

## DEVELOPMENT OF SCIENCE TEXTBOOK BASED ON SCIENTIFIC LITERACY FOR SECONDARY SCHOOL

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### ABSTRACT

The purpose of this research is to develop scientific literacy-based science text books and to determine the characteristics, validity, readability, as well as the effectiveness of the textbooks. The study started with product development and then continued by feasibility test and readability test. Feasibility test was done with the respondent of lecturer and science teachers of VII, VIII, IX grade at SMP N at Central Java. Readability test used cloze test that filled by VII, VIII, and IX grade students at that schools. The data analysis was done with percentage discription and t-test. The study results in feasibility test showed that the developed literacy science textbook has average score 90,74%. It means the literacy science textbook is suitable. Based on the readability test result, science literacy textbook is easy to learn. The average of score of cloze test was 88,14%. The effectiveness of the developed science textbook was classified as an effective stimulant to increase students' scientific literacy.

### ABSTRAK

Tujuan penelitian ini adalah mengembangkan buku ajar IPA berbasis literasi sains, menentukan karakteristik, kevalidannya, tingkat keterbacaan, dan keefektifannya. Penelitian pengembangan ini dimulai dengan analisis kebutuhan, penyusunan tema, pengembangan buku ajar, uji kevalidan dan keterbacaan buku yang telah dikembangkan. Validasi dilakukan oleh dosen dan guru IPA kelas VII, VII, IX. Uji validitas, tingkat keterbacaan dan keefektifan buku dilakukan di SMP N di Jawa Tengah. Subjek ujicoba adalah siswa kelas VII, VIII, IX. Teknik analisis data menggunakan deskriptif persentase untuk uji kevalidan dan keterbacaan, dan uji t untuk keefektifan. Hasil validasi menunjukkan seluruh buku yang dikembangkan adalah valid dengan rata-rata skor 90,74% berada pada kategori sangat valid. Skor rata-rata tingkat keterbacaan sebesar 88,14% beradapada kategori mudah dipahami. Buku ajar yang dikembangkan efektif untuk meningkatkan kemampuan literasi sains.

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**Keywords:** science textbook; scientific literacy

### INTRODUCTION

Understanding and using science concepts in daily life problems and simple technology is the goal of science education. Based on that goal, education must focus on scientific literacy as stated by *National Research Council* (1996). Science education has been applied in Indonesia for years, but the result for Indonesia in international level especially for scientific literacy is still poor. Based on Hayat & Yusuf (2011) and the OECD (2015), the *Programme*

*for International Student Assesment (PISA)* results for Indonesian students scientific literacy are as follow in Table 1. All the results were under international mean score that is 500.

**Table 1.** The Score and Rank of Indonesian Student Scientific Literacy at PISA

| Year | Score | Rank                 |
|------|-------|----------------------|
| 2000 | 393   | 38 from 41 countries |
| 2003 | 395   | 38 from 40 countries |
| 2006 | 393   | 50 from 57 countries |
| 2009 | 383   | 60 from 65 countries |
| 2012 | 383   | 64 from 65 countries |

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Scientific literacy defined by OECD (*Organization for Economic Co-operation and Development*) as an ability to conclude and to solve problem about nature and interaction between nature and society (Nbina & Obomanu, 2010). The factors that influence student's scientific literacy result are the textbook selection and the lowness of student's scientific literacy (Rusilowati, Susilowati & Nugroho, 2015). Textbook is the learning source that connected directly to the students. A science textbook that based on scientific literacy must has some basics categories (Chiapetta, Filman & Sethna, 1991). Those basics categories are science as the body of knowledge, science as the investigative nature, science as a way of thinking, and Interaction of science, technology and society. Rusilowati, Susilowati & Nugroho (2015) added in interaction category with environment.

1. *Science as the body of knowledge.*  
This category typifies most textbook and presents information to be learned by the reader. Textbook materials in this category are presents facts, concepts, principles, laws, hypotheses, theories, models and asks student to recall knowledge or information.
2. *Science as the investigative tools of nature.*  
This category reflects the active aspects of inquiry and learning, which involves the student in the methods and processes of science such as observing, measuring, classifying, inferring, recording data, making calculations, experimenting, etc.
3. *Science as a way of thinking.*  
This aspects of the nature of science represent thinking, reasoning, and reflection, where the student is told about how the scientific enterprise operates.
4. *Interaction of science, environment, technology, and society.*  
This aspects of scientific literacy pertains to the application of science and how technology helps or hinders humankind.

Scientific literacy content on the science textbook that used in common schools especially for secondary school had not balance (Yuliyanti & Rusilowati, 2014). It's appropriate to the Hastiti's study result (2014) and Rusilowati (2013), that the contains of the scientific literacy aspects have been include in textbook, but the proportion of each aspects have not balanced. The available textbook in only concentrate in *science as a body of knowledge* aspect. This aspect present fact, concepts, principles, laws,

hypothesis, theory, model and questions and has biggest percentage, 58.24%. Student's scientific literacy can be raised by presenting the science material which interrelated with technology and society issues. One of the present issue which connect with science in society is pollution (Subiantoro, Ariyanti & Sulistyono, 2013). It is obvious that the development of science textbook which encourage students to have the literacy science skills is essential to do.

**METHODS**

This study was used Research and Development (R&D) procedure that has been modified as potential and problem, data collecting, product design, product validation, product revision, initial product try-out, product revision, product try-out, and product revision as a final product. The product of this study is science textbook based on scientific literacy for secondary schools. Product try-out conducted in Junior High School at Central of Java. The subject of product try-out shown at Table 2.

**Table 2.** Subject of Product Try-out

| Code of Textbook | Grade/N | School                   |
|------------------|---------|--------------------------|
| A                | VII/32  | SMP N 1 Magelang         |
| B                | VII/32  | SMP N 1 Purwokerto       |
| C                | VII/32  | SMP N 1 Sidareja Cilacap |
| D                | VIII/32 | SMP N 24 Semarang        |
| E                | VIII/34 | SMP N 1 Purwodadi        |
| F                | VIII/33 | SMP N 1 Welahan Jepara   |
| G                | IX/35   | SMP N 1 Boyolali         |
| H                | IX/32   | SMP N 1 Ambarawa         |
| I                | IX/33   | SMP N 2 Pekalongan       |

Based on the literatures study, the potential and problem of the research are the lowness of student scientific literacy in international level and the lack of science textbook that developed based on scientific literacy aspects at school. Data of science curriculum for secondary school and scientific literacy aspects as collected before designing the product. Product design was validated by validator.

The assessment of validity done by lecturer at Universitas Negeri Semarang and science teacher as in Table 2. Feasibility textbook

uses questioner based on National Council of Standard Education or Badan Standar Nasional Pendidikan (BSNP) in Indonesia. The readability level of the textbook was measured by Cloze Test at Junior High School student. The textbook effectiveness was measured using pretest and posttest, with *pretest-posttest control group design* as the research design. Experimental and control group in this study are student at VII, VIII, and IX grade. The experimental group uses developed science textbook and the control group uses regular science textbook provided by the BSNP for VII, VIII, and IX grade that published by National Educational Department or Departemen Pendidikan Nasional in 2013.

Benchmark of validity categories of science literacy textbook is more than 80%. The score readability of cloze test the developed science textbook is more than 37% from each respondents. The science literacy textbook effectiveness showed that the gain of each scientific literacy aspects in experimental group with gain factor at least 0.3. Based on statistics test of both group, the result showed that statistically of the gain factor and posttest of the scientific literacy of experimental group higher than the control group's one.

## RESULTS AND DISCUSSION

Results of this study are characteristics, feasibility, readability, and effectiveness of sci-

ence textbook based on scientific literacy are as follows.

### Characteristics of Science Textbook Based on Scientific Literacy

The developed science textbook contains scientific literacy aspects completely. Product of the studies are nine theme of science textbook. Three theme science textbooks for each grade. Table 3 is shown the themes of product of developed science literacy textbook.

The balance proportion of the scientific literacy aspects are showed by the indicators for each aspect in every material in textbook. The aspect of science as the body of knowledge has 40% of indicators from all indicators in one material. The others aspects, science as the investigative nature, science as a way of thinking, and interaction of science, environment, technology and society have 20% of indicators for each.

Science materials are presents as integrated subject, and in this product the integration type of the materials uses *connected* model. This model relates one main topic to the next topic, one concept to the other concept, one skill to the other skill and today's work to the tomorrow's work in the study (Fogarty, 1991). Materials of science textbook are construct of some indicators. The indicators are construct of four scientific literacy aspect. Table 4 is shown the sample of indicators for construct of the material textbook theme Matter Changes in

**Table 3.** Theme of Science Textbook Based on Scientific Literacy

| Grade | Theme   | Code |
|-------|---|------|
| VII   | Knowing of Heat<br>(Asyiknya Mengenal Kalor)  | A    |
|       | Motion<br>(Asyiknya Mempelajari Gerak)  | B    |
|       | Matter Changes in Environment (Pencemaran Lingkungan dan Pemanasan Global)              | C    |
| VIII  | Force Application for life<br>(Apilkasi Gaya dalam Kehidupan)                           | D    |
|       | Energy and Application for Life<br>(Apilkasi Konsep Energi dalam Kehidupan)             | E    |
|       | Sound and Optic in Technology<br>(Bunyi dan Optika dalam Teknologi)                     | F    |
| IX    | Electricity in Life<br>(Listrik dan Kehidupan)  | G    |
|       | Electricity for Organism and Universe (Kelistrikan pada Makhluk Hidup dan Alam Semesta) | H    |
|       | Navigation System (Sistem Navigasi)   | I    |

Environment (Puspaningtyas, Rusilowati, Nugroho, 2015).

Indicators for construct of the other material textbook theme were constructed of four scientific literacy aspects like the Matter Changes in Environment theme.

Textbook characteristics are contain all of four scientific literacy aspects and has a balance proportion of scientific literacy aspects. Four scientific literacy aspects presented on main part in textbook, they are “Let’s go to Learn” or “Ayo Belajar (in Indonesian language)”, “Let’s go to Try” or “Mencoba Yuk (in Indonesian language)”, “Let’s go to Scientific Thinking” or “Ayo Berpikir Ilmiah (in Indonesian language)”, and “Science in Life” or “Sains dalam Kehidupan (in Indonesian language)”. “Ayo Belajar” is representation of Science as the body of knowledge. “Mencoba Yuk” is representation of Science as the investigative nature, “Ayo Berpikir Ilmiah” is representation of Science as a way of thinking, and “Sains dalam Kehidupan” is representation of Interaction of Science, Invironment, Technology and Society). Main parts of this textbook presented at Figure 1.

Especially for representation of Interaction of Science, Technology and Society, in this textbook conducted with environmental (Rusilowati, Susilowati & Nugroho, 2015). Schroeder, et al. (2009) were said that effectiveness of textbook looked at a content of science literacy, interested, colourful, and familiar format with student. This development of textbook to conducted with content of science lit-

eracy, interested, colourful, familiar format, and propotional of science literacy aspect is balance.



Figure 1. Feature of Science Textbook Based on Scientific Literacy (the picture of feature courtesy at internet)

**Feasibility of Science Textbook Based on Scientific Literacy**

Feasibility textbook aspects was used questioner based on BSNP. There aspects of feasibility are content, language, graphic, and science literacy content. Results of score feasibility textbook by validator presented at Table 5.

**Table 4.** Indicators to Construct Material Textbook by Scientific Literacy Theme Matter Changes in Environment.

| Scientific Literacy   | Indicators   |
|---|--|
| Science as the body of knowledge                            | Mention the characteristics of material in student’s environment.<br>Define and differentiate physics changes and chemistry changes from phenomenon in the environment.<br>Mention the signs of chemistry changes.<br>Differentiate mixture and non-mixture. |
| Science as the investigative nature                         | Mention the signs of chemical reaction in simple experiment.<br>Doing mixture separation based on physics and chemistry characteristics.   |
| Science as a way of thinking                                | Describe the idea development of dynamite making.<br>Describe cause and effect from physics changes and chemistry change in rain phenomenon.   |
| Interaction of science, environment, technology and society | Describe the work steps and benefit of water distillation technology<br>Describe the use of science as problems solution for humankind (artificial rain technology)  |

The balance proportion showed on the percentage indicators for each aspect. The first aspect (Science as a way of thinking) has 40% number of all indicators, and the other aspect has 20% for each. The balance proportion of scientific literacy aspects for science textbook is 2:1:1:1. This design conducted using Wilkinson (1999) statement.

Feasibility test result was shown on Table 5. From the data, the average feasibility result got percentage >81.25%. It means the developed science textbook classified as a very feasible learning source. The result showed that the textbook as the product was well developed. The developing process was pointed from Guidance of Development of Textbook or Panduan Pengembangan Bahan Ajar that published by Department of National Educational in Indonesia or Depdiknas (2008). One of the important point for textbook development according to Department of National Educational in Indonesia or Depdiknas (2008) is that the material must be derived from competences that will be achieved. Those competences were shown as the indicators or learning objectives.

Science as the body of knowledge on this book makes the student to have compe-

tences of mentioning the characteristics of material; defining and differentiating physics and chemistry changes of environment phenomena; mentioning the chemistry changes features; and differentiating mixture and non-mixture. The other theme, competences student's are: sort the position of living creature in the food chain; describe the effects of Greenhouse Effect in life and global warming phenomenon; mention the Greenhouse Gases and the emitter technologies; mention the activity that cause the ozone layer damaged; mention the effect of Ultraviolet Radiation, mention the activity that can reduce the ozone layer damage, etc.

Science as the investigative of nature on Matter Changes in Environment theme encourage the student to have some competences. They are of mention the signs of chemical reaction in simple experiment and doing mixture separation based on physics and chemistry characteristics. Competences for Pollution and Global Warming materials are: describe the unbalance ecosystem effects; doing water filtration from grey waste water into clean water through simple experiment, and conclude the main cause of pollution based on the showed data.

**Table 5.** Result of Score Feasibility of Science Textbook

| Theme | Validator | Content Feasibility (%) | Presentation Feasibility (%) | Language Feasibility (%) | Graphic Feasibility (%) | Science Literacy Content (%) | Average (%) | Category      |
|-------|-----------|-------------------------|------------------------------|--------------------------|-------------------------|------------------------------|-------------|---------------|
| A     | 1         | 87,50                   | 86,30                        | 88,50                    | 89,60                   | 88,00                        | 89,22       | Very Feasible |
|       | 2         | 87,50                   | 93,80                        | 86,50                    | 93,80                   | 89,80                        |             |               |
| B     | 3         | 95,31                   | 98,75                        | 94,23                    | 97,73                   | 96,30                        | 90,42       | Very Feasible |
|       | 4         | 95,31                   | 92,50                        | 98,08                    | 100,00                  | 98,15                        |             |               |
| C     | 5         | 89,71                   | 80,00                        | 92,31                    | 88,46                   | 90,74                        | 87,34       | Very Feasible |
|       | 6         | 85,29                   | 85,00                        | 84,62                    | 86,54                   | 90,74                        |             |               |
| D     | 7         | 89,71                   | 92,50                        | 88,46                    | 88,46                   | 87,04                        | 90,84       | Very Feasible |
|       | 8         | 86,76                   | 88,75                        | 100,0                    | 92,31                   | 94,44                        |             |               |
| E     | 9         | 90,63                   | 90,00                        | 90,38                    | 90,91                   | 87,96                        | 91,73       | Very Feasible |
|       | 10        | 95,31                   | 88,75                        | 98,08                    | 97,73                   | 84,26                        |             |               |
| F     | 11        | 87,50                   | 87,50                        | 84,61                    | 84,46                   | 86,11                        | 88,01       | Very Feasible |
|       | 12        | 98,44                   | 98,75                        | 76,92                    | 86,54                   | 88,89                        |             |               |
| G     | 13        | 95,59                   | 95,00                        | 88,46                    | 88,46                   | 87,94                        | 88,70       | Very Feasible |
|       | 14        | 89,71                   | 87,50                        | 80,77                    | 86,54                   | 87,04                        |             |               |
| H     | 15        | 86,25                   | 88,84                        | 85,27                    | 94,17                   | 85,12                        | 83,81       | Very Feasible |
|       | 16        | 86,25                   | 89,84                        | 85,27                    | 94,17                   | 81,12                        |             |               |
| I     | 17        | 94,12                   | 90,00                        | 88,46                    | 94,23                   | 89,81                        | 90,04       | Very Feasible |



*Student Competences' of Science as a way of thinking* describe the idea development of dynamite making and cause and effect from physics changes and chemistry change in rain phenomenon. In Pollution and Global Warming theme, the competences student's are: describe the cause and effect from Acid Rain phenomenon; mention the activity that can reduce Acid Rain phenomenon; and describe the mechanism of Sea Water Increasing as the effect of global warming.

Example of the competences student's of Interaction of science, technology and society are describe the work steps and benefit of water distillation technology; and describe the use of science as problems solution for humankind (artificial rain technology). In Pollution and Global Warming theme, the competences are: describe the effects of air conditioning technology into global warming phenomenon; mention the use of technology to decrease the cause of global warming; analyze the society culture to the pollution, etc.

**Readability of Science Textbook Based on Scientific Literacy**

Data of the readability textbook were collected by test cloze. The data were shown in Table 6. Readability test result showed positive score that got percentage average > 57% that is 81.97%. Higher percentage is 98.25% and lowest is 61.93% for each person. It means the developed textbook was easy to read and to learn. Some of the result was means some correspondent that having difficulty to learn the developed science textbook. One of those difficulties is their lack of vocabulary. This result is connect with Essem Educational Limited (2007). They said the textbook readability was influenced by text format, ability reader, difficulty of vocabulary, structure text, and syntax.

Good readability was easy to read. It means the good quality of textbook. It's a accordance with Devetak & Vogrinc (2013) statement. They said that the textbook quality looked at word, sentences, and text.

**Effectiveness of Science Textbook Based on Scientific Literacy**

*Effectiveness* of the developed science textbook classified as an effective stimulant to increase students' scientific literacy. It's showed on the gain factor and posttest score of experimental group that higher than the control group. The result of effectiveness textbook shown at Table 7. From the data, the learning

strategies that used in experimental group and control group were the same. The effectiveness result showed by gain score from pretest to posttest, at the theme A, B, and C. The strategy teaching that used in gain score were Cooperative Learning, Direct Instruction.

**Table 6.** Average of Readability Index of Textbook

| Theme   | Readability Index (%) | Category     |
|---------|-----------------------|--------------|
| A       | 72,43                 | Easy to read |
| B       | 71,80                 | Easy to read |
| C       | 80,05                 | Easy to read |
| D       | 88,42                 | Easy to read |
| E       | 91,51                 | Easy to read |
| F       | 89,53                 | Easy to read |
| G       | 76,60                 | Easy to read |
| H       | 89,80                 | Easy to read |
| I       | 77,55                 | Easy to read |
| Average | 81,97                 | Easy to read |

The experimental group were used the Science Textbook Based on Literacy, and the control group were used non Science Textbook Based on Literacy. The Direct Instruction gain was better than the Cooperative Learning. But the average gain of science literacy learning achievement students' experimental group better than control group. The average score gain of experimental group in this research which classified as middle category and score gain of control group which classified as low category.

On the other hand, effectiveness result showed by posttest, at the theme G, H, and I. The teaching strategy that used in posttest score were Demonstration, Discussion, and Experiment. The experimental group were used the Science Textbook Based on Literacy, and the control group were used non Science Textbook Based on Literacy. The average posttest of science literacy achievement of students in experiment group is better than those in control group. The average posttest score of the experimental group in this research belongs to middle category.

Another factor that supports the effectiveness of developed science textbook is the learning strategy that used in the learning process. The learning strategies that used in experimental group were same with control group. It's chosen because the learning strategy which

**Table 7.** Result of Effectiveness of Textbook

| Code of Textbook  | Method of Teaching  |   | Gain Factor*)      |               |
|-------------------|---|---|--------------------|---------------|
|                   | Experimental Group  | Control Group   | Experimental Group | Control Group |
| A                 | Cooperative Learning + Science Textbook Based on Literacy | Cooperative Learning + Non Science Textbook Based on Literacy   | 0.60               | 0.30          |
| B                 | Direct Instruction + Science Textbook Based on Literacy   | Direct Instruction + Non Science Textbook Based on Literacy     | 0.63               | 0.42          |
| C                 | Cooperative Learning + Science Textbook Based on Literacy | Cooperative Learning + Non Science Textbook Based on Literacy   | 0.37               | 0.18          |
| <b>Posttest*)</b> |   |   |                    |               |
| G                 | Demonstration, + Science Textbook Based on Literacy       | Demonstration, + Non Science Textbook Based on Literacy         | 72.45              | 64.24         |
| H                 | Discussion + Science Textbook Based on Literacy           | Discussion Eksperiment + Non Science Textbook Based on Literacy | 69.95              | 58.50         |
| I                 | Eksperiment + Science Textbook Based on Literacy          | Eksperiment + Non Science Textbook Based on Literacy            | 70.38              | 55.64         |

\*) Note: maximum score of gain factor is 1.00 and maximum of posttest is 100.00

start with reading and integrated with scientific literacy textbook using would a positive effect on student's learning result. It was appropriate with a study result of Taslidere and Eryilmaz (2010) that an integration of reading and scientific literacy textbook using was more effective to increase student's learning result than other learning strategy.

The result of this research was appropriate with a study result of Budiningsih, Rusilowati, Marwoto (2015) the average enhancement of science literacy learning achievement students' experimental class better than control class, and the average science literacy learning achievement of experiment students better than control class. The result is also appropriate with a study result of Shwartz, Ben-Zvi & Hofstein (2006). That an teaching program using scientific literacy textbook was more effective to increase student's learning result of Chemistry than other learning strategy.

## CONCLUSION

Based on results and discussion above, it can be concluded that the developed science textbook has a complete scientific literacy aspects that presented on the main part of the textbook. They are "Let's go to Learn" or "Ayo Belajar (in Indonesian language)", "Let's go to Try" or "Mencoba Yuk (in Indonesian language)", "Let's go to Scientific Thinking" or "Ayo Berpikir Ilmiah (in Indonesian language)", and "Science in Life" or "Sains dalam Kehidupan (in Indonesian language)". Developed science textbook also has a balance proportion of scientific literacy aspects that showed at the percentage of indicators for each aspect. The first aspect (*Science as a way of thinking*) has 40% number of all indicators, and the other aspect has 20% for each.

The feasibility test result of developed science textbook is > 81.25%. It is mean that science textbook is very feasibility. The reada-

bility science textbook is 81.97%. It means the developed textbook was easy to read and to learn. The Effectiveness of the developed science textbook classified as an effective stimulant to increase students' scientific literacy. It's showed on the score gain and score posttest of experimental group which science textbook based on science literacy, that higher than the control group's score gain and score posttest. Both of them show that the developed science textbook is feasible, readable, and effective.

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