How to Develop Scientific Literacy Enrichment Book on Earth Science Content Using Plomp Method?

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Abstract. The purpose of this study is to produce a book on enriching scientific literacy in Earth Science context that is feasible and appropriate for junior high school students. The development of science literacy enrichment books uses the Plomp method which consists of problem analysis, prototype design and development, evaluation, and revision. In the process of developing the book an instrument is used in the form of a list of indicators which are a combination of material and competencies developed. The material developed includes Atmosphere, Hydrosphere and Lithosphere which includes discussions on environmental pollution, global warming, the water cycle, earthquakes, tsunamis, volcanoes and soil. Competencies developed include the competence to explain phenomena scientifically, interpret scientific data and evidence, and evaluate and design investigations. In the evaluation process the instruments used were questionnaires, readability test instruments and scientific literacy tests. The participating participants numbered 30 of grade 7 students from one of the junior high schools in Cilacap District. The results of the study showed that the developed scientific literacy enrichment book was feasible to use with a percentage of eligibility of 79.2%.

Keywords: Scientific Literacy, Enrichment Book, Earth Science Content, Plomp Method

1. Introduction
Miller in Yuenyong & Narjaikaew stated that people's daily lives are significantly influenced by science demonstrated in the increase in the amount of technology that used [1]. These conditions indicate that science learning plays an important role in civilization and people's lives. Based on the 2013 curriculum learning syllabus, science learning goal is making students have competencies needed for life in the present and the future such as abilities to apply in the context of carrying out scientific investigations, problem solving and making creative work related to everyday life. As for skills related to the acquisition of knowledge of science and its application in solving problems in everyday life is known as scientific literacy. Holbrook and Rannikmae [2] argues that scientific literacy is the knowledge of science which includes application in critical thinking, problem-solving to the self-development of the scientific interest and social attitudes.

The global scientific literacy assessment is conducted by the OECD (Organization for Economic Cooperation and Development). Science literacy is one of the PISA (Program for International Student Assessment) studies which is held every three (3) years. As quoted from the OECD [3,4,5], Table 1 shows the results of the evaluation of Indonesian students' scientific literacy on PISA.
Table 1. PISA scores in the realm of scientific literacy for Indonesian students

| Year | Score | Information |
|------|-------|-------------|
| 2009 | 383   | Rank 57th from 65 countries |
| 2012 | 382   | Rank 64th from 65 countries |
| 2015 | 403   | Rank 64th from 72 countries |

Based on Table 1, Indonesian students' scientific literacy scores still below the average score (500) and made Indonesia as one of the ten (10) countries in the lowest rank of all participating countries PISA. The level of scientific literacy of students is closely related to their science lessons applied and used textbooks [2]. The use of teaching materials is limited to textbooks and syllabus is one factor that causes low achievement of learning objectives [6].

Reading and writing have an important role in the achievement of scientific literacy skills [7]. Results of research Fang and Wei [8] that the reading has a positive impact on the scientific literacy of students in secondary schools. In line with the results of the study, data from research conducted by Kartal, Dogan and Yildirim [9] show that scientific literacy skills are one of the needs of students that can be grown with the help of books. Most of teachers rely on textbooks as a source of information and curriculum and this can continue to increase if there is a decrease in funding for learning equipment, an aging teacher population, or an increase in the number of students in the class [10]. It can be said that textbooks have the same role as the learning methods used by the teacher. Analysis of the textbooks used in science learning is carried out to determine whether the textbooks support the achievement of the expected scientific literacy competencies.

According to Taconis, Den Brok and Pilot [11] contextual learning material is easy to reach and recognize by students so that learning science contextually provides meaningful learning for students. The results of Nofiana and Julianto's [12] research show that the analysis of students' scientific literacy in the context aspects which is still very low is caused by partial (separate) or not integrated science learning, as a result the concept of science received by students is also separate. For this reason, contextual and integrated science learning cannot be separated. One of the materials at the junior high school level that is contextual and contains integration between physics, chemistry and biology is a discussion of the earth. Earth Science is an integrated science that unites the disciplines of Biology, Chemistry and Physics in its application to Earth's performance [13].

Discussions on earth science at the junior high school level in the 2013 curriculum generally cover the earth's crust, atmospheric layers, global warming, earthquakes, tsunamis to pollution that causes floods and landslides. Referring to the 2015 PISA Framework, there are several Earth-related material that was tested in PISA but not yet included in textbooks such as rocks (fossils), energy transformation on Earth, and climate change. In addition in the form of textbooks, presenting potentially objectionable material and allow it to be studied independently by the students can also be through non-text book lessons or better known as enrichment books. Based on Permendikbud No 8 of 2016, non-textbooks are enrichment books to support the learning process at every level of education and other types of books available in school libraries. In formal conditions, enrichment books play a role as supporting textbooks or complement the lack of textbooks in developing certain skills.

In the process of developing a scientific literacy enrichment book, a certain development model is needed so that the products produced are in accordance with the expected goals and their eligibility and compatibility can be accounted for. Plomp in van den Akker, Bannan, Kelly, Nieveen & Plomp [14] argues that research and development (design research) has two types of goals: 1) to develop research-based solutions to address the complex problem of education practices and 2) develop or validate the theory. According to Plomp, whatever the purpose of development research is carried out, the research process always includes a systematic educational design process. The process includes problem analysis, design and development of prototypes (products), evaluations and revisions [14]. The whole process can be repeated in accordance with the needs and achievement characteristics of the desired product. These processes can be presented in illustrations on Figure 1.
Characteristics of scientific literacy enrichment book developed refers to the competence of which is tested scientific literacy in PISA and contain aspects of scientific literacy that is appropriate for a science book. Evaluation of scientific literacy in PISA 2015 are arranged in three competencies that are explain phenomena scientifically, evaluate and design scientific inquiry, and interpret the data and evidence scientifically [15]. Aspects of scientific literacy in science textbooks according to Chiappeta, Filman, and Sethna [16] are aspect of science or scientific knowledge as a torso, aspect of science as a process of investigation, aspect of science as a way of thinking, as well as aspect of the interaction between science, technology and society.

2. Method

As an educational development study, in this study the final result is educational products namely enrichment books on scientific literacy on earth content. The method used in this study adopted the development research concept proposed by Plomp. Therefore in this research the problem analysis, design and development of prototypes (products), evaluation and revision are carried out. The product or prototype in this study is a literacy enrichment book science on earth content. Analysis of the problem includes analysis scientific literacy skills of students in the PISA program and analysis of terrestrial material and the competence of PISA science literacy in natural science textbooks that are commonly used in educational institutions especially in the junior high school level. The results of the analysis used as the basic of product design and development. The design process includes the process of determining parts of the book and selection content (material) that is appropriate to the earth content and science literacy competencies. From the results of product analysis and design, information about the characteristics of the product being developed can be obtained. The product development process is arranging the selected material into parts of the book by referring to the scientific literacy competencies that desired in the book. A prototype will appear when the development process is completed. The next process is evaluation. Evaluation process includes feasibility test of the product that consist of several aspects and criteria. Those processes can be shown on Figure 2.

![Figure 1. Illustration of Plomp Method](image1.png)

![Figure 2. Illustration of Plomp Method on Book Development](image2.png)
Feasibility test of the book consists of scientific literacy and content aspects, language aspects, technical aspects and graphical aspects. Language, technical and graphics aspects are adapted from the National Education Standards Agency (BSNP). However, aspects of scientific literacy and content compiled based on the domain of PISA scientific literacy and PISA 2015 scientific literacy competencies. The feasibility test instrument was a questionnaire with a Likert scale consisting of five (5) choices. Here is the equation used to calculate the percentage of feasibility studies book.

\[
y = \frac{\bar{x}}{x_{max}} \times 100\%
\]

Information:
- \(Y\) = Feasibility test percentage
- \(\Sigma x\) = Total scores of each aspects
- \(\Sigma x_{max}\) = Total maximum scores

The following are general book eligibility criteria based on calculating the frequency distribution of scores that might be obtained when using a Likert scale with 5 choices [17].

- \(80.00\% < \text{value} < 100\%\) = very feasible
- \(60.00\% < \text{value} < 79.99\%\) = feasible
- \(40.00\% < \text{value} < 59.99\%\) = good enough
- \(20.00\% < \text{value} < 39.99\%\) = not feasible
- \(0.00\% < \text{value} < 19.99\%\) = very inappropriate

### 3. Result and Discussion

#### 3.1. Product Characteristics

Developed enrichment book contains earth science content in which scientific literacy competences are raised. The needs of content that appeared is selected and mapped before. Table 2 shows the selected and mapped contents.

| Content Materials | Sub-Content Materials |
|-------------------|-----------------------|
| Atmosphere        | Earth’s Characteristics |
|                   | Atmosphere layers     |
|                   | Weather and Climate   |
|                   | Atmosphere Gases Cycles |
|                   | Air Pollution         |
|                   | Global Warming        |
|                   | Climate Change        |
| Hydrosphere       | Hydrosphere Layers    |
|                   | Ocean (Sea) Current   |
|                   | Rainy and Dry Season  |
|                   | Water Cycle           |
|                   | Water Pollution       |
| Lithosphere       | Lithosphere definition|
|                   | Plate Tectonic Theory |
|                   | Volcanos              |
|                   | Earthquake            |
|                   | Tsunami               |
|                   | Soil                  |
|                   | Soil Pollution        |

In accordance with the statement of Devetak and Vogrineg [18] that good science books are developed based on certain competencies to be achieved. On this developed book, the competencies are explain phenomena scientifically, interpret data and scientific evidence and evaluate and design investigations.
Each material content is developed based on one of these competencies. In order to facilitate the development of material content, each competency is developed with subcontent material into several learning objectives. Table 3 shows some examples of learning objectives that form the basis of developing the contents of enrichment books developed.

| Contents       | Scientific Literacy Competencies | Scientific Literacy Sub-Learning Objectives | Competencies                                                                 |
|----------------|----------------------------------|-------------------------------------------|-------------------------------------------------------------------------------|
| Atmosphere     | Explain phenomena scientifically  | Identify concepts in graph representation | Identify the layers of the atmosphere based on the characteristic temperature at atmospheric illustrations. |
| Hydrosphere    | Explain phenomena scientifically  | Explain phenomena scientifically          | Explain the causes and effects that occur in the water cycle.                 |
| Lithosphere    | Interpret scientific data and evidence | Analyze data on a representation and draw conclusions | Interpret data related to the causes of soil pollution.                       |

According to Schroeder, Mckough, Graham, Stock, & Bisanz [19] the effectiveness of science books can be seen from the peculiarities of scientific literacy content, colors that are diverse, attractive, and have a familiar format. The specificity of scientific literacy content is shown by the parts of the book that bring up the aspects of scientific literacy as well as the contents of books developed based on scientific literacy learning objectives.

The contents of scientific literacy (competencies and aspects of scientific literacy) appear in a special section of the book being developed. They are “Sekitar Kita”, “Menurut IPA”, “Penyelidikan”, and “Uji Kemampuan”. Sekitar Kita section in the book contains the phenomenon, issues, and technologies that serve as an introduction before discussing the science concepts that will be explained. Science literacy competencies have not been raised in this section. Competence to explain phenomena scientifically and interpret data and scientific evidence raised in the Menurut IPA and Penyelidikan sections. As for the Penyelidikan section, competencies for evaluating and designing investigations are raised.

For scientific literacy aspects, those appear in the book’s sections too. The aspect of science as the body and aspect of the interaction of science with technology and society are contained in the "Sekitar Kit" and "Menurut IPA" sections. The aspect of science as a way of thinking and aspect as a process of inquiry are contained in the Penyelidikan section. Those sections are displayed in the Figure below.

Figure 3. Section of “Penyelidikan” on Lithosphere Content
3.2. Product Eligibility

In accordance with the theory put forward by Devetak and Vogrine [18] that the content in good science books is in accordance with the concept and validated by expert experts with a minimum level of Ph.D or Doctor. So, to ensure the validity of the content that is developed will require expert validation of the content developed in the book. It was done before the feasibility test to know the eligibility of the product. There are three experts who act as validators. In the validation process, things that are validated include a) the suitability of the material with the competence and indicators of scientific literacy, and b) the truth / accuracy of the theory, law, facts, concepts and application of the concepts, examples or illustrations presented. The validation results generally show that the concepts presented in the scientific literacy enrichment book are appropriate and appropriate.

Feasibility of the developed book was tested based on four (4) aspects, they are aspects of scientific literacy and content accuracy, technical presentation aspect, language aspect and graphical aspect. Aspects of scientific literacy and content accuracy refers to Chiapetta, Filman, and Sethna [16] and PISA 2015 Framework. While the others refers to BSNP aspects and criteria. Table 4 shows the feasibility test result based on those aspects.
Table 4. Feasibility test result

| Aspects                        | $x$  | $x_{max}$ | $y$       |
|-------------------------------|------|-----------|-----------|
| Aspect of scientific literacy and content accuracy | 71.8 | 85        | 84.47%    |
| Technical presentation aspect | 42.2 | 60        | 70.33%    |
| Language aspect               | 46.8 | 60        | 78.00%    |
| Graphical aspect              | 49.2 | 60        | 82.00%    |
| RATA-RATA                     | 52.5 | 66.25     | 79.25%    |

Aspects of scientific literacy and the accuracy of the content classified as very feasible. Aspects of the technical presentation and language considered as feasible. The graphic aspect is classified as very feasible so that as a whole the percentage of the feasibility of enrichment books is oriented towards scientific literacy on earth content can be said to be suitable for use by students.

4. Conclusion
The contents of scientific literacy (competencies and aspects of scientific literacy) appear in a special section of the book being developed. They are “Sekitar Kita”, “Menurut IPA”, “Penyelidikan”, and “Uji Kemampuan”. Feasibility test of the developed book was done based on four (4) aspects. The whole percentage of the feasibility test result can be said as feasible so that the developed book is suitable for use by students.

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