Development of Student Worksheet with Conceptual Attainment Method to Improve Concepts Understanding and Science Process Skills in Equilibrium and Rotational Dynamics

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ABSTRACT

This research aims were to: (1) produce Conceptual Attainment worksheet, (2) know concepts understanding improvement, (3) know science process skills improvement. This was a development research by using 4-D models (define, design, develop, and disseminate). The development product was tested in grade XI SMA Negeri 1 Magelang, 20 students for limited test and 33 students for field test. The research results: (1) produced worksheet based on validator’s score from language structure and design PA 96.97%, appropriate learning with Conceptual Attainment method PA 95.24%, and learning to improve science process skills PA 95%, which all aspects got the best category. Almost students agreed to the worksheet with presentation 78% for limited test and 89% for field test. Concepts understanding improvement based on normalized gain (g) was 0.56 for limited test and 0.50 for field test. Science process skills improvement wasn’t significant for all the test with range 0.1-0.3.

Keywords: student worksheet, Conceptual Attainment, concept understanding, science process skills

INTRODUCTION

In 21\textsuperscript{st} century, there is competition between countries, especially in technology. Therefore, Indonesia needs to prepare human resources who capable in mastering and developing technology. Good quality education mainly in science including Physics influences to developing of technology. Based on PISA (Program for International Student Assessment), science literacy result of Indonesian students in 2012 got 64 rank from 65 countries, it was one level above Peru (Yuvita Oktasari, 2014). The result proved that science literacy including Physics concepts understanding of Indonesian students still weak.

Conceptual Attainment worksheet is one of idea to optimize Physics concepts understanding by developing learning media. Previous research revealed that Conceptual Attainment method could be used to develop and improve student concepts understanding and practice critical thinking in learning. Based on (Navdeep Kaur, 2014), Conceptual Attainment was better and more effective method in understanding Physics concept compared with conventional method. Therefore, this developed Conceptual Attainment worksheet is expected to improve student concepts understanding and science process skills.

Learning material which used in this research was Equilibrium and Rotational Dynamics. This material was chosen because it contained of classical mechanics basic concepts which applied a lot in daily life. At schools, this material was rarely presented in experimental activities. The learning usually given by mathematical equation so students just memorized the formulas and applied it to solve exercise problems. Therefore, this research will develop Conceptual Attainment worksheet for XI class in Equilibrium and Rotational Dynamics material to improve Physics concepts understanding and science process skills.

METHODS

Research Type

This was a development research using design of 4-D Models which developed by Thiagarajan and Semmel (Trianto, 2009). The research steps included: (1) define, (2) design, (3) develop, and (4) disseminate.
Developed product in this research was Conceptual Attainment worksheet to improve concepts understanding and science process skills in Equilibrium and Rotational Dynamics material.

**Time and Place of the Research**
This research had been done on January 2016. Limited test was done in XI MIA 6 and field test in XI MIA 1, SMA Negeri 1 Magelang.

**Research Subjects**
The subjects for limited test were 20 students of XI MIA 6 and for field test were 33 students of XI MIA 1.

**Procedure**
1. Define
   This step aim was to decide and define what be needed in learning. This step consisted of five basic steps:
   a. First Analysis
      The aim was to find basic problem of physics learning process which needed a new innovative learning or solution.
   b. Students Analysis
      This was analysis about student characteristics which concluded thinking skills level, activation in classroom and response to learning that given by teacher.
   c. Assignment Analysis
      This was procedure to decide contents in learning by detailing the outline of teaching material assignment from Core Competences, Basic Competences, and Indicators.
   d. Concept Analysis
      This analysis was to identify main concepts which be taught and arrange systematically some relevant concepts so it could form a mind mapping.
   e. Learning Aims Specification
      This step was to formulate learning aims based on Core Competences, Basic Competences, and Indicators which listed in the syllabus.

2. Design
   The aim was to prepare learning media. This step consisted of four basic steps:
   a. Arranging the Research Instrument
      This step started by preparing validation sheets for lecturer and teacher, student questionnaires, observation sheets of Conceptual Attainment learning, and observation sheets of science process skills. Then also arranged the data collecting instrument such as worksheet, lesson plan, pretest and posttest.
   b. Choosing Media
      Media in this developing research was Conceptual Attainment worksheet to improve concepts understanding and science process skills.
   c. Choosing Format
      The format was appropriate with Conceptual Attainment worksheet format to improve student concepts understanding and science process skills.
   d. Worksheet First Design
      It would produce worksheet draft which consisted of cover, preface, content list, mind mapping, Core Competences, Basic Competences, some experiments, and exercise problems.

3. Develop
   This aim was to produce revision worksheet based on comments, suggestions, and scoring from lecturer, teacher, limited test, and field test.
   a. Lecturer and Teacher Validation
      Conceptual attainment worksheet had to be validated by lecturer and teacher before using. Revision based on lecturer validation result would produce draft II. Validation consisted of worksheet scoring in language structure and design, appropriate learning with Conceptual Attainment method, and appropriate learning to improve science process skills. Second validation was done by teacher. Through this validation produced draft III.
   b. Limited Test
      Worksheet as the learning product and supporting instrument such as lesson plan, pretest posttest, and student questionnaire which be produced from draft III revision would be tested in small group (limited). Suggestions, corrections and revisions from limited test would be used as revision for bigger group (field test).
   c. Field Test
      The aim of this test was to know worksheet feasibility and learning method effectiveness in bigger group. Revision result based on field test and student questionnaire would produce final product.

4. Disseminate
   This step aim was to share the development product in bigger group than the field test, such as other classes, other schools, or other teachers.
Data, Instruments, and Technic of Collecting Data

Instruments which used in this research were learning instrument and data collecting instrument.

1. Learning Instrument
   a. Lesson Plan
      Lesson plan was used as guidelines for teacher in learning process so the materials which given were appropriate with learning aims. This was validated by lecturer and teacher so it could be appropriate with learning to improve concepts understanding and science process skills.
   b. Conceptual Attainment Worksheet
      This worksheet was used in learning process. The contents were expected to improve student concepts understanding and science process skills.

2. Data Collecting Instrument
   a. Observation Sheets of Learning Process
      This observation sheets were made to determine student first condition in learning before giving treatment, which concluded level thinking skills, activation in classroom and response to learning that given by the teacher. Through this observation result could be developed learning instrument which be appropriate with students condition.
   b. Validation Questionnaire
      This questionnaire was used to get worksheet feasibility data in language structure and design, appropriate learning with Conceptual Attainment method, and appropriate learning to improve science process skills. Furthermore, it was used to get lesson plan feasibility data in appropriate learning to improve concepts understanding and science process skills.
   c. Student Responses Questionnaire
      This questionnaire consisted of positive and negative statements which be arranged randomly to know student responses of Conceptual Attainment worksheet.
   d. Pretest and Posttest
      This instruments were used to measure student cognitive ability after using Conceptual Attainment worksheet.
   e. Observation Sheets of Science Process Skills
      This observation sheets were used to know the improvement of science process skills for each students when using Conceptual Attainment worksheet.

Data Analysis Technic

Analysis data concluded learning media feasibility from lecturer and teacher scoring, instrument reliability, student responses questionnaire, pretest posttest data, and observation result of science process skills.

1. Learning Media Feasibility from Lecturer and Teacher Scoring
   a. Calculating average score from each assessment component aspects with formula:

   \[
   x = \frac{\sum x}{n}
   \]  

   Note:

   \[
   x = \text{Average score} \\
   n = \text{Total assessors} \\
   \sum x = \text{Score total for each assessment aspects}
   \]

2. Instrument Reliability
   Instrument reliability calculation used Percentage of Agreement. The formula was:

   \[
   \text{Percentage Agreement} = \left(1 - \frac{A - B}{A + B}\right) \times 100\% 
   \]  

   Note:

   \[
   A = \text{high score} \\
   B = \text{low score}
   \]

   Good instrument happen when reliability coefficient more than or equal with 0.75 or 75% (Borich, 1994).

3. Student Responses Questionnaire
   Analysis steps of student responses questionnaire were:
   a. Changing positive and negative statement scale into 1-4 scale, for positive statement: strongly disagree = 1, disagree = 2, agree = 3, strongly agree = 4, and for
negative statement: strongly disagree = 4, disagree = 3, agree = 2, strongly agree = 1.
b. Discarding unreliable scale between positive and negative statement from each students in same aspect.
c. Calculating total students who answer in every aspects from scale 4 until 1.
d. Calculating total students percentage (%) who answer in every scale (from 4 until 1) for all aspects.

3. Pretest Posttest Data

Pretest posttest data in this research was used to find the improvement of student concepts understanding. It was expressed by the value of gain. Normalized gain \((g)\) was used to know the gain of each students.

\[
(g) = \frac{\sum_{s}^{m} s - \sum_{-p}^{s} s}{m}
\]  

(3)

Then the calculation result of normalized gain was converted into normalized gain criteria:

<table>
<thead>
<tr>
<th>Standard Gain Score ((g))</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.70 &lt; ((g))</td>
<td>High</td>
</tr>
<tr>
<td>0.30 (\leq) ((g)) (\leq 0.70)</td>
<td>Medium</td>
</tr>
<tr>
<td>((g)) &lt; 0.30</td>
<td>Low</td>
</tr>
</tbody>
</table>

(Richard R. Hake, 1999)

4. Observation Result of Science Process Skills

Steps to analyze the observation result of science process skills were:
a. Calculating average score between two observers.
b. Summing and averaging each students score in every science process skill aspects.
c. Changing student average quantitative score to qualitative score with five scales. Conversion criteria of the score can be seen on Table 1.
d. Calculating average score for each science process skills aspects in experiment 1, 2, 3, 4, 5, and 6.
e. Calculating science process skill improvement by using normalized gain \((g)\).
f. Grouping the gain score to high, medium, or low. Normalized gain criteria can be seen on Table 2.
g. Calculating the reliability of each aspects in science process skills observation sheets.

RESULTS AND DISCUSSION

1. Worksheet Validity Result

Validation result was used to know the worksheet feasibility. Quantitative score as the result of validation then converted to qualitative category for each aspects. Worksheet quality was known from lecturer and teacher average score.
a. Worksheet Validation by Lecturer
Lecturer score result in language structure and design 32, appropriate learning with Conceptual Attainment method 11, and learning to improve science process skills 21, which all aspects got the best category.
b. Worksheet Validation by Teacher
Teacher score result in language structure and design 34, appropriate learning with Conceptual Attainment method 10, and learning to improve science process skills 19, two aspects got the best category and for appropriate learning with Conceptual Attainment method just got good category.

2. Lesson Plan Validity Result

Validation aspects consisted of lesson plan identity, Core Competences, Basic Competences, learning indicators, learning material, learning process, student assessment system, lesson plan language, media/instrument, language, and learning references. This validation result got one enough category, two good categories, and five best categories, which can be seen below:

<table>
<thead>
<tr>
<th>No</th>
<th>Aspects</th>
<th>Average Quantitative Score</th>
<th>Qualitative Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Identity</td>
<td>3</td>
<td>Very Good</td>
</tr>
<tr>
<td>2</td>
<td>Core Competences and Basic Competences</td>
<td>3</td>
<td>Very Good</td>
</tr>
<tr>
<td>3</td>
<td>Learning Indicators</td>
<td>3</td>
<td>Very Good</td>
</tr>
<tr>
<td>4</td>
<td>Learning Material</td>
<td>2.5</td>
<td>Good</td>
</tr>
<tr>
<td>5</td>
<td>Learning Process</td>
<td>3</td>
<td>Very Good</td>
</tr>
<tr>
<td>6</td>
<td>Assessment</td>
<td>3</td>
<td>Very Good</td>
</tr>
<tr>
<td>7</td>
<td>Language</td>
<td>2</td>
<td>Enough</td>
</tr>
<tr>
<td>8</td>
<td>Media/instrument, language and learning</td>
<td>2.5</td>
<td>Good</td>
</tr>
<tr>
<td></td>
<td>references</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Lesson plan reliability using Percentage of Agreement:
Table 4. Lesson Plan Reliability

<table>
<thead>
<tr>
<th>No</th>
<th>Aspects</th>
<th>PA (%)</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Identity</td>
<td>100</td>
<td>Reliable</td>
</tr>
<tr>
<td>2</td>
<td>Core Competences and Basic</td>
<td>100</td>
<td>Reliable</td>
</tr>
<tr>
<td></td>
<td>Competences</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Learning Indicators</td>
<td>100</td>
<td>Reliable</td>
</tr>
<tr>
<td>4</td>
<td>Learning Material</td>
<td>80</td>
<td>Reliable</td>
</tr>
<tr>
<td>5</td>
<td>Learning Process</td>
<td>100</td>
<td>Reliable</td>
</tr>
<tr>
<td>6</td>
<td>Assessment</td>
<td>100</td>
<td>Reliable</td>
</tr>
<tr>
<td>7</td>
<td>Language</td>
<td>100</td>
<td>Reliable</td>
</tr>
<tr>
<td>8</td>
<td>Media/instrument, language and</td>
<td>80</td>
<td>Reliable</td>
</tr>
<tr>
<td></td>
<td>learning references</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. Development Test

Second revision worksheet was used as product development test. The test was given to XI class students SMA Negeri 1 Magelang. There were two types of test, limited test and field test. Each group test consisted of 3 meetings, at first meeting students solved pretest problems and did experiment 1 and 2, at second meeting students did experiment 3, 4, and 5, and the last meeting students did experiment 6 and solved posttest problems.

a. Limited Test Result
1) Cognitive Assessment Result
Cognitive assessment from pretest and posttest result was used to know the improvement of student concepts understanding. Data for cognitive assessment result of limited test:

Table 5. Pretest and Posttest Result

<table>
<thead>
<tr>
<th>Pretest Score Average</th>
<th>SD</th>
<th>Posttest Score Average</th>
<th>SD</th>
<th>Average Gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>39</td>
<td>10.90</td>
<td>74</td>
<td>8.83</td>
<td>0.56</td>
</tr>
</tbody>
</table>

Based on calculation, average gain for limited test class was 0.56 or in medium category. If maximal improvement is 100%, so this improvement of student concepts understanding had been significant because more than 50%.

2) Observation Result of Science Process Skills
Science process skills data was gotten from observation to student as long as using the worksheet. Diagram of science process skills in limited test:

Figure 1. Science Process Skills Diagram

The average improvement each science process skills aspects from experiment 1 until 6:

Figure 2. Gain Diagram of Science Process Skills

Reliability of science process skill aspects in limited test:

Table 6. Reliability of Science Process Skill Aspects

<table>
<thead>
<tr>
<th>No</th>
<th>Aspect</th>
<th>PA (%)</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Observing</td>
<td>98.1</td>
<td>Reliable</td>
</tr>
<tr>
<td>2</td>
<td>Making Hypotheses</td>
<td>98.9</td>
<td>Reliable</td>
</tr>
<tr>
<td>3</td>
<td>Doing Experiment</td>
<td>98.8</td>
<td>Reliable</td>
</tr>
<tr>
<td>4</td>
<td>Classifying Data</td>
<td>99.3</td>
<td>Reliable</td>
</tr>
<tr>
<td>5</td>
<td>Interpreting Data Analysis</td>
<td>98.0</td>
<td>Reliable</td>
</tr>
<tr>
<td>6</td>
<td>Summarizing</td>
<td>99.0</td>
<td>Reliable</td>
</tr>
<tr>
<td>7</td>
<td>Communicating</td>
<td>98.5</td>
<td>Reliable</td>
</tr>
</tbody>
</table>
3) Student Questionnaire Result

It was an assessment result for the developed worksheet. Student respond propensity to all worksheet assessment aspects can be seen at pie diagram:

![Pie Diagram of Student Questionnaire Result](image)

**Figure 3.** Pie Diagram of Student Questionnaire Result

Percentage of student who strongly agree to worksheet in limited test was 6%, agree 78%, disagree 15%, and strongly disagree 0%. Student response propensity to the developed worksheet was agree with percentage 78%, which meant that Conceptual Attainment worksheet was proper to be used in learning process.

b. Field Test Result

1) Cognitive Assessments Result

Pretest and posttest result in field test was:

<table>
<thead>
<tr>
<th></th>
<th>Pretest Score</th>
<th>Posttest Score</th>
<th>Average Gain</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average</td>
<td>SD</td>
<td>SD</td>
</tr>
<tr>
<td></td>
<td>42</td>
<td>12.27</td>
<td>71</td>
</tr>
</tbody>
</table>

Based on calculation, average gain for field test class was 0.50 or in medium category. It meant that Conceptual Attainment worksheet can be used to improve student concepts understanding although it haven’t improved into high category yet.

2) Observation Result of Science Process Skills

Science process skills result of students in field test can be seen at diagram below:

![Science Process Skills Diagram](image)

**Figure 4.** Science Process Skills Diagram

The average improvement each science process skills aspects from experiment 1 until 6 based on normalized gain (g):

![Gain Diagram of Science Process Skills](image)

**Figure 5.** Gain Diagram of Science Process Skills

The diagram explained that 6 science process skills aspects improved although in low category and just an aspect got medium category, which was communicating aspect with average gain (g) 0.3. Low category improvement was on observation and classify data to table aspect with average gain 0.1. This meant that Conceptual Attainment worksheet could be used to improve science process skills of students although it doesn’t significant with range from 0.1-0.3.

Reliability of science process skill aspects in limited test:

<table>
<thead>
<tr>
<th>No</th>
<th>Aspect</th>
<th>PA (%)</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Observing</td>
<td>98.3</td>
<td>Reliable</td>
</tr>
<tr>
<td>2</td>
<td>Making Hypotheses</td>
<td>99.2</td>
<td>Reliable</td>
</tr>
<tr>
<td>3</td>
<td>Doing Experiment</td>
<td>98.6</td>
<td>Reliable</td>
</tr>
<tr>
<td>4</td>
<td>Classifying Data</td>
<td>98.9</td>
<td>Reliable</td>
</tr>
<tr>
<td>5</td>
<td>Interpreting Data Analysis</td>
<td>98.3</td>
<td>Reliable</td>
</tr>
<tr>
<td>6</td>
<td>Summarizing</td>
<td>98.8</td>
<td>Reliable</td>
</tr>
<tr>
<td>7</td>
<td>Communicating</td>
<td>98.1</td>
<td>Reliable</td>
</tr>
</tbody>
</table>
3) Student Questionnaire Result

Student response propensity to all assessment aspects of the worksheet can be known at pie diagram below:

![Pie Diagram of Student Questionnaire Result](image)

**Figure 6.** Pie Diagram of Student Questionnaire Result

Percentage of student who strongly agree to worksheet in field test was 7%, agree 89%, disagree 4%, and strongly disagree 0%. Student respond propensity to the developed worksheet was agree with percentage 89%, which meant that Conceptual Attainment worksheet was proper to be used in learning process.

**CONCLUSION**

Based on results and discussion, it can be concluded that:

1. Conceptual Attainment worksheet was proper to be used based on Percentage Agreement score in language structure and design 96.97%, appropriate learning with Conceptual Attainment method 95.24%, and learning to increase science process skills 95%, which all aspects got the best category. Almost students agreed to the worksheet with presentation 78% for limited test and 89% for field test.
2. Concepts understanding improvement based on normalized gain (g) was 0.56 for limited test and 0.50 for field test, which both of them got medium category.
3. Science process skills improvement wasn’t significant for all the test with range 0.1-0.3.

**BIBLIOGRAPHY**


