



CONCEPT ATTAINMENT WORKSHEET TO ENHANCE CONCEPT KNOWLEDGE AND SCIENCE PROCESS SKILLS IN PHYSICS INSTRUCTION

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ABSTRACT

This research aims to: (1) produce conceptual attainment worksheet; (2) know concept understanding improvement; and (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 of SMA Negeri 1 Magelang with 20 students for limited test and 33 students for field test. The research 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%, in which all aspects got the best category. Almost students agreed to the worksheet with presentation 78% for limited test and 89% for field test. Conceptual understanding improvement based on normalized gain was 0.56 for limited test and 0.50 for field test. The improvement of science process skills wasn't significant for all the test with range 0.1-0.3.

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Keywords: student worksheet; conceptual attainment; science process skills

INTRODUCTION

Science included physics is a study to understand about nature. There are four dimensions of science, as a way of thinking, a way of investigating, body of knowledge, and interaction with technology and society (Chiappetta & Koballa, 2010). One of the challenges of 21st century is competition between countries, especially in technology. Therefore, Indonesia needs to prepare human resources who capable in mastering not only the technology which needed but also all the 21st century skills to ensure the competitive in globalization era, such as skills for life and career, learning and innovation skills, and for sure information, media, and technology skills (Trilling & Fadel, 2009).

Good quality education mainly in science including Physics is expected to solve the 21st century challenges. However, based on PISA (Program for International Student Assessment), science literacy result of Indonesian students in 2012 got rank of 64 from 65 countries, it was one level above Peru (Oktarisa, 2016). The result proved that science literacy of Indonesian students are still weak. So it should be increase by how the Physics exactly should be learned.

Learning of science in 21st century is focused on investigation method through inquiry process. A learning strategy that using structure of inquiry process is conceptual attainment (Jones & Hilaire, 2014). conceptual attainment is a learning model to help student easily understand about concept. This model applicable from pre-kindergarten to higher education because included of critical inquiry, reasoning skills, and inductive thinking process (Wenno et al., 2016;

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McDonald, 2015). Conceptual attainment is designed to classify objects or events as same as the scientific procedures (Mohan, 2007). Through conceptual attainment model, students compare and contrast examples that contain concept attributes with examples that do not contain. By observing, students discuss and identify the attributes until they develop a concept definition.

Conceptual attainment teaching plan consist of identifying topic, deciding learning aims, choosing examples and non-examples, arranging examples and non-examples (Eggen, 2012). Based on (Kaur, 2014; Kumar & Mathur, 2013; Anjum, 2014), conceptual attainment was better and more effective method in understanding physics concept compared with conventional or traditional method. Therefore, one of idea to learn physics more effectively is by implementing that conceptual attainment model to make a learning-media, such as worksheet which expected to increase not only physics concept understanding but also science process skills. The common difficulty of learning physics (Hung & Jonassen, 2006) is the lack of concept understanding. Kurniawan (2013) stated that to get concept understanding, students required to learn more active. Active and directly learning activity, students would get the concept in long term memory that very helpful for them.

Process skills also needed to get the learning comprehension, which means the whole of concept understanding. Science process skills is main purpose of science concept. This skills include to the scientific inquiry which also support the 21st century learning of science (Chiappetta & Koballa, 2010). Concept understanding and psychomotor skills were related each other. Real activity was important in creating the link of life, enabling students to more understand the lesson, getting knowledge, and developing psychomotor skills that included of observation, measurement, classification, data recording, creating hypotheses, using data and gaining the creating

ability, changing and controlling variables, and conducting scientific experiments (Sumarni, et al., 2016). Then, science process skills consist of basic and integrated skills. Basic science process skills consist of observing, classifying, communicating, using time and space relation, measuring and using number, predicting, and inferring. Integrated science process skills consist of defining operationally, controlling variables, interpreting data, hypothesizing, and experimenting (Turiman et al., 2012; Karamustafaoglu, 2011).

Learning material in this study 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 to solve exercise problems. Therefore, this study will develop conceptual attainment worksheet for XI class in materials of 'Equilibrium and Rotational Dynamics' to improve physics concept understanding and science process skills.

METHODS

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 concept understanding and science process skills in Equilibrium and Rotational Dynamics.

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. The subjects for limited test were 20 students of XI MIA 6 and for field test were 33 students of XI MIA 1. The procedure of conducting this research can be seen on Table 1.

Table 1. Procedure of Conducting The Research

Procedure	Steps
<p>1. Define This step aim was to decide and define what be needed in learning.</p>	<p>a. First Analysis The aim was to find basic problem of physics learning process which needed a new innovative learning or solution.</p> <p>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.</p> <p>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.</p>

Procedure	Steps
	<p>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.</p> <p>e. Learning Aims Specification This step was to formulate learning aims based on Core Competences, Basic Competences, and Indicators which listed in the syllabus.</p>
<p>2. Design The aim was to prepare learning media.</p>	<p>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.</p> <p>b. Choosing Media Media in this developing research was Conceptual Attainment worksheet to improve concept understanding and science process skills.</p> <p>c. Choosing Format The format was appropriate with Conceptual Attainment worksheet format to improve student concept understanding and science process skills.</p> <p>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.</p>
<p>3. Develop This aim was to produce revision worksheet based on comments, suggestions, and scoring from lecturer, teacher, limited test, and field test.</p>	<p>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.</p> <p>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).</p> <p>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.</p>
<p>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. Instruments which used in this research were learning instrument and data collecting instrument.</p>	<p>1. Learning Instrument</p> <p>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 concept understanding and science process skills.</p> <p>b. Conceptual Attainment Worksheet This worksheet was used in learning process. The contents were expected to improve student concept understanding and science process skills.</p>

Procedure	Steps
	<p>2. Data Collecting Instrument</p> <p>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.</p> <p>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 concept understanding and science process skills.</p> <p>c. Student Responses Questionnaire This questionnaire consisted of positive and negative statements which be arranged randomly to know student responses of Conceptual Attainment worksheet.</p> <p>d. Pre-test and Post-test This instruments were used to measure student cognitive ability after using Conceptual Attainment worksheet.</p> <p>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.</p>

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:

$$\bar{x} = \frac{\sum x}{n}$$

Notes:

\bar{x} : Average score

n : Total assessors

$\sum x$: Score total for each assessment aspects

b. Converting score to five grades scale

1. Calculating ideal average score (\bar{X}_i)
2. Calculating ideal standard deviation (sb_i)
3. Determining assessment criteria:

Table 2. Ideal Assessment Criteria

Quantitative Scores Range	Category
$\bar{X}_i + 1.8sb_i < X$	Very Good
$\bar{X}_i + 0.6sb_i < X \leq \bar{X}_i + 1.8sb_i$	Good
$\bar{X}_i - 0.6sb_i < X \leq \bar{X}_i + 0.6sb_i$	Enough
$\bar{X}_i - 1.8sb_i < X \leq \bar{X}_i - 0.6sb_i$	Less
$X \leq \bar{X}_i - 1.8sb_i$	Very Less

(Widoyoko, 2009)

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 : High score

B : 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; and (d) Calculating total students percentage (%) who answer in every scale (from 4 until 1) for all aspects.

4. Pretest Posttest Data

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

$$(g) = \frac{\text{posttest score} - \text{pretest score}}{\text{maximum score} - \text{pretest score}}$$

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

Table 3. Normalized Gain Interpretation

Standard Gain Score (g)	Criteria
$0.70 < (g)$	High
$0.30 \leq (g) \leq 0.70$	Medium
$(g) < 0.30$	Low

(Hake, 1999)

5. 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 2; (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; (f)

Grouping the gain score to high, medium, or low. Normalized gain criteria can be seen on Table 3; (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 in Table 4.

Table 4. Lesson Plan Validity by Lecturer and Teacher

Aspects	Average Quantitative Score	Qualitative Score
Identity	3	Very Good
Core Competences and Basic Competences	3	Very Good
Learning Indicators	3	Very Good
Learning Material	2.5	Good
Learning Process	3	Very Good

Assessment	3	Very Good
Language	2	Enough
Media/instrument, language and learning references	2.5	Good

Based on the results of this study, the reliability using Percentage of Agreement of lesson plan can be seen on Table 5.

Table 5. Lesson Plan Reliability

Aspects	PA (%)	Criteria
Identity	100	Reliable
Core Competences and Basic Competences	100	Reliable
Learning Indicators	100	Reliable
Learning Material	80	Reliable
Learning Process	100	Reliable
Assessment	100	Reliable
Language	100	Reliable
Media/instrument, language and learning references	80	Reliable

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 concept understanding. Data for cognitive assessment result of limited test:

Table 6. Pretest and Posttest Result

Pretest Score		Posttest Score		Average Gain
Average	SD	Average	SD	
39	10.90	74	8.83	0.56 (medium category)

From the calculation on Table 6, average gain for limited test class was 0.56 or in medium category. If maximal improvement is 100%, so this improvement of student concept understanding had been significant because more than 50%.

Atmojo (2012) stated that conceptual understanding would be better if the students involved actively in the learning process. The improvement would be better than the students who passive or just listening to the teacher explanation. Based on the study of (Hussain & Akhtar, 2013; Ates & Eryilmaz, 2011; Jones et al., 2003), active learning that included student learning interaction would produce significant result of student achievement.

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.

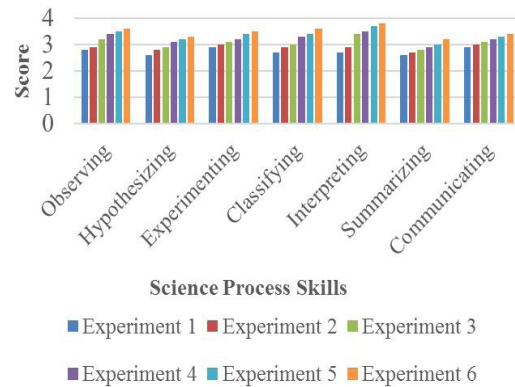


Figure 1. Science Process Skills Diagram

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

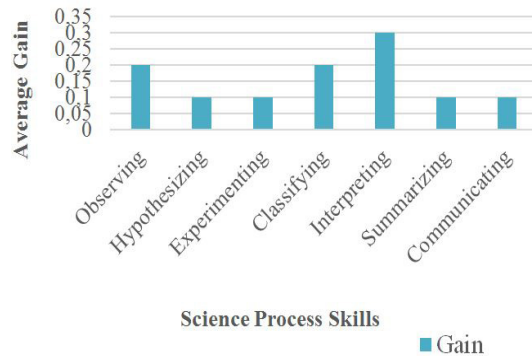


Figure 2. Gain Diagram of Science Process Skills

From Figure 2, the lowest aspects were seen on hypothesizing, experimenting, summarizing, and communicating. Based on the study of (Hodosyova et al., 2014), from three science process skills: hypothesizing, interpreting, and summarizing, the hypothesizing aspect got the lowest score (33%) because of the limitation in process of collecting data. In this study, hypothesizing aspect also got the lowest score of average gain 0.1 but the score was same with experimenting, summarizing, and communicating. Reliability of science process skill aspects in limited test can be seen on Table 7.

Table 7. Reliability of Science Process Skill Aspects

Aspect	PA (%)	Criteria
Observing	98.1	Reliable
Making Hypotheses	98.9	Reliable
Doing Experiment	98.8	Reliable
Classifying Data	99.3	Reliable
Interpreting Data	98.0	Reliable
Summarizing	99.0	Reliable
Communicating	98.5	Reliable

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:

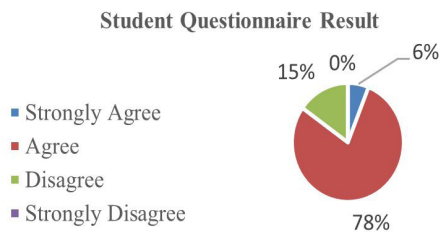


Figure 3. Pie Diagram of Student Questionnaire Result

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

The result of pretest and posttest in field test can be seen on Table 8.

Table 8. Pretest and Posttest Result

Pretest Score		Posttest Score		Average Gain
Average	SD	Average	SD	
42	12.27	71	11.09	0.50 (medium category)

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 concept understanding although it haven't improved into high category.

2. Observation Result of Science Process Skills

Science process skills result of students in field test can be seen at Figure 4:

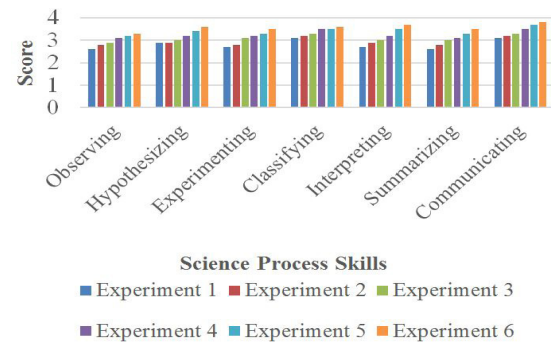


Figure 4. Science Process Skills Diagram

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

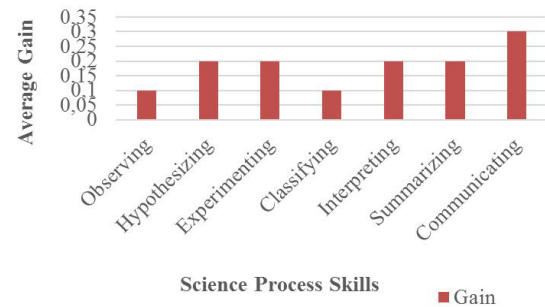


Figure 5. Gain Diagram of Science Process Skills

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 imp-

rove science process skills of students although it didn't significant with range from 0.1-0.3. Based on the study of (Ozlem & Cakiroglu, 2011), student attitude didn't get significant result if the treatment just given as long as short period (3 weeks). This study also conducted as long as 3 meeting (2 weeks) so the improvement of science process skills didn't have significant result. The result would be significant if conducted more than 12-13 weeks.

Reliability of science process skill aspects in limited test can be seen on Table 9.

Table 9. Reliability of Science Process Skill Aspects

No	Aspect	PA (%)	Criteria
1	Observing	98.3	Reliable
2	Making Hypotheses	99.2	Reliable
3	Doing Experiment	98.6	Reliable
4	Classifying Data	98.9	Reliable
5	Interpreting Data	98.3	Reliable
6	Summarizing	98.8	Reliable
7	Communicating	98.1	Reliable

3. Student Questionnaire Result

Student response propensity to all assessment aspects of the worksheet can be seen on Figure 6.

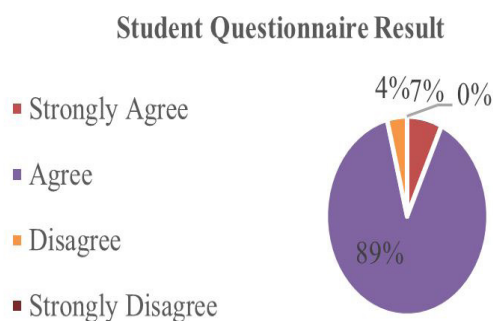


Figure 6. Pie Diagram of Student Questionnaire Result

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) Concept 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.

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