Measuring Critical Thinking based Multimedia on Buoyant Force Concept: A Preliminary Design

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Abstract. This study aims to develop critical thinking test (CTT) based multimedia to assess students’ critical thinking on buoyant force concept. The buoyant force has been developed utilizing ADDIE method with five stages which are analyze, design, develop, implement and evaluate. The respondnet the third semester of the academic year 2020/2021 at the Program of science Education, Universitas Islam Lamongan. The ADDIE developing steps has been utilized to describe comprehensively from the stage of analysis program up until the evaluation stage. CT based multimedia has measured pre-service science teachers, indicator of critical thinking has high score is recognize the need for more information in drawing conclusions that got 25% and the lowest indicator is Predict the probability of event got 15%. Based on data analysis, it can be concluded that CT based multimedia could able to effectively measure pre-service science teachers’ critical thinking. The CT based multimedia has been developed by macromedia flash software.

1. Introduction

One of the goals of Century education 21 is developing thinking skills of students, one of which is critical thinking skills. According to Ennis [1], critical thinking is a reflective thinking ability that focuses on patterns of decision making about what to believe, do and be accountable for. Critical thinking skills are needed because someone who thinks critically will be able to think logically, answer problems well and can make rational decisions about what to do or what to believe. Communicates that critical thinking is a process of intellectual discipline that is active and with the skills to conceptualize, apply, analyze, synthesize, and / or evaluate information by observing, reflecting, reasoning, or communicating as a guide for belief and decision makers on a problem faced [2].

Critical thinking is a high-order thinking skill that has the potential to increase the critical analytical power of students. Therefore, developing critical thinking skills of students in learning is an effort to improve student learning outcomes. Explains that the definition of critical thinking is a process of knowledge in depth to identify the relationship of all disciplines and being able to find creative problem solutions by making reflective decisions and thinking about solving problems to analyze a situation, evaluate arguments and describe appropriate inferences [3].

And according to Halpern defining critical thinking is using a thinking strategy that increases the likelihood of the expected results. With five indicators of critical thinking, namely reasoning, hypothesis testing, argument analysis, likelihood and uncertainty analysis, problem solving and...
decision making [4]. The best effort to develop critical thinking skills that can be done is by linking learning materials with real experiences of students in the everyday environment. So that in learning it is necessary to design a learning strategy that allows the development of critical thinking skills of students. Strategy has an impact on students' perceptiveness of what is learned [5].

With the development of information, communication and information technology, computers in today's development have become a primary need in the world of education. The use of computerized technology in assessment is becoming more demanding in the assessment and teaching of the New World of Work in the 21st century [6].

Computer-assisted learning and assessment further enhances the skills potential of the 21st century. Assessment makes use of developments in ICT not only as traditional assessment tools but also presents a new test instrument that was previously difficult to measure. E-assessment has the potential to utilize technology to support educational innovation and develop 21st century skills such as creativity, critical thinking, communication, collaboration and problem solving [7].

The development of critical thinking skills is not only carried out in learning, but must also be supported by assessment instruments that reflect critical thinking skills. Critical thinking requires practice, one of which is the habit of working on problems that develop critical thinking [6]. So in this study will discuss the level of thinking skills of students as measured by the form of essay questions based on critical thinking skills. This study aims to develop critical thinking test (CTT) based multimedia to assess students' critical thinking on buoyant force concept.

2. Methods

This study has been utilized by ADDIE model research to develop CT-based multimedia [8], which has five steps that are: Analyzing, Design, Development, Implementation and Evaluation. The CT-based multimedia development through ADDIE model has been applied to the seven pre-service science teachers who took fluid and thermodynamic course. The research was conveyed in the third semester of the academic year 2020/2021 at the Program of science Education, Universitas Islam Lamongan.

Implementing CT-based multimedia to the pre-service science teachers utilized evaluation rubric via Liekert Scales (4 scales). The assessment given depends on the reason for the answer given by the students, the scoring rubric for each question is different. This is due to variations in the questions and students are expected to give answers that are close to correct and according to the concept. Instruments test was adapted by Halpern's critical thinking framework which have been developed by Tiruneh become some domains specific critical thinking [9]. Students' critical thinking used rubric scoring as shown in Table 1 is used.

| Score | Criteria |
|-------|----------|
| 4     | The student chooses the correct answer and provides a scientifically explanation, focus and accurate. |
| 3     | Students choose the correct answer and give less explicit, less focused and incomplete explanations. |
| 2     | Student chooses the correct answer and gives a less correct explanation. |
| 1     | Student choice the wrong answer and gave the correct explanation. |
| 0     | No answer or giving wrong answers. |
3. Results and Discussions

The development of CTT-based multimedia on buoyant force concepts was more importance on the reasoning approach to assist pre-service science teachers more thoughtful the concepts. The CT-based multimedia development has been applied by ADDIE model which involved development phases, 1) Analyzing, 2) Design, 3) Development, 4) Implementation and 5) Evaluation. In detail, CTT-based multimedia development is discussed follow.

3.1. Analyzing

The analyzing step investigated how instrument test and indicators of critical thinking that can measure pre-service science teachers’ critical thinking on buoyant force concept. The output of analyzing the process was needed an instrument test that can visualize the phenomena that appear on each problem in order to communicate the critical thinking indicators. Besides that, case study to identify difficulties or problem needs and to perform tasks' analyze. Analyzes were also accompanied on learning plans and syllabus of fluid and thermodynamic courses that concepts that need to be visualized in the form of media so that it is effectively to measure pre-service science teachers. The CT based multimedia which developed in multi-response format, pre-service science teachers will choice the correct answer and give the reason for answers they have chosen. In this study, domain-specific or critical thinking indicators used can reflect critical thinking that is measured and sensitive because the indicators are scientific. The following are critical thinking indicators adapted Halpern critical thinking framework [9], it can be seen in Table

| Critical thinking categories | Indicators of critical thinking outcome                        |
|-----------------------------|----------------------------------------------------------------|
| Hypothesis testing          | Recognize the need for more information in drawing conclusions |
|                             | Criticize the validity of generalizations in experiment        |
| Argument analysis           | Judge the credibility of an information source                  |
|                             | Infer a correct statement from a given data set                 |
| Likelihood and uncertainty  | Predict the probability of event                                |

3.2. Design

This stage was making story board to construct instrument test on paper. CT-based multimedia design focused on static fluid especially in the main concept of buoyant force by simulations and videos. This instrument test design involved physics concepts such as; hydrostatic, Pascal law, buoyant force and Archimedes Law. Sample of instrument test design developed in the storyboard of CT-based multimedia was given follows.
3.3. Development

Development step is realizing the storyboard design has become a CT based multimedia. Sample of the design, the development stage has been organized based on multimedia as the following example.

Figure 1. Storyboard of an ICI-based multimedia.

Figure 2. Example of CT based multimedia on buoyant force.
Figure 3. An example of video experiment on density concept.

Multimedia design was using the Flash program, there are simple experiment on video and simulation to realize critical thinking indicators.

3.4. Implementation
At this stage, CT-based multimedia was tested in pre-service science teachers on buoyant force. The product (CT based multimedia) can be tested seven pre-service science teachers then evaluated and revised. Sample of implementation CT based multimedia who have studied buoyant force concept in fluid and thermodynamic course.

Figure 4. The Implementation of CT-based Multimedia on fluid and thermodynamic course.

3.5. Evaluation
At this stage, evaluating CT based multimedia was used to test pre-service science teachers’ critical thinking at the implementation stage. CT based multimedia had deficiency in performance or applications are fixed to improve CT based multimedia. Based on activities in the implementation phase, here are the results of the CT based multimedia test.
Table 3. Students’ critical thinking profile on buoyant concept

| Critical Thinking Indicators                                           | Percentage score (%) |
|----------------------------------------------------------------------|----------------------|
| Recognize the need for more information in drawing conclusions        | 25                   |
| Criticize the validity of generalizations in experiment               | 20                   |
| Judge the credibility of an information source                        | 27                   |
| Infer a correct statement from a given data set                       | 21                   |
| Predict the probability of event                                      | 15                   |

The table showed that the number of pre-service science teachers' critical thinking on buoyant force concept, the lowest score in the indicator predicting the event that will occur based on the phenomenon given to the questions on the multimedia based CT test instrument. This can happen because the students' reasoning skill was not trained during classroom learning activities. Students should be included in learning by visualizing concepts with simple media that are easily found in everyday life. It could be concluded that learning activities in fluid class need visualization in order to pre-service science teachers' critical thinking intensively.

4. Conclusion
Based on the analysis data, it can be concluded that the development of CT based multimedia on buoyant concept through ADDIE model (Analyzing, Design, Development, Implementation and Evaluation) was able to effectively measure pre-service science teachers' critical thinking. The CT based multimedia has been developed by macromedia flash software.

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