. Method of discovery is a constituent of education practice comprise instruction technique that encourage active study, road oriented, directing his own, to discover yourself, and reflective [20]. So that it can be interpreted that the detection method is the theory and study process of the teacher allowing learner to discover, direct, seek, investigate their own knowledge, attitudes and skills so as to cause changes in student behavior.

Chemistry can be described in 3 different extent of representation, macroscopically, microscopically, and symbolic [13]. Multiple representations, one way of presenting a concept at the macroscopically level, is a level that is directly observed, through real observations of event, such as changes in shape, temperature, color, pH of the solution, formation of precipitates and gases that can be investigated through experimental activities. Microscopically representation is description at the particle level, such as the movement of atoms, molecules. Symbolic representation is a representation of chemical event, apply chemical equations, chemical formulas, and symbols [9].

To understand the concept of chemistry as a whole, macroscopically, microscopically and symbolic representations must connect in a balanced manner in study. However, most teachers teach chemical theory only at one level of representation and do not teach 3 extent equally. Someone comprehension of chemistry is insistent on by his expertise, providing macroscopically to microscopically and symbolic facts [9].

Critically thinking is thinking well and reflecting on or studying other people's thought processes. Schools must teach children the right way of thinking. Then Jhon Dewey defines critically thinking as the same as speculative thinking, namely: "reliable, persistent, and careful review of a belief or form of insight that is received in the view of various points of reasons that support and conclude it. [8]"

This study is to develop student a paper listing questions based on the Discovery learning model and Multiple Representations which consists of 6 steps, where each process is followed by problems that lead: 1) Stimulation, at this phase learner are led to something that makes their doubts, later proceed without giving generality, there is a willingness to investigate. 2) Problem statement (statement / problem identification), the teacher gives learner time to identify real problems with the study material. 3) Data collection (data collection), replay problems and verify the fact of hypothesis. 4) Data processing (data processing), processing data and info get by learner by means of debriefing, observations, then explained. 5) Verification (proof), learners analyze to verify the fact of the hypothesis that has been arranged with findings of other, linked with output data that has been his editorial. 6) Generalization (draw conclusions), which concludes the common belief and be valid to all event or issue the same with proof. [17].

2. Methodology
This type of study is experimental and expansion or Research and Development (R&D) study that is planned, structured, with the aim of discovering, formularizing, rectifying, expanding, generating, trying the effectiveness of certain products the best new, impactive, streamlined, prolific, and intends [18]. The experimental pattern is Non Equivalent Control Group Posttest Only Design. Selection of the sample classroom with cluster purposive sampling which is a sampling technique with selecting classrooms (not the kind of people).
The expansion design used in this study is the Plomp model. This model consists of 3 main phases, namely: (1) initial investigation phase to get an overview of the characteristics of the product being developed so that it can be used in the study process. (2) the prototyping phase (the pattern phase) to design solutions to problems that have been identified during the initial investigation phase, and (3) the trial and study phase, is final phase in educational expansion study [16].

The formative evaluation layer, the evaluation methods used in this study are: 1) Self-evaluation or screening, which is a self-assessment of the first product design developed. 2) Expert review (expert review) which is a product assessment conducted by an expert / expert. 3) Evaluation of one - one (one to one-evaluation), products evaluation made by three learners of different skill extent. 4) Small group evaluation (small group evaluation) product assessment carried out by 6 learners with different skill extent [2]. 5) Large group trials (field tests) product assessments conducted by a group of users apply products in study [19].

The data collected in this study were: 1) Product validity in the form of validation outcome from student worksheet by validators who are experts in their fields. 2) The practicality of the product obtained from the outcome of the student worksheet trial the field regarding the practicality and implementation of the product being developed. 3) The impactiveness of the product obtained from the outcome of the student worksheet trial in the field concerning changes in student study outcomes before and after apply the product developed from the observation of student study activities.

To obtain the outcome, analysis technique used is descriptive statistical analysis. The data analysis technique of the study results can be described as follows:

2.1. Validity analysis technique

Kappa Cohen (Moment Kappa) is used to analyze the final value of the value given by the validator.

\[
Kappa \text{ Moment (} k) = \frac{P - Pe}{1 - Pe}
\]

Explanation:
K = Kappa moment that shows the validity of outcome
P = Real comparison, namely total value given by validator divided by total maximum value.
Pe = no real comparisons, namely total maximum value minus the total value given by validator divided by the total maximum value

The validity level product produced will be seen after the kappa moment calculation outcome are change into the following group in Table 1:

| Interval   | Group      |
|-----------|------------|
| 0.81 - 1.00 | Very high |
| 0.61 - 0.80 | High      |
| 0.41 - 0.60 | Low       |
| 0.01 - 0.20 | Very low  |
| <0.00      | Invalid    |

Found on criteria in Table 1 it can be resume that student worksheet is said to be valid if on average it is obtained more than 0.40.

2.2 Practicality Analysis Techniques
The practicality sheet assessment was obtained from giving problem sheets to teacher responses and student problem sheet responses which were also analyzed apply Kappa Cohen. Similar to the validation
sheet analysis, found on criteria in Table 10 it can be resume that student worksheet is said to be practical if the average is more than 0.40.

2.3 Effectiveness Analysis Techniques

2.3.1 Analysis of Student Study Outcomes Tests. Analysis of impactiveness data was get from learner’ study result evaluation sheets apply the final study test. The impactiveness of student worksheet on student study result can be known through hypothesis testing. Before testing hypotheses, the first assumption test brought, namely normality and homogeneity test with the help of SPSS software version 20.

To determine the distribution of the two groups of data (normal or not), the normality test used was the Kolmogorov-Smirnov test. To find out are both data category have homogeneous discrepancy or not, a homogeneity test is used which is used is the Levene test. The t test to prove what data is normal distributed and homogeneous. The value of meaning taken is the value for the similar variances affected.

2.3.2 Analysis of Critically Thinking Skills. Analysis of learner 'critically thinking skills data is obtained thru objective problems given to learner according to Ennis' critically thinking indicators. Student worksheet test outcome generated on learner' critically thinking skills carried out on 2 classrooms, namely the experimental classroom and the control classroom. Experimental classroom learning activities during the study process apply the student worksheet colloidal system based on discovery study and multiple representations, which have been developed, while the control classroom uses teaching materials used in schools such as textbooks. The design of the field trial practice can be illustrated in table 2 below:

| Classroom       | Treatment | Final Test |
|-----------------|-----------|------------|
| Experimentation | X         | T          |
| Control classroom | Y       | T          |

Information:
X = study by apply student worksheet colloidal system based on discovery study and multiple representations.
Y = Study without student worksheet
T = Final Test

3. Result and Discussion

3.1 Validity of student worksheet
Validity value was analyzed apply the moment kappa formula the outcome of the student worksheet validation in table 3.

| Rated Aspect          | k   | Validity |
|-----------------------|-----|----------|
| Constituent contents  | 0.80| High     |
| Construct constituent | 0.76| High     |
| Language constituent  | 0.90| Very high|
| Graphic constituent   | 0.86| Very high|
| Average               | 0.80| High     |
The outcome of colloid system student worksheet validation showed the student worksheet was valid.

3.2 Practicality of student worksheet
Overall outcome of the practicality problem sheet learner at the field test phase obtained a kappa moment of 0.815 with a very high category.

The practicality of student worksheet by teachers on the prospect of ease of use, the benefits of lesson material have a high level of practicality and prospect of study time efficiency indicate a high level of practicality. Therefore the practical outcome of student worksheet indicated the prepared student worksheet was practically used by learner and teachers for the study process the colloid system.

3.3 Effectiveness
Student worksheet can be said to be effective if it operationally provides outcome as expected [15]. In this study, the impactiveness of the student worksheet colloid system found on discovery learning with a scientifical approach is seen from study outcomes learner (cognitive aspects) and critically thinking skills of learner.

3.4 Student Study Outcomes of Learner
Analysis of study result data is determined systematically starting with knowing the contradiction scores from the experimental classroom and the control classroom, normality, homogeneity, and t-test. These two sample classrooms are based on the percentage score of learner who think critically. Critically thinking scores of learner after being treated during the study process indicate that the posttest average of experimental classroom is higher than the control classroom.

The outcome of the posttest score are used to test the hypothesis that was previously tested for normality and homogeneity. The normality test used is Kolmogorov-Smirnov.

Test outcome for the normality of experimental classroom data with sig values. 0.081 and sig. control classroom 0.199. Both classrooms have notable values > 0.05 so that the study outcomes of both classrooms are normal division.

Homogeneity test used Levene test. Homogeneity test outcome from sample classrooms with sig values. 0.766. The sample data has a notable value > 0.05, so the scores of the study outcomes of these two classrooms have homogeneous variants.

From the data obtained, it can be determined that the sample classroom can be distributed normally and has a homogeneous variant. Therefore, to do a hypothesis (t test).

From the data obtained sig. (2-tailed) of the sample classroom is 0.047 <0.05 with the distribution of Ho rejected, there are diverse the average study outcomes of learner among experimental classroom study apply the student worksheet and the control classroom not apply student worksheet.

The study result of learner who learn to use student worksheet principle on Discovery Learning with a scientifical approach and without student worksheet differ notably which have been previously reported [11]. The use of student worksheet Colloidal Systems based on Discovery Study and Multiple Representations with a scientifical approach carried out in a group study system can make learner work together in building their understanding and knowledge so that learner are easier to remember and understand. Some study shows that discovery study models can increase study outcomes [22], increase investigator skill [3] math analogy skill [14], reduce conception miss [21] and increased understanding of critical thinking concepts and skills [23].

Through problems investigating the teacher trying to make learner explain the replays to increase student understanding. While problems that implicate the use of signals, or instructions that are used to help learner replay correctly [12].

5
3.5 Outcome of Critically Thinking Skills

Critically thinking skills are seen from five aspects, namely conveying explanations easily, compiling basic skills, designing conclusions, providing further explanations, and designing strategies and tactics. The outcome of the analysis of learner' critically thinking skills in table 4.

![Table 4. Outcome of analysis of learner' critically thinking skills](image)

| Aspects of Critically Thinking Skills | % Critically Thinking Skills and their Categories |
|--------------------------------------|-------------------------------------------------|
|                                      | Parianman 1 High School | Parianman 3 High School |
|                                      | Experiment Classroom | Control Classroom | Experiment Classroom | Control Classroom |
| Provide Basic Explanations           | 71.43 | Well | 60.00 | Well | 65.71 | Well | 60.00 | Well |
| Establish the basis for making a decision | 45.71 | Enough | 45.71 | Well | 42.86 | Enough | 51.43 | Enough |
| Make a Conclusion                    | 54.29 | Enough | 37.14 | Well | 60.00 | Well | 62.86 | Well |
| Make further explanation             | 71.43 | Well | 60.00 | Well | 62.86 | Enough | 60.00 | Well |
| Set strategy and tactics             | 74.29 | Well | 60.00 | Well | 62.86 | Well | 45.71 | Well |
| Average                              | 63.43 | Well | 52.57 | Enough | 58.86 | Enough | 56.00 | Enough |

Homogeneity test, normality test and hypotheses are apply to decide the impact of apply student worksheet on critically thinking skills of learner.

Sourced on the data, for homogeneous tests the sample has a sig value. 0.426, so the scores of the study outcomes of these two classrooms have homogeneous variants because of the sig. > 0.05. As for the normality test of the experimental classroom the value of sig. 0.056, for the control classroom sig. 0.062 so value of critically thinking skills of both classrooms is normally distributed with sig. > 0.05.

From the values obtained it can be determined that the sample classroom can be normally distributed and has homogeneous variants. Therefore, proceed with doing the hypothesis (t test).

From the data get the value sig. (2-tailed) for the outcome of learner' thinking skills are 0.038 <0.05, with Ho's decision reject edit means are diverse the average outcome of student critically thinking skills between the experimental classroom study to use student worksheet and the control classroom not apply student worksheet.

Study discovery can increase learner 'reasoning, skills for critically thinking, train learner' cognitive skills to solve problem [7].

4. Conclusion

From the outcome of the study conducted, can be concluded: 1) Research conducted resulted in student worksheet on Discovery Learning based Colloid System Material and Multiple Representations to Increase Critically Thinking Skills of Classroom XI Learner of high school. 2) The outcome show that: a) In the form of the Colloid System Material Based on Discovery Study and Multiple Representations developed, it very high level of validity with a kappa moment value of 0.83. b) The developed student worksheet has a very high level of practicability from the outcome of the individual evaluation problem sheet, very high from the outcome of small group problem sheet, and high from the outcome of field test problem sheet, and has a high level of practicality from the outcome of the teacher response problem sheet. c) The impactiveness of student worksheet is seen from the comparison of the study outcomes of learner in the experimental classroom (study apply student worksheet) and control classroom (study without student worksheet). Hypothesis testing shows that a notable diverse among experimental classroom study and control classroom. d) student worksheet developed is impactful in improving critically thinking skills of experimental classroom learner higher than the control classroom.
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