Video supported critical thinking test in the kinetic theory of gases: validity and reliability

A Silvianty1*, A Suhandi2 and W Setiawan3

1Program Studi Magister Pendidikan Fisika, Universitas Pendidikan Indonesia, Jl. Dr. Setiabudhi No. 229, Bandung 40154, Indonesia
2Departemen Pendidikan Fisika, Universitas Pendidikan Indonesia, Jl. Dr. Setiabudhi No. 229, Bandung 40154, Indonesia
3Departemen Pendidikan Ilmu Komputer, Universitas Pendidikan Indonesia, Jl. Dr. Setiabudhi No. 229, Bandung 40154, Indonesia

*asilvianty@student.upi.edu

Abstract. This study is conducted to figure validity and reliability of Video Supported Critical Thinking Test (VSCT-Test). VSCT-Test has already been constructed to evaluate students' critical thinking skills in Physics subjects. The study used the descriptive quantitative method. Seventy students of a high school in West Bandung Regency have been chosen with purposive technique sampling. The VSCT Test was constructed, according to five critical thinking categories framework developed by Tiruneh consisting of 1) Reasoning, 2) Hypothesis Testing, 3) Argument Analysis, 4) Likelihood and Uncertainty Analysis, and 5) Problem Solving and Decision Making. VSCT-Test validity was determined through expert judgment involving construct validity and content validity, whereas VSCT-Test reliability was concluded through field testing with the test-retest method. The results showed that all VSCT-Test items that were constructed had met a good construct validity as well as content validity and had high reliability characterized by reliability index of 0.82. Thus, this indicates that the VSCT-Test instrument has good quality and suitable for measuring the critical thinking skills of high school students.

1. Introduction
In the present era of the 21st century, the world of education faced with the challenges of the current globalization is increasingly bolted. Critical thinking skills as part of the 21st-century skills are expected to prepare learners to adapt to the challenges of the 21st century. The Partnership for 21st-century skills supports the integration of mastery of material concepts with 21st and 4C’s skills (critical thinking skills, communication skills, collaboration skills, and creativity and innovation). Learners are expected to succeed in solving the problems of the world of work and daily life with the combination [1].

Critical thinking skills are thought processes that have a purpose, either proving purpose, interpreting what is meant, interpreting what something means, and solving a problem [2]. Critical thinking skills should be provided in the classroom learning process thus to prepare learners for the challenges of life in the 21st century [1,2]. Critical thinking skills are a deep and reflective process of thinking in decision-making and problem-solving to analyze the situation, evaluate the argument and conclude precisely [1]. Critical thinking skills have an important role in analyzing arguments, situations and problems based on factual data and information, therefore, they can solve problems logically in a variety of conditions and can make decisions based on reason appropriately referring to data.
Halpern explains that critical thinking is using a thinking strategy that increases the probability of expected outcomes. Critical thinking requires skills that involve mental and cognitive abilities. Some aspects and indicators of critical thinking are established by logical thinking activities, collecting data, assessing and interpreting information thoroughly, explaining the reasoning outcomes to clarify, making decisions on the various problems encountered and applying the concepts learned in various conditions [3].

When the learning process is established it must equip or train critical thinking skills through the use of various models, strategies, approaches, and methods. Consequently, to measure the achievement of learning outcomes in this aspect of critical thinking skills needs to be constructed a valid test or non-test instrument. It is now known that some critical thinking skills tests are developed by some content-based and content-free researchers [4-11]. Several tests of critical thinking skills related to physics content have also been developed by several researchers [12,13].

Physics is a field of science that examines the physical phenomena in nature both macroscopic and microscopic. In addition, physics also studies both static and dynamic phenomena. Physics test questions are usually enriched with pictures, diagrams, or graphs. For questions related to the dynamic physical and abstract phenomena, the addition of a static image is less helpful, even to obscure the issue being tested by the question. For questions related to the phenomenon, it is suitable if there is the addition of dynamic image feature in the form of a video that can clarify in representing the real condition in question both in the form of experimental video and simulation.

Donkor concluded that the benefits of video viewing are able to display real-life and practical activities. In addition, the video can present a dangerous experiment or require expensive tools so it can be repeated playback as needed. The presence of sound and visual simultaneously in the video will certainly accommodate the needs of heterogeneous learners [14]. Therefore, to be effective in its implementation, teachers can use Video Supported as a tool in conducting the assessment.

The kinetic theory of gases matter discusses the characteristics of gases in enclosed spaces related to the experiments of Boyle’s Law, Charles Law, Gay-Lussac Law, Boyle-Gay-Lussac equations, average molecular velocity, and equipartition of energy and energy in, so in its study much related to abstract microscopes phenomena and dynamic phenomena. It would be appropriate to understand the issues related to the kinetic theory of gases by adding video features to clarify the point of the problem in question. The video supported critical thinking test on the material of kinetic theory of gases has not been found so it will be constructed as a critical thinking skill test supported by video related kinetic theory of gases. Tests by utilizing information and communication technology have advantages that teachers can save the use of time because it does not need to duplicate the question sheet. In addition, teachers also save paper usage. Benefits of video support in the evaluation, learners can better understand the problem because it is clarified with video support. The video displayed in the question will clarify the questions asked, thus learners are expected to answer the questions well.

The quality of an instrument used for research is very important. The researchers will describe the results based on the information they get through the instrument. The researchers used a number of procedures that showed that the conclusions they took based on the data obtained were valid and reliable [15]. A test instrument is said to be good and can be used if it has validity and reliability that meet the criteria. Validity refers to the appropriateness, significance, truth, and usefulness of the conclusions made by the researcher. Reliability refers to the consistency of scores or answers from one instrument administration to another, and from one set of items to another [15]. These two concepts are important to consider when selecting or designing the instrument that the researcher wants to use. Therefore, VSCT-Test instruments vital to gauge the level of validity and reliability.

2. Method
The descriptive quantitative method was used in this study. Seventy students of a high school in West Bandung Regency have been chosen with purposive sampling technique. The selected students have obtained the kinetic gas theory material from the learning process in the classroom, and they have computer laboratory and internet access. VSCT-Test validity was determined through five experts’
judgment involving construct validity and content validity, whereas VSCT-Test reliability was concluded through field testing with the test-retest method. Tests are done twice with an interval of one week.

The reliability level of the VSCT-Test instrument is determined by the test-retest method. The results of VSCT-Test scores in the first test and the second test were calculated using the Pearson product-moment correlation coefficient equation [16] with the formula:

$$r_{xy} = \frac{N\Sigma XY - (\Sigma X)(\Sigma Y)}{(N\Sigma X^2 - (\Sigma X)^2)(N\Sigma Y^2 - (\Sigma Y)^2)}$$

with $r_{xy}$ is the correlation coefficient, $\Sigma X$ is the number of scores for each item in the first test, $\Sigma Y$ is the sum of a score of each item in the second test, and $N$ is the entirety of subjects. Then, the $r_{xy}$ value is compared to the reliability criteria in Table 1. If the reliability level is high, then the VSCT-Test is acceptable. If the reliability is low, it will not be used or used with revisions.

| $r_{xy}$ | Category     |
|---------|--------------|
| 0.800 – 1.000 | Very High   |
| 0.600 – 0.799  | High        |
| 0.400 – 0.599  | Enough      |
| 0.200 – 0.399  | Low         |
| < 0.200        | Very Low    |

The VSCT-Test instrument is constructed by following the scaffolding matrix item test construction [17]. Scaffolding was adopted includes five phases of construction activity of instruments test item of critical thinking category: 1) descriptions of domains-specific critical thinking, 2) operationalization of domain-specific critical thinking, 3) construction of frames VSCT-Test items, 4) writing of test item, and 5) checking of the test item. Furthermore, in practice, scaffolding is used for the process of constructing VSCT-Test instruments using the matrix shown in table 2.

| The test form | Description of domain-specific CT | Evaluated physics content | Op. of domain-specific CT | Construction of frame VSCT-Test item | Writing test item | Checking of constructed VSCT-Test item |
|---------------|----------------------------------|---------------------------|---------------------------|-------------------------------------|-------------------|----------------------------------------|
| MC            | Predict the possibility or physical event that will occur | Boyle-Gay-Lussac equation | SP                        | Stimulus, Problem, and Answer option | F1                | Yes / No                                |

CT: Critical Thinking
F1: Figure 1
LU: Likelihood and Uncertainty Analysis
MC: Multiple Choice
Op.: Operationalization
SP: Students can predict physical events that will occur in the experiment of a candle that is lit on a plate filled with water then covered with a transparent glass when added another candle.
Stimulus in construction of frame VSCT-Test item about question in Figure 1 are presented a video of a candle lit on a plate filled with water and then covered with a transparent glass, then the problem is about students are asked to predict the possibilities that will occur in water if more candle is installed, finally the answer option include choice of various possibilities that will occur along with their explanation. Furthermore, the validators will check the constructed VSCT-Test then choosing Yes/No.

3. Result and discussion
This study is conducted to figure validity and reliability of Video Supported Critical Thinking Test (VSCT-Test). VSCT-Test has already been constructed to evaluate students’ critical thinking skills in the kinetic theory of gases. The VSCT-Test was constructed, according to five critical thinking categories framework developed by Tiruneh consisting of reasoning, hypothesis testing, argument analysis, likelihood and uncertainty analysis, and problem-solving and decision making. Then, five domain-specific comprise evaluate the validity of data, interpret a relationship between variables, infer a correct statement from a given data set, predict the probability of event, identify the best among a number of alternatives in problems. VSCT-Test instrument was constructed in multiple-choice with reason tests.

The VSCT-Test instrument has been constructed using a matrix for the use of scaffolding in the construction process. Certain categories and domains of critical thinking skills have been analyzed to construct VSCT-Test questions. Specific domain descriptions based on the analysis and implementation of specific categories and domains of critical thinking skills have also been undertaken. Questions are made on the operationalization of domain-specific critical thinking and construction of frames VSCT-Test items. For example, the result of VSCT-Test that has been constructed as shown in figure 1.

![Figure 1. Example of VSCT-Test Instrument.](image)

The VSCT-Test instrument has been reviewed to determine the validity of the instrument. The validity of the instrument has been determined on the basis of consideration by the expert. The VSCT-Test instrument has been validated by five experts consisting of two educational experts and three physicist content experts. The results of the validity of the VSCT-Test instrument are presented in table 3.
Table 3. The result of validation by experts.

| Problem Test Item | Suitable domain-specifics | Aspects ratings | Use item problem | Suggestions |
|-------------------|---------------------------|-----------------|------------------|-------------|
|                   | Corresponding (%)         | Not available (%) | Not be used (%) | Revision (%) | Can be used (%) |
| 1                 | 80                        | 20              | 0                | 20          | 80             |
|                   |                           |                 |                  |             |                |
| 2                 | 80                        | 20              | 0                | 40          | 60             |
|                   |                           |                 |                  |             |                |
| 3                 | 100                       | 0               | 0                | 0           | 100            |
|                   |                           |                 |                  |             |                |
| 4                 | 100                       | 0               | 0                | 0           | 100            |
|                   |                           |                 |                  |             |                |
| 5                 | 100                       | 0               | 0                | 20          | 80             |
|                   |                           |                 |                  |             |                |

Notes:
Validator 1: the instrument can be used after revision.
Validator 2: be alert to the questions redaction and the answer key.
Validator 3: the instrument can be used after revision.
Validator 4: the instrument can be used after revision.
Validator 5: the instrument can be used after revision.

All validators have determined that the VSCT-Test instrument has no significant problems. Furthermore, the VSCT-Test instrument consisting of 5 items can be prepared for further tests after revision. Expert advice is then used to improve the VSCT-Test instrument. Thus, the instrument is completely valid for use.

The VSCT-Test has been tested to measure seventy students' critical thinking skills. The VSCT-Test has been tested twice with an interval of one week. The results of the first and second tests have been analyzed to obtain the reliability level of the VSCT-Test instrument. The two-time test shows a steady result or consistent answer from the student. Once analyzed, the VSCT-Test instrument reliability test result shows the correlation coefficient as 0.82 in Table 4 and includes a very high category. VSCT-Test Instruments otherwise reliable.

Table 4. The data of measuring correlation coefficient.

| Sum of subjects (N) | Sum of scores for each item in the first test (ΣX) | Sum of scores for each item in the second test (ΣY) | Correlation coefficient (rxy) |
|---------------------|---------------------------------------------------|--------------------------------------------------|-----------------------------|
| 70                  | 1060                                              | 1274                                             | 0.82                        |

4. Conclusion

In this study, has been constructed five items of video supported critical thinking skills test instruments of high school students related concept on the kinetic theory of gases with five categories and five domains-specific of critical thinking framework by Tiruneh such as evaluate the validity of the data, interpret a relationship between variables, infer a correct statement from a given data set, predict the probability of event. Based on validity test that has been done by experts and calculation of instrument reliability revealed that VSCT-Test instrument has good quality, therefore feasible to be used for activity evaluation of critical thinking skill of student either in physics learning process in school and also in research activity.
References
[1] Stobaugh R 2013 Assessing Critical Thinking in Middle and High Schools (New York: Routledge) p 3
[2] Facione P A 2018 Critical Thinking: What It Is and Why It Counts (Hermosa Beach: Measured Reasons LLC)
[3] Halpern D F 2014 Thought and knowledge: An introduction to critical thinking (New York: Psychology Press)
[4] Facione P A 1991 Using the California Critical Thinking Skills Test in Research, Evaluation, and Assessment (Millbrae: California Academic Press)
[5] Ennis R H 1993 TIP 32(179)
[6] Wagner T A and Harvey R J 2006 Psychol Assess 18(100)
[7] Ku K Y 2009 Think Skills Creat 4(70)
[8] White B, Stains M, Escriu S M, Medaglia E, Rostamnjad L, Chinn C and Sevian H 2011 J Coll Sci Teach. 40(102)
[9] Mapela R and Siew N M 2015 Springerplus 4(741)
[10] El Hassan K, Madhum G 2007 High. Educ 54(361)
[11] Franco A R, Costa P S, Butler H A and Almeida L S 2017 Psychol Rep 120(707)
[12] Tiruneh D T, De Cock M, Weldeslassie A G, Elen J and Janssen R 2017 IJSME 156(63)
[13] Mabruroh F and Suhandi A 2017 J. Phys.: Conf. Ser. 812
[14] Donkor F 2011 IRRODL 12(71)
[15] Fraenkel J R 2012 How to design and evaluate research in education (New York: McGraw-Hill)
[16] Arikunto S 2010 Research Procedures a Practice Approach (Jakarta: Rineka Cipta)
[17] Arif W 2017 J. Phys.: Conf. Ser. 812 012053