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Improving Secondary School Students' Scientific Literacy Ability Through The Design Of Better Science Textbooks

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ABSTRACT

This study assessed ways by which science textbooks can be designed and developed to increase scientific literacy in secondary school students. . Here inThe research and development method was used. The draft of the new science textbooks was incorporated into school instruction using a non-equivalent control group design with pretest and posttest measures. The instruments used comprised a test of textbook quality test, a text's main idea readability test, and a scientific literacy ability test. Data on text's main idea's readability and textbook quality tests were analyzed qualitatively; an increase in scientific literacy was determined by the percentages of average normalized gains, Cohen's d and t-test. The results reveal that the science textbooks developed in from the research have medium to high readability for of their main ideas, appropriate quality to be used as students' handbooks or books accompanying teaching and learning, and can significantly increase scientific literacy.

Keywords: Scientific literacy, science textbook, design textbook of science, secondary school students, better science textbooks.

INTRODUCTION

One of the method by which to improve the quality of education in Indonesia is to improve the curriculum; however, education management of education in Indonesia faces many obstacles. In science, student achievements are assessed by two-large scale international surveys, namely the Trends in International Mathematics and Science Study (TIMSS) and Programme for International Student Assessment (PISA). In general, TIMSS aims to assess "what students know", while PISA attempts to find "what students can do with their knowledge."

The results of a PISA study indicated that the average scientific literacy score for Indonesian students was far below the international average, which shows that the scientific literacy in Indonesian students is still very low. According to the Kemendikbud. (2013), this low level of scientific literacy is caused, partly, by some of the PISA's testing materials which were not included in the Indonesian science curriculum, but also by the unavailability of science textbooks that meet the demands of the curriculum and the competency standards

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for graduates. Noy every change in the Indonesian curriculum has been accompanied by textbooks that are appropriate to for the new demands. More specifically, according to the Balitbang Depdikbud (2011), the low achievement levels of Indonesian students indicate that science teaching and learning in Indonesia has not emphasized scientific applications to the real world.

The large number of students who do not possess the basic skills in science is an important indicator of the quality of education. According to the Organisation for Economic C0-operation and Development (OECD,2006), students who reach level one have limited scientific knowledge, which they apply only in certain familiar situations; they are also able to clearly and explicitly provide scientific explanations only according to the proof given. Students below level one are not able to display their basic scientific competencies in specific situations such as required by PISA in its easiest testing tasks. This lack of skills can inhibit a student's full participation in society and in the economy. High- quality science education is important not only for preparing students to pursue a career in the science fields,, but also to contribute to preparing a population of citizens who are literate in science and who can "face current global challenges" (Wieman, 2007). In this regard, science education helps realize the students' potentials and contributes to the development of a nation's human resources (Reddy, 2006).

Science textbooks have great impacts on science education in schools. One of the goals of science education in the school is to prepare individuals for lifelong science education in the real world, therefore, it is important to study to what extent science textbooks are designed to meet thatthe goal. Textbooks are an important resource in the teaching and learning process; therefore, efforts should be made to ensure that high quality science textbooks will be selected and recommended to schools. A high quality textbook is regarded as the main tool in promoting the education of a nation and its national development. Science teachers depend to great extent on existing textbooks. If the books do not have components of scientific literacy, such as investigative protocol, it is possible that the students will have tinadequate information about scientific methods (Yager as cited in Chiappetta et al., 1991). Designing a textbook to increase scientific literacy does not only promote an understanding of scientific phenomena and concepts (Lemke, 2004), but also the ability to create collective interpretation using visual representations, mathematical connections, manual operations or techniques, and verbal concepts.

Basically, science textbooks help teachers to provide the organizational structure of the subject or lesson. Textbooks also provide various resources for the collection of additional information and the formation of clearer concepts. In addition, they help train students and develop the necessary science skills. Another benefit of textbooks is that they help reduce the problems associated with the students' lack of background information. Thus, one or more textbooks can be selected for teaching science, as long as they can provide added values (Lump & Beck, 1996). There are specific requirements for selecting learning resources. Ehindero (1994) stated that it is a teacher's responsibility to ensure that learning resources are in accordance with the goals of the curriculum and hence can help meet program goals; are selected to suit the more specific classroom learning regulations; are in accordance with the various intellectual abilities of students so that the learning resources encourage and motivate students to participate directly or indirectly; and are directed to help transfer and implement the appropriate teaching and learning in a new situation, increasing social interaction, and encouraging the skills and attitudes of problem solving.

Science textbooks are the key to developing scientific ideas and clarifying scientific concepts in the early stages of teaching and learning. They are the main source used by science educators worldwid to guide them in their teaching of the content and skills dictated by the curriculum. When teachers use textbooks as their guide for the curriculum and resource

for preparation their class syllabus, the quality of these textbooks has a great impact on the quality of their teaching (Lemmer et al., 2008; Newton & Newton, 2006; Ogan-Bekiroglu, 2007; Reys & Reys, 2006; and Brandt, 2005).

Within the education system, the issue of textbooks and instructional materials has become the subject of attention. For centuries, textbooks have been the key component in producing quality education. Ideally, they serve as a good complement for teachers and students to inquire. Where education, and ultimately the availability of teacher training, is very limited by resources, textbooks and instructional materials can play a very important role (United Nations Educational, Scientific and Cultural Organisation [UNESCO], 2003). Science textbooks are extremely important to both teachers and students, but studies are limited on how to create science textbooks for secondary school students that can empirically increase their scientific literacy. The majority of research reports reviewed or analyzed only the quality of textbooks already used in schools using specific indicators, such as those by Wang. (1998), American Association for the Advancement of Science (AAAS, 2006), and Idrees et al. (2014). The analysis of textbook quality in terms of the written language used has been largely conducted by Bazerman (1988), Halliday (1996), Lemke (1993), and Myers (1990a). There has also been research that analyzed the visuals in textbooks (Jacobi & Schiele, 1989; La Follette, 1990; Myers, 1990b; Veel, 1998; and Dimopoulos et al., 2003). In an attempt to increase scientific literacy, research has been conducted on the use of a specific learning model or method, such as problem-based learning (Ahtee & Varjola, 1998; Alsop, 2001; Lundeberg & Yadav, 2006), inquiry-based learning (Bryant, 2006; Campbell, 2006; Rudd et al. 2001), history-centred learning (Brown, 1991), and narrative-centered learning (Bezzi, 1999). Very little information available on the results of studies conducted on the efforts to increase scientific literacy in secondary school students using instructional materials in the form of science textbooks.

Purpose

Thus, the aims of our study were to develop science textbooks for secondary school students that can accommodate the demands of the curriculum and the competency standards for graduates, and effectively increase the students' scientific literacy. The question identified for the study were as follows: 1) How is can we improve the readability of science textbooks ? 2). Has the scientific literacy of students who used the new science textbooks increased compared to those using the standard science textbooks? and 3) Is there any significant difference in increased scientific literacy between of the students using the science textbooks developed in this research and those using the standard science textbooks ?. This article contributes to the development of science by expanding the general model of the writing process proposed by Hayes and Nash (1996) and commonly used as a guide in writing a free essay on learning English. The method was developed into a model for the process of writing teaching materials for science learning.

METHODS

a) Research Design

We adopted the research and development method, for our study and implemented the following stages: preliminary research and information collection, planning, preliminary product development, preliminary testing, preliminary revisions, field testing, product revisions, field testing, final revision, and dissemination and implementation (Borg & Gall, 2010); however, the research and development was conducted up to only the field testing and product revisions atages. Two prototypes of science textbooks were developed in this research, namely for the secondary school students, in the eighth and ninth grades. This was done to test whether the draft science textbooks produced using the model for the process of

writing teaching materials have had the same tendency to increase the scientific literacy of the audience, regardless of the domain and level of students.

b) Procedure

We developed the science textbooks using the model for the process of writing teaching materials (Sinaga et al., 2014). The steps in writing the textbooks weree as follows: 1) Analyzing the secondary school science curriculum: forcore competencies, basic competencies, and graduates' competency standards in accordance with each level; 2) Formulating writing goals containing the statements of what competencies should be acquired by audiences after learning or reading the teaching materials, such as competency in scientific literacy and the knowledge that builds scientific literacy. Writing goals were elaborated using a series of indicators; 3) Selecting and sorting materials or contents that would be internally suitable and so that their breadth would be in accordance with the demands of the curriculum; 4) Outlining the sequence of discussions in the science textbooks; 5) Creating concept maps; 6) Revising the outlines; 7) Representing the concepts covered in the outlines and translating them so that each concept was create in multiple representations; 8) Translating outlines into writing by combining the verbal and visual representations so that the writing became cohesive; 9) Testing the quality of the science textbooks using stakeholders, namely teachers and a team of experts; 10) Testing the understandability or readability using secondary school students; 11) Using the results of the quality and readability tests to revise the drafts of the science textbooks; 12) Field testing by implementing the instructional materials in the schools' teaching and learning method. The field tests were conducted to identify whether there was a significant difference in scientific literacy between the students using the new science textbooks developed in the research and those using the standard textbooks.

The drafts of the new science textbooks were then evaluated by experts and secondary school teachers to gain feedback relating to following: a) the appropriate relationship between curriculum demands and goals and the contents of the science textbooks; b) the quality of the science textbooks as rated by the secondary school teachers; and c) the quality of science textbooks according to the experts. Twenty four ninth- grade and 10 eighth- grade secondary school teachers were recruited, and four experts were selected to provide assessments. In addition, the science textbooks were tested for their readability by the secondary school students. The feedback was then analyzed and used to determine the appropriateness of the science textbooks as teaching materials and to provide references for revising the drafts.

We used the quasi-experimental research method to field test the science textbooks at the schools because the researchers did not have the capability to randomly determine the number of participants and/or to ensure that the selected sample was homogeneous as was desired. In addition, the researchers were limited in their ability to fully control all research variables and implications for the treatment of the groups studied (Leedy & Ormrod, 2010).

This particular research design involved two eighth and ninth-grade classes that were divided into the experimental group and control group, respectively, using the nonequivalent control group design with pretest and posttest measures (Cohen et al., 2007). Teaching and learning activities in both the control and experimental classes were conducted using the same instructional method, namely the reading to learn method. The experimental class used the draft science textbook developed in this research, while the control class used the standard textbooks. Teaching and learning activities using the draft of the new science textbook in both the eighth and ninth grade classes was conducted in three meetings. The activities performed during the three meetings were the pretest, implementation treatment, and posttest at the final meeting. One chapter was taken from the science textbook drafts to be used to test teaching and learning success. For the ninth- grade class, a chapter from the science textbook on electrical energy and its uses was used; for the eighth- grade class, a chapter on the adaptation

of organisms to the impacts of the earth and moon's rotational movements and revolutions around the sun was used. Both chapters were chosen because they were so closely related to the life of the students and the environment. For example electrical energy is lilited in Indonesia much so that it is not avaliable to all those who live there. It is important to learn how to save energy, and how to use nature for renewable energy resources. It is also important that students understand the current problem in the environment and how to resolve them.

c) Sample

The study sample was purposively, determined without stratification; samples were selected based on specific goals (Arikunto, 2013). The subjects comprised 129 eighth and ninth grade students from the 2015/2016 academic year in a junior secondary school in Bandung. There were 64 ninth graders, who were divided evenly into the experimental and 65 eighth graders who also divided into the experimental and control groups, with 33 and 32 in each, respectively.

d) Instrument

The instrument by which to measure any increase in scientific literacy was designed by adapting and matching PISA's Test of Scientific Literacy Skill (TOLS)) (OECD,2013). The TOLS instrument for the ninth graders consisted of 35 multiple choice questions with four options per question. The validity of the instrument was evaluated using Pearson product-moment correaltion, and its reliability was evaluated using Kuder-Richardson KR-21 (Arikunto, 2013). The correlation coefficient of each item was between 0.4 and 0.53, and its reliability coefficient was quite high, at 0.81. Meanwhile, the TOLS instrument for the eighth grade class comprised 25 multiple choice questions with four options for each question. The correlation coefficient of each item was within the range of 0.4 – 0.63, and its reliability coefficient was quite high, at 0.87.

e) Data Analysis

The data were analyzed by determining the percentages of average normalized gains and interpreted according to Hake's criteria (1998), while the difference between treatments was analyzed by determining Cohen's d (Coe , 2000) and a parametric test using the independent sample *t*-test aided by SPSS 23.

The analysis of the readability/understandability of a paragraph's main idea adapted the scoring rubric of the Georgia Department of Education (2004). and was interpreted using the classifications of readability categories by Rankin and Culhane, where an average ≤ 40.0% is considered low (difficult), ane average between 40.0% and 60.0% considered moderate, and an average ≥ 60.0% under the high..

FINDINGS

a). Readability of the main idea of a paragraph in the new science textbooks

The draft of the ninth- grade science textbook was tested onto 36 students. An averadge of 61.0% was obtained from the readability test of the main idea in one paragraph. The draft of the eighth- grade science textbook was tested on 72 students. An averaged of 73%and the average readability score of the main idea of a paragraph was 73.0% was obtained from the readability test of the main idea of one paragraph. These values indicate that the readability levels of the new science textbooks for both the eighth and ninth- grades, were in the high category. Based on the results of this readability test, the paragraphs in the science textbooks for the eighth and ninth grades were classified as readable.

b). Scientific literacy increased in secondary school students

In both the experimental and control classes, was analyzed based on the pretest and posttest data by determining the percentages of average normalized gains, as shown in Table 1. From the analysis, we found that students from both the experimrntal and control groups experienced an increase in their scientific literacy, and the increase was categorized as medium.

Table 1. *Increased scientific literacy in the eighth- grade students*

	<pretest>	<posttest>	<g>
Experimental	47.51	76.12	0.55
Control	46	66.37	0.38

Based on PISA's framework, scientific literacy consists of the competencies and knowledge that build it. The domain of scientific literacy competencies includes explaining phenomena scientifically, designing and evaluating experiments, and interpreting data and scientific evidence. The knowledge domain that builds scientific literacy comprises content knowledge, procedural knowledge, and epistemic knowledge. The increase in each of these aspects in the students using the developed science textbooks is displayed in Table 2.

Table 2. *Eighth-grade students' Increased Scientific Literacy in each domain*

Scientific literacy domain	<pretest>	<posttest>	<g>
Explaining scientific phenomena	45.99	75.26	54.19
Evaluating and designing research	47.47	79.80	61.54
Interpreting scientific data and evidence	52.12	76.97	51.90
Content knowledge	45.83	76.52	56.65
Procedural knowledge	44.16	70.44	47.03
Epistemic knowledge	48.48	71.52	44.72

Based on the analysis results displayed in Table 2, we found that the new science textbooks developed for the eighth grade moderately increased scientific literacy in the six domains.

c). The Impacts of different treatments on the eighth-grade students' increased scientific literacy

Based on the percentages of normalized gains shown in Table 1, both the experimental and control groups experienced a moderate increase in scientific literacy. To determine whether there was a difference in this increase between students using the new science textbook and those using the standard textbook, Cohen's d and *t*-test were conducted. The results are presented in Table 3.

Table 3. *Effects of using the new sciencetextbook*

Mexp	Mcont	STDEV exp	STDEV cont	Cohen's d
28.1	20.37	9.08	12.85	0.69

The data analyses demonstrated that the using the new science textbooks had positive impact on the scientific literacy of the eighth- grade students. This impact was within the medium effect range compared to that of those who used the standard textbook.

d). Analysis of independent sample *t*-test

We used the Shapiro-Wilk test for gain normality at the level of $\alpha = 0.05$. The significance values of the experimental and control groups were 0.163 and 0.597,

respectively, meaning that the gain in both classes was normally distributed. We used the Levine statistic at α = 0.05, for the homogeneity test for the increase in the scientific literacy . The significance value was 0.498; therefore. The data on the two classes were homogeneous.

We used the independent sample *t*-test at α = 0.05, to test difference in the results showing that t = 3.388 with Df = 62 and sig. (two-tailed) = 0.001. It can be inferred from this that there was a significant difference in the increased scientific literacy between experimental and control groups.

e). The increased scientific literacy of the ninth -grade students

The increased scientific literacy from the pretest to the posttest was determined by calculating the percentages of average normalized gains. These are displayed in Table 4.

Table 4. *Increased scientific literacy of the ninth-grade students*

	<pretest>	<posttest>	<g>
Experimental	31.01	57.48	0.38
Control	31.75	50.32	0.27

We found that the ninth grade students who used the new science textbook had a medium increase in their scientific literacy, while those using the standard textbook had a low increase in their scientific literacy.

The increase of scientific literacy ability among students using the new science textbooks is shown in Table 5.

Table 5. *Increased scientific literacy in ninth- grade students in each domain*

Scientific literacy domain	<pretest>	<posttest>	<g>
Explaining scientific phenomena	28.91	65.38	51.30
Evaluating and designing research	25.0	64.94	53.25
Interpreting scientific data and evidence	30.59	61.47	44.48
Content knowledge	38.91	65.38	43.33
Procedural knowledge	25.0	52.84	37.12
Epistemic knowledge	30.59	56.47	37.28

The findings demonstrate that based on the percentages of the average normalized gains; there was a medium increase in the six scientific literacy competency domains in students using the new science textbook.

f). The impacts of different treatments on increased scientific literacy inf the ninth-grade Students

Based on the average normalized gains shown in Table 4, the experimental group realized a medium increase in scientific literacy, while the control group realized a low increase. To determine whether there was a significant difference in scientific literacy between two groups, we used Cohen's d and the statistical analysis of the independent sample *t*-test. The results of Cohen's d determination are shown in Table 6.

Table 6: *Cohen's d of the ninth-grade's increased scientific literacy*

Mexp	Mcont	STDEV exp	STDEV cont	Cohen's d
27.47	19.57	11.66	8.73	0.77

The value of Cohen's d = 0.77.which indicate that the use of the new science textbooks had medium impact on increased scientific literacy in ninth-grade students compared to that in students who used the standard textbook.

g). Statistical analysis of independent samples *t*-test

We used the Shapiro-Wilk test was to find the normality of sample with the aid of SPSS 23 at α = .05. Based on the results of the gain normality test using the Shapiro-Wilk test, it was found that the significance values for the experimental and control classes were .722 and .363, respectively. The significance values of both groups were > .05 , which means that the increased scientific literacy in both groups was normally distributed. The homogeneity test was done through a variance test aided by Microsoft. Excel with the significancy level of $\alpha = .05$. Based on the results the homogeneity test for the gain in both groups, we found that $F < F_{table}$, or 2.03 < 2.87, therefore the variances of the experimental and control groups were homogeneous at the 95% confidence level.

Based on the previous test, the gain in both groups was normal and homogeneous, therefore, the hypotheses coulg be tested using parametric statistical tests with the independent sample *t*-test. The data of the gain were processed using SPSS 23. The hypothesis was as follows: the physics teaching and learning using the science textbooks developed in this research can more significantly increase the students' scientific literacy than the teaching and learning using the physics textbook commonly used in the school. The hypothesis is impartial to one of the samples; hence, one-tail (right) hypothesis testing was conducted. Based on the difference test of the two average gains of the experimental and control groups, we found that Df = 68, t = 3.364, and sig (two-tailed) .001 < .05. It can thus be concluded that new science textbooks had an impact, which was, namely a more significant increase in scientific literacy than the use of the standard science textbook.

DISCUSSION and CONCLUSION

Based on the analysis of the data on the readability of the new science textbooks for secondary schools, we found that the new science textbooks are more readable by students and are appropriate to be used either as a companion or main textbook in the schools. In other words, two book chapters from the draft of the new science textbooks are appropriate to be used in secondary schools.

One factor for this result was using is the model of the procces of writing teaching materials to write the science textbooks, which appeared to have met the criteria of creating quality science textbooks, such as that put fort by Gu et al., (2004) and Roseman et al., (1999). The model of the procces for writing teahing materials consists of several stages. The first stage is analyze the curriculum, which includes determining the intended audience, analyzing the curriculum, and writing a description of the teaching materials to be created. This stage ensures that the book's content will be in accordance with the curriculum and adjusted the intended audiences.

The second stage is formulate the writing goals.of the science textbook, which is done after the writer learn about the core competencies, basic competencies, and graduates' competency standards. The goals contain statements of the competencies that will be acquired by the audiences after studying or reading the science textbook. The goals are elaborated in a series of indicators that describe the scientific literacy ability that will be acquired by the audiences. In this research, scientific literacy ability is elaborated into several domains. The quality of textbooks is defined as "quality in accordance with the goals" (Sursock, 2001). According to this definition, a quality science textbook is determined by its ability to support students and teachers in achieving the goals of science education (Kesidou & Roseman,

2002). The second stage of writing a science textbook is designed using its definition. This stage is also in accordance with the description of a quality textbook according to Roseman et al. (1999).

The third stage is to determine content coverage. Based on the results of curriculum analysis and goal formulations, as well as an analysis of the audiences' initial knowledge, the writer should then select and sort the material or content so that its breadth and depth will be in line with the demands of the curriculum. The content covered is then linked to its relevance in daily life. The phenomena presented are adjusted to the concepts covered in the subject matter. In addition, the learning activities are designed to encourage students to learn by working with real situations or through simulation. The phenomena and direct or indirect situations are used to encourage students to connect scientific concepts, make reasonable conclusions, and build their own knowledge. This stage is in line with the second and third categories used to determine the quality of textbooks in Roseman et al. (1999). The result of this stage is a list of subjects or topics and subtopics that will be described and developed in the new science textbooks.

The fourth stage is to draftan outline. The list of selected topics and subtopics are made into an outline, namely in the form of a sequence of discussions to be included in the planned science textbook. One of the criteria of quality textbooks is coherence; therefore, the outline should be evaluated in advance to ensure that it meets that criterion.

The fifth stage is to create concept maps. The concepts covered in the topic outline are mapped in a concept map. The use of concept maps on write teaching materials is supported by Candan et al (2006) who stated that concept mapping is still an effective tool for teaching scientific concepts in science courses. The stages of making the concept map follow those explained in the articles of Hale (2003), Novak and Gowin (1984), and Steitner et al. (2007). The concept maps provide the hierarchical arrangement of topics to be written. The sequence of creating concept maps begin with the key concepts, and proccesses to the general concepts, less general concepts and examples of applications. In this research, the textbook of one chapter were developed to increase the scientific literacy in the audiences; therefore, the examples in the concept map are those of the conceptual phenomena in nature and of applications found in the environment and in the students' daily lives. The writer revises the concept map by adding new concepts, eliminating unnecessary concepts, or selecting better concepts. This is one factor that provide a draft of one chapter in the science textbook that the students found easy to read and understand.

The sixth stage is to revise the outline. The result of concept mapping is the basis for revising the first outline to create a final outline with a sequence of the general to the specific or the specific to the general. Hence, the final outline will be created as the reference for writing the new science textbook. The writing process from the first to the sixth stages results in a draft or outline of a science textbook that meets the demands of the curriculum, is in accordance with the writing goals, is adjusted to the audiences, is arranged from the general to the specific or vice versa, and has considered the breadth and depth of the subject matter according to the goals. This process explains the findings of this research that show that the developed textbooks are of high quality.

The seventh stage is to create multiple representations of concepts. The purpose of using multiple representations of concepts in science textbooks is so that the students can easily understand them. The science textbooks developed in this research are intended for secondary school students. Secondary school students have varying backgrounds, therefore, they also have varying abilities to understand the information contained in textbooks. The new science textbooks should accommodate these varying audiences and abilities. One of the ways to do this is to have one concept represented by at least two modes of representation. Students who have difficulties in understanding the concepts represented by one modes of

representations can be aided using a different mode of representation. The final product in this stage is a list of multiple representations of each concept covered in each subtopic. Multiple representations of a concept can be created by, among other, means translating among the modes of representation.

The eighth stage is translate the outline into writing using multimodal representations. In this research, multimodal representation entails explaining a topic or subtopic by integrating verbal modes of representation (text/narration) with a visual mode, so that the written explanations will be more cohesive. This stage is an effort to ensure that the science textbook to meet the criteria in terms of coherence and cohesion, which are the characteristics of a quality textbook. The fifth to the eighth stage are in line with the four measures of the quality of textbook formulated by Roseman et al. (1999). The writing stages are an attempt to make the science textbook more readable for the audiences.

The ninth stage is to evaluate whether the goals are met. Problem sets are included in the textbooks to evaluate these goals.. A number of questions are posed to the students to asses their understanding after they have completed certain activities and help them apply their knowledge to daily lives. Questions, problems, and exercises are designed in line with the curriculum indicators and also to emphasize a higher order of thinking and applying these scientific concepts in daily life. The questions included under each topic or subtopic also consider each scientific literacy domain. The ninth stage is in conformity with the fifth and sixth categories of quality textbooks as stated in Roseman et al. (1999).

The integrated construction model of text understanding stresses that the knowledge domain encourages an understanding of the text; therefore, students with limited knowledge about scientific concepts will have difficulties in understanding science textbooks (Best et al., 2005). Chambliss and Calfee (1989) recommended that the content of a science textbook should be organized coherently and explicitly. The writer should link subjects by taking the students' initial knowledge into consideration and using functional devices, such as introductions, transitions, and conclusions. Carnine and Carnine (2004) also argued that the amount of unfamiliar information in secondary school textbooks will greatly decrease if the content is simplified and instructions are focused on some key concepts. To help increase a student's retention of the text's information, the writer should encourage an overview of key concepts in the chapter by providing questions embedded within each topic and questions for discussion related to the text.

The tenth stage is to review and edit the draft. The first draft of the teaching materials should be reviewed. The reviewing process is first done by the writer. Some question to consider during this process is as follow: a) Dose the draft conforms to the outline, or does it have a good hierarchy? b) Is there any concept with incorrect explanations or misconceptions? c) Is every concept correctly and properly represented to ensure that the audiences understand it easily; are the visual and verbal modes cohesive? d) Is the content contextual? and e) Have the sentences been written according to the guidelines of correct procedures? Each error or inappropriate text should be marked for revision. The results of the review will be the basis for the writer to edit the draft. The final product of this stage is the draft of the science textbook. The edited book will be the second draft of the teaching materials.

The eleventh stage is the readability or understandability test of the main idea and the quality test of the draft given to a number of students. The students are asked to read a chapter and then write the main idea from each paragraph. In addition, they are asked to write down each word or sentence that they cannot understand. The test of book quality is conducted by stakeholders, such as the teachers and experts in higher education. This quality test uses a five-rating scale questionnaire with columns for comment. Feedback from the readability and quality tests is use for reference for revising the draft to create the final draft of the textbook.

The writing process up to the eleventh stage accommodates the criteria for determining a quality textbook in terms of the language of the writing.

Based on the results of both Cohen's d and independent sample *t*-test analyses, we found that there was a significant difference in the increased literacy ability between students using the new textbook and those using the standard textbook. This significant difference was result of certain factors. The readability test shows that the science textbooks developed in this research was readable by audiences. This result shows that the students were able to easily process and understand the content or information in the new textbooks. This finding is in line with that put forward by Zimmerman et al. (2007) who sateted that reading to understand involves a series of multifaceted and interconnected skills that enable students to accurately process and understand a text's information during the process.

The processes involved in reading to understand are to focus on relevant and important parts and to make connections between the information and previous knowledge. In addition, students should understand the meanings of each word and integrate many internal connections among the important and relevant pieces of information in one part (Baker, 1985; Cook & Mayer, 1988). To accommodate students in the process of reading to understand, the science textbooks during the third stage of writing, should be adjusted to audience's initial knowledge. This adjustment can be accomplished by analyzing the curriculum of the grade below the intended grade. The content covered should be connected to its application in daily life and the designed learning activities designed should encourage students to learn by working in real life situations or simulations. The phenomena and direct/indirect situations are used to enable students to connect scientific concepts, make reasonable conclusions, and build their own knowledge.

Scientific literacy according to PISA is the ability to apply the knowledge learned to solve problems encountered in daily life. According to Bloom's taxonomy, the cognitive level of the ability to apply knowledge to practice is achieved when students reach a certain level of comprehension. The case which with audiences understands content is determined not only by their ability to use reading strategies, but also the readability of the text itself. The stages of the development of science textbooks explained here have considered this idea, so that the stages begin with explanations to enable audiences to understand the concepts and then direct them to observe natural phenomena and various technological devices at home and around the school, which are the applications of the concepts being learned. Each concept described in the textbook should be always linked to an application in technology and daily life, although there is a limitation to providing examples from students' surroundings.

Some researchers such as Cook and Mayer (1988) and Magliano et al. (2005), have broadened the typical definition of understanding by suggesting results of in-depth understanding. Students are intentionally made to attemp to reach a more coherent understanding of the text they read. When reading difficult texts, a skilled reader will use various comprehension strategies to build more in-depth meanings. In the process of textbook development, each concept is explained using multiple representations. The findings of this research indicate that the use of multiple representations of concepts in writing of science textbooks can help students more fully understand scientific concepts and enable them able to pose questions/problems. This is in line with the findings of previous research on the use of multiple representations in science teaching and learning (see for example, Finkelstein et al., 2005; deLeone & Gire, 2005; Rosengrant et al., 2005; Meltzer, 2005; Kohl & Finkelstein, 2005; Rosengrant et al., 2006; Dancy & Beichner, 2006; Kohl & Finkelstein, 2006; Kohl et al., 2007; Kohl et al., 2008; Prain et al., 2009; Atila, et al , 2010., & Sinaga et al., 2015).

The textbooks developed in this research were written by taking into account the varying thinking and intellectual abilities of the students based on their diverse backgrounds. The strategy is to present teaching materials in the form of explanations of (concrete)

scientific phenomena, followed by helping students understand the concepts (abstract). This is done by balancing the design of science discourse/issues not only in the personal context, but also in local and global contexts. Even in a personal context, the example given of science discourse/issues is related to a student's daily life at all social levels. This practice is related to the attitudes expected in PISA's 2015 framework to increase scientific literacy.

Involving students with issues pertaining to daily life can train their abbility to apply their scientific literacy. Presenting science discourse/issues is the main component in the textbook as a practical means by which to develop this ability. Some examples of science discourse adapted from scientific phenomena or issues students might encounter in daily life and in technology are included in the development of the science textbooks in this research. This ensures that the new science textbooks will be readable for students and will accommodate a transfer of knowledge. The practice is done by taking into account the statement of Chambliss and Calfee (1989) that there are several factors that can contribute to student's lack of understanding of the information contained in science textbooks. The science textbook itself can cause problems if the text is inaccurate, focused on isolated facts, boring, and unorganized. Furthermore, the development of science textbooks in this research we considered the argument of Carnine & Carnine (2004), who stated that texts containing too many concepts, or too many ideas simultaneously will be less clear and will fail to transfer knowledge.

Conclusions

Increasing a secondary school student's scientific literacy can be done by using appropriately developed science textbooks. Secondary school science textbooks developed in this research using the model for the process of writing instructional materials have a medium to high category of readability of main ideas. The results of the implementing the new science textbooks in teaching and learning activities show that the textbooks can significanly increase student's scientific literacy in each domain, and that there is a significant difference in the increased scientific literacy between students using the new science textbooks and those using the standard textbook.

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