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Curriculum Reform Movements and Science Textbooks: A Retrospective Examination of 6th Grade Science Textbooks

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Over 50 years, two major reform efforts in science education took place. The purpose of the present study is to explore how the educational reforms were reflected in nine 6th grade science textbooks published in 1975, in 1985 and in 1997 in terms of (a) the materials used, (b) the contexts to which the electricity concept was related, (c) the type of student activities, and (d) the domain of learning objectives dealing with text activities. For the analysis, a checklist was developed. Our findings show that the concept of teaching electricity has moved from transmitting a body of knowledge and the discipline of science orientation to a more social learning and a student centered pedagogical orientation.

Keywords: Textbook analysis, history of science education, science textbooks, science education reforms.

INTRODUCTION

Science education the United States has been a perpetual issue of national concern because scientific and technologic knowledge is thought to be the key to success in politic, economic, and military status of the United States (De Boer, 1991; National Research Council. 2007). In April of 1983, "A Nation at Risk," for example, blamed on the educational system for the declining status of the United States in world economic system, just like it was blamed for the failure to win the space race with Soviet Union (De Boer, 1991). Even today, the debate about the quality of science education is still continuing as major public policy (National Research Council, 2007).

To fully examine and understand the current context of science education, one must first have a clear understanding of history of science education in the United States. It is because the current context of science education is shaped by initiatives happened in past few decades (National Research Council, 2007). Examining trends occurred in science education in the United States can inform us about future directions in science education in the United States. The study illustrates the educational trends past four decades, providing a solid empirical basis. The purpose of the study is explore how educational reforms were reflected in the 6th grade science textbooks published in 1975 through 1997 in terms of (a) the materials used, (b) the contexts to which the particular concept was related, (c) the type of student activities, and (d) the domain of learning objectives dealing with text activities.

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Reform Movements in U.S. Science Education

For over 50 years, two major reform movements took place in science education. The first one, called the Post-Sputnik era, occurred between the years 1950 and 1980. The Post-Sputnik reform movement aimed at designing courses to help students *thinks like scientists* (Rudolph, 2002). The second movement, called *science for*

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State of the literature

- The Post-Sputnik reform movement intended for designing courses to help students think like scientists.
- The second movement, called science for all was initiated in the 1980s, and it still leads the majority of the science education research efforts.
- The ultimate goal of the science for all movement was to cultivate scientific literacy and educate citizens to be able to effectively participate and function in democratic societies that are greatly dependent upon the innovations in science and technology.

Contribution of this paper to the literature

- Examining trends occurred in science education in the United States can inform us about future directions in science education in the United States and elsewhere.
- The study sheds light on the educational trends past four decades, providing a solid empirical basis.
- Having a clear understanding of the history of science education in the United States will help us fully examine and understand the current context of science education because the current context of science education is shaped by initiatives happened in past few decades.

all was initiated in the 1980s, and it still leads the majority of the science education research efforts. The ultimate goal of the *science for all* movement was to cultivate scientific literacy and educate citizens to be able to effectively participate and function in democratic societies that are greatly dependent upon the innovations in science and technology (Osborne, Duschl, & Fairbrother, 2002).

1970s- 1989: Think like a scientist

After the Soviet Union launched the *Sputnik* in 1957, the United States' science education community began paying more attention to the crucial role of scientific knowledge in society and for the country (DeBoer, 2000). Hickam (1998) summarized it as:

- *Sputnik was launched in the fall of 1957. In the fall of 1958, it felt to the high-school students of the United States as if the country was launching us in reply. A more challenging academic curriculum was to be installed the result of Sputnik and the worry over how badly educated America's children were compared to Russian kids. (p. 140)*

In 1960, the National Society for the Study of Education (NSSE), in its Fifty-ninth Yearbook titled the *Rethinking Science Education* claimed that science teachers should work to cultivate citizens who understood science and were sympathetic to the work of scientists (DeBoer, 2000). The President's Scientific Research Board sought ways to improve the level of science and technology education at the high school level for all youth, and to explore the scientist of the future. In the post-Sputnik era, the active role of designing science education curricula and materials was taken by scientists. Turner (2008) describes the post-Sputnik years being when the science curricula were in the hands of scientists who promoted curricula organized around scientific knowledge, scientific disciplines, and scientific careers. However, this reform wave lost its momentum by mid-1970s due to an important pedagogical shift

1980s- Today: Science for all

There was another increase in attention to science education in 1980s in the United States. The economic competition with Japan had increased national concerns about the quality of science education (De Boer, 1991; Rudolph, 2002; National Research Council, 2007). In the report, A Nation at Risk, the National Commission for Excellence in Education proposed a new assessment of U.S. K-12 education. It was said that "once unchallenged preeminence in commence, industry, science, and technological innovation was being overtaken as U.S. schools had lost sight of the high expectation and disciplined effort needed to attain" (National Research Council, 2007, p.15). This report took policy makers' attention to renew course contents and to bring high school graduation requirements.

Before A Nation at Risk, social atmosphere of the United States had been changing. Persistent and oppressive poverty, racial prejudice, and gender inequity caused many Americans to look for ways to improve society (De Boer, 1991). One way to improve society was to provide the equity of educational opportunities regardless of race, gender, or physical handicap. Taken all together, attentions in education shifted from scientists' interests to students' interests. That led to science education's move from a *think like scientists* orientation to a *science for all* orientation (Duschl, 2008). This movement was initiated in the 1980s, and it still leads the majority of the science education research efforts in the US. According to Gallagher (1971):

- *"For future citizens in a democracy, understanding the interrelations of science, technology, and society may be as important as understanding the concepts and processes of science" (p. 337).*

Textbooks help shape the curriculum delivered to the students and help teachers attain the desired educational outcomes when they use the textbooks effectively. Textbooks can play a significant role in cultivating student-centered pedagogies and promoting learning (Pinto, 2007). Pedagogical innovations can be prescribed within the organization and the content of a textbook (Hamm, 1989). The primary consumers of the textbooks, teachers and students, make use of the pedagogy embedded in the textbooks. If the content organization and the activity structure of a textbook are predominantly informed from a logical positivist epistemological orientation, it is likely that the teacher will follow a knowledge-centered, teacher-focused pedagogical orientation. If the textbook is written from a social constructivist epistemological orientation, it provides more opportunities for the teacher to use learner-centered, student-focused pedagogies (Bransford, Brown, and Cocking, 2000).

Electricity is one important topic most K-12 curricula encompass (Cook & Tulip, 1992). The electricity--current or static--is a physical phenomenon, yet it is not possible for the human eye to detect its movement or energy. Our conceptualization of energy mostly stems from its impact on electronic devices, for example, on electric motors as movement, on light bulbs as illumination, on resistances as heat, etc. Students often learn how to measure the electric current on a given wire in a closed circuit or the electric potential difference on a battery source. It is particularly difficult for K-12 students to conceptualize current electricity, static electricity, and the other parameters associated with this concept (e.g., voltage, resistance, energy, etc.) (Yalvac, 1998). Research indicates that even pre-service and in-service teachers have alternative conceptions about electricity that are not aligned with their scientific counterparts (Baser & Durmus, 2010; Kucukozer & Demirci, 2008).

Many technological devices that students are familiar with in their daily life experiences run by the electricity. Electricity is one of the most common energy sources, and most students have some familiarity and preconceptions of its use. Recently, with the emergence of electric- powered vehicles and their adaption in transportation, electricity and its unique uses has begun to receive more attention by the mass media and public. Textbooks interpret the predominant curricular policies of a culture (Pinto, 2007). Textbook authors often write the chapters of their textbook using a coherent language, similar style and organization, and a consistent pedagogical orientation. In this study, we have assumed that a chapter selected from a textbook will represent the overall language, style, organization, and pedagogical orientation of that particular textbook. Considering the importance of electricity, we have chosen the electricity chapter as the representative of the other chapters in a typical science textbook.

This study's purpose was to explore the extent to which the characteristics of the two educational reform movements were represented in 6th grade science textbooks published in three decades. Specifically, our analyses focused on (a) the types of materials used in the textbooks, (b) the contexts to which the electricity concepts were related, (c) the types of activities presented in the textbooks, and (d) the characteristics of the domain learning objectives targeted in the textbook activities.

Our main research question is: "How were the two leading educational reform movements over the last 50 years reflected in 6th grade science textbooks published

Table 1. A checklist for analyzing the textbooks

Dimension and sub-dimensions
• Materials used to present electricity
• Tables, graphs, figures, etc. (visual materials)
• Pictures and images of machines, technical and/or laboratory equipment, etc.
• Reading text (essays on a topic/electricity)
• Contexts to which the electricity concepts were related
• Scientific (electricity is related to science)
• Technological (electricity is related to the technology)
• Social (electricity is related to everyday life and the society)
• Experience (electricity is related to students' experiences)
• Types of learning activities on electricity concept (asking students to do hands-on/practical/collaborative activities other than reading a text)
• individual activities (completed by an individual student)
• group activities (completed by a group of students)
• out-of-school activities (completed outside of the school)
• Learning objectives associated with the activities
• Knowledge
• Comprehension
• Application
• Analysis

Table 2. Descriptions of the textbooks

Title of textbooks	Authors of textbooks	Publication year
STEM Elementary School Science (STEM)	Rockcastle and Salamon	1975
Concepts in Science (CIS)	Brandwein et al.	1975
Science: Understanding Your Environment (SUYE)	Mallinson et al.	1975
Addison-Wesley Science (AWS)	Rockcastle et al.	1984
HBJ Science (HBJS)	Avakian et al.	1985
Silver Burdett Science (SBS)	Mallinson, Mallison & Smallwood	1985
Science Interaction (SI)	Avakian et al.	1996
Glencoe Physical Science: Texas Edition (GPS)	McLaughlin and Thompson	1997
Science Insights Exploring Matter and Energy (SIEME)	Dispezio et al.	1997

Table 3. *Types of materials used in the textbooks (numbers)*

Types of Materials	Textbooks					
	1975		1985s		1997	
	M	SD	M	SD	M	SD
Tables, Graphs, Figures, etc.	-	-	0.3	0.6	3.7	0.6
Pictures and images from machines, lab equipment, etc.	62	25.2	56.7	2.5	37.3	5.8
Reading texts by the textbook author	0.7	1.2	1.3	0.6	4	2

in 1975, in 1985 and in 1997?" We posed the following questions to investigate the inclusions of the two abovementioned reform movements: (1) what were the characteristics of the materials used in the textbooks? (2) which topics were emphasized in the textbooks?, and (3) what types of activities were used in the textbooks?

METHODS

Instrumentation

We developed a checklist that offered us guidelines in our analysis and specified the concrete aspects that should be paid attention to (Fraenkel and Wallen, 2000). Sub-dimensions in the checklist were created to better explain the main dimensions. The developed checklist's main-dimensions and sub-dimensions are presented in Table 1.

For detailed analysis, we looked at the electricity chapter in the nine textbooks. We chose three textbooks representing each decade. This was done to get more evidence to capture the existing trends in decades. Table 2 represents the descriptions of the nine textbook analyzed.

FINDINGS

After analyzing each textbook using the checklist, we created tables to compare the nine textbooks' characteristics. The frequencies of the observed parameters in the checklist (Table 1) were averaged in the tables. We report the mean scores of textbook and its standards deviation in each decade to show the characteristics of each textbook by referring to the frequencies of those parameters.

Table 3 shows the number of pictures, graphs, and reading texts in each decade's textbook. The detailed findings are presented in Appendix A. In the *STEM*, for example, there was no graph or reading text. The only pictures included were descriptions of the basic concepts in electricity. The pictures found in the same book were primarily to prescribe to students how to conduct the activities (See Figure 1). The pictures in the *SBS*, for instance, were the actual photographs of the experimental devices (See Figure 2).

In the electricity chapter in the *SBS*, the authors, Mallinson, Mallinson & Smallwood (1985) provided two reading texts, a graph, a 'prefix & suffix,' and matching scientific definition test and vocabulary test at the end of the chapter. The authors also provided two reading texts titled "Science in Career" and "People in Science" at the end of the chapter. The purpose of these reading texts was to inform students about the career options in science. For example, the "Science in Career" reading text in the *Silver Burdett Science* aimed at explaining what a chemist and a physicist do.

… study of matter and energy falls under two general areas in science. These are chemistry and physics. Both the chemist and the physicist are interested in the nature and behavior of matter. Both study the relationship between energy and matter, but they investigate different aspects. (p. 204)

In the *SIEME* electricity chapter, Dispezio, Lisowski & Skoog (1997) included a concept map, a table, a quote, and six reading texts authored by them. In the *SIEME* book after each electricity concept covered, reading texts titled "Science and You," "Science and Society," and "Science and Technology" were placed.

The reading texts aimed at making students aware of how science affects society and technology. For example, the science and society reading text presented how using new energy-efficient appliances affected our life.

… replacing old appliances with the new energy-efficient models reduces household electricity use. Each time you use less electricity, more electricity is available for someone else. When less energy is needed to make electricity, nonrenewable resources like coal and oil are conserved. (p. 278)

We analyzed the written texts and reading texts sentence by sentence and categorized them into four groups as science, technology, social, and experience-related. Sentences communicating the scientific facts were grouped into the science category. Sentences communicating the technology relevance were grouped into the technology category. Sentences addressing the social aspect of science were grouped into the social category. Sentences that encouraged students' own thinking (including meta-cognition and pre-conceptions) and experimentation were grouped into the experience category. Table 4 shows the frequencies of the sentences emphasizing science, experience, society and technology domains in percents in each textbook.

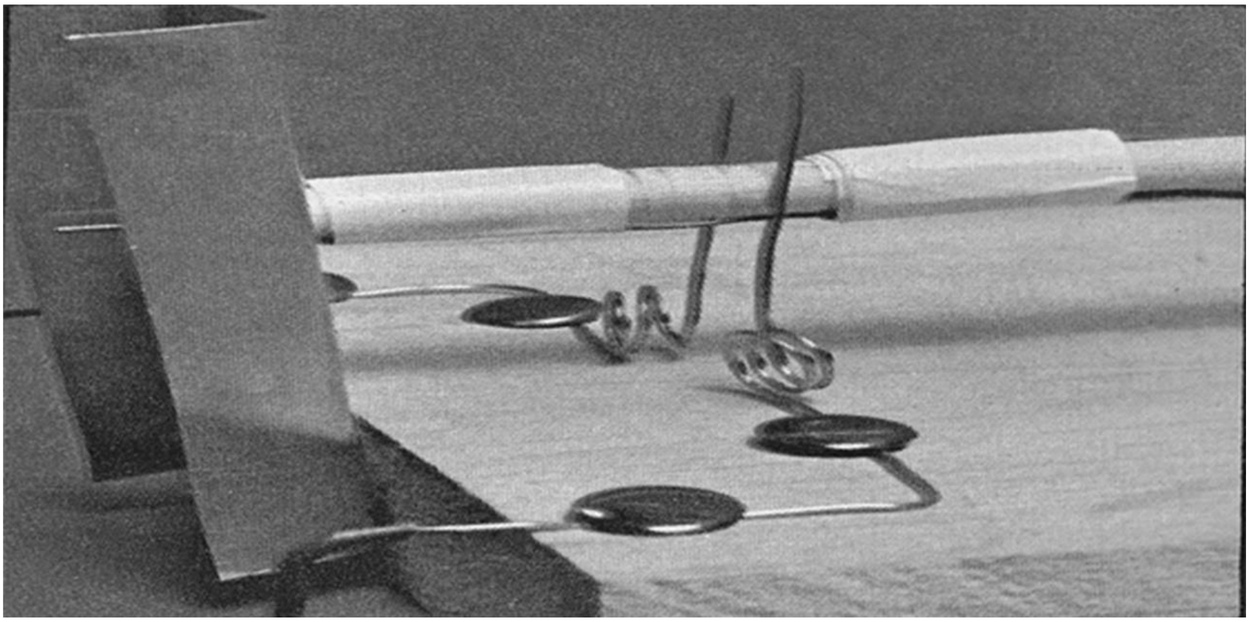

Figure 1. *A picture image from the STEM book illustrating how to perform the experiment (p. 153)*

Figure 2. A picture image from the SBS book showing a scientist working in a lab (p. 205)

In the *STEM*, as shown in Table 4, the majority of sentences were aimed at providing scientific information for students; however, little emphasis was made on social aspect of science. Although the authors of the SBS gave more space to the technological relevance, the emphasis on social aspect of science did not change. In the *SIEME* the majority of the sentences were aimed at giving students scientific information. In contrast to the low emphasis in the *STEM* and *SBS*, the authors of the *SIEME* promote the social aspect of science intensively. In the *STEM* and the *SBS,* imperative sentences starting with 'make and do' were mostly used. Unlike other textbooks, the *SIEME,* question sentences were predominantly used.

We quantified the characteristics of the activities in the textbooks and grouped them according to their types. Table 5 shows how many activities the textbooks covered. In the *STEM* book, there was no in-class group activity or any kind of out-of-school activity. The only nine activities written in it were individual activities that students can complete without collaborating with their peers or anyone outside the school. The activities were mostly titled "something to try" and "do something." In the activities, all directions were provided to students and depicted with pictures. For example, the activity titled something to make is:

- *"Here is an electric motor you can make. You will need these materials" (p. 153)*

Similar to the *STEM* book, the *SBS* book did not include group or out-of-school activities. The *SBS* included four individual activities. The activities were focused on making some electronic devices or applying scientific content knowledge to technological devices. For example, an activity required students to make a telegraph:

- *"How can you make a telegraph? One device that uses electromagnets is a telegraph. To make a telegraph, nail a block that measures 7 cm on each side to a board." (p. 181)*

In contrast, the *SIEME* book included two group activities, nine individual activities and three out-of-school activities. The activities were open-ended, and directions rarely were presented in activities. For instance, one activity asked students to collect and interpret data:

- *Look at information on six electric devices you own. Write down how many amperes each device uses. Compare the items on your list with those of a classmate. Which devices use the most current? (p. 273)*

We categorized the activities according to their cognitive domain objectives based on Posner's curriculum analysis protocol (Posner, 2004). In the *STEM* book eight out of nine activities were in the comprehension domain and one activity was in the

Table 4. *Domain of the sentences (percentages)*

Domain	Textbooks					
	1975		1985		1997	
	M	SD	M	SD	M	SD
Scientific	54.7	6.8	38.0	3.6	49.3	7.0
Technological	25.0	8.2	38.7	6.1	18.7	2.1
Social	5.7	0.6	6.3	0.6	16.0	3.6
Students' Experience	14.7	3.5	17.0	3.6	16.0	5.3

Table 5. *Numbers and types of learning activities in each textbook*

Types of Activities	Textbooks					
	1975		1985		*1997*	
	M	*SD*	M	*SD*	*M*	*SD*
Group activity	-	-	-	-	1.7	0.6
Individual activity.	7.3	2.1	6.3	2.1	9.0	2.0
Out of school activity	-	-	-	-	1	1.7

Table 6. *Learning Objectives of the Activities*

Domain	Textbooks					
	1975		1985		1997	
	M	SD	M	SD	M	SD
Knowledge	-	-	0.7	1.2	0.3	0.6
Comprehension	7	1.7	5.3	2.5	4.7	3.1
Application	0.3	0.6	0.3	0.6	4.3	3.2
Analysis	-	-	-	-	2.3	0.6

application domain (Table 6). In the *SBS,* book one activity was in the application domain and three activities were in the comprehension domain. In the *SIEME* book one activity was in the knowledge domain, two were in the comprehension, eight were in the application, and three were in the analysis domains.

CONCLUSION/DISCUSSION

In this study we developed a checklist and used it to descriptively analyze the electricity chapters in nine textbooks published between 1975 and 1997. Our descriptive findings shed light on the differences among the textbooks' curriculum approaches and the educational trends in science teaching from 1975 to 1997.

As shown in Table 3, different teaching materials, for example, graphs, tables, and concept maps, were included in the nine books. In the *STEM* book, the technological devices were mostly depicted in pictures. There was no table or other visual representation or any reading text. This suggests that the educational trends in the 1970s in science teaching were to emphasize technology, and the function of the textbook was to get students familiar with technology. Technology was still the first emphasis in the 1980s, whereas different teaching materials such as tables and reading texts were used in the *SBS*. The educational trends in the1980s depicted an emphasis on multiple representations in teaching science. Multiple representations are aligned with multiple intelligence theory (Gardner, 1983) and advocates of different student learning styles (Armstrong, 2009). This result can be evidence for the *science for all* movement. The use of the reading texts titled "Science and Society" and "Science and Technology" showed that in 1997 social dimension had been added as a new emphasis in science textbooks. The number of reading texts and visual representations increased as the publication dates became more recent. The educational trend also emphasized help for students who had different learning styles and abilities.

The electricity chapter content emphasized the importance of scientific knowledge in 1975, of interaction of science and technology in 1985, and of interaction of science, technology and society in 1997. In the *STEM*, the sentences mostly emphasized the concept definition of electricity phenomenon. The textbook served as a knowledge resource similar to an encyclopedia. This parallels the educational materials used in the textbook and aligns with the "think like scientists" movement. With the emphasis of technology and science, the *SBS* book served as a lab manual for students. However, in the *SIEME* book*,* more science-technology-society interaction was emphasized. This is also evidence for the *science for all* movement.

Paralleling the difference in the context and teaching materials in textbooks, the activities in textbooks were different in terms of participants and targeted cognitive domains. Although in both the 1975 and 1985 textbooks the student activities included were individual, in 1997 group activities and out-of-school activities took place, and students were asked to conduct research and interpret the data they collected outside of the school environment. The content of the activities shifted from purely lab work and "think like scientists" orientation to the STS orientation with an emphasis on *science for all.* The activities' cognitive domains were enriched as the years increased and the books aimed at promoting *science for all.* Along with the emphasis of the STS interaction, group activities in the *SIEME* show that social learning came to education.

The findings of this study are consistent with the previous studies regarding the content of science textbooks between 1970s and 1990s (e.g., Orpwood & Soque, 1984; Wilkinson, 1999). Qrpwood and Soque (1984) reported the authors of science textbooks in the late of 1970s and beginning of 1980s mainly aimed at fostering students' scientific process skills, acquisition of scientific content knowledge and attitude towards science and scientists. Wilkinson (1999) also found that the authors of physics textbooks in 1990s paid more attention on the interactions of science, technology and society than did the authors in the end of 1970s and the beginning of 1980s. consistent with the previous studies, the results of this study provide evidence that the science textbooks in 1970s and beginning of 1980s were primarily intended to develop students' attitude towards science whereas the science textbooks in the late of 1980s and 1990s were mainly aimed at promoting the interactions of science, technology and society.

Considering the changes in textbooks over the years, we predict—we hope—that future textbooks will include more science-technology-society interaction—and in the age of the World Wide Web, much more access to datasets and other opportunities to connect with students from other schools and with scientists and engineers. Along with the importance of social learning in education, more group activities and out-of-school activities would be found in the textbooks. In the activities students would be mostly asked to collect and to interpret data—or in the case of computer datasets, to analyze existing data and make predictions. Considering the STS mainstream in textbooks, out-of-school activities would be given more attention in order for students to link science with its implementations in life rather than science for technology.

As discussed early in the paper, educational trends are evolving. The goal of science education has shifted from "purely thinking like scientists" and "cook-book" or "lab-manual" approach to "multiple-representation for *all* students" and "science-technology-society" approach. Today's science textbooks emphasize social learning and a collectivist science approach instead of an individualist and one scientific method approach.

Because of the current educational trend and the advancements in communication technologies, we can predict that future textbooks will be quite different from traditional hard copy textbooks. The traditional textbooks primarily served as information resources. The function of the future textbooks will likely to serve as a guide to students rather than being a source of the scientific information. The future textbooks will be able to interact more with student, if it pays more attention to the use of different visual representation, such as concept maps, graph, and analogies. Considering the effects of technology in education, there is an expectation of more use of interactive e-books in science education to make textbooks more reachable for students.

Curriculum developers and teachers should focus on the developing communication technologies and prepare their "guide" books accordingly to respond to the students' needs. Real scientific data that can be easily accessed on the electronic databases could be a valuable resource for students' science learning activities. Out-of-school collaborations for students can be achieved on the Internet by asking scientists and experts to interact with students. Students all around the world can participate in group-works or in peer-to-peer activities using the global science education databases and web resources. The textbook of the future will most likely be the one that serves as a communication tool among the science education students with many links and electronic resources that guide students to search, locate, and make use of the scientific information. Accompanied with the 21st century skill expectations, these textbooks will most likely provide platforms for the students to communicate their design endeavors, and peer-review each other's scientific investigations, and publish or present their conclusions. More research on the emerging electronic textbooks can shed light on the future of the textbook materials and their embedded pedagogical orientation. Just as World War II and Sputnik led to a "purely thinking like scientists" pedagogical orientation, recent societal issues are leading to new pedagogical orientations. Exploring the role of educational movements and their reflection on textbooks can help science educators be aware of the critical epistemologies and pedagogies that we adapt over time and operationalize in our teaching.

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Appendix A

Detailed findings of textbooks analysis

Dimensions and sub-dimensions	STEM	CIS	SUYE	AWS	HBJS	SBS	SI	GPS	SIEME
Materials used to present electricity									
• Tables, graphs, figures , etc. (visual materials)	-	-	-	-	-	1	4	4	3
• Pictures and images of machines, technical and/or laboratory equipment, etc.	75	78	33	57	59	54	34	44	34
• Reading text (essays on a topic/electricity)	-	2	-	1	1	2	2	4	6
Context to which the electricity concepts are related									
• Scientific (electricity is related to science)	60	47	57	42	35	37	42	56	50
• Technological (electricity is related to the technology)	16	32	27	32	40	44	21	17	18
• Social (electricity is related to everyday life and the society)	6	6	5	6	7	6	19	17	12
• Experience (electricity is related to students' experiences)	18	15	11	20	18	13	18	10	20
Types of learning activities on electricity concept (asking students to do hands-on/practical/collaborative activities other than reading a text)									
• Individual activities (completed by an individual student)	9	8	5	8	7	4	11	7	9
• Group activities (completed by a group of students)	-	-	-	-	-	-	2	1	2
• Out-of-school activities (completed outside of the school)	-	-	-	-	-	-	-	-	3
Learning objectives associated with the activities									
• Knowledge	-	-	-	-	2	-	-	-	1
• Comprehension	8	8	5	8	5	3	8	4	2
• Application	1	-	-	-	-	1	3	2	8
• Analysis	-	-	-	-			2	2	3

Table 7

Note: The number shows the percentage in the context dimensions

