OSW-CTST: A Developing Study of Oscillation and Sound Wave-Critical Thinking Skills Test

S R Hidayat, A H Setyadin, H Hermawan, S S Bhakti, N J Fratiwi, A Zulfikar, M H Muhaimin, F N Sholihat, M G Purwanto, D S Jubaedah, S A Amalia, N F Afif, I Kaniawati, E Suhendi, D T Chandra, P Siahaan, and A Samsudin

Departemen Pendidikan Fisika, Universitas Pendidikan Indonesia, Bandung, Indonesia

E-mail: syarif.rokhmat.h@student.upi.edu

Abstract. Nowadays, the main goal of education in the world is required to promote critical thinking skills for junior high school students in term of being better future-live. To analyze students’ critical thinking skills, we developed critical thinking test items on Oscillation and Sound Wave named Oscillation and Sound Wave-Critical Thinking Skills Test (OSW-CTST). The aim of this study is to develop the test of critical thinking skills through the development model. The development model which is utilized is ADDIE (Analyze, Design, Development, Implementation, and Evaluation). The OSW-CTST items have already been developed through Ennis’s indicators of critical thinking skills. The critical thinking indicators which were utilized in this study are: (1) identifying/formulating the criteria of possible answers, (2) identifying reasons or premises, (3) explaining the hypotheses, (4) defining the scientific terms and considering the definitions, and (5) choosing the possible criteria as a solution to the problems. On validity test to experts, the OSW-CTST get the score greater than 4.3 of 5. The test items difficulty, distinguishing power, validity, and reliability value and criteria are good enough. In conclusion, critical thinking skills test on oscillation and sound wave could be well developed though ADDIE model and it could measure the junior high school students’ critical thinking skills.

1. Introduction

Today, in the 21st century, science and technology grow quickly. The grows of science and technology impact on the quality of human life, for example in science education area [1]. In this century, the goal of science education is to inform persons who can adjust to different situation, imagine flexible, query, be original, imagine critical and multi-directional, solve problems, utilize the science procedure skills whereas solving the troubles, regard as the humankind from the point of view of a scientist, respect the people, and tolerate the ideas [2]. One of these aims is to educate individuals who can think critically.

The critical thinking skills (CTS) is a judgment technique where the discriminations, statements, all kinds of information offered were tested and evaluated, their unlike parts and answers were arguing, and which intends to get to a conclusion in time. CTS refers toward to a skill to examine information, to resolve the worth of information gathered and then to know it in solve the problems [3, 4]. It needs complex-level thinking; involves the process of investigation, evaluation, rationality, and suggestion[5].

Even if the CTS development is the main aim of science education, tolerable importance is not given to the measurement of CTS in specific science domains such as physics [6]. The advance of CTS is extensively claimed in place of a main goal of science instruction [6, 7]. CTS includes the skill to draw lawful inferences, classify relations, examine chances, make guesses and rational decisions, and resolve
intricate problems [8]. Greatest earlier efforts to address the challenge of CTS development took place in a context in which general CT skills were educated unconnectedly from systematic issue substance areas.

This aim of this study is developing a test instrument that could measure students’ critical thinking skills on oscillation and sound wave material called Oscillation and Sound Wave Critical Thinking Skill Test (OSW-CTST). OSW-CTST is developed using five phases in ADDIE (Analyze, Design, Development, Implementation, and Evaluation) model. One of concept in OSW-CTST is oscillation concept. Oscillation is back and forth movement of an object. The example of oscillation movement is pendulum oscillation. The period of a pendulum oscillation is given by the following equation.

$$T = 2\pi \sqrt{\frac{l}{g}}$$

(1)

2. Research methodology
The method that used in this study is research and development method ADDIE (analyze, design, development implementation, and evaluation) [9, 10]. In analyze phase, the procedure that used is to analyze the critical thinking indicator based on Ennis’ critical thinking aspect, the curriculum that used and concept deepness. On design and development phase, OSW-CTST is created and developed based on the result of analyzing phase. The OSW-CTST was judged by the experts. After that, it was implemented to measure students’ CT skill. Last, the OSW-CTST and students’ critical thinking score is evaluated to get the result and conclusion of this study.

3. Result and discussion
The OSW-CTST is developed using ADDIE method. The phases of this study are explained below.

3.1. Analyze Phase
At analyze phase, the procedure that used is to analyze the critical thinking indicator based on Ennis’ critical thinking aspect [8], the curriculum that used and concept deepness. The critical thinking indicators that utilized described in Table 1.

| Critical Thinking Domain          | Indicator                                           |
|----------------------------------|-----------------------------------------------------|
| Basic Clarification              | identifying/formulating the criteria of possible answers |
| Bases for a Decision             | identifying reasons or premises                      |
| Inference                        | explaining the hypotheses                            |
| Advanced Clarification           | defining the scientific terms and considering the definitions |
| Supposition and Integration      | choosing the possible criteria as a solution to the problems |

3.2. Design Phase. Based on analyze of concept deepness, the oscillation and sound wave concept for junior high school student load some sub concepts, there are oscillation, wave, and sound wave [11]. These concepts are explained below.

3.2.1. Oscillation. Oscillation is back and forth movement of an object. The example of oscillation movement is pendulum oscillation. The period of pendulum oscillation is given by equation 1.

3.2.2. Wave. Wave is energy transfer in oscillation form that travels through a medium. The travel speed of a wave is given by following equation 2.

$$v = \lambda f$$

where $v$ is speed, $\lambda$ is wavelength, and $f$ is wave frequency.
3.2.3. Sound Wave
The sound wave is produced by object oscillation. Sound wave divided to three kinds based on the limit of human hearing sound frequency. Those are infrasound, audio sound, and ultrasound. The human can only hear the audio sound that has the frequency range between 20 Hz to 20 kHz. Sound with the frequency below 20 Hz named as infrasound and sound with the frequency 20 kHz named as ultrasound. The application example of audio sound is on music, like the guitar. On guitar, sound frequency produced by guitar strings is depended to string tension (F), length of the oscillated string (L), and type of string that used (µ). The relation of the properties is given by equation 3 below.

\[ f = \frac{1}{2L} \sqrt{\frac{F}{\mu}} \]  

(3)

3.3. Development Phase
The instrument item is formed in the development phase. Each item on the OSW-CTST is formed based on CTS indicator and concept description on the design phase. The distribution of instrument items to each CTS indicator and concept description is given in Table 2.

| Indicator                                           | Oscillation Concept | Wave Concept | Sound Wave Concept |
|-----------------------------------------------------|---------------------|--------------|--------------------|
| Identifying/formulating the criteria of possible answers | 1                    | 1            | 1                  |
| Identifying reasons or premises                     | 1                    | 1            | 1                  |
| Explaining the hypotheses                            | 1                    | 1            | 1                  |
| Defining the scientific terms and considering the definitions | 1                    | 1            | 1                  |
| Choosing the possible criteria as a solution to the problems | 1                    | 1            | 1                  |

The example of critical thinking skills test item that has been created is shown in Figure 1.

A pendulum is used to rotate clock machine as shown by following picture.

The thing that could be done to adjust period of pendulum is ….  
A. set the pendulum mass  
B. adjust density of pendulum  
C. set oscillation amplitude  
D. set length of pendulum rod

Figure 1. Example of oscillation and sound wave critical thinking test item that was designed and developed.
After the instrument was created, the instrument items are judged by the experts. The expert judgment score is used $1 - 5$ scales. The result of experts’ judgment to the instrument is shown in Table 3.

Table 3. Expert judgments on instrument

| Judgement Criteria                      | Expert 1 | Expert 2 | Expert 3 | Average |
|----------------------------------------|----------|----------|----------|---------|
| Concept suitability with CT indicator  | 4.0      | 5.0      | 4.0      | 4.3     |
| Test item construction                 | 4.5      | 4.8      | 4.4      | 4.5     |
| The use of language                    | 4.3      | 5.0      | 4.3      | 4.5     |

3.4. Implementation Phase

After the design phase of instrument done, the next phase is implementation. On implementation phase, the instrument test is tried to measure student’s CT skill sample to get its validity and reliability. Subjects who used the trial of these items is the 8th-grade students who have been studying the oscillation, wave, and Soundwave material in one of the junior high school in Bandung city.

Figure 2. Students fill out the answer test in instrument implementation phase

Instrument’s difficulty, distinguishing power, and validity test is used to measure test instrument eligibility. The result value is compared to validity table [12]. The result is given by Table 4.

Table 4. The difficulty, distinguishing power, and validity of test items

| Item number | Difficulty | Distinguishing power | Validity | Result         |
|-------------|------------|----------------------|----------|----------------|
|             | Value      | Category             | Value    | Category       |                |
| 1           | 0.71       | low                  | 0.47     | Good           | high           | Ready to used  |
| 2           | 0.29       | high                 | 0.47     | Good           | high           | Ready to used  |
| 3           | 0.54       | moderate             | 0.06     | Poor           | very low       | Repaired       |
| 4           | 0.14       | high                 | 0.29     | Enough         | low            | Ready to used  |
| 5           | 0.49       | moderate             | 0.29     | Enough         | moderate       | Ready to used  |
| 6           | 0.71       | low                  | 0.24     | Enough         | high           | Ready to used  |
| 7           | 0.51       | moderate             | 0.53     | Good           | low            | Ready to used  |
| 8           | 0.31       | moderate             | 0.35     | Enough         | moderate       | Ready to used  |
| 9           | 0.57       | moderate             | 0.41     | Good           | moderate       | Ready to used  |
| 10          | 0.59       | moderate             | 0.47     | Good           | moderate       | Ready to used  |
| 11          | 0.43       | moderate             | 0.47     | Good           | moderate       | Ready to used  |
| 12          | 0.63       | moderate             | 0.53     | Good           | high           | Ready to used  |
| 13          | 0.6        | moderate             | 0.24     | Enough         | moderate       | Ready to used  |
| 14          | 0.71       | low                  | 0.29     | Enough         | moderate       | Ready to used  |
| 15          | 0.42       | moderate             | 0.18     | Poor           | very low       | Repaired       |
The reliability test of the instrument used KR-21 reliability test [6]. The result is shown in Table 5 below.

| $k$ | $M$   | $S_k^2$ | $r_{11}$ | $r_{a=0.5;N=35}$ | Criteria |
|-----|-------|---------|----------|------------------|----------|
| 15  | 12.062| 3.356   | 0.73     | 0.334            | High     |

### 3.5. Evaluation Phase

The last phase is the evaluation. On the evaluation phase, instrument items were repaired again based on the result of implementation. Based on discussion upstairs, there are some deductions.

1. The result of experts’ judgement shown a high score with the mean score of three judgment criteria was greater than 4 of 5.
2. The variety of each test items difficulty is enough and distinguishing power of the test items are good enough.
3. There are 13 of 15 test item that ready to use for measure students’ critical thinking skills on oscillation, wave, and sound wave concept.
4. The instrument test was reliable with high criteria based on KR-21 reliability test result.

### 4. Conclusion

Critical thinking skills as one of students’ important skills in the current day. That skill can be measured using the oscillation and sound wave critical thinking test (OSW-CTST) that has been developed using ADDIE method. On conclusion, the OSW-CTST test item that was developed could measure junior high school students’ critical thinking skill.

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