Developing textbook based on scientific approach, critical thinking, and science process skills

A Rofiq1, I Hindun1, L Shultonnah1 and F J Miharja1*

1Department of Biology Education, Universitas Muhammadiyah Malang, Jl. Raya Tlogomas 246 Malang, East Java, Indonesia

Email:fuad.jayamiharja@umm.ac.id

Abstract. Several researchers have done the development of textbooks as a source of learning. However, most only partially develop students' academic abilities. This study aims to develop biology textbooks based on a scientific approach to improve students' critical thinking and process skills. This mix-method research consists of research development and quasi-experiment. Model development refers to modifying the Borg & Gall development model, which consists of preliminary studies, model development, and model testing, whereas the quasi-experiment uses the pretest and posttest groups design. This study's population were all students of Kepanjen Islamic High School, while the sample involved was 24 students of class X MIA. The data collection method used expert questionnaire validation, pretest, and posttest. Data analysis used the dependent t-test with a significance level of α = 0.05. The model test results show that there were significant differences in the average between pretest and posttest scores. Besides, the validation test results indicate that teaching materials were declared appropriate and effective in learning.

1. Introduction
Success in facing millennial challenges in the 21st Century is determined by various factors, including scientific literacy skills [1–3]. Various studies in different parts of the world state that the ability of community scientific literacy is one of the critical parameters of a country's progress and civilization [4–6]. According to some experts, scientific literacy emphasizes the community's ability to integrate their knowledge with comprehensive scientific inquiry measures [7–9]. Furthermore, people accustomed to thinking with a scientific approach are believed to be able to deal with and solve complex problems [10,11].

As a scientific thought process, scientific literacy is closely related to critical thinking skills and process thinking skills. Both of these are manifestations of scientific literacy as a skill and as a scientific process. In another perspective, it can be explained that someone who can develop critical thinking skills has qualified literacy skills. Likewise, people who are skilled at thinking the scientific process show that they can think structurally in a scientific context. Thus, the three elements of literacy need to be developed in a continuous learning process.

Development of thinking skills must be balanced with attitudes that arise from a person due to the learning process [12,13]. Attitudes aspects related to natural science, including biology, emphasize scientific approaches that are important for maintaining the purity of knowledge and continuity in student development. The scientific attitude can be formed through scientific work processes called process skills [14,15].

Research on scientific approaches, critical thinking skills, and scientific process skills has been carried out in the last ten years [16–18]. Interestingly, the study was carried out in almost all education levels, starting from elementary school, high school, and even college level. However, research with critical thinking skills is carried out more than research that raises the question of scientific approaches and science process skills. Furthermore, efforts to implement critical thinking skills are carried out by integrating them into learning models identified as being able to activate higher-order thinking skills. Inquiry [19], problem-based learning [20,21], and project-based learning [22,23] are learning models that are widely used by researchers to improve the critical thinking skills of students.

On the other hand, research that develops and analyzes scientific approaches and their impact on science process skills in learning biology is still not much developed. Integration of scientific methods
that have been carried out includes the development of learning models [24], learning media [25], as well as interdisciplinary and technology-based development [26]. In fact, in studying biological phenomena, a scientific approach is needed with the dimensions of observation, reasoning, validation, and relevant explanations. Furthermore, the analysis can be done deductive, inductive, or a combination of both. This research aims to compile a biology textbook based on a scientific approach integrated with critical thinking skills and science process skills.

2. Methods

This mixed-method research consists of two stages, i.e., development research and quasi-experiment. The development model in this study used the modified Research and Development (R&D) model [27] consists of preliminary studies, development, and model testing (Figure 1). Activities carried out in this stage include field surveys and literature studies. The field survey was conducted at Kepanjen Islamic High School. A literature study was conducted to find concepts that strengthen product development. Preliminary studies produce materials that are put together and integrated.

The model development stage is carried out by explaining the essential concepts of the preliminary study results. Activities undertaken include (1) analysis of preliminary studies, (2) identification of basic concepts and theories based on indicators of scientific approach concepts, critical thinking, and process skills, (3) determination of essential competencies and indicators, (4) determination of material concepts to be displayed in the textbook, (5) design questions that refer to critical thinking skills and process skills. The planning and development stage produces a draft product as an initial product that will be consulted with material experts and media experts. Limited trials were conducted involving students using pretest and posttest questions. The final result of this model's development stage is a hypothetical product, so that testing needs to be done on a broader scale.

Model testing is a formative evaluation process to assess whether the product design, in this case, the product draft, can improve students' critical thinking skills and process skills. Model testing was conducted with a quasi-experimental study involving 24 students of class X natural science at Kepanjen Islamic High School. The implementation and testing of textbooks used quasi-experiments using the one group pretest-posttest model.

The data collection instruments were carried out by interview, questionnaire, and test methods. The types of data in this study consisted of qualitative and quantitative data. Qualitative data were obtained from the advice of material experts and media experts. Quantitative data were collected from the score assessment results of material experts and media experts through a questionnaire (rating scale) of the quality of the textbook and students’ pretest and posttest. Questionnaire answers use a Likert scale.
measured variables was translated into indicator variables. The Likert scale used consists of five categories, as shown in Table 1.

| No | Score | Indicators                                      |
|----|-------|-------------------------------------------------|
| 1  | 5     | Strongly agree/very decent/very good/very helpful/very motivating |
| 2  | 4     | Agree/decent/good/helpful/motivating            |
| 3  | 3     | Quite agree/quite decent/quite good/quite helpful/quite motivating |
| 4  | 2     | Disagree/not feasible/not good/not helpful/not motivating |
| 5  | 1     | Strongly disagree/very unworthy/very bad/very unhelpful/very unmotivating |

Data analysis used descriptive qualitative and quantitative methods. Qualitative analysis is used to process data from material experts and media expert reviews, while quantitative analysis is used for expert validation and student test results. Decision making about the quality of textbook products uses the conversion achievement level with a Likert scale with a 1 to 5. Data analysis results are then interpreted and concluded based on the classification criteria about product quality adapted from [28] as in Table 2. Data analysis of students’ process skills was analyzed using mean scores and percentages [29].

| Percentage (%) | Qualification | Indicators                                      |
|----------------|---------------|-------------------------------------------------|
| 0 - 20         | Very low      | Very improper, revision required                |
| 21 - 40        | Low           | Not decent, revision required                   |
| 41 - 60        | Moderate      | Pretty decent, revision required                |
| 61 - 80        | High          | Decent, no revision needed                     |
| 81 - 100       | Very high     | Very decent, no revision needed                |

\[ P = \frac{f}{N} \times 100\% \]  

Note: P (percentage of students' process skills), f (score of each process skills aspect), N (total number of students). The process skills are then interpreted based on criteria: very low (≤ 40%), less (40-55%), sufficient (55-70%), good (70-85%), and very good (≥85%). Analysis of increasing critical thinking skills and process skills were analyzed using paired t-tests. Paired t-test calculations are performed using calculations through the SPSS 17 program after the Kolmogorov-Smirnov normality test.

3. Results and Discussion

3.1. Development stage

The draft product includes the preparation of the text and the design of the textbook. The textbook has developed using the Indonesian language containing a material substance adapted to the learning goals to practice students' critical thinking and process skills. The results of the draft textbook framework are used as a basis for the preparation of initial products. The design of the textbook includes (1) determination of basic competencies and indicators, (2) determination of scientific concepts and methods, (3) compilation of components and derived concepts to be taught, and (4) designing the appearance of the book. Otherwise, the design of the textbook contents includes (1) branches of biology and their meanings, (2) the ratio of the scientific method and its components, (3) the steps of the scientific method and its practice, and (4) how to use the textbook in learning.

The draft textbook is composed of three main parts, namely the introduction, content, and conclusion. The introduction contains information regarding the title, curriculum used, book user, author and validator, year of publication, relevant picture, and publishing agency. Also, to facilitate use, the textbook is equipped with a table of contents, characteristics, and usage guidelines. The usage guide contains informative sentences about a brief description of each activity in the textbook.

The contents section explains the subject matter that was developed. The contents of the learning material have been adjusted to the basic competencies and the development of indicators. The material
The scope of biology is divided into two sub-chapters, which were developed, namely sub-chapter one about the branches of biology and sub-chapter two about the scientific method. Presentation of material is complemented by an activity rubric representing a scientific approach, namely observing, asking, associating, reasoning, and communicating. These scientific activities are facilitated through several features developed in the textbook, consisting of “Let’s Explore”, “Act Creatively”, “Independent Task”, “Project”, “Summary”, “Evaluation”, and “Reflection”. Before the description of the material in this textbook is given, at the beginning of the chapter is equipped with an apperception that is equipped with illustrations and what will be learned.

Figure 2. The distribution of pretest data based on the normality test

The concluding section contains reference information in textbook development and a glossary that summarizes essential terms related to the material being studied. The concluding section’s availability represents scientific activities in the learning process because students can identify and confirm further by accessing relevant references. These steps are essential so that the understanding that is built by students after the learning process is holistic.
Creative students, you've learned about life through learning about biology as a science. As part of science, biology studies nature through the symptoms of living things and all the problems of life. Science refers to the system for gaining knowledge. Well, how do you think science works? How does science gain that knowledge? Let's find out...

**A. Introduction**

Various problems in the field of biology can occur at all levels of life organization. Problems are studied through research by scientists. Research is done by applying science from the branches of biology and solved systematically through the workings of science called scientific methods.

Scientific methods require scientific attitudes to accountable research results. How are the steps in scientific methods? To find out, do the following activities “Let's Explore”

**“Identifying Steps in Scientific Methods”**

1. Look for literature from various sources such as reference books or the internet on how a researcher works using scientific methods.
2. Read the literature carefully and thoroughly, then take notes for the steps of the scientific method used by the researcher.
3. Have discussions with your group friends politely and courageously in asking questions and arguing and applying willingness to cooperate and diligently in solving the following problems:
   a. What is the scientific method?
   b. How are the steps in scientific methods?
   c. Why is doing research needs to apply scientific methods?
4. Make an activity report that includes the title, objectives, observations and discussions with conclusions as well.

**Figure 3.** The distribution of pretest data based on the normality test

The expert review provides some notes regarding the content and suitability of the biological scope material displayed. Some material expert notes refer to material compatibility aspects with basic competencies, material accuracy, and availability of supporting material in the textbook (Table 3). The results of the expert material review, among others, need to strengthen apperception and improve the integration of activities that are able to stimulate students' process skills. At the same time, media experts
give notes related to appearance and design (Table 4). Input from media experts, namely the foreword or preface presented in the book, does not describe the textbooks that were developed, and the book cover does not adequately describe the scope of biology.

Table 3. The results of expert material assessments

| No. | Assessment Component                              | Percentage (%) | Category     |
|-----|---------------------------------------------------|----------------|--------------|
| 1   | Material suitability with basic competencies      | 66             | Very decent  |
| 2   | Material accuracy                                 | 51             | Very decent  |
| 3   | Supporting material                               | 51             | Very decent  |

Table 4. The results of expert media assessments

| No. | Assessment Component     | Percentage (%) | Category     |
|-----|--------------------------|----------------|--------------|
| 1   | Presentation eligibility | 88             | Very decent  |
| 2   | Graphic eligibility      | 97             | Very decent  |
| 3   | Content design           | 90             | Very decent  |

3.2. Quasi Experiment

The normality test results showed that students' pretest and posttest (Figure 4) are normally distributed. Thus, data analysis was continued with a paired t-test. The results of paired sample t-tests showed that the significance was < 0.05 (Table 6). These results indicate differences in critical thinking skills and process skills in the scope of biology material before and after using the textbook. Some researchers believe that the emphasis and practice of critical thinking skills through training or new learning resources can help trained students improve their critical thinking skills [30–32].

![Figure 4. The distribution of pretest (a) and posttest (b) data based on the normality test](image)

Meanwhile, observations of science process skills show varied results. The assessment was carried out based on eight aspects observed during the learning process using a textbook. The results of observations as outlined in Table 6 show that there are two very dominant indicators, namely the ability to make observations and measurements with an average score of 91.5 and 98.5, respectively. Indicators of hypothesizing, experimenting, interpreting, and delivering skills. These results indicate that the textbook that has been developed can make a difference and improve students' science process skills. In other words, the features integrated into the textbook can facilitate students' thinking abilities and provide space for the development of science concepts so that students' skills increase simultaneously during the learning process.

Table 6. The results of students’ science process skills

| No. | Indicators  | Score (%) | Total (%) | Average (%) | Criteria     |
|-----|-------------|-----------|-----------|-------------|--------------|
| 1   | Observing   | Observer 1 | Observer 2 | 89          | 94           | 183          | 91.5         | Very high    |
2. Measuring 100 97 197 98.5 Very high
3. Questioning 76 62 138 69 Moderate
4. Hypothesizing 70 75 145 72.5 High
5. Experimenting 75 75 150 75 High
6. Data interpreting 80 80 160 80 High
7. Concluding 68 72 140 70 Moderate
8. Data delivering 80 75 155 77.5 High

However, the other indicators of science process skills showed that they are acceptable, including questioning skills (69) and making conclusions (70). These results indicate an area of development that needs to be done in further refinement. In other words, the textbook that has been developed has not been able to improve students' questioning skills and the ability to conclude. If further analysis, two factors can underlie these results. The first factor is that students are not accustomed to learning by developing questions, even with the non-optimal ability to make conclusions. Another factor is that the textbook is not enough to stimulate students in developing their analytic abilities.

4. Conclusions
The results showed that the textbook developed was integrated with learning indicators based on a scientific approach and feasible to use because it showed significantly different results in improving students' critical thinking skills and science process skills.

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