 제31권 제3호, pp. 398~412 (2012)

A Review of Elementary Science Textbook Analysis Research Conducted over the Past Three Decades in the United States and Analysis of the Nature of Science in the Introductory Chapter of U.S. Elementary Science Textbooks

Lee, Young-Hee
(University of Houston)

최근 30년간 미국에서 행하여진 초등 과학 교과서 분석에 대한 연구 및 초등 과학 교과서 도입 단원에 나타난 과학의 본성에 대한 분석

이영희
(휴스턴 대학교)

국문초록

과학 교과서는 과학 교육에 있어서 아주 중요한 역할을 하여 왔다. 교과서는 학생들이 학문적 경험을 하게끔 주도하며 학교 교육을 대표하는 수단이라고 할 수 있다(Valverde, Bianchi, Wolfe, Schmidt, & Houang, 2002). 그러나 과학 교육에서 교과서의 중요한 역할에도 불구하고, 국내외에서 그 연구가 미비하였다(Good, 1993). 이 연구의 첫번째 과제로써 과학 교과서 연구 현황을 살펴보기 위해 지난 30여년간 미국에서 이루어진 초등 교과서와 관련된 연구들을 분석 및 정리하였다. 한편 과학의 본성에 대한 이해는 지난 반세기 동안 과학 교육에서 하나의 중요한 목표가 되어 왔으며, 미국의 여러 국가적 차원의 지침서에서는 그 중요성을 강조하였다 (NRC, 1996; AAAS, 1990, 1993). 그럼에도 불구하고 과학 교과서 연구에서 과학의 본성에 관련한 선행 연구가 거의 없다는 것을 알고, 본 연구의 두번째 과제로써 현재 미국 초등 교과서에 나타난 과학의 본성에 대한 연구를 4가지 주제에 근거하여 분석하였다. 과학의 본성에 대한 4가지 주제는 (a)지식 체계로서의 과학, (b) 탐구 방법으로의 과학, (c) 생각의 방법으로의 과학, 그리고 (d) 과학과 기술, 그리고 사회와 연관된 관계 (Chiappetta, Fillman, & Sethna, 2004)로서, 본 연구에서는 미국 초등 과학 교과서에 나타난 이 4가지 주제를 학년별 및 출판사별로 4가지 영역의 포함 정도를 퍼센트로 산출하였다. 또한 도입 단원 전체를 분석하였으므로, 단원 전반적 내용에 내포된 과학의 본성에 대한 측면을 연구자의 직관과 전문성에 근거하여 서술적인 방식으로 토의하였다.

주요어 : elementary science, elementary science textbooks, textbook analysis, nature of science, content analysis

I. INTRODUCTION

The role of textbooks in science education cannot be overemphasized (Yager, 1983). Researchers have reported that textbooks play a major role in science education (Lloyd, 1990), and studies have shown the importance of textbooks for teacher use as well as for student learning about science. Most educators agree that textbooks are valuable teaching resources that support planning and delivering instruction to meet local and

2012.7.23(접수), 2012.8.24(1심통과), 2012.8.28(최종통과)
E-mail: ylee@mail.coe.uh.edu (이영희)

national curricular standards (Chiappetta & Koballa, 2002). According to Harms and Yager (1981), more than 90 percent of science teachers use a textbook most of the time. Science teachers rely heavily on science textbooks in order to determine their curriculum and instructional choices (Yore, 1991). Most teachers use a textbook to provide the content taught in the classroom and plan their instruction by the organization of the textbook. Thus, textbooks often dictate students' science "curriculum" (Gottifried & Kyle, Jr., 1992). Textbooks, which utilize a number of instructional strategies, provide teachers with a means to construct their curriculum as well as approaches to teaching it (Chiang-Soon & Yager, 1993).

Unfortunately, for such an important component of the curriculum, science textbook research is comparatively small in comparison to most of the research conducted in science education and has not been widely disseminated in order to inform science teachers. According to the *National Science Education Standards* (National Research Council [NRC], 1996), the importance of the availability and organization of curriculum materials, equipment, media, and technology in science teaching are noted. Without an efficient evaluation of the instructional materials, it is possible that teacher preparation might fail to provide effective curriculum materials for professional training (Wang, 1998). Project 2061's *Benchmarks for Science Literacy* (1993) and the National Research Council's *National Science Education Standards* (1996) indicate that researchers and material developers need to analyze how well curriculum, instruction, and assessment support student achievement of learning goals. Both Project 2061 and the National Research Council articulated these goals in terms of a national consensus among educators and scientists on what K-12 students should know in science.

Science for All Americans (AAAS, 1990) emphasizes the importance of the nature of science in guiding science educators in accurately portraying science to students. The National Research Council (1996) also calls for teaching students the nature of science in its National Science Education Standards which specifically includes standards for teaching the nature of science across all grade levels. The National Science Teachers Association emphasizes the importance of understanding the nature of science in its official position statement designed for all professionals involved in science teaching and learning.

Although helping students to achieve an adequate understanding of the nature of science has been a consistent goal for science education for over half a century, current research reveals that the majority of students and teachers have naïve views of the nature of science (Abd-El-khalick & Akerson, 2004; Bianchini & Colburn, 2000). This problem could be attributed not only to the complex nature of science, but also to the way the nature of science is presented to students during instruction. Thus, research must be conducted to examine how the science is taught, especially in science textbooks, which are a major instructional resource for teaching science.

Given this background, the purpose of the first stand of study is to examine science textbook analysis research conducted on elementary science textbooks over the last several decades in the United States to learn about what types of elementary science textbook analysis has been conducted in science education. Also, as a second strand of research, the present analysis was conducted to determine the balance of the nature of science themes in the first chapter of 1st - 5th grade elementary science textbooks in U.S.

The research purpose can be summarized as the following research questions:

1. What types of textbook analysis research has been conducted at elementary level over the last 30 years in U.S.?
2. What are the conceptual frameworks, analytical techniques, reliability measures used by researchers and findings from each of the studies examined?
3. What is the balance of the themes for the nature of science in the introductory chapters of current elementary science textbooks?
4. How does the presentation of the content for the nature of science compare among the texts included in this study?

METHODS

1. The First Research Strand- A Review of Elementary Science Textbook Analysis Research: Meta-Content Analysis

The research effort reported in this review may be characterized as a "meta" content analysis of research reports of elementary science textbook analysis. The author engaged in this study with the primary aim of articulating what can be learned from an examination of selected research reports of elementary textbook analysis conducted over the last 30 years, ranging from studies published between 1985 and 2010.

Research reports of science textbooks analyzed in this study were mainly selected from refereed science education journals. Citations of relevant refereed articles and other research reports were obtained by searching various electronic databases (e.g., Wiley InterScience, ERIC, and Elsevier Science Direct). Abstracts of these reports were scanned before the full-text reports were obtained and reviewed for inclusion in this review. The refereed journals primarily comprise the following: *Journal of Research in Science Teaching*, *Science Education*, *and the International Journal of Science Education*. In addition, volumes of these three primarily refereed journals were physically scanned for articles and relevant references. As I believe that most, but certainly not all, of the elementary science textbook analysis reports in these journals have been examined for this review.

As the research reports of elementary science textbook analysis were obtained, they were read and categorized by date of publication from earliest to most recent. The summaries were developed with specific attention to the textbooks analyzed, the conceptual framework used in the analysis, the analytical technique applied in the content analysis, reliability measures used in the analysis, and the reported findings. For each research report of elementary science textbook analysis read, the summaries were entered into a set of tables organized. This data management technique facilitated comparison of selected aspects of the research reports examined in the study.

2. The Second Research Strand – Presentation of the Nature of Science in Elementary Science Textbooks: Content Analysis

A content analysis was used to determine the extent to which 20 elementary science textbooks are balanced for the nature of science. Content analysis has been defined as "a research technique for the objective, systematic, and quantitative description of the manifest content of communication" (Berelson, 1952, p. 18). According to Budd, Thorp, and Donohew (1967), "Content analysis is a systematic technique for analyzing message content and message handing-it is a tool for observing and analyzing the overt communication behavior of selected communicators." Similarly, Weber (1990) described content analysis as "a research method that uses a set of procedures to make valid inferences from text" (p. 9). He explains that these inferences are about the senders of the message, the message itself, or the audience of the message, and the process of the inferences vary with the theoretical and substantive interests of the investigator (Weber, 1990).

According to Krippendorff (2004), content analysis is "a research technique for making replicable and valid inferences from texts (or other meaningful matter) to the contexts of their use" (p. 18). He also described content analysis as a scientific research technique for making replicable and valid inferences from texts to the context of their use. Research techniques should result in findings that are replicable, which means that researchers working at a different point in time and under different circumstances should get the same results when applying the same technique to the same data. Replicability is the most crucial form of reliability (Krippendorff, 2004). In addition to replicability, scientific research must yield valid results (Krippendorff, 2004). A central idea in content analysis is that the text's many words are classified into fewer content categories. To make valid inferences from the text, the classification process must be reliable, that is, generate variables that are valid (Weber, 1990). A discussion of reliability and validity is vital to content analysis.

The nature of science has been defined as the "epistemology of science, science as a way of knowing, or the values and beliefs of scientific knowledge and its development" (Lederman, 1992, p. 331). As researchers have explored many aspects of the nature of science to describe and inform science education about the character of science itself, they have developed a more encompassing definition. "The nature of science is a fertile hybrid arena which blends aspects of various social studies of science including the cognitive sciences such as psychology into a rich description of what science is, how it works, how scientists operate as a social group, and how society itself both directs and reacts to scientific endeavors" (McComas, Clough, & Almazroa, 1998, p. 4).

The preparation of scientifically literate students is a persistent goal of science education (American Association for the Advancement of Science (AAAS, 1990, 1993; Millar & Osborne, 1998). Moreover, an adequate understanding of nature of science is a central element of scientific literacy (AAAS, 1990, 1993; Klopfer, 1969; National Science Teachers Association (NSTA, 1982). As such, helping students develop adequate understandings has been a long-standing concern of science educators and has recently been reemphasized in the national reform efforts in science education (AAAS, 1990, 1993; National Research Council (NRC, 1996).

There is significant agreement among science educators in the science education community that understanding science and how science works is important. However, providing students with an authentic view of the nature of science presents a big challenge for all teachers, especially those at the elementary level. One means to accomplish this goal is for the textbooks teachers use to include an accurate and balanced presentation of the nature of science. Therefore, the need exists for educators to examine how science textbooks present the nature of science.

1) Sample

The elementary science textbooks used in this study are:

1. Science, First-Grade, Second-Grade, Third-Grade, Fourth-Grade, and Fifth-Grade (Harcourt, 2000)
2. Science - Discovery Works, First-Grade, Second-Grade, Third-Grade, Fourth-Grade, and Fifth-Grade (Houghton Mifflin, 2000)
3. Science, First-Grade, Second-Grade, Third-Grade, Fourth-Grade, and Fifth-Grade (McGraw Hill, 2000)
4. Science, First-Grade, Second-Grade, Third-Grade, Fourth-Grade, and Fifth-Grade (Scott Foresman/ Pearson Education, 2000)

The sample consisted of the nature of science chapters found within the textbooks published by the four major publishing companies used in the State of Texas. Traditionally, the nature of science chapter has been placed at the beginning of the text. It is in this section that the authors define for students what science is and the method(s) used by scientists. Therefore, the decision was made to include the entire first introductory chapter of each textbook.

Analyses of the 20 elementary science textbooks were carried out using a procedure described in a manual entitled, the *Procedures for Conducting Content Analysis of Elementary Science Textbooks*. This instrument was adapted from the original, *Procedures for Conducting Content Analysis of High School Science Textbooks* (Chiappetta, Fillman, & Sethna, 2004). The *Procedures for Conducting Content Analysis of Elementary Science Textbooks* manual discusses the nature of science, the four themes, the procedure followed for unitizing the sample, how the inter-rater reliability would be determined among the three coders, directions and practice in identifying the different aspects of the themes of the nature of science, text (units of analysis) from the 20 textbooks, and a data sheet to identify the units of analysis.

First, the entire sample was unitized. This was done by consecutively numbering each unit of analysis on each page. The units for analysis included complete paragraphs, questions, figures with captions, tables with captions, marginal comments or definitions, and each step of a lab or hands-on activity.

The Nature of Science themes used for this study included:

1. Science as a body of knowledge; text that pre-

sents: (a) Facts, concepts, principles, and laws; (b) hypothesis, theories, and models; in addition to, (c) asking students to recall knowledge or information.
2. Science as a way of investigating; text that: (a) Requires the student to answer a question through the use of materials, (b) requires the student to answer a question through the use of charts, tables, etc., (c) requires the student to make a calculation, (d) requires the student to reason out an answer, (e) engages the student in a thought experiment or activity, or (f) instructs the student to get information from the Internet. However, if a question simply asks for recall of information or is immediately answered in the text, it is classified as Category1, science as a body of knowledge.
3. Science as a way of thinking; text in this category: (a) Describes how a scientist experimented, (b) shows the historical development of an idea, (c) emphasizes the empirical nature and objectivity of science, (d) illustrates the use of assumptions, (e) shows how science proceeds by inductive and deductive reasoning, (f) gives cause and effect relationships, (g) discusses evidence and proof, or (h) presents the scientific method(s) and problem solving steps.
4. The interaction of science, technology, and society; Text in this category: (a) Describes the usefulness of science and technology on society, (b) stresses the negative effects of science and technology on society, (c) discusses social issues related to science and technology, or (d) brings out careers and jobs in scientific and technological fields. (Chiappetta & Koballa, 2002)

This framework of the nature of science supports the call for reforms in science education, in addition to those required by Science for All Americans (AAAS, 1990) and the National Science Education Standards (NRC, 1996). For a study to be valid and reliable it is important that the tools and procedures used be valid and reliable. To accomplish this goal, first, the categories used for the nature of science have been found to be accurate and exhaustive, corresponding to the contextual meanings of the conceptual framework, the nature of science (Garcia, 1985). Second, this study's framework has been tested and found to be both valid and reliable to analyze the content of science textbooks for the nature of science on both the middle and secondary levels by Garcia (1985), Fillman (1989), Chiappetta, Sethna, and Fillman (1991), Lumpe and Beck (1996), Chiappetta and Fillman (2005), Phillips (2006), and Lee (2007). Third, the coders have extensive backgrounds in the nature of science and science education. Fourth, inter-rater reliability was accomplished by training the coders for the study using the *Procedures for Conducting Content Analysis of Elementary School Science Textbooks* manual.

RESULTS & DISCUSSIONS

1. A Review of Elementary Science Textbook Analyses Research

Overall few studies have been conducted at the elementary school levels over the last three decades. Because of the need to educate elementary school students and their teachers, more textbooks analyses should be undertaken at elementary level. The research should examine science textbooks to learn more about the images they convey to teachers and students about science. Below are the elementary textbook analyses including the researchers and the findings that have been conducted previously over the past three decades in the United States.

Powell and Garcia (1985) conducted content analysis to determine how males, females, minorities, and non-minorities are quantitatively and qualitatively represented in the illustrations of seven elementary science textbooks (grades 1-6) published in the early 1980s. They developed an evaluation instrument for the study and recorded the total number of illustrations in each textbook. Each human illustration and/or photograph on each page was evaluated according to sex, race, child or adult, and degree of activity. Two raters were involved in the analysis to ensure intercoder reliability using two approaches. One approach consisted of a simple percentage agreement between the two coders. The second reliability index was calculated using Cohen's *kappa* (Cohen, 1960). The median reliability scores for all textbooks combined were .93 for simple agreement and .85 for Cohen's *kappa*. The results indicate that the total number of human illustrations in each textbook varied from 554 to 1,129. On average, 60% of the individuals represented were males, 35% were females, and 5% were unidentified. Seventy five percent (75%) of the individuals represented were non-minorities. Also, female children were represented with greater number of frequency than male children and adult females were represented in a variety of science and non-science career roles. Minority adults and children were represented with less frequency than nonminorities and minority adults were rarely shown in science related roles. Powell and Garcia concluded that the textbooks limit science as a potential career role for minorities by illustrating the groups less often in the role than white male adults. Finally, they found that elementary science textbooks did not provide young learners with a broad, comprehensive, multicultural, and balanced view of science in society.

Staver and Bay (1987) examined 11 elementary science textbook series using sentence, illustration, activities, and miscellaneous as the units of analysis with regard to Project Synthesis goal clusters: (a) academic preparation, (b) personal needs, (c) career education/awareness, or (d) societal issues. The inquiry emphasis of text activities was categorized as (a) confirmation, (b) structured inquiry, (c) guided inquiry, or (d) open inquiry. They chose two representative units from the primary level (K-3) and intermediate level (4-6) for analysis. "Units were chosen by first identifying units common to most texts at the primary and intermediate levels, then randomly selecting one unit from each level for analysis" (p. 633). For the 415 items analyzed by two researchers, the first researcher rated 346, 52, and 16 as academic, personal, and career; the second rated the same 415 items as 354 academic, 46 personal, and 15 career. Staver and Bay's ratings were identical on 94.12 %, of the units analyzed. They did not report using a written protocol for their analysis. Staver and Bay concluded that most text information was academic in orientation, and most of the student activities/experiments were absent or limited in number. Further, for the activities/experiments that were included in the textbooks, most were of the confirmation type where the answers were already given in the text. Therefore, these resources did not reflect the recommendations of the National Science Teachers Association for a scientifically literate person.

Meyer, Crummey, and Greer (1988) conducted an analysis of elementary school science textbooks. They examined and compared content domains and vocabulary in 12 textbooks from four science programs (publishers) for: grades 1-5 published by Merrill and by Silver-Burdett, grade 4 published by Holt, and grade 5 by McGraw-Hill. This analysis was a part of a longitudinal study of science concept acquisition (Meyer & Linn, 1985) and these books were selected because they were used in the school districts that were a part of the longitudinal study. Their content analysis was conducted to answer three research questions: "What is the content of the four programs? How is common content presented across grade levels in the programs? How well is the content presented?" (pp. 439). Their conceptual framework was developed from the literature they reviewed. They examined the texts for content domain, pedagogy, propositions, and considerateness (pp. 438-439). Every page from each textbook appropriate for the content domain was coded. Although chapter or unit titles helped determine content domains, the authors found it necessary to read each chapter or unit to title the content domains.

Meyer et al. counted vocabulary as those words clearly specified for students to learn (indicated in lists at the end of chapters or highlighted and defined in the text). In order to examine pedagogy, they reported selecting all chapters on the same topics within grade levels across publishers and then identified the major ways in which content was presented and tallied them. In examining for propositions, they used the definition of a proposition offered by Omanson, Beck, Voss, and McKeown (1984) as "a cohesive set of units of meaning." Using this definition Meyer et al. counted the propositions in the texts as a measure of the density of text in each program. Lastly, considerateness was reported as examined using the guidelines set forth in Anderson and Armbruster (1984). They searched for and tallied "inconsiderate text" defined as text with "illogical structure" or "text [that] has confusing or incorrect headings." In searching for considerateness, they examined the structure (e.g., logical connectives, referents, and antecedents), content (e.g., language-activities, procedures, vocabulary beyond common experiences of children at the intended grade level, problematic technical terms), and pictures & diagrams (e.g., unnecessary to text, hard to see, or unlabeled) (pp. 439). Results were presented in the form of tally tables showing the number of content domains, vocabulary, etc. Meyer et al. found (a) substantial differences between programs/publishers and that variation occurred in content and pedagogy, (b) the programs that have the greatest amount of text (i.e., the highest number of content domains, propositions, and vocabulary) also had the most hands-on activities and have fewer problems with considerateness, (c) the programs with the greatest amount of content also had more teacher-directed activities and subsequently fewer activities that appeared only in student materials. Although sufficient details were provided with regard to the analysis method used by the authors, methods (if used) to validate the content analysis procedure or the reliability of coding were not presented.

Using qualitative analysis, Jeffrey and Roach (1994) examined elementary and middle-school science textbooks for the presence of evolutionary protoconcepts. Protoconcepts are "topics that prepare students to study evolution in later years" (p. 507). Five textbook series were chosen for this analysis spanning grades one through eight. Seventeen protoconcepts considered important for student understanding of evolution were used to analyze the texts. An example of the concepts used include: dinosaurs, camouflage, heredity, extinction, fossils, earth history, evolution, and concept of time. These concepts were chosen by exploring all of textbooks for topics that might qualify as evolutionary protoconcepts, thus generating grounded theory that was used to guide the study. Additional life science textbook protoconcepts were gleaned from the misconception literature. This part of the research was conducted after the topics were generated from a review of all textbooks so that bias was reduced. The protoconcepts from the life science texts were validated by matching them with those previously generated. Therefore, all categories were grounded in the data with life science categories also grounded in the literature.

Jeffrey and Roach found coverage of protoconcepts varied considerably among all published textbooks. For example, all texts deal with most protoconcepts at one time or another. However, there was a lack of consistency in presentation of concepts across the grade levels. And, some texts were found to be missing information such as fossil correlation with rock layers. "Therefore, if students were taught from a different text series each year they may get exposure to fewer protoconcepts than if they had been taught from the same series throughout their elementary school experience" (p. 513). Jeffrey and Roach recommended that teachers be aware of the protoconcepts necessary for students' conceptual growth of evolution and the extent to which they are addressed by publishers. Then, as teachers select texts and plan activities they can use supplementary materials to fill the gaps. Jeffrey and Roach did not report on the protocol that they used, which would inform researchers on how to identify evolution protoconcepts or the reliability of the procedure.

While these studies do summarize previous reviews of elementary science textbooks they do not examine textbooks for the themes of the Nature of Science. Given the national focus on increasing understanding of the Nature of Science (NRC, 1996) and increasing scientific literacy (NSTA, 1982) it is necessary to understand what components are emphasized in elementary science textbooks. Therefore, it is important to examine what aspects of the Nature of Science students are exposed to through their elementary science textbooks. Researchers have identified discrepancies in students' knowledge of scientific concepts by as early as third grade. (Kohlhaas, Lin & Chu, 2010) Given that elemen-

Table 1. A Review of Elementary Science Textbook Analyses Research

Conceptual framework	Analytical technique	Reliability of protocol and of coding	Findings
Powell and Garcia (1985): Seven elementary science textbooks and published in the early 1980s			
· Examined the quantitative and qualitative portrayal of females and minorities in the illustrations of science textbooks	· The number of illustrations in each textbook was recorded and each human illustration and photograph on each page was recorded separately by group, race, sex, and as active and passive using the *Science Text Evaluation Process* (STEP)	· The median reliability scores for all books combined produced a .93 percent agreement among coders and a Cohen's *kappa* of .85.	· The total number of human illustrations in each series varied from 554 to 1,129. · On average, 60% of the individuals represented were males, 35% were females, and 5% were unidentified. · 77% of the adults represented were non-minorities. · Female children as a group are represented with greater frequency than are other groups of children. · Minorities children are represented less than non-minority children, and female minority adults are depicted less than non-minority male adults. · Minorities are underrepresented in a limited number of career roles.
Staver & Bay (1987): 11 elementary science textbooks published between 1979 and 1985.			
· Project synthesis goal clusters were used to categorize the unit of analyses: (a) academic preparations, (b) personal needs, (c) career education/awareness, and (d) societal issues. · The extent to which inquiry is presented in the textbooks.	· Performed two analyses; one for the grades 1-3 textbooks, the other for grades 4-6. The units of analyses were: sentences, illustrations, activities, and miscellaneous.	· Interrater agreement was 94.12 %. No reliability reported for the protocol.	· The results are: (a) most text prose focus on academic science, (b) most remaining text prose focus on personal goals, which is only minor (c) text activities/experiments are academic in orientation, (d) inquiry is absent or present in only limited form, and (e) texts allocate only a minor portion of space to activities/experiments.
Meyer, Crummy, & Greer (1988): 12 textbooks from four publishers for grades 1-5.			
· Determined the content domains, pedagogy, propositions and considerateness. · Used Omanson, Beck, Voss, & McKeown (1984) definition for propositions and Anderson & Ambruster (1984) guideline for considerateness.	· Counted the number of content domains, pedagogy as major ways in which content was presented, propositions and considerateness or lack thereof. · Each page of every textbook appropriate to content domain was read. · Compared results across publishers.	· No reliability reported for the protocol. · No reliability reported for the textbooks analyzed.	· Substantial differences existed between programs particularly with content and pedagogy. · Program with the greatest amount of text also had the most hands-on activities and had fewer programs with considerateness. · Programs with the greatest amount of content also had more teacher-directed activities.
Jeffrey & Roach (1994): Five elementary and middle school science textbook series.			
· Seventeen evolutionary protoconcepts, such as; concepts of time, dinosaurs, camouflage, heredity, earth history, etc. · Generated protoconcepts using grounded theory.	· Evaluated textbooks with respect to the 17 evolutionary protoconcepts.	· No reliability reported for the protocol. · No reliability reported for the textbooks analyzed.	· Evolutionary protoconcepts vary considerably among published textbooks. Found a lack of consistency in presentation across all grade levels.

tary science textbooks are a primary source of scientific content in the classroom, it is significant to understand how they could be contributing to these discrepancies in scientific knowledge and the Nature of Science.

2. Presentation of the Nature of Science in the Introductory Chapter of Elementary Science Textbooks

Inter-rater agreement was calculated using percent and Inter-rater reliability was calculated using Cohen's (1960) *kappa*. Cohen's *kappa* is a statistic that uses the nominal scale that factors in guessing. Values for Cohen's *kappa* range from 1.00 to −1.00, with 0 equal to agreement by chance. A *kappa* value of .75 or greater is considered good to excellent agreement beyond chance; a value between .40 and .75 indicates fair to good agreement beyond chance; and, a value below .40 is considered poor agreement beyond chance. A high reliability coefficient is more desirable because the data can be considered more trustworthy.

The inter-rater agreement for the instrument, *Procedures for Conducting Content Analysis of Elementary School Science Textbooks* ranged from 85.2% to 93.4% among the three coders with a range in *kappa* values from 0.80 to 0.9. Table 2 presents the intercoder agreement and reliability values for the analysis of four categories of the nature of science in the twenty elementary science textbooks. The percentage of agreement for the coding of the Methods of Science Chapters ranged from 85.1% to 99.2%. *Kappa* values for the coding of the Methods of Science chapters ranged from 0.80 to 0.99. Results for assigning units of text to nature of science categories resulted in good to excellent agreement for all coding of, the instrument, all methods of science chapters. Therefore, the data collected of the nature of science themes in the 20 elementary science textbooks can be considered trustworthy.

After the sample was unitized, it was randomly distributed among the coders, who coded each unit of analysis for the four aspects of the nature of science. The units were tabulated and the percentages and proportions of each aspect of the nature of science to the whole were calculated. Table 3 lists the percentages of the four nature of science categories found in the twenty elementary science textbooks methods of science chapters by grade level. For this study the entire first chapter of each textbook was examined. It is the first chapter that publishers have traditionally placed the content for the methods of science.

Table 2. Intercoder Agreement and Reliability Values for the Analysis of Four Categories of the Nature of Science in the Twenty Elementary Science Textbooks

Textbook	Chapters	Coders	Percent agreement	Cohen's *kappa*
Harcourt	Methods of Science	A/B	90.4	0.87
		A/C	90.4	0.87
		B/C	99.2	0.99
Houghton Mifflin	Methods of Science	A/B	85.1	0.8
		A/C	95.5	0.94
		B/C	86.6	0.82
McGraw Hill	Methods of Science	A/B	96.1	0.95
		A/C	96.4	0.95
		B/C	95.8	0.94
Scott Foresman	Methods of Science	A/B	94.9	0.94
		A/C	99	0.99
		B/C	95.9	0.95

For the percentage of the presentation of the four elementary science textbooks, the mean percentage of Category I, Science as a Body of Knowledge, ranges from 0.0% to 50.0% across the grade levels in four publishing companies' elementary science textbooks. While this is a dominant theme in *Scott Foresman* with more than a mean value of 30.0% in all grades, *Harcourt* does not focus on this theme at all with a value of 0.0% in all levels. Category II, Science as a Way of Investigation, has a mean range of 17.9% to 100.0%. This category is the most emphasis theme in all four types of elementary science textbooks with more than a value of 30.0% in most of grade levels. The mean percentage of Category Ⅲ, Science as a Way of Thinking, ranges from 0.0% to 54.1% in the four types of elementary science textbooks. It indicates that

Table 3. Percentage of Nature of Science Categories Found in the Science Textbooks

Textbook	Grade	Nature of science categories			
		Ⅰ	Ⅱ	Ⅲ	Ⅳ
Harcourt	1st	0.0	100	0.0	0.0
	2nd	0.0	100	0.0	0.0
	3rd	0.0	100	0.0	0.0
	4th	0.0	96.0	4.0	0.0
	5th	0.0	92.5	7.5	0.0
Houghton Mifflin	1st	1.0	74.0	25.0	0.0
	2nd	1.0	74.0	25.0	0.0
	3rd	18.2	48.5	33.3	0.0
	4th	15.4	50.3	34.4	0.0
	5th	15.1	41.5	43.4	0.0
McGraw Hill	1st	14.3	30.5	37.1	18.1
	2nd	14.3	30.5	37.1	18.1
	3rd	26.5	23.0	35.8	14.7
	4th	18.8	22.6	54.1	4.5
	5th	24.5	27.0	37.6	11.0
Scott Foresman	1st	50.0	17.9	32.1	0.0
	2nd	50.0	17.9	32.1	0.0
	3rd	32.1	31.0	36.9	0.0
	4th	30.4	30.4	39.2	0.0
	5th	30.6	32.2	36.1	1.1

Note. Nature of Science Categories: Ⅰ= science as a body of knowledge; Ⅱ= science as a way of investigating; Ⅲ= science as a way of thinking; and, Ⅳ= interaction of science, technology, and society (STS).

while the three types of textbooks focus on this aspect of the nature of science with approximately one third portion of the content in the methods of science chapter, only Harcourt does not emphasize on this aspect of the nature of science in all grade levels. For Category IV, Interaction of Science with Technology and Society, the four types of elementary science textbooks place their focus on this aspect of scientific enterprise, ranging from 0.0% to 18.1%. Compare to other categories, this aspect of the nature of science is the least emphasis theme across the grade levels in all four types of elementary science textbooks.

To discuss the presentation of the nature of science specifically by the publishing company, Harcourt textbook greatly emphasize on the first theme, Science as a Body of Knowledge, among the four aspects of the nature of science. Interestingly, Harcourt textbook focuses on the Category II by giving most of the percentages in all grade levels with little emphasis on other categories. This finding is undesirable because even though the exactly same portion of the four categories was not expected from the results, it is pleasing to present a variety of aspects of the nature of science in the chapter because of the multifaceted features of the nature of science.

Specifically, the first and second grade textbooks published by Harcourt share a similar format with one another. The nature of science chapter illustrates basic science-process-skills and includes a one-page summary focusing on lab safety. A variety of hands-on activities are interspersed throughout the Harcourt textbooks for the purpose of engaging first and second-grade students in learning as they develop their understanding of science-process-skills and concepts. A science handbook is included at the end of the chapter of Harcourt textbook for explaining the process of conducting scientific inquiry, introducing lab safety, providing ideas for scientific investigations, and displaying instructions for using scientific tools (e.g.: hand lens, thermometer, ruler, measuring cup, clocks, stop watch, balance, and computer).

The first, second, and third-grade textbooks in the Harcourt series are similar, but show some unique differences. In the upper grades, the authors elaborate on the steps for using tools in the science classroom. Examples and more descriptive instructions for properly using a hand lens, microscope, balance, spring scale, rulers, and timers are included within the pages. The steps for using scientific tools are quite detailed and labels are included with pictures for easy identification (e.g.: microscope and balance). The authors also go into greater depth in the third, fourth, and fifth-grade science textbooks by discussing how to use computers as a tool for writing reports, making graphs, charts, and doing research. The third, fourth, and fifth-grade textbooks include instructions for creating graphs. In the instructions, the authors discuss how to generate graphs using computer software programs as well as the benefits of doing so. Tips are given for using search engines and navigating the Internet safely.

Category Ⅱ, Science as a Way of Investigation, and Category Ⅲ, Science as a Way of Thinking, is the two emphases of the Houghton Mifflin series. The nature of science is carried throughout the chapter as underlying themes. This finding indicates that the authors of the Houghton Mifflin series seem to want students to understand the nature of science as a process of science - not by presenting scientific knowledge or the interaction of science with technology and society. In addition, the Houghton Mifflin textbooks feature a section called *Thinking like a Scientist*. The *Thinking like a Scientist* section provides illustrations and definitions for students as they learn to use science-process-skills (e.g.: observing, questioning, hypothesizing, planning and doing tests, recording facts, and drawing conclusions). An activity is given to encourage students to investigate and practice using the same process skills that scientists use. The authors also include ideas for further research and lab safety. The third, fourth, and fifth-grade textbooks emphasize careers in *People Using Science* located on the first page of every chapter.

In addition to emphasizing the nature of science by encouraging students to use science-process-skills and by highlighting careers in the Houghton Mifflin textbooks, the authors provide multiple opportunities for activities including reading, math, and science integration. In fact, distinct sections on reading and math skills are included in the back of every unit along with a science and math tool box. The Houghton Mifflin authors provide a variety of activities for teachers and students to use for improving their reading skills. Some of the activities include comparing and contrasting, using cause and effect, determining the main idea, and drawing conclusions. Also, the Houghton Mifflin textbook series gives young readers assistance on how to read a science textbook in general. Reading tips are provided for the upper grade levels with increasing levels of depth. Similarly, math skills in the Houghton Mifflin science edition involve students in the process of graphing, using tables, and analyzing data.

The McGraw Hill textbook series consistently emphasizes the nature of science throughout the chapter. It appears as the most balanced treatment of the presentation of the four themes throughout the entire chapter from the 1st to 5th grade. Significantly, the textbook content in McGraw Hill engages students in the methods of science and presents the work of practicing scientists, their discoveries, and explains how scientists conduct their investigations. The McGraw Hill textbooks also expose students to the interaction of science, technology, and society. Science, technology, and society issues are woven into each textbook and demonstrate how scientists collaborate and work together to accomplish their goals. Each McGraw Hill textbook includes a Science Magazine or a National Geographic (World of Science) section embedded within some of the chapters. The National Geographic and Science Magazine sections focus on appreciating the work of different scientists and how scientists conduct their work. In addition to emphasizing the nature of science, the McGraw Hill textbook series includes distinctive features. A glossary is provided at the end of each textbook to help students with new terminology. Also, vocabulary words are highlighted and underlined for easy reference. The third, fourth, and fifth-grade textbook editions include a *Methods of Science* chart to illustrate the nonlinear aspect of the methods of science.

In Scott Foresman textbooks the percentage of presentation of the four themes shows an overall similarity across the grade levels. While the mean percentage of the presentation of the four themes is almost evenly in the first chapter, Category IV, Science and its Interaction with Technology and Society, it does not appear in the content of the methods chapter. The Scott Foresman textbook integrates social studies and technology with science. Integrated activities are embedded within the chapters. The integrated activities focus on math, science, social studies, reading, writing, and even music. In the first and second grade textbooks, a science song serves as an introduction for each chapter. The fourth-grade textbooks integrate math and science by asking students to solve word problems.

The Scott Foresman textbooks also include a science handbook in the back for showcasing science-process-skills in addition to providing suggestions for making measurements. Each grade level includes a timeline highlighting important inventions and historical events for both social studies and science. The first and second-grade textbooks highlight inventions while the third, fourth, and fifth-grade textbooks focus is on the history of science. Concept maps are included in the beginning of the chapter and serve as a graphic organizer for students trying to understand the content found within the textbook chapters.

CONCLUSIONS AND IMPLICATIONS

Textbooks have long played an important role in the teaching and learning of science in the elementary classroom. In the same way that scientists utilize books to further their research and practice, students can similarly acquire useful knowledge from reading textbooks in the science classroom. Thus, teachers should examine their own beliefs about how they use textbooks to inform their instruction and practice. The way teachers view the textbook directly influences the way their students will perceive their own textbook and the nature of science (Ulerick, 2011).

A review of U.S. elementary science textbook analysis research is informative in some ways. Most of the elementary textbook analysis researches under the review were conducted during the 1980s and early 1990s. It means that most elementary science textbooks that were analyzed were published previously before early 1990s. Thus, there is a strong need to be conducted elementary science textbook analysis with current elementary science textbooks. For the topics of the analysis under the review varies from content domains to societal issues such as gender and race. Because the U.S. is to achieve the goal: "Science for All Americans.", gender and minority representation in science is essential (Chiappetta, L. E., Ganesh, T. G., Lee, Y. H. & Phillips, M.C., 2006). Perhaps additional science textbooks analysis should be undertaken to determine current textbooks have modified their presentations to include more females and minorities.

Currently, there is a growing need to consider the "Multicultural Issues" in Korea as the rate of foreign workers increasing in the nation. In fact, science education in Korea has been focused on some other pedagogical issues rather than societal issues. Even though there were some curriculums analysis researches in science education across the countries (Shim, S. & Choe, Y., 2005; Chung, C., Oh, H., Choi, J. & Kang, K., 2007; Kim, M. & Kim, K., 2010; Shin, D. & Oh, K., 2011), most researches emphasized on science content and pedagogy such as core concepts, topics, illustrations, etc. Because the elementary science impacts on heavily students' attitude and minds in science, there is an important need for Korean science educators to examine science curriculum in terms of the view of multiculturalism.

For the second-strand of research, the elementary science content analysis portrays the balance for the nature of science themes in all four elementary science textbook editions. The revealed data should prove useful to the elementary science teacher as he or she seeks to examine his or her beliefs regarding how textbooks should be used in elementary science instruction and practice. All twenty of the elementary science textbooks reviewed in this study focus on science as a body of knowledge and science as a way of investigating. Content is provided in all textbooks for students to learn about science in general and to generate interest for furthering their inquiry investigations. All of the elementary textbooks provide students with the process for conducting inquiry investigations, however some of the textbooks portray the scientific method as more a step-by-step process for organizing scientific inquiries. The authors of these textbooks are beginning to emphasize issues in science, technology, and society as well as science as a way of thinking. This is a nice start. McGraw Hill uses the scientific enterprise as a context for providing students with an understanding of what science is and how science is conducted.

Presently, textbook publishers seem to be slowly moving toward a more balanced representation of the nature of science in elementary textbooks. All textbooks are providing science content with greater emphasis on hands-on, minds-on opportunities for students to engage themselves in inquiry investigations. It is hoped that in future publications of textbook editions authors continue to shift towards incorporating different aspects of science including science as a way of thinking as well as science and its interaction with technology and society to provide a more authentic view of the nature of science.

These findings are instructive to Korean science educators in some respects. Few people deny that the role of science textbooks in Korean classrooms is more significant because of more use of textbooks by teachers and students. Since the understanding of the Nature of Science has been a critical goal in science education across the nations, there is a strong need for conducing Korean elementary science textbooks analysis to examine how the Nature of Science is presented in the textbooks. Significantly, since the elementary school science is very important to construct students' scientific attitude and literacy, it is essential to include authentic views of the Nature of Science in elementary science textbooks.

It is important to note that individuals often conflate the Nature of Science with science processes and inquiry skills (Abd-El-Khalick, Bell, & Ledermann, 1998). While scientific processes such as observing and inferring are related to the collection and interpretation of data in scientific activities, the Nature of Science refers to the epistemological commitments underlying the activities of science. Consequently, it can be said that individuals' scientific processes are often influenced by ones' understanding of the Nature of Science. Because elementary science textbooks in Korea seem to emphasize heavily on the science processes and inquiry skills, it is important for authors of science textbooks to distinguish the two even though there is overlap and interaction between science processes and Nature of Science.

REFERENCES

Abd-El-Khalick, F. & Akerson, V. L. (2004). Learning about nature of science as conceptual change: Factors that mediate the development of preservice elementary teachers' views of nature of science. *Science Education*, *88(5)*, 785-810.

Abd-El-Khalick, F., Bell, R. L. & Lederman, N. G. (1998). The nature of science and instructional practice: making the unnatural natural. *Science Education*, *82*, 417-436.

American Association for the Advancement of Science (AAAS). (1990). *Science for all Americans*. New York: Oxford University Press.

American Association for the Advancement of Science (AAAS). (1993). *Benchmarks for scientific literacy*. New York: Oxford University Press.

Anderson, T. H. & Armbruster, B. B. (1984). Content area textbooks. In R. C. Anderson, J. Osborn & R. J. Tierney (Eds.), *Learning to read in American schools* (pp. 193-224). Hillsdale, NJ: Erlbaum.

Berelson, B. (1952). *Content analysis in communications research*. New York: Free Press.

Bianchini, J. A. & Colburn, A. (2000). Teaching the nature of science through inquiry to prospective elementary teachers: A tale of two researchers. *Journal of Research in Science Teaching*, *37*, 177-209.

Budd, R. W., Thorp, P. K. & Donohew, L. (1967). *Content analysis of communications*. New York: The Macmillan Company.

Chiang-Soong, B. & Yager, R. E. (1993). The inclusion of STS material in the most frequently used secondary science textbooks in the U. S. *Journal of Research in Science Teaching*, *30*, 339-349.

Chiappetta, E. L. & Fillman, D. A. (2005). *Analysis of five high school biology textbooks used in the United States for inclusion of the nature of science.* Paper presented at the National Association for Research in Science Teaching Meeting. Dallas, TX.

Chiappetta, E. L. & Koballa, Jr., T. R. (2002) *Science instruction in the middle and secondary schools (5th ed.)*. Upper Saddle River, NJ: Pearson.

Chiappetta, E. L., Fillman, D. A. & Sethna, G. H. (2004). Procedures for conducting content analysis of science textbooks. Department of Curriculum and Instruction, University of Houston. (Original work published 1991).

Chiappetta, E. L., Ganesh, T. G., Lee, Y. H. & Phillips, M. C. (2006, April). *Examination of science textbooks published over the past 100 years in the United States.* Paper presented at the National Association for Research in Science Teaching meeting. San Francisco, CA.

Chiappetta, E. L., Sethna, G. H. & Fillman, D. A. (1991).

A qualitative analysis of high school chemistry textbooks for scientific literacy themes and expository learning aids. *Journal of Research in Science Teaching*, *28*, 939-951.

Chung, C., Oh, H., Choi, J. & Kang, K. (2007). A comparative study on illustrations on science textbooks in Korean and American elementary schools-Focus on biology section of 3rd-6th grades. *Journal of the Korean Association for Science Education*, *27*, 639- 644.

Cohen, J. (1960). A coefficient of nominal scales. *Educational and Psychological Measurement*, 20(1), 37- 46.

Fillman, D. A. (1989). Biology textbook coverage of selected aspects of scientific literacy with implications for student interest and recall of text information. *Dissertation Abstracts International*, *50*, 1618- A.

Garcia, T. D. (1985). An analysis of earth science textbooks for presentation of aspects of scientific literacy. Dissertation. Houston, TX: University of Houston.

Good, R. (1993). Science textbook analysis. *Journal of Research in Science Teaching*, *30*, 619.

Gottfried, S. S. & Kyle, W. C. Jr. (1992). Textbook use and the biology education desired state. *Journal of Research in Science Teaching*, *29*, 35-49.

Harms, N. C. & Yager, R. E. (1981). *What research says to the science teacher* (Vol. 3). Washington, DC: National Science Teachers Association.

Holsti, O. R. (1969). *Content analysis for the social sciences and humanities*. Reading, MA: Addison-Wesley.

Jeffery, K. R. & Roach, L. E. (1994). A study of the presence of evolutionary protoconcepts in pre-high school textbooks. *Journal of Research in Science Teaching*, *31*, 507-518.

Kim, M. & Kim, K. (2010). A comparative study of science textbooks in Korea, Singapore, and Taiwan-Focus on the field of biology. *Journal of the Korean Association for Science Education*, *30*, 498- 518.

Klopfer, L. E. (1969). The teaching of science and the history of science. *Journal of Research in Science Teaching*, *6*, 87-95.

Kohlhaas, K., Lin, H. H. & Chu, K. L. (2010). Science equity in third grade. *Elementary School Journal*, *110(3)*, 393-408.

Krippendorff, K. (2004). *Content analysis: An introduction to its methodology. 2nd Edition*. Thousand Oaks, CA: Sage.

Lederman, N. G. (1992). Students' and teachers' conceptions about the nature of science. A review of the research. *Journal of Research in Science Teaching*, *29*, 331-359.

Lee, Y. (2007). How do high school biology textbooks introduce the Nature of Science? Dissertation. Houston, TX: University of Houston.

Lloyd, C. V. (1990). The elaboration of concepts in three biology textbooks: Facilitating student learning. *Journal of Research in Science Teaching*, *27*, 1019-1032.

Lombard, M., Snyder-Duch, J. & Bracken, C. C. (2002). Content analysis in mass communication assessment and reporting of intercoder reliability. *Human Communication Research*, *28(4)*, 586-604.

Lumpe, A. T. & Beck, J. (1996). A profile of high school biology textbooks using scientific literacy recommendations. *The American Biology Teacher*, *58*, 147-153.

McComas, W., Clough, M. P. & Almazroa, H. (1998). A review of the role and character of the nature of science in science education. In W. F. McComas (Ed.). *The nature of science in science education: Rationales and strategies* (p. 3-39), Dordrecht: Kluwer.

Meyer, L. A. & Linn, R. L. (1985). A longitudinal study of the acquisition of science concepts in elementary school. Proposal submitted to the National Science Foundation 2/1/85.

Meyer, L. A., Crummey, L. & Greer, E. A. (1988). Elementary science textbooks: Their contents, text characteristics, and comprehensibility. *Journal of Research in Science Teaching*, *25(6)*, 435-463.

Millar, R. & Osborne, J. (Eds.). (1998). *Beyond 2000: Science Education for the future*. London: King's College.

National Research Council (1996). *National science education standards*. Washington, DC: National Academy Press.

National Science Teachers Association (NSTA) (1982). *Science-technology-society: SciEnce education for the 1980's (An NSTA position statement)*. Washington, D.C.: Author.

Neuendorf, K. (2002). *Content analysis guidebook*. Thousand Oaks, CA: Sage.

Omanson, R. C., Beck, I. L., Voss, J. F. & McKeown, M. G. (1984). The effects of reading lessons on comprehension: A processing description. *Cognition and Instruction*, *1(1)*, 45-67.

Phillips, M. C. (2006). A content analysis of sixth- grade, seventh-grade, and eighth-grade science textbooks with regard to the nature of science. Dissertation. Houston, TX: University of Houston.

Powell, R. R. & Garcia, J. (1985). The portrayal of minorities and women in selected elementary science series. *Journal of Research in Science Teaching*, *22*, 519-533.

Shim, S. & Choe, Y. (2005). A comparative study on science textbooks for primary and secondary education in Korea and Japan-Focusing on the field of physics. *Journal of the Korean Association for Science Education*, *25*, 480-493.

Shin, D. & Oh, K. (2011). Analysis of earth science content of elementary school science textbooks in five Asian countries: For the children of foreign workers. *Journal of Korean Elementary Science Education*, *30*, 38-50.

Staver, J. R. & Bay. M. (1987). Analysis of the project synthesis goal cluster and inquiry emphasis of elementary science textbook. *Journal of Research in Science Teaching*, *24*, 629-643.

Ulerick, S. L. (2011). Using textbook for meaningful learning in science. *Research Matters - to the Science Teacher*, an electronic publication of the National Association for Research in Science Teaching [On- Line]. Retrieved June 1, 2011 from http://www.narst.org/publications/research/textbook2.cfm

Valverde, G. A., Bianchi, L. J., Wolfe, R. G., Schmidt, W. H. & Houang, R. T. (2002). *According to the book: Using TIMSS to investigation the translation of policy into practice through the world of textbooks.* Dordrecht: Kluwer.

Wang, H. A. (1998). *Science textbook studies reanalysis: Teachers "Friendly" content analysis methods*. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (71st, San Diego, CA, April 19-22, 1998).

Weber, R. P. (1990). *Basic content analysis (2nd ed.).* Newbury Park, CA: Sage.

Yager, R. E. (1983). The importance of terminology in teaching K-12 science. *Journal of Research in Science Teaching*, *20*, 577-588.

Yore, L. D. (1991). Secondary science teachers' attitudes toward and beliefs about science reading and science textbooks. *Journal of Research in Science Teaching*, *28*, 55-72.

Yore, L. D. (1991). Secondary science teachers' attitudes toward and beliefs about science reading and science textbooks. *Journal of Research in Science Teaching*, *28*, 55-72.