Revitalizing students activities in reading and writing in science: An investment in educational improvement

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Abstract. A literate science-information-technology people in the future cannot be prepared if based only on facts and concepts of the content areas that students acquired during school years. In a scientific literacy curriculum, reading and writing can serve as dynamic vehicles for learning science meaningfully. The explicit modeling of reading-writing to learn needs to be integrated with teaching the curriculum at all school levels. The role expectation for teachers must change from dispensers of knowledge to developers of self-regulated learners, thinkers, and problem solvers who know to use reading and writing to learn. Our real challenge is teaching children how to read, write, and to think about science. This paper described briefly some theoretical perspectives, numerous research results, and meaningful and practical strategies on reading-writing in science. It concludes that reading-writing to learn should be developed together throughout the school years. Improving the quality of reading and writing actually improve the quality of thought and, therefore, can be regarded as an investment in educational improvement.

1. Introduction
Internationally, until now, scientific literacy is one of the crucial focuses and goals in the improvement of science education. United State of America, for instance, acknowledged that National efforts in science education are focus on scientific literacy for all students[1]. Glynn & Muth [2] argued that in a scientific literacy curriculum reading and writing can serve as dynamic vehicles for learning science meaningfully. The task of educational researchers is to show how reading and writing can be used most effectively to support science learning [3]. Although many science school teachers realize that more and more hand-on activities are not the solution to unsatisfactory science literacy [4], however, practical efforts to enhance students reading comprehension of texts are the neglected area in science curricula [5,6,7].

Reading skills truly essential for all subject areas during school years and used nearly all workplaces [8] and assumed as a key for student success [6,9,10]. Most of textbooks in schools are used as a major source of learning. Unfortunately, many students have difficulty to gain a deeper understanding about the text they read. The difficulty of understanding textbook was due to lack of knowledge about techniques of reading and making good notes [11,12]. In many traditional approaches using a textbook, teachers ask students to read a chapter and answer questions typically found at the end of the chapter. The questions tend to be low in cognitive level, inviting a search-and-find learning strategy. The main purpose of answering these questions is tend to engage students at a very low cognitive level [13,14]. Therefore, it is not surprised that many students are unable to attain the essential meanings and information from science texts. Tobias in Halloun [10] reported that many students in school even in college forgot quickly and did not get much information from the text they read. When further explored, the lack of modeling and training provided by teachers at school can be suspected as one of the causes. Students who are not skilled in reading textbooks, according to Halliday [14], will only spend a lot of time unproductively. They also are not more likely to able to solve the problems related to the text reading.

Program for International Student Assessment (PISA) in 2015 had assessed proficiency in mathematics, reading, and science of 540,000 students that representing 29 million 15-year-olds in the
schools of the 72 participating countries and economies and reported that Indonesia’s score in science = 403, reading=397, and mathematics=386. These scores are in basic proficiency category. Indonesia’s proficiency ranking for science is 62, mathematics is 63, and reading is 64. Since 2012, Indonesia’s science test scores have increased—by roughly 0.7 school years. Reading and mathematics, while on the rise, are statistically unchanged [15]. PISA suggested a policy action which has to be undertaken by Indonesian government for improving the educational quality is to strengthen teacher subject matter competencies through stronger quality control at teacher training colleges and through high quality continuous professional development.

Achieve Report [1] confirmed that an integrated science-reading-writing approach has an important place in the educational improvement. Therefore, learning to read and reading to learn should develop together throughout the school years [16]. Tilaar [17] stated that if there is an educational policy and effort to improve Indonesian educational quality, those endeavors should be as microscale improvement-based-classrooms that mainly involved teachers in schools. Based on the current issues regarding the lack of students’ competencies in science and reading in the most countries, the main purpose of this article is to review the published literature and current research results on reading and writing to learn in science, to expose some practical strategies and examples that could be applied by teachers in science classrooms, and to recommend a focus for future research.

2. Theoretical Views on Reading and Writing in Science

There was a significant shifting of views on learning regarding the acquiring of knowledge by the learner over the past 20 to 30 years i.e. from behaviorist theories to a "constructivist" view. According to the constructivist, learning is a process of connecting new to existing knowledge to schema, involving active engagement of the learner's mind. To gain a knowledge the learner must actively construct it by modifying the information. Learning is a construction of knowledge [5]. Similarly, when a student learn from the experience of reading, he will perceive and choose the sensory input which depends upon what he already know [18,19]. Simply stated, we use what we already know to make sense of what we don’t. A well-documented by reading researchers have acknowledged that reading is a process of active construction of meaning of the text [4,20].

Reading and writing are thinking processes [21,22]. By integrating reading with writing activities in the learning of science, the students’ previous existing knowledges will be accommodated to modify a new ones in their schema. Students’ mind actively engage in this construction of knowledge [20]. Carin and Sund [23] confirmed that reading and scientific process skills have a similar in terms of intellectual processes, both involve thinking processes. As teacher involved students to do “hands-on science” activities, the teacher is also simultaneously helping students to improve their reading comprehension [14,24]. Therefore, if the teachers want to improve students writing, they would do well to understand better how students go about reading. As the teachers improve the quality of writing, they actually improve the quality of thought of the students [25]. A real challenge for teacher in teaching science is how to move students from thinking about science as a collection of facts to be memorized toward a deeper understanding of concepts and scientific ways of thinking [6].

To create reading and writing activities effectively in learning science, a teacher must shift their roles and beliefs regarding the meaningful science instruction. First, the role expectation for teachers must change from dispensers of knowledge to developers of self-regulated learners, thinkers, and problem solvers who know to use reading and writing to learn. Second, the goals of science teaching from regurgitating facts to understanding and applying a few major concepts [9]. The teacher should be to get students to learn from their textbooks and to use them in more meaningful ways to gain more resourceful information. Thus, in the best of all worlds, science instruction would have two major goals: understanding a few major concepts and principles; and acquiring the reading and writing, and thinking strategies necessary to solve problems and construct new understanding [1,26].

3. The Strategies for Meaningful Learning in Reading and Writing in Science

The school curriculum the textbook dominates what is learned and how it is taught. The studies compiled by Woodward and Elliot in Cox estimate that as much as 75% of classroom instruction and 90% of the homework time is structured around text materials. Although in the classroom the
textbook dominates the curriculum, in many cases the students lack the basic skills and strategies for comprehending science textbooks. Because much of the knowledge gained by students in school is from textbooks, knowledge acquisition depend greatly on the skills and strategies students use to read, write, and comprehend the text [18]. Woolfolk[27] argued that reading and writing strategies students employed in the process of learning reflect their metacognitive knowledge. She also confirmed that the emphasis today is on helping students develop effective learning strategies and tactics (p.271).

Explicit instruction on science reading strategies improve metacognitive awareness, reading comprehension, and science achievement [28]. Therefore, those skills and strategies related to the reading texts and writing (making notes) in the learning of school science, are of greatest concern in this article as described briefly below.

3.1. Reading to Learn

Reading to Learn is a literacy methodology which based on the core principles, one of them is reading is a fundamental mode of learning in primary and secondary school. Therefore explicit teaching of reading needs to be integrated with teaching the curriculum at all levels, and all teachers need skills to teach reading in their subject areas. Yore, et al.[4] confirmed that expert science readers have metacognitive knowledge about science reading, science text, and specific science reading strategies. Several strategies critical to constructing meaning have been identified, they include: (1) assessing the importance of text-based information and prior knowledge; (2) generalizing questions to set purpose; (3) summarizing; (4) inferring meaning; (5) monitoring comprehension; (6) utilizing text structure; (7) reading and reasoning critically; (8) improving memory; (9) self-regulating to fix-up comprehension failures; (10) skimming, elaborating, and sequencing. The skills and strategies that a student brings to a learning situation greatly affect what is learned.

According to Fogarty [26], there are three essential strategies which should be applied by the readers to construct meaning from text, namely: (1) develop a plan before reading; (2) monitor their understanding of text, and (3) evaluate their thinking after reading. Through modeling and practice, a teacher should teach and guide students to follow some respectively phases:

- **Planning before reading**
  In this phase a student should think about, such as the text features, the main objectives of reading the text, the questions might be answered, and the structure of the text.
  There are six types of text structures of science: (1) cause and effect; (2) compare and contrast; (3) sequence of events; (4) problem and solution; (5) enumeration or description; and (6) a combination of these text structures [11,25].

- **Monitoring during reading**
  The students should monitor their own comprehension. To do this, they could ask themselves: Do I understand what I just read. Other ways, the students should make connections predictions, or inferences; (2) use context clues, text features; (3) identify text structures; (4) use graphics organizers to pinpoint particular types of text information; and (5) write comments or questions on self-stick notes or in the margins.

- **Evaluating after reading**
  When finish reading, students reflect the applicability of the reading technique they used. Generally, they should answer the questions they posed and relate the answers to headings or subheadings.
  Cox [18] confirmed that numerous studies show that children need to practice reading every day in order to improve their reading skills. Developing and teaching reading strategies to students will help increase their reading ability. Several reading techniques for improving students’ reading ability and enhance academic achievement could be found in the book entitled “Reading Strategies and Practices: Guide for Improving Instruction” [26]. One of the most familiar reading techniques which can be used to enhance students’ academic achievement in any subject matter (discipline) and to develop metacognitive knowledge in reading text is SQ4R (Survey, Question, Read, Reflect, Recite, Review) developed by E.L Thomas and H.A Robinson in 1972 [2].
3.2. Writing to Learn
The act of writing require students to gather, organise, and formulate old and new knowledge and record their ideas. Writing, thus, provides a method for recording or eliciting of students’ thoughts. Swinson explained the use of writing as an aid for teaching and learning that is supported by the results of cognitive research and described briefly as below.

3.2.1. Writing is a strategy for eliciting preconceptions
Mason in Swinson argued that what is going on inside students’ head is endemic to teaching. When discussing preconceptions, Postner, et.al [29] suggested that new information is fitted or assimilated into existing cognitive structure. As they put it, what students learn and what they are capable of learning depend on the mental models each of them has developed. Sometimes students preconceptions are inaccurate, hence they have misconceptions and these do not offer a sound basis for construction of new knowledge. It is important to realise that many approaches to instruction fail to correct misconceptions, for if new knowledge is presented while the misconceptions still exists, effective learning may not take place. It is obvious then that when previously learned knowledge is in accurate, the goal of instruction must first be corrected the misconception by modifying the schema concerned and then, and only then, introduce the new information [20].

3.2.2. Writing as a diagnostic tool
Classroom research supported the use of writing prompts for classroom diagnosis. These prompts are statements developed by the teacher and used to solicit a written response from the student. Examples of phrases that can be used to create writing prompts are:
In your own words, describe why ....
Explain the process you used to ....
In your own words, define ....
Explain the errors you made in solving the problem of ....
These prompts can be used at any stage during the lesson[20]. Used before teaching begins, the prompts enable the teacher to determine the misconceptions being brought to lesson. Used during the lesson, they help clarify ideas and indicate when understanding is inaccurate. Used at the end of a lesson, they enable the teacher to asses the level of understanding achieved, identify in accuracies and direct the planning of the next lesson.

3.2.3. Writing as a knowledge construction
Teacher and text are an essential source of information which may be used to construct new knowledge. Opportunities need to be provided that allow students to actively use and explore information in order to understand it. During these interaction activities the students’ existing knowledge structures undergo modification to accommodate the new information resulting in the creation of new knowledge. A student who is actively building connections between what is being learned and what is already known is creating new knowledge[30]. However, the mere memorization information obtained from the teacher or the textbooks doesn’t constitute effective learning. Learning can be thought of as the change from knowing what to knowing how and our ability to remember depends on the nature of the information we have previously acquired and how the information is linked to it. Those who are efficient at constructing new knowledge acquire an understanding that is more general than a memorization of specific steps or facts and this was often achieved by engaging in a process of self-explanation. The work of Davidson and Pearce offers further guidance, namely that writing activities should be used on a regular basis two or three times each week if they are to be effective [31].

3.3. Types of Writing Strategies
Rivard’s study summarised that they are two writing strategies which commonly employed in science learning, namely; expository writing and expressive writing, or the combination of these two writing modes. Expository writing includes tasks like note taking, summarizing, and analyzing. Note taking strategies that are more likely to develop or apply for students in learningscience are mnemonics and
graphic (post)organizers, whereas expressive writing is the informal kind of writing associated with journals and diaries [32].

3.3.1. Mnemonics
Mnemonics as systematic procedures for improving one’s memory. These techniques have been demonstrated to be effective for students of all ages, from preschool to college. Many of these mnemonics strategies use imagery. The five of types of mnemonics are mentioned as follows:

a. The loci method. The loci method derives its name from the plural of the Latin word *locus*, meaning “place”. To use loci, student must first imagine a very familiar place, such as his/her house or pick out particular locations. Every time student has a list to remember, the same locations serve as “pegs” to “hang”. For instance, let’s say student want to remember to buy milk, bread, butter, and cereal at the store. Imagine a giant bottle of milk blocking the entry hall, a lazy loaf of bread sleeping on the living room couch, a stick of butter melting all over the dining room table, and dry cereal covering the kitchen floor.

b. Peg-type mnemonics. Peg-type mnemonics use a standard list of words as pegs. For instance, let’s say a Indonesian student want to remember the names of spherical mirrors. For convex mirror student can use “*cembung*” as a peg whereas other peg “*cekung*” for concave mirror.

c. Acronym method. An acronym is a form of abbreviation—a word formed the first letter of each word in a phrase. For instance, the colours of rainbow are “*mejikuhibiniu*” (merah, jingga, kuning, hijau, biru, nila, ungu).

d. Chain mnemonics. Since the words must make sense as a sentence, chain method use to connect the first item to be memorized with the second, the second item with the third, and so on. For instance, *Every God Boy Does Fine* to remember the lines on the G clef—E,G,B,D, F.

e. Keyword method. Keyword method has two stages. To remember a foreign word, for example, first choose an English word, preferably a concrete noun, that sounds like the foreign word or part of it. Next, student associate the meaning of the foreign word with the English word through an image or sentence. For instance, the Spanish word *carta* (meaning “letter”) sounds like the English word “cart”.

3.3.2. Graphic organizers
A graphic organizer is a visual display that demonstrates relationships between facts, concepts, or ideas. A graphic organizer guides the learner’s thinking as they fill in and build upon a visual map or diagram. The types of graphic organizers used in visual learning to enhance thinking skills and improve academic performance on written paper, tests, and homework assignments [5][22]. A graphic postorganizer is any form of two-dimensional graphics, figures, or diagrams, etc. constructed by students after reading texts e.g. concept map and mind map [33,34].

Based on meta-analysis of 23 experimental studies, Moore and Readance in Spiegel and Barufaldi [11] reported that making notes in any form of graphic organizers increased students’ recall, retention, and concept comprehending or information in texts they read. Inspiration Sofware Inc [33] stated that graphic organizers are some of the most effective visual learning strategies for students and are applied across the curriculum to enhance learning and understanding of subject matter content. Detailed examples of concept map, mind map, and graphic (post)organizer can be cited in Inspiration Sofware Inc.

3.3.3. Journal
One of the forms of expressive writings is writing associated with journal. Using journals in the science classroom has been proposed as possible method for improving the problem-solving skills, monitoring students thinking, and enhancing student learning and self-regulated strategies. The journal writing encourages students to report on the hands-on activities in science lessons and enhances students’ self-regulation strategies such as self-awarenesses, enthusiasm, confidence, and positive attitudes [35,36].
4. Conclusion
A crucial way to understand student ability in writing is for the students to go about reading. As a teacher improves the quality of writing, he/she actually improves the quality of thought. Therefore, reading-writing to learn should develop together throughout the school years to support a program of educational improvement. If we all agreed that the essential goal of science education is also to enhance the quality of students’ thinking, we should move outside of traditional science instruction that simply overemphasize on the acquisition of subjects matter. Teachers in schools may sometimes model, teach, and encourage metacognitive strategies explicitly including reading and writing any text. Classroom-based studies which investigate how teachers can use a reading – writing - to learn science within existing instructional situations should be a high priority for future research.

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6. References


