Integrated science teaching materials oriented on critical thinking skills and information literacy

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Abstract. Critical thinking and information literacy are skills that need to be developed to deal with the challenges of the 21st century. This study aimed to produce integrated science teaching materials oriented on critical thinking skills and information literacy. The research method used was Development and Research (R&D) that be limited to preliminary test. Development of teaching materials used the Model for the Process Writing Teaching Materials. There were two kinds of instruments applied in this research, quality questionnaires and comprehension test. The quality of teaching materials assessed by 3 experts and 10 science teachers. The comprehension test was conducted by 30 ninth grade students. All data were analyzed qualitatively. The results showed that the quality of integrated science teaching materials developed in good category with 88.81% and the comprehension of main idea in high category with the percentage of 88.08%, therefore it was feasible to be used in improving critical thinking skills and information literacy of junior high school students.

1. Introduction
The US-based Partnership for 21st Century Skills identifies the competencies required in the 21st century, that is communication, collaboration, critical thinking, and creativity [1]. Assessment and Teaching of 21st Century Skills (ATC21S) categorizes 21st century skills into 4 categories: way of thinking, way of working, tools for working and skills for living in the world [2]. Way of thinking includes creativity, innovation, critical thinking, problem solving, and decision-making. Way of working includes communication, collaboration and teamwork skills. Tools for working include awareness as a global and local citizen, life and career development, and a sense of personal and social responsibility. While skills for living are skills based on information literacy.

Some of that skills are written on the science-learning syllabus in accordance with Regulation of Ministry of Education and Culture No. 20 of 2016 on Graduate Competency Standards (SKL) of Primary and Secondary Education in the skill dimension, which has the skills of thinking and acting creatively, productively, critically, independently, collaboratively and communicatively through scientific approaches as studied in educational units and other sources independently [3]. Critical thinking is part of the complex thinking process [4]. Critical thinking skills have long been a capability developed explicitly in learning. Students should be able to look for solutions from different angles to solve problems [5]. Critical thinking skills describe other skills such as information literacy.

In the 21st century, highly abundant information made the community, especially students having difficulty in finding, evaluating, using and communicating information. Students need ability to select relevant sources and information, find quality sources, and assess resources from various aspects [6].
These abilities are part of the information literacy. Information literacy allows us to overcome the data fog. With information literacy, we can determine when, where and what information is needed, and how information is used effectively and efficiently. This will help decision-making and problem-solving. Traditionally, students have information literacy skills automatically, but educators (teachers and librarians) need to train the information literacy skills of students [7].

Learning process involves three main components, teachers, students and teaching materials [8]. In the process occurs the interaction between teachers with students through teaching materials. Students gain knowledge and learning experience from this interaction. Teaching materials have an effect that is as great as or greater than the quality of teachers [9]. Learning does not work well without teaching materials. This means teaching materials affect learning. Teaching materials have advantages that the interaction of students with teaching materials are not limited by time, so students can learn independently in training critical thinking skills and information literacy.

The most conventional teaching materials used nowadays are textbooks from Ministry of Education and Culture. The analysis of the book stated that proportion of interaction of science, technology, and society, as well as thinking skills is still very low [10]. The low level of thinking skills in the research is supported by the fact that secondary school teachers have different interdisciplinary educational backgrounds. This is the limitation of teachers in conveying various interdisciplinary studies of science and hampering improvements in student achievement [11]. Thus, the developed teaching materials need to integrate knowledge and skills.

Integrated science teaching materials to improve critical thinking skills and information literacy should be compatible with the characteristics of integrated learning, that is holistic, meaningful and authentic [12]. Development of integrated science teaching materials used the Model for the Process Writing of Teaching Materials [13]. The concepts in integrated science are presented from phenomena and problems close to the condition of students, then studied with theories of science. Teaching materials that present the real and contextual problems will facilitate the implementation of learning [14]. Therefore, the aim of this study is to produce the good and independent integrated science teaching materials oriented on critical thinking skills and information literacy, so it is feasible to be used in improving critical thinking skills and information literacy.

2. Research Method
The type of this research was Research and Development (R&D). Research and development is an attempt to develop and validate the products used in education [15]. Research and development consists of ten stages and in this study was limited to the fourth stage, namely preliminary field testing. The development of integrated science teaching materials used the Model for the Process Writing of Teaching Materials consisting of eleven stages, from curriculum analysis to quality and comprehension test [13]. The instruments used in this research were quality and comprehension test. The quality test was conducted by 3 experts and 10 science teachers, while the comprehension test was conducted by 30 ninth grade students. Data of the quality of teaching materials was analyzed qualitatively. The percentage of quality assessments was categorized in Table 1. The comprehension test was analyzed by determining the main idea and supporting sentences in accordance with scoring rubric [16]. Data were interpreted using category of comprehension [17] in Table 2.

| Table 1. Teaching materials quality criteria |
|---------------------------------------------|
| **Percentage (%)** | **Criteria** |
| 0 – 30          | Very less   |
| 31 – 60         | Less good   |
| 61 – 90         | Good        |
| 91 – 100        | Very good   |
Table 2. Category of comprehension

| Percentage (%) | Criteria (Category)         |
|----------------|----------------------------|
| x < 40         | Low (difficult)            |
| 40 < x < 60    | Average (instructional)    |
| 60 < x         | High (independent)         |

3. Result and Discussion

3.1. Results
The quality of integrated science teaching materials developed was assessed by 3 experts and 10 science teachers. Assessment of teaching materials' quality got the average of 88.81%. This percentage included in good category. The quality of teaching materials could be seen in Table 3.

Table 3. Quality of integrated science teaching materials

| Component                                         | Percentage (%) |
|---------------------------------------------------|----------------|
| Basic competencies, indicators, and teaching materials suitability | 87.98          |
| Integration of science content                    | 87.18          |
| Content updates                                   | 87.50          |
| Rules of writing                                  | 88.74          |
| Logical reasoning and skills                      | 90.14          |
| The width and depth of matter                     | 89.29          |
| Mean                                              | 88.81          |

Development of integrated science teaching materials also conducted comprehension test to 30 ninth grade students. Main idea comprehension test got an average of 88.08%. This percentage included in high category and each paragraph on the developed teaching material could be understood independently. Data from students' comprehension test on teaching materials could be seen in Table 4.

Table 4. Students’ comprehension test on integrated science teaching materials

| Text /Sub Subject     | Percentage (%) | Text /Sub Subject     | Percentage (%) |
|-----------------------|----------------|-----------------------|----------------|
| 1/ light travels in straight line | 88.75          | 15/ optic instruments | 95             |
| 2/ reflection of light | 100            | 16/ optic instruments | 88.75          |
| 3/ reflection of light | 87.5           | 17/ optic instruments | 92.5           |
| 4/ reflection of light | 86.25          | 18/ animal eye        | 97.5           |
| 5/ reflection of light | 96.25          | 19/ animal eye        | 92.5           |
| 6/ refraction of light | 80             | 20/ animal eye        | 90             |
| 7/ refraction of light | 93.75          | 21/ bioluminescence   | 75             |
| 8/ refraction of light | 88.75          | 22/ photosynthesis    | 92.5           |
| 9/ dispersion of light | 78.75          | 23/ etionom movement  | 85             |
| 10/ light is electromagnetic waves                 | 81.25          | 24/ etionom movement  | 76.25          |
| 11/ human skin                                    | 100            | 25/ etionom movement  | 76.25          |
| 12/ human eye                                     | 90             | 26/ human adaptation to light | 76.25 |
| 13/ human eye                                     | 100            | 27/ animal adaptation to light | 83.75 |
| 14/ optic instruments                             | 91.25          | 28/ plant adaptation to light | 82.5 |
| Mean                                               | 88.08          |

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3.2. Discussion

Based on quality assessment and comprehension data analysis of integrated science teaching materials developed, it was found that the teaching materials are good and easily understood by the students so it is feasible to be used in science learning. Teaching materials had a good quality, at least comply the relevance and consistency aspect that was obtained in quality judgment by experts [18]. Integrated science teaching materials developed were categorized good with 88.81%. Figure 1 is examples of activities on the theme of light interaction with organisms to improve critical thinking skills while Figure 2 is examples of activities on the theme of light interaction with organisms to improve critical thinking skills information literacy.

![Figure 1. Critical thinking skills activities](image1)

These activities complied the quality components of teaching materials on: (1) the suitability of basic competencies, indicators and teaching materials, that was, materials and indicators in accordance with the basic competencies on light and refers to critical thinking skills and information literacy; (2) integrity of science content, that was, the material of integrated science teaching materials on the theme of light interaction with the organisms involves the properties of light in the field of physics and organism, such as eye, human skin and plant adaptation in the field of biology; (3) content updates, the concepts explained were valid and obvious, and the material presented was associated with its application in daily life; (4) the rules of writing integrated verbal and visual representations, the order of used of various representational modes according to the need to explain the concepts written, and used of punctuation and phrases according to grammar; (5) logical reasoning and skills, the activities provided referred to indicators of critical thinking skills and information literacy and developed students' reasoning; and (6) the width and depth of teaching materials adjusted to the cognitive level of student.
Based on data analysis of main idea comprehension test, the developed teaching material obtained 88.01%. Main idea comprehension test was conducted to know the students' understanding of the discourses. The comprehension test on the developed teaching material consisted of 28 different discourses. Students understood the discourse about the reflection of light, skin and human eyes very well. The understanding of students in understanding a discourse was influenced by words that are easy or difficult to learn [19]. Thus, integrated science teaching materials could be understood easily by students and possible to be used in improving critical thinking skills and information literacy.

![Image of integrated science teaching materials](image_url)

**Figure 3.** Multimodal representations on integrated science teaching materials

One of the factors over these findings was development model used. Development of integrated science teaching materials used the model for the process writing teaching materials [13]. The development model consisted of eleven stages, namely: (1) analyze the curriculum, so that the teaching materials in accordance with the applicable curriculum; (2) determine the indicators, adjusted for the aims of writing the teaching materials, that is, to improve critical thinking skills and information literacy; (3) determine the range of materials so that the width and depth are suitable with the curriculum and cognitive level of student; (4) arrange draft outline 1, to sort the material on teaching materials; (5) create concept maps, to map out the scientific concepts to be presented in teaching materials; (6) revise draft outline 1 to draft outline 2, considering the fifth stage to be used as a guide when writing integrated science teaching materials; (7) create multimodal representations, as in Figure 3, to make it easier for students to understand each concept [20] in the presence of a meaningful relationship of various language components such as text, mathematical formulas, tables, diagrams and drawings [21]; (8) translate draft outline into writing using multimodal representations, to ensure that the teaching material comply the criteria in terms of coherence and cohesion, which is the characteristic of a quality teaching material [22]; (9) evaluate the indicator, whether the indicators made in the second stage have been in accordance with the problems, activities, and questions presented; (10) review and edit the draft of teaching materials, and (11) test the quality and comprehension of teaching materials, as feedback from the reading and reference to revise the draft of teaching material prior to be used wider. The development of integrated science teaching materials in this study will be used to determine its effectiveness in improving critical thinking skills and information literacy.

### 4. Conclusion

Based on the objectives, the results of research, and discussion, it can be drawn the conclusion that the integrated science teaching materials oriented on critical thinking skills and information literacy developed for secondary school included in good criteria and independent categorized. It is feasible to be used in improving critical thinking skills and information literacy secondary school students.
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