2008

A comparative study of six decades of general science textbooks: Evaluating the evolution of science content

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A Comparative Study of Six Decades of General Science Textbooks: Evaluating the Evolution of Science Content

By

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A dissertation submitted in partial fulfillment
Of the requirements for the degree of
Doctor of Philosophy
Department of Secondary Education
College of Education
University of South Florida

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Date of Approval:
November 17, 2008

Keywords: 8th and 9th grade science, science content standards,
transforming science education, science curriculum, science textbook publishers

DEDICATION

This work is dedicated to my mother, Margaret and to her sister, my Aunt Clare, who ignited the spark for the love of learning in my sisters and me. Through them was transmitted the curiosity, the excitement, and the joy of teaching from a long line of educators who have influenced the minds of generations of students. I also want to thank you both for your patient and persistent attention to detail.

Thank you Naraiya, Meg and Andy, you never doubted for a moment that I would succeed; you each inspire me every day in countless ways.

Dad, I love you, thank you for always being there for me.

The *P* in this Ph.D. is officially yours Mama - you are *Perfect* in every way.

ACKNOWLEDGEMENTS

I would like to thank Dr. Dana Zeidler for his continuous support and council throughout my graduate career. I'm also grateful to my committee members Dr. John Ferron, Dr. Deidre Cobb-Roberts, and Dr. Troy Sadler. A special thank you to Dr. John Ferron, without his support, direction and compassion I never would have started or finished this dissertation. I'd like to thank Patricia J. Finney from the Center for Research Libraries for her assistance in finding and acquiring the textbooks used in this study. The USF Inter-Library loan team was also instrumental in making this research possible and I am grateful for all their assistance. Finally, I'd like to thank the CORE department and Dr. Ha Phan for her patience and assistance in the statistical analysis conducted in this study.

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Evaluating the Evolution of Science Content

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ABSTRACT

This study examined science textbooks over time to better understand the *science content* expectations that the U.S. educational system deems appropriate for 8th and 9th grade science students. The study attempted to answer the questions: 1) What specific science content has been presented via the textbook from 1952 to 2008? 2) Within which areas and in what way does the science content change? 3) Are new scientific findings reflected in 8th and 9th grade U.S. general science textbooks? Twenty-six themes were identified which reflect five areas in science: Chemistry, Physics, Earth Science, Biology, and Process of Science. Trends in science content in U.S. 8th and 9th grade general science textbooks, as revealed by this data sample, indicated no statistically significant change in depth of coverage in Physics and Process of Science over the past 60 years, no significant change in depth of coverage in Earth Science and Biology in the last 40 years, and no significant change in coverage in Chemistry over the last 30 years. Additionally, a total of sixteen new discoveries were found in the textbook sample. For classroom teachers this information may alert them to the necessity of going beyond the textbook in preparing students for life in a global society. In educational practice, this research

supports and reinforces the need for inquiry learning and socioscientific curricula. It may also influence educators to challenge assumptions regarding the value and selection of the traditional classic science content.

CHAPTER ONE – STUDY OVERVIEW

Introduction

More than a century ago a noted British educator posed the question "What knowledge is of most worth?" (Spencer, 1859, p.3) and educators continue to struggle with this question today. Learning to learn is the single common goal of the 150 countries involved in science curriculum reform (OECD, 1998). In the United States this goal is stated directly and indirectly in many science reform documents (e.g. AAAS, 1989; NRC, 1996; NRC, 2003; NRC, 2007). However, *what* every student should *learn* from the wide array of scientific knowledge available and what it means to *know science* are contentious issues. School science curricula are usually modeled on disciplines such as Biology, Chemistry, Earth Science and Physics. The notion of *integrated science content* proposes breaking down these traditional barriers and teaching subjects as an interwoven and unified system. However, current texts simply include units for each disciple (Physics, Chemistry, Biology, etc.) but do not present the content in truly integrated manner. Today the hard sciences encompass a multitude of sub-disciplines and research fields. Biology has fractured into more than 400 named fields (e.g., Biochemistry, Biophysics, Marine Biology, Cell Biology, Evolutionary Biology, etc.) each having its own research methods and infrastructure (Hurd, 2002). The American Chemical Society noted "…like a species that has moved into open niches, evolved, and diversified, chemistry can no longer be regarded as a discrete scientific field. Its methods, concepts, and practitioners are penetrating virtually every nook and cranny of science and technology" (Keer, 1991, p.1212). Of all that is known in science today, what then should every student know and what does it mean to *know science*?

> For the entire history of science education each successive reform has been simply an updating of the traditional subject matter…Although all reform movements for the past 100 years have emphasized the goal of 'meeting the needs of the students,' there has been neither much research nor a definition of what these needs are in today's knowledge-intensive culture (Hurd, 2002, p.6).

There is an implicit assumption that the science content provided in schools is relevant to students' lives and appropriate for learning. This assumption is implicit because so few scholars and researchers have questioned the basic science content offered in the U.S. public school system. Innumerable studies have attended to aspects such as age-appropriate content (e.g. Friedlander, Wetstone, Scott, 1974), accuracy in science content (e.g. Hubiz, 2001), misconceptions in science (e.g. Ebert-May, Williams, Luckie, Hodder, 2004), importance to underlying scientific themes (e.g. Shymansky, Woodworth, Norman, Dunkhase, Matthews, -Tang Liu, 2006), moral and ethical considerations (e.g. Zeidler & Keefer, 2003; Sadler, 2004), and pedagogy (e.g. Mayberry, 1998). However, no study has questioned the worthiness of *traditional science subject matter* as a platform for science learning. Is the classic science content the most relevant platform for teaching children how to exist in society today? How has the classic science content met the needs of students? Has the subject of science become petrified into narrow spheres of importance? In what way does education keep science new, fresh, and relevant?

To fully examine and consider the ramifications of these avenues of thought one must first have a clear understanding of the science content that has been and is currently being offered to students as required learning. This study illustrates the science content considered foundational in the U.S. educational system over the past six decades, providing a solid empirical basis in which to further examine the relevancy of the required science content. It is important not to obfuscate the discussion by making assumptions that have been neither proved nor disproved.

A first step in reinventing or revitalizing the science curriculum is to analyze and understand the trends in science content. The reality of science in society today is vastly different from past decades. Has science education responded to these changes? What *exactly* is the *traditional content subject matter* in the U.S. and how accurately does it reflect our current scientific knowledge? By explicitly articulating the science content taught to children over the last six decades through general science textbooks we have a meaningful starting point in which to begin this discussion and determine which ideas are still *of the most worth*.

Purpose of the Study

The Impetus

What constitutes a good science textbook is an open question. The criteria used by committees in textbook selection runs the gamut of educational, social, and political policies (Bianchini & Kelly, 2002; Schmidt, Wang, & Mcknight, 2005). Educational researchers also attempt to answer this question in a variety of ways: analyzing the prevalence, function and structure of photographs in biology texts (e.g., Pozzer & Roth, 2003); determining the extent of inclusion of the history of science (e.g., Leite, 2002); assessing comprehension demands (e.g., Walpole, 1998-1999), analyzing culturally specific patterns of conceptualizations of science (e.g., Cogan, Wang, & Schmidt, 2001); determining how non-white people are represented in science texts (e.g., Kim, Hannafin, & Bryan, 2007).

Unlike other studies, this research was not designed to either validate or refute assumptions regarding the adequacy of science textbooks. However, it provides a foundation for educators to evaluate the efficacy and appropriateness of science content for today and to shape science content requirements for the future. This research documents the science content delivered via science textbooks over the past six decades in the United States. It follows the progression of information that has been deemed most important for students to know via the classroom science text and it documents when and how new scientific information is incorporated into these texts. By identifying explicit science content and documenting changes (if any) through time, this study presents empirical evidence rather than suppositions from which scholars, educators, policy makers, and text book writers may discuss and evaluate the direction of science education.

This study provides a basis for a fundamental re-evaluation of the substance of science content and thus science curriculum. However, one must concede the more pragmatic reality that fundamental change in any system or institution transpires at an unhurried and deliberate pace. In addition to the long-range effects this study may have on the educational system as a whole, more immediate implications of this research may also be explored. For example, it raises the question as to the usefulness, equity, or necessity of multiple science content standards currently in use throughout the United States.

Historically, science content has been selected via societal norms (Spencer, 1949), intellectual elites (Elliott, 1990) and big business (Sadker & Sadker, 2000). New science has also been greatly influenced by national, state, and local government policy (e.g., National Commission on Excellence in Education, 1983; National Educational Goals Panel, 1994; No Child Left Behind, 2001; Committee on Science and Engineering and Public Policy, 2007). Chapter two discusses in greater detail how these sectors have affected the science content delivered via general science textbooks. Considering the multitude of players involved in providing science content (over 15,000 local school districts in the U.S., fifty state boards of education, state and federal judiciaries, schools of education, researchers, universities, unions, publishers of tests and textbooks, and journalists) it remains unclear as to what *specific content* has been presented to students over the past six decades. Because of the many different centers of power, change is slow and uncertain. “This system…may or may not be the right way, but it is the

American way, a way determined by the decentralized politics of American education and by this society's use of public schools not only as educational agencies, but also as instruments of social policy" (Ravitch, 1995, p.2). The U.S. is one nation, not fifty independent states, yet an ongoing debate rages as to the necessity and feasibility of national science content standards.

> The reality is that most American public schools already have one [national standard]. It is not a very good one. If visitors from another nation were dropped into an American public school classroom without knowing the state or region, they would be likely to see the same lesson taught in the same way to children of the same age. In the most important subjects, schools throughout the country use textbooks that are so similar in content as to be indistinguishable from each other (Ravitch, 1995, p.xxiv).

This study was designed to affirm or disprove these types of claims regarding similarity of texts by obtaining empirical evidence that will clearly portray the science content found in science textbooks. Textbooks may be found to have little in common over time and location. If this should prove to be the case, questions will arise as to the fairness and equity of state, national, and college testing. As a nation we are striving to provide students with equal opportunities to learn and achieve success. Because state and national tests act as gatekeepers to greater educational and professional opportunities, the delivery of widely diverging educational or science content would raise questions as to what or *whose* science content is required to pass these critical exams.

If textbooks over time and location should prove to be similar this would reframe the national science standards debate. The discussion could be refocused to investigate how to create, distribute, and assess a single science content standard rather than to ask, *should* there be a U.S. national science content standard. The U.S. Constitution does not give the federal government authority for education, leaving that power to the states, thereby precluding a *national curriculum*. If science content were found to be the same states could focus on the business of *how* to teach science to meet the unique needs of students rather than on *what* science to teach. Findings from this study could justify the move to consolidate individual state and local *content* standards and resources to support a *nationwide* content standard, text, curricular materials, and assessments, thereby saving tax-payers and school districts millions of dollars[i]. A positive response to these findings could help to create a tight and cohesive curriculum that focuses on the needs of the individual student, multiple means of teaching known content standards, and teacher training. It would result in wiser use of the dwindling resources now expended at every local and district level in debating specific science standards and textbook adoptions.

It would be remiss to discount the notion that the curriculum is more than a textbook or series of textbooks. The curriculum includes the goals, objectives, day-to-day interactions, ancillary materials, and evaluations. The teacher, the learning environment, and the students themselves also influence the curriculum. However, studies have shown that textbooks are a mainstay in K-12 public education in the United States (McKnight et al., 1987; NCES, Fox, & Snyder, 2005). Teachers depend on textbooks as instructional aids, sources of information, tests, review questions, lab activities, diagrams, homework assignments, and many other features (Yore, 1991; Chiappetta, Fillman, & Sethna, 1991; Shepardson & Abell, 1992;Chiappetta, Sethna, & Fillman, 1993). As observed in Schmidt, McKnight, and Raizen (1997)

> Textbooks are, by default and overwhelming demand, the backbone of the 'micro' organization of classroom activities. They provide the fine detail of curriculum expressed more broadly and less directly supportive of official curriculum documents. Textbooks define the domain of implementable day-to-day curricular possibilities. (p.53)

It has also been documented that the prospect of learning is linked not only to the instructor or method of instruction but also to the content and quality of the textbook (McKnight, 1992; Schmidt et al., 1997; Valverde, Bianchi, Wolfe, Schmidt, & Houang, 2002). Research has shown the classroom text influences teachers' opinions, pedagogy and the subject matter (Ball & Feiman-Nemser, 1988). To go beyond the text requires that the teacher possess sufficient scientific knowledge and concern for innovation to enable the preparation of activities and content not found in the textbook (Chiappetta et al., 1991; Mellado, Blanco, & Ruiz, 1998). Unfortunately, many teachers seem unwilling or unable to make these innovations, compounding their reliance upon textbooks (Garcia-Barros, Marinez-Losada, Vega, & Mondelo, 2001). Therefore, by investigating science textbooks one can draw inferences regarding the content presented to most students within the course of their science studies.

This study focused on 8th and 9th grade general (sometimes called physical) science textbooks. These grades and courses are usually the expansion of earlier scientific learning. They prepare students to branch out into more specific scientific domains and in-depth investigations offered in high school classes such as Physics, Chemistry and various advanced placement courses. For students not interested in further science studies, the 9th grade general or physical science class is still required by most states in the hope of providing students the minimum scientific proficiency. In conducting a thorough content analysis of science textbooks produced over a six decade period it is expected that an unambiguous representation of science content will emerge that can be used as a foundation for further studies. By systematically examining *if* and *how* science content has changed over time educators can fully understand the evolution of past endeavors and more wisely plan for the future.

Statistics Regarding Science Achievement in the US

The National Assessment of Education Progress (NAEP), which evaluates over 15,000 schools and over 300,000 students each review period, has shown no significant changes in 8th grade science scores since 1973. Although, 12th grade science scores remained steady between 1973 and 1996, they showed a significant decrease in 2000 and have remained at that new low for the past five years (NCES, et al., 2003; NCES, Grigg, Lauko, & Brockway, 2006). Perhaps more disturbing than the stability of these low scores is that they indicate students have only a *basic* or minimum understanding of science[ii]. Recent tests are scored on a 300-point scale. Eighth grade students have consistently scored an average of 149 whereas 12th grade students have scored an average between 151 and 146 since 1996. This indicates that once students are in high school they are generally do not advance in their scientific proficiency.

Curriculum materials such as textbooks are but one resource available to the teacher. However, research has shown that textbooks play a significant role in the classroom. Many teachers, especially novices and those teaching outside their content area, rely on the textbook to provide not only their content but pedagogical framework as well (Ball & Feiman-Nemser, 1988; National Educational Goals Panel, 1994). The National Survey on Science and Mathematics Education Trends from 1977 to 2000 shows textbook usage has remained significantly unchanged since 1977. Over this time period more than 92 percent of all 5th through 12th grade science classrooms use commercially published textbooks. Sixty-six percent of these teachers reported completing from 75 to more than 90 percent of the entire text during the course of study (NCES, et al., 2003; NCES, et al., 2005). It is noteworthy that a single textbook may have from 25 to 45 chapters[iii].

Although teachers in 2000 reported that students spent less time completing textbook/workbook problems than in 1993, there was no significant change in the frequency of students doing hands-on/laboratory activities between 1993 and 2000. In fact, 90 percent of all 5th through 12th grade teachers reported using the lecture/discussion format in their most recent lessons (NCES, et al., 2003). Despite the push to teach inquiry science, which advocates hands-on activities over textbooks and lectures, it appears that science textbooks still have the greatest influence over how science content is delivered and what science topics are covered[iv].

Standards

It seems reasonable to suggest that instead of reviewing textbooks for science content, one might investigate state and national standards documents to determine the science content offered in classrooms. Although this may seem logical, there is no conclusive research that adequately substantiates this assumption and in fact there are several studies that indicate textbooks do not adhere to state or national standards

(Posada, 1999; Stern & Ahlgren, 2002; Kesidou & Roseman, 2003; Brito, Rodríguez, & Niaz, 2005).

In the U.S. the state is responsible for overseeing public education. Spurred by national science content standards many states have created their own criteria for content standards. It is these state standards that drive curriculum, "establish criteria for the profession of teaching, and devise accountability schemes for assessing student learning" (Bianchini & Kelly, 2002, p. 381). However, unlike the national science standards, state standards documents are notoriously ambiguous and open to multiple interpretations[v]. Standards are often presented as discrete, isolated statements without an explicit evidentiary base. To date no state standards document contains citations, qualifications to statements made, or a bibliography. Most state standards documents fail to provide substantive information regarding selected topics, highlight multiple meanings, situate the standard within educational research, or provide additional references to facilitate understanding of their intent. They are inadequate as indicators of what science content should be taught in the classroom. Additionally, state standards are a relatively new concept first developed and adopted in the early 1990s, so there are no state standards to apply to content before this time.

Research Questions

This study examined the science content in 8th and 9th grade general/physical science textbooks from 1952 to 2008. The researcher's intention was to document the evolution of science content over time, tracing changes (if any) in content topics or emphasis on topics presented. This study also documents the emergence of new topics over time to establish how science textbooks reflect changes in scientific findings.

The study focuses on the following research questions:

1. What *specific science content* is presented in each of the selected 8th and 9th grade U.S. general science textbooks from the 1950s to the present day?

Rationale: Thelen (1989) maintains that: "the challenge of history is to recover the past and introduce it to the present" (p. 12). Past behavior and experiences are important determinants and clues to conditions in the present. Many prefer to define themselves in terms of where they are going, rather than where they have come from, "therefore our ignorance of the past is not the result of a lack of information, but of indifference. We do not believe that history matters. But history does matter…[it] shapes the way we view the present, and therefore it dictates what answers we offer for existing problems" (Crabtree, 1993, p. 1). By clearly understanding past endeavors we can evaluate their efficacy, determine their value, and arrive at truly fresh approaches to science education for today and the future.

Unlike many of the countries in the international community, the U.S. public school system does not have a national curriculum. Although many educational leaders have distinct ideas about what should be taught there is no nationwide consensus on the appropriate K-12 science content. The majority of countries participating in the Third International Mathematics and Science Study (TIMSS) have national content standards specified by national centers responsible for curriculum policy (Schmidt et al., 2001). These boards specify the science content to be studied and require all schools to follow the mandates prescribed by the board. This process leaves no question as to what specific science content has been taught or what will be taught; one may simply consult the specified standards.

The U.S., however, has a complex decentralized arrangement for schooling and curriculum development as well as a long tradition of shared responsibility in educational decision-making from the local to the national level. Therefore, no mandatory national standards exist, only non-binding recommendations. This has led to endless debates regarding content, generating confusion rather than discussion on the particulars of the relevant subject matter (Schmidt et al., 2005). Shared decision-making has led to multiple, conflicting visions and these multiple visions are commonly supported by nationally developed textbooks and standardized tests. “The all-inclusive characteristic of standards reflects the fact that it is politically safer to include topics than to exclude them especially those over which there is controversy” (Schmidt et al., 2005, p.530). The resulting multiple visions coupled with the U.S. notion of individualism increases the likelihood of ad hoc approaches to science content and raises the question as to what science content has been and is being presented to students in the classroom. This study will provide a definitive answer to this question by performing a content analysis on science textbooks utilized over the past six decades.

2. In what way has the *science content changed* in each of the selected 8th and 9th grade U.S. general science textbooks from the 1950s to the present day?

Rationale: In anticipation of how science content and texts may evolve in the future it is helpful to consider how science content has changed and developed over the past six decades. This question allows us to better place science content within the context of the forces that influence science content. By observing and noting the manner in which changes occur, we can obtain a more complete view of the influences affecting science content. The ability of science education to respond to the needs of the students within time, culture, and location can also be noted.

3. Do 8^{th} and 9^{th} grade U.S. general science textbooks reflect new scientific findings?

Rationale: To answer this final question the entire content list will be reviewed to track occurrences of scientific discoveries and new conceptualizations of how the world functions. Some researchers believe mass media is the major conduit through which scientific discoveries are understood. According to the sociologist Nelkin most people "understand science less through direct experience or past education than through the filter of journalistic language and imagery. The media are their only contact with what is going on in rapidly changing scientific and technical fields, as well as a major source of information about the implications of these changes for their lives" (Nelkin, 1995, p.2). This study then looks at what role (if any) science textbooks play in keeping students abreast of the latest scientific information. Jackson reviewed forty-four secondary-level geography texts from 1900 to 1970 to determine how long ideas persisted even though they had been abandoned at the university level. He used the concept of environmental determinism as an index of change. Jackson found at least a twenty-year gap between the appearance of this scientific concept published in texts at the university level and the same concept found in secondary level texts (Jackson, 1976). This study will record new science content as it appears in the textbook sample. This data will then be used to better illustrate the trends in science content in the 8th and 9th grade texts.

Significance of the Study

To date no research has conducted a comparative study that explicitly looks at the science content provided in general science textbooks over time. There have been many science textbook studies. However, these studies have focused on other textbook dimensions such as the history of science (e.g., Wang, 1998), literacy attainment through science texts (e.g., Chiappetta et al., 1991), instruction strategies (e.g., Kragler, Walker, & Martin, 2005), conceptual change models (e.g., Shiland, 1997), metacognition and comprehension (e.g., Koch, 2001), the use of analogy (e.g., Glynn & Takahashi, 1998; Newton, 2003), the use of illustrations (e.g., Pozzer & Roth, 2003), gender (e.g., Westbury, 1990), multicultural material (e.g., Eide & Heikkinen, 1998), and homosexuality (e.g., Snyder & Broadway, 2004). This study used textbooks as a means to better understand explicit science content offered in U.S. public schools. It is expected to produce results that offer both long and short-term value.

Long-Term Implications of this Study

One of the science standards-based reform processes delineated in the *Practice Process* (Bybee, 1996) mandates that all instructional materials need to be examined to comply with the reform movement. This study attends to a fundamental examination of science textbooks. Providing data to assist researchers in understanding our past educational system, making decisions regarding current science content, and ultimately in developing science curriculum for the future. This analysis will be useful to educators and leaders in science education reform in several ways. Findings of this study will delineate past and current science content and the expected science knowledge levels for 8^{th} and 9^{th} grade science students. With this information educators will be in a better position to assess the value of current science content found in texts. Once educators and researchers have a clear understanding of the science content presented, even more pertinent questions can be addressed. Is this science content relevant for the students of today and adequate preparation for the future? Is the actual science content in these general science textbooks meaningful? Does the science content assist students in facing a complex world where the number of scientific discoveries, innovations, and advances are multiplying at a dizzying pace? It is hoped that the answers found in this study will create a clear starting point from which to view the content of science education and engender further research into developing meaningful and relevant science curricula.

Short-Term Implications of this Study

This research will provide data that could potentially refocus the debate (Ravitch & Brookings Institution. Brown Center on Education Policy, 1995; Ohanian, 1999) regarding the implementation of a *nationwide* science content standard. It may also facilitate a cohesive and cost effective foundation for U.S. science education. A nationwide unified public school standard in science content could provide many advantages such as:

1) Improve achievement by clearly defining expectations,

2) Ensure equal access to information and learning opportunities by providing uniform content goals across the nation and allowing teachers to focus on the unique needs of the child to help each student meet those goals,

3) Provide a means of coordinating content and assessments nationally and a more meaningful dialogue internationally,

4) Provide consumer protection to parents, teachers and students (everyone knows what is expected),

5) Conserve resources of time and money. (Ravitch, Brookings Institution & Brown Center on Education Policy, 1995, p. 27)

Additionally, these findings may assist standards and textbook adoption committees to create documents that discard science topics found to be out-dated or not germane to students' needs and to incorporate topics that are more inclusive of contemporary science knowledge appropriate for students of today and the future. Textbook publishers will be obliged to create textbooks that meet the current content goals. In fact, these findings can assist in selecting and improving all instructional materials and ultimately help teachers in providing instruction on topics that are meaningful and relevant to the student. The experienced teacher will be able to use her advanced skills and unique teaching style to implement science content standards in meeting the educational goals of her class anywhere in the U.S. Likewise, the novice teacher, or one who is teaching outside her area of expertise, would be able to rely upon the standard text to supplement and guide her in presenting the required material and meeting required outcomes.

This study will also provide important information to educators interested in global education and reform. The findings in this study may be used to compare and contrast the content expectations of science texts used in other countries to create curricula and prepare students to share in the global scientific network. As research expands to articulate guidelines for the improvement of all aspects of science instruction, it is hoped that more relevant texts as well as updated approaches to teaching and learning science will be realized.

Delimitations

Assessing the complete worth of a science textbook is a long and complex task requiring the answers to many questions. Is the information accurate? Is the treatment of various groups in society fair and unbiased? Is the reading level appropriate for the students who will be using the material? Is the book written in a clear and comprehensive manner? Do the review questions and other end-of-chapter exercises support the material presented in the narrative? Are pictorial and sidebar materials relevant to the subject matter? These questions and many more have been asked and investigated by a variety of researchers to the benefit of all students. However, this study does not intend to assess the worth of science textbooks. The goal of this study is to examine the science textbooks over time to better understand the science content expectations that the U.S. education system has placed upon the student. The textbook is a means to evaluate which science constructs have been and are today valued as worthwhile topics of learning.

Due to the study parameters there are several intrinsic boundary conditions:

- By focusing the study at two selected grade levels the measurement does not allow the tracing of the full continuum of topic coverage through all the grades in the K-12 system.
- The analysis will determine only if a topic is covered and to what depth, but not the accuracy of the information delivered.

With regard to the accuracy of the content reviewed, Chapter Two presents recent research regarding this issue. It would be beyond the scope of this study to assess the value of the content in each text. In determining what content expectations have been placed upon the student it must be acknowledged that the mere presence of specific content in the textbook does not ensure that the subject matter is accurate or, more importantly, that students learn the desired information.

Limitations

Inherent in this study are several limitations as delineated below:

- The absence of a topic or perspective presents a dilemma since we cannot know if this topic is intended as a goal at some other grade level and therefore not included in the focal grade or if it is simply not included in the K-12 curriculum.
- Along this same vein, the presence of a topic or perspective at the focal grade level only tells us of its presence at that level and not whether this is the grade level at which it was first introduced or whether this is a grade level at which

instruction on this topic is concluded. Further, the grade may be a point of special concentration for the topic at this grade level or only one of several grades in which it is included.

To address these limitations, this study examines 8th and 9th grade general science texts. General science is considered the foundational course offered to all incoming freshman. Usually students must show mastery over the basic general or physical science material before they can discontinue taking science courses or take more advanced science courses. Eighth grade is the culmination of elementary and middle school--the capstone grade before entering high school, which often is considered more demanding and rigorous. The intent is to ameliorate the itemized shortcomings by capturing content from culminating 8th grade expectations and content expectations from introductory foundational general science classes offered in the ninth grade.

Organizations of the Study

The next chapter provides a brief history of science textbooks in the United States and discusses previous studies regarding science textbooks. Chapter three outlines the methodology used in this study. The forth chapter examines the data and displays the results of the content analysis. The fifth and final chapter discusses the results and implications of the data and provides directions for further research.

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[i] Each state spends an average of 0.95% of its budget every four to seven years for textbooks alone[i] (Association of American Publishers, 2005). According to the National Center for Educational Statistics (NCES, National Center for Education Statistics, Cohen, & Johnson, 2004) the total expenditures for each state ranges from 52 billion (California) to a low of 794 million (Nevada). Using these numbers it is safe to estimate the costs of textbooks range between $490 million and $7.5 million for individual states.
[ii] From years 1973 to 1999 the NEAP science test was scored on 500-point scale. On this scale "performers at the 150 level know some general scientific facts of the kind that can be learned from everyday

experiences. Performers at the 200-level are developing some understanding of simple scientific principles, particularly in the life sciences; performers at the 250 level can interpret data from simple tables and make inferences about the outcomes of experimental procedures. A score of 300 implies the ability to evaluate the appropriateness of the design of an experiment and the skill to apply scientific knowledge in interpreting information from text and graphs. These students also exhibit a growing understanding of the principles from the physical sciences. A score of 350 implies the ability to infer relationships and draw conclusions using detailed scientific knowledge from the physical sciences, particularly chemistry". see Appendix A for NAEP science scores for 1973 to 2006. The test was not given in 2004. After 2000 the scoring scale was converted to a 300-point scale where 130 to 170 indicated a basic understanding of science concepts, 170 to 205 indicated a proficient understanding of science concepts and above 205 indicated an advanced understanding of science concepts.

[iii] There are approximately 36 weeks in an average school year.

[iv] Interestingly, for all students from the 5^{th} to 12^{th} grades, science teachers reported a significantly higher frequency of hands-on activities in 1977 than science teachers from 1993 to 2000 (2000 National Survey of Science and Mathematics, p. 56).

[v] A case in point is the standard (7.a) under the Investigation and Experimentation strand of Grade 6 of the California standards document. This standard requires sixth grade students to "develop a hypothesis" (California State Board of Education, 2000, p.21). However, the document does not mention the multiple meaning of this term nor does it specify the context in which hypotheses might be appropriately posed. More specifically, according to McComas (1998), a hypothesis can be defined in multiple ways: as a speculative law, a tentative theory and/or a predication. Equally important, is the fact that many scientists and science educators consider development of hypotheses irrelevant to the scientific investigations they conduct (see AAAS, 1998; McComas, 1998; National Academy of Sciences, 1998).

CHAPTER TWO – LITERATURE REVIEW

Introduction

This chapter provides a brief discussion on how textbooks influenced public education and examines the social, political, and commercial interests that influenced science content selection. Potential trends found in data acquired later in this study may be recognized and better explained by identifying these influences and cultural shifts in ideology. Several significant content analysis studies are presented to explicate the obvious limitations inherent in the science texts and the questionable, if not erroneous, science perpetuated by out-dated and fragmented contributions to published texts over the past fifty years. Finally, an examination of 24 published studies is presented to underscore the relevance of and the difficulties encountered in content analysis research.

Historical Overview of Education & Science Textbooks in the U.S.

1600 – 1920 - The Textbook and its Influence on Public Education

The history of schooling as an institution in the western tradition as an institution is closely linked to the history of printing and the capacity to mechanically reproduce text. "With the invention of the printed book the tasks of thought could be separated from the immediate problem of preserving tradition" (Westbury, 1990, p.4). Freed from the constraints of purely oral instruction and memorization, new teaching agendas could be created using texts as a basic resource. This potential was first realized in the early sixteenth century where writers such as John Amos Comenius (1592-1670) invented textbooks detailing a systematic curriculum. These texts are much like modern textbooks that use pictures and meticulously developed layouts to support thoroughly developed vocabulary-controlled text. Comenius wrote the first text for elementary Latin, *Orbis sensualium pictus* (*The Visible World in Pictures*, 1658), which remained in print for more than 200 years as a *basal* text. The format of this text is still used today in many disciplines.

While similar in format to modern textbooks these early texts differed in their *use* and thus differed in *meaning* and *content*. Prior to the nineteenth century teachers worked with individuals or small groups with little or no formal structure. Each school would have a small collection of texts often brought by the students and teachers themselves. As Perkins notes (in Westbury, 1990) "at the turn of the nineteenth century one student in a school might work on Noah Webster's Spelling Book (1783), while other students might use other spellers, such as Dilworth's (published first in England in 1740), Fleming's (English, 1754) or Perry's (Scottish, 1777). Each such text provided its own method of instruction and curriculum; each student learned what was in his or her text and teachers heard them recite their exercises individually or in small groups" (p.5).

During this period curriculum and educational content decisions were often made by the aristocracy and higher education was the domain of wealthy white males. However, the choices offered were being questioned for their usefulness and pertinence to the life of the common man. Spencer (1949), a strong advocate for science education for all students, including girls, writes “among mental as among bodily acquisitions the ornamental comes before the useful…if we inquire what is the real motive for giving boys a classical education we find it to be simply conformity to public opinion. Men dress their children’s minds as they do their bodies, in the prevailing fashion” (p.22-23). This social component of education continues to be a powerful influence on what and how science topics are presented in classrooms not only in the U.S. but globally. As can be seen in the creationism phenomenon in the U.S. (Bambach, 1983; Grobman & Grobman, 1989; Scott, 1996), Lysenkoism in the former Soviet Union (Joravsky, 1970; Soyfer, 1989), the biased view of evolutionary issues in the People’s Republic of China (Swetz, 1986) and Brazil (Bizzo, 1994), and the influence of the Catholic Church over the national science curricula in Spain (Barbera, Zanon, & Francisco, 1999), religious and social groups continue to exert their influence over science content. Of course, this influence is not surprising, as the very nature of education must inherently be supported and shaped by the mores and values of the society it serves.

In the eighteenth and nineteenth centuries it was the emerging social imperative that a national educational system replace the formerly eclectic style of instruction with more systematic methods. Textbooks were explicitly written for use across school districts. Textbooks became “the dominant influences on their subjects and the treatment of subject matters, and the approaches to teaching embedded in such text came to define the subjects of the new school system, methods of instruction and sometimes implicitly but often explicitly, the standards that the schools were expected to achieve” (Westbury, 1990, p.5). While these changes were significant, the decisive influence in the emergence of the modern school in the U.S. occurred in the middle of the nineteenth century. At that time the state government made the commitment to replace individualized and small group instruction with a uniform approach to elementary education appropriate for large numbers of students.

Mass education required new methods of education. “The key social invention that lay behind this new kind of school was the discovery that a ‘trained’ but often poorly trained adult could teach large numbers of students simultaneously in classrooms” (Westbury, 1990, p.6). However, to be effective there needed to be a common structure to all classrooms. The center of attention became the teacher, and the grade structure was created to define the range of achievement to which each teacher was responsible. Methods of teaching many students simultaneously spread and became the pattern for the modern educational system. The emergence of such mass educational systems gave rise to the standardized graded series of readers and classroom resources (Westbury, 1990, p.6). W.B. Smith, the publisher of the *McGuffey's Reader* and *Ray's Arithmetic* realized that while “each community could create the kinds of schools it wanted…what each community wanted was, it seemed, less anarchy and more uniformity” (Perkinson, 1985, p. x).

1920-1940 - The Progressive Movement – the First Round of Reforms

By 1920 most citizens took for granted that the textbooks and curriculum offered in New Hampshire would be the same as (or at least quite similar to) the ones used in California. This accomplishment is one worth noting especially considering the lack of public services in other areas, such as public health care. By the 1930's textbooks had become ubiquitous in U.S. schools and their presence had long been taken for granted.

However, around the early 1930s a new Progressive movement emerged. Proponents of this movement believed that teachers relied too heavily on textbooks and students simply memorized facts and recited them back to the teacher. The purpose of the textbook was questioned. It was believed that schools should use a variety of sources to teach students and not rely exclusively on textbooks. Advocates of the movement supported careful planning of sequential development within the same textbook and from the textbook of one year to that of the next; textbooks should include new materials such as those relating to the personal-social problems of students…textbooks should take into account the wide individual differences among learners" (Tyler, 1941, p.335).

Proponents of the Progressive movement urged teachers to place less emphasis on the textbook and make use of inquiry projects, hands-on experiences, and teacher-student interactions. The movement also emphasized questioning and critical thinking skill development. However, "close observers of classroom practice…noticed that most teachers continued to teach from the textbook, much as they and their predecessors always had" (Foshay, 1990, p.26).

There are many suggestions as to why the Progressive movement ultimately failed. Some believed that the demands of WWII took attention away from educational reform and thus the Progressive movement was not sustained politically or financially. Foshay offers the notion that the textbooks were viewed as containers of *uncontroverted* truth, almost as some view the bible. "Teachers should never offer anything controversial to their students because they, like the texts, were supposed to be perfectly virtuous, and like the Prophets deal with unalterable, permanent truth. This perspective explains why the Progressive movement failed to survive. It attempted to carry into the lower schools the questioning tradition of the nineteenth-century university, which to this day worries our cultural, political, and intellectual conservatives" (Foshay, 1990, p.34). This supposition is an interesting reflection of commentaries found today in educational research where institutional hierarchies are questioned and often held responsible for the persistence of power differentials within the classroom and society in general (e.g., (Cunningham & Helms, 1998; Barton & Yang, 2000; Barton, 2001).

1950-1970 - The Influence of Scientists and Scholars on Public School Science Content

Following World War II and the launch of the Russian satellite *Sputnik* new attempts at curriculum reform were under way. The cold war enkindled the competition for technological and scientific dominance. Spurred by public critiques outside the ranks of professional educators, such as Rudolph Flesch (*Why Johnny Can't Read*), Arthur Bestor (*Educational Wasteland*), and Hyman Rickover (*Education and Freedom*), the U.S. educational system underwent a significant transformation. Texts were needed to symbolize and support the needs of this new mission. The Physical Science Study Committee (PSSC) initiated by the National Science Foundation (NSF) and Jerrold Zacharias, a physicist from MIT, became dominating forces in curriculum development. *PSSC Physics*, one of the several texts produced by the committee, was used by millions of science students throughout the world. These textbooks were developed outside both the schools and the publishing industry through government grants (Elliott, 1990, p.46). In 1958 the National Defense Education Act (NDEA) alone allocated over $100 million for science education over a three year period and another $600 million to support education and educational studies from 1961 to 1975 (U.S. Department of Education, 1958). More than 75 new projects were initiated, such as the Chemical Bond Approach (CBA), Biological Sciences Curriculum Study, (BSCS), Chemical Education Materials Study (CHEM-Study) and the Earth Science Curriculum Project (ESCP). The new curriculum replaced teacher lectures and discussions and student recitation with inquiry and discovery, laboratory experiences, multimedia packages, and applied science activities.

> In these projects, participating scholars initially intended to update content of elementary and secondary science, but soon found that explicit ways of controlling and manipulating information had to be taught if any integrity of content was to be achieved. That is, in order for children to understand the knowledge in any subject area, it was found that they had also to be introduced to what Bruner called the 'structure' of that subject area, or the ways in which things are related within it. The science curriculum products had modernized content, which was up-dated and selected to permit in-depth study, a rich variety of multimedia materials with emphasis on science process – on 'doing' science through 'hands-on' learning activities – and on the use of unifying themes (Elliott & Woodward, 1990, p.46).[6]

Because these projects were strongly influenced by scholars from individual disciplines rather than elementary or secondary education, they resulted in the proliferation of individual subjects, including new areas not previously taught, such as astronomy and anthropology (Goodlad, 1966, p.46).

Many projects emphasized the importance of teacher guides and teacher training for both pre-service and in-service teachers. Some, but by no means all, of the new courses were widely used for a short while but failed to take root in the schools. Historians offer several reasons for the decline and eventual termination of these projects. Elliot points out that when textbooks were prepared by commercial publishers only the textbooks were printed and the training aspects neglected, "this neglect of teacher training was perhaps the weakest link in this whole curriculum reform movement and the key cause of its demise" (Elliott, 1990, p.47). Longstreet saw the problem as an inability of the school system as a whole to change its emphasis from teachers and textbooks as the "unquestioned distributors of truth; they were, instead to be questioned, tested, and doubted" (Goodlad & Shane, 1973, p.252). In practice the materials were distributed and used in the classroom but without teachers modifying their traditional ways of teaching. By the late 1970s these "new processes and perspectives [were] dropped by the wayside" (Goodlad & Shane, 1973, p.253). An overlapping influence during the 1960s and 70s focused on issues of equity and fair distribution of educational instruction with little to no attention paid to changing science content.

1980-2006 - The Influence of Corporate America on Public School Science Content

The pedagogy or instructional method rather than the content of textbooks was the main concern of educators in the late 70s and 80s. Most textbook changes during this time were "more evolutionary than revolutionary" (Elliott, 1990, p.48). A Department of Education had been created in 1867 to collect and distribute information regarding the nation's schools. In 1980, Congress established the Department of Education as a cabinet level agency, "to promote student achievement and preparation for global competitiveness by fostering educational excellence and ensuring equal access"[7]. The school reform movement of the early 1980s was initiated by the U.S. Department of Education based on the report *A Nation at Risk: The Imperative for Educational Reform* written by the National Commission on Excellence in Education. Triggered by the decline of the U.S. economy the "media, educational groups, business, and the public sought to restore America's allegedly failing schools and, in turn, improve the nation's economic well-being" (Berube, 1994, p.94). The document clearly sees the need for educational reform as a restorative for the failing U.S. economy:

> Our Nation is at risk. Our once unchallenged preeminence in commerce, industry, science, and technological innovation is being overtaken by competitors throughout the world… The risk is not only that the Japanese make automobiles more efficiently than Americans and have government subsidies for development and export. It is not just that the South Koreans recently built the world's most efficient steel mill, or that American machine tools, once the pride of the world, are being displaced by German products. It is also that these developments signify a redistribution of trained capability throughout the globe. Knowledge, learning, information, and skilled intelligence are the new raw materials of international commerce and are today spreading throughout the world as vigorously as miracle drugs, synthetic fertilizers, and blue jeans did earlier. If only to keep and improve on the slim competitive edge we still retain in world markets, we must dedicate

> ourselves to the reform of our educational system for the benefit of all--old and young alike, affluent and poor, majority and minority. Learning is the indispensable investment required for success in the 'information age' we are entering (National Commission on Excellence in Education, 1983, p.1-3).

A Nation at Risk further exacerbated public fears regarding the nation's economic stability. "For the public it seemed easier to focus on educational reform than business reform" (Berube, 1994, p.94). This clarion call can still be heard today in such publications as *Rising above the Gathering Storm* (COSEPUP, 2007). The Business Higher Education Forum (2004) declares "Failure to succeed in this commitment [to deliver a high-quality mathematics and science education] guarantees America's immediate and accelerated decline in economic leadership and global influence" (p.5). A small minority challenged these assumptions[8] but those voices were lost in the rush to accept the endowments that big businesses were now offering. Business did not involve itself in education during the social reform movement but seemed compelled to intervene in school reform when motivated by economic considerations. Corporations became involved in school reform and educational policy in a variety of ways. They provided monetary support in the form of grants, technology (computer labs), and laboratory equipment and materials. Partnerships developed between local business and school districts. Corporate and school collaborations rose from 42,300 to 124,800 between 1984 and 1988 (Berube, 1994). In 1982 the *Boston compact* was initiated where businesses pledged to offer 3,000 students summer jobs and local colleges awarded 2.5 million dollars in scholarships (Berube, 1994). Interestingly enough, even though Boston school performance did not improve (as evidenced by the absence of improvement in standardized tests and dropout rates) this collaboration became a national model and spurred the creation of the National Alliance for Business (NAB) leading to additional compacts nationwide. In 1991 NAB reported limited success. Two cities noted some school improvement as measured by increased school attendance and higher scores on standardized tests (National Alliance for Business, 1991; DeBoer, 1991; Berube, 1994). Consequently, policy makers felt this indicated business needed to play a more direct role in educational reform and local schools. Businesses in general proposed greater accountability within schools to improve outcomes.

In 1995 the Business Roundtable, composed of 200 of the most influential chief executive officers (CEOs) in the nation, proposed nine essential components to improve schools; the first four being state standards, state tests, sanctions and the transformation of teacher education programs (Business Roundtable, 1995). Local industry-education councils were formed to allow CEOs and other business leaders greater access and involvement in educational policies. Alternative certification for school administrators was ratified in the America 2000 Reform Act in 1991. This allowed business executives with no prior experience in education to manage schools. CEOs of major corporations regularly testified on federal education legislation (DeBoer, 1991; Celis, 1993; Berube, 1994) and served on national and state government policy panels and forums. David Kearns, former chairman and CEO of Xerox Corporation, was appointed deputy U.S. secretary of education in 1991. In one statement Kerns (2005) declared "Americans have come to realize that their own quality of life…depends on the ability of our schools to prepare our children for the global workforce and economy, and that our 'human capital' is our greatest strategic resource" (p. 1)[9].

Under the same AMERICA 2000 reform document business leaders were urged to "establish and muster the private resources for – the New American Schools Development Corporation [NASDC]" (U.S. Department of Education, 1991, p.15; Berube, 1994). NASDC raised nearly $200 million to research new and innovative models for breaking the mold of existent public schooling and in turn "help communities to create schools that will reach the national education goals" (U.S. Department of Education, 1991, p.15; Berube, 1994, p.97). Inevitably corporate involvement led to experiments in running schools as *for-profit* institutions, the use of voucher systems, and the development of the *No Child Left Behind* (NCLB) 2001 legislation. This understandably mirrors corporate interest in profit, choice, and the bottom line. Sandy Kress, a Dallas based lawyer, with no professional educational background, served as senior advisor on Education in 2000 and was influential in the passage of this 2001 Act (Emery, 2002). Today, NCLB promotes education by mandating standardized tests, encouraging standardized and measurable outcomes for each grade, and enforcing sanctions for non-performance, as well as providing parents flexibility in school choice.

The influence of business and the concept of accountability have had a direct impact on science education. In 1985, with grants from the Ford and Carnegie foundations the American Association for the Advancement of Science (AAAS) developed Project 2061, a long-term reform directed at K-12 science education. In 1989 when the AAAS created the National Council on Science and Technology (NCST) to oversee Project 2061, William Baker, one-time president and chairman of the board for AT&T and co-author of *A Nation at Risk*, was hired as co-chairman (Raizen & Britton, 1997). Project 2061 began its reform efforts by enumerating learning goals for all children in all grades and subjects. *Science for All Americans*, the first publication produced by Project 2061 recommends "what all students should know and be able to do in science, mathematics and technology by the time they graduate from high school" (American Association for the Advancement of Science, 1993, p. xi). Four years later they published *Benchmarks for Science Literacy*. This 400-page document lists 830 goal statements that specify "…how students should progress toward scientific literacy, recommending what they should know and be able to do by the time they reach certain grade levels" (American Association for the Advancement of Science, 1993, p. xi). These two documents greatly influenced the direction of science education since the 1990s. They were also important tools in the development of *U.S. National Science Standards* (NSS) document. Today state and local school districts look to NSS as a framework in which to create their own standards.

Critics note the inherent conflict of interest in corporate involvement in education by pointing to the tax breaks and subsidies businesses receive for partnering with schools often undermine and weaken the tax base used for supporting public schooling. They also note that while working to improve educational outcomes to produce more skilled workers at home U.S. businesses are hiring skilled workers outside the country and paying them a fraction of what they would pay U.S. employees. More relevant to this study, however, is the increased influence big business has exerted upon the development and distribution of educational materials. A case in point is that the same Sandy Kress who acted as senior advisor on education, five months later became a paid adviser, consultant, and lobbyist for Pearson Education (a worldwide company that publishes textbooks and produces high-stakes test programs), Educational Testing Services, Kaplan

Inc. (provider of test prep courses) and HOSTS Learning (on-line publisher of learning tools) (Pyle, 2005). The top four players in the textbook market are also the top players in the testing market "as the focus on testing intensifies, the test prep materials these companies offer are becoming the standard curriculum" (Pyle, 2005).

Textbook Publishers' Influence over Science Content and Pedagogy

Unlike other countries, the U.S. does not impose a national system of control for curriculum published in science textbooks. This leaves the burden and responsibility to national publishers of not only providing textbooks but also creating the curriculum. "Even in states that have aggressive regulation of textbooks, publishers propose while regulators dispose" (Westbury, 1990, p.8). States have developed guidelines that specify content and curriculum. However, the state's control is limited when dealing with publishers who develop books for an unregulated national market.

> Thus while states can direct some of what publishers do, they do not have an effective capability to control the work of their own schools (the real market place which determines the character of the curriculum) and they have no capability to direct the national market place or the national curriculum (Perkinson, 1985, p. xiv-xv).

This explains publishers' powerful incentives to produce texts that are inclusive of many topics and their attempts to be all things for all audiences. "No one punishes a publisher for having too much material in a textbook", says Stephen Driesler, executive director of the Association of American Publishers' school division. "On the other hand, if a textbook fails to cover the lists of topics, names, pedagogical exercises, ideas, facts, keywords, sanitized language, and curriculum standards from California or Texas, it may get rejected in the adoption process" (Finn & Ravitch, 2004). U.S. textbooks are the thickest textbooks to be found in the world – however shallow they may be in actual content coverage (Schmidt et al., 2005). Not only are the textbooks thicker, there is also a host of multi-media instructional materials such as videos, internet links, web-quests, and computerized activities, labs, and games that are offered by educational publishers. Students are provided with an abundance of instructional materials yet nowhere can we find an accurate, systematic, and comprehensive report of what content these textbooks and materials provide.

Textbook Selection

After the Civil War railroads unified the nation. With this increased ability to communicate and distribute goods a small number of the larger publishing houses quickly dominated the national market (Westbury, 1990). Due to this perceived oligopoly, publishers were blamed for the rising costs of books and demands were made to regulate prices. Citizens pushed for government subsidies to assist schools in providing textbooks for all students. In 1882 Massachusetts became the first state to require local school districts to provide free textbooks to all students. With this legislation the institution of textbook *adoption and approval* was conceived. This policy "created a need for a structure of regulation of the pricing and physical quality of textbooks, *but not of the curriculum which those textbooks define*[10], which has survived to the present" (Perkinson, 1985, p. xiv-xv). Since then twenty-two states have enacted laws that put in place a centralized textbook adoption agency - the remaining 28 states leave textbook decisions to local school districts. These agencies, found mainly in the Southern and Western states, develop lists of approved textbooks from which local districts can select. The incentive to do so is provided by granting reimbursements for district textbook expenditures only if the books used are drawn from the state approved list. Those who favor state adoption boards believe that it creates a common statewide curriculum, controls the costs, and ensures that textbooks are of the highest quality.

Those not in favor of state adoption boards contend that the uniformity of textbooks will not ensure that all students receive the same education and claim that there is no evidence that the use of state adoption committees results in lower cost books or higher quality textbooks (Tulley, 1985). States with local adoption committees also worry that those states having the largest number of students and consume the largest number of books unduly influence textbook selections offered to the rest of the nation. According to many scholars, (e.g. Ravitch, 1995 and Apple, 1998) political and ideological controversies over content in the states of Texas, California, and Florida have a real impact on what and whose knowledge is not only available but required learning for all students throughout the nation.

Reading Comprehension in K-12 Textbooks

Donald Hays from Cornell University conducted a study that sampled over 800 textbooks used in the U.S. schools between 1860 and 1992. Hayes found that word choices in all reading materials skewed to some degree either toward or away from the most common words used in the English language. He and his colleagues then devised a statistical measure that placed texts along a log-normal distribution ranging from “an undemanding set of texts (mothers talking with their 3-year-old children), a text which closely fits the theoretical model (a sample from the *New York Times*), and the pattern of word choice in articles taken from the journal *Nature*” (Hayes, Wolfer, & Wolfe, Michael F., 1996, p.494). These measures are called LEX scores. A score of 0.0 is the LEX value of text that fits the log-normal perfectly (the average Newspaper text). LEX scores that are positive (+) are more difficult than newspapers and use more uncommon English words. Text or language with a negative (-) score is less difficult than newspapers tending to use small words, short sentences and very common English words. The larger the numeric score the harder and more complex the language (For example, the journal *Nature* has a LEX score of +58, a dairy farmer talking to his cows LEX=-56). The LEX scoring has proven to be stable across centuries. Samples from British and U.S. newspapers were examined and were found to “have grown more difficult at the rate of 1 LEX/century since 1665” (Hayes et al., 1996, p.495).

After examining over 800 textbooks Hayes and his colleagues found: 1) the most difficult readers were generally published before 1918, 2) after WW I the mean LEX levels for all grades were generally simplified, 3) after WW II the mean level of readers for all but third grade became even simpler, 4) 1990’s mean sixth, seventh and eighth grade readers are simpler than fifth grade readers were before WW II, 5) when early readers in a series are simplified by a publisher so too (generally) are the readers for later grades (Hayes et al., 1996, p.495). It is interesting to note that textbook publishers in Great Britain did not simplify their readers after WW II. The justifications given at the time for simplifying American texts were to increase student accessibility and raise reading level success (J. S. Chall, 1977).

From 1963-1992 the mean LEX levels for first and second grade were raised due to media attention that alerted the public to the drastic over-simplification (LEX levels were between -53 and -65) of early texts. However, "publishers made the fourth, fifth, sixth, seventh and eighth grade text even easier – to the point where these are now at their lowest level in American history" (Hayes et al., 1996, p.500)[11].

The study investigated texts for grades 9-12 as well. Though this analysis is not comparable in scale to their work with the lower grades, it does present a test case to consider. In this second study the researchers examined all required textbooks used in English and science classes at a local high school located in Ithaca, New York. Researchers found the English texts used in the high school averaged around a LEX of -19, independent of the type of class (AP, honors, regular or remedial) or grade level (9th - 12th). However, researchers found large differences in LEX scores between English and science texts. All science books were at a higher reading level than the average book required in honors senior English. The ninth grade Earth science book was the simplest science text (LEX=-16), and other texts for biology, chemistry and physics were 20 or more LEX points higher than the English books for the same grade. The only high school texts with a positive LEX scores were the AP science books (chemistry, biology and physics) with scores as high as +9.9 (Hayes et al., 1996, p.501). This research identifies one of the core difficulties faced in science education. The inability of students to understand science may be in large part due to their inexperience with more advanced English reading levels.

In response to these criticisms current textbook publishers are creating textbooks with prose that is more fragmented. Sentences are chopped or cropped in order to add pictures of people and places as requested by specific state agencies (Trowbridge & Bybee, 1996). Often when publishers shorten sentences they choose to leave out qualifying or connective words (e.g. like, therefore, only, and but) that act to clarify meaning and the relationship between events and concepts (Ravitch, 2003). Precision is also often lost in an attempt to make science texts more readable. Smaller words replace larger words that have a clear and precise meaning such as when the word "esophagus becomes food tube and protoplasm becomes stuff" (Sadker & Sadker, 2000, p.248). This same problem is further exacerbated for the five million students who have only limited English speaking and reading skills (Hawkins, 2004).

Yet another aspect of this same issue lies in the ability of school texts to develop a child's knowledge base. Early schooling years are the primary source for expanding academic knowledge that is not built-in but must be acquired. Much of the academic knowledge is domain specific. According to Damasheck, domains are conceptual clusters (such as sailing, classical music, and biology) that are differentiated from one another by domain-specific lexicons (Damashek, 1995). When a sailor calls out *hard alee* those with experience understand what is expected and move to action, those without prior experience will have an empty sailing lexicon domain with no knowledge or understanding of referent concepts or relationships. This failure to recognize domain specific words is detrimental to learning. Additionally, research has shown that prior knowledge "can determine the ease with which learners can perceive and interpret visual representations in working memory" (Cook, 2006, p.1073). In a study of 290 students, Carmichael & Hayes (2001) examined how children's prior domain knowledge influenced concept acquisition and how exposure to novel exemplars caused children to revise their understanding of concepts. They found that in all cases across age and content domain prior knowledge independently improved children's conceptual understanding (Carmichael & Hayes, 2001).

In simplifying K-12 general textbooks the depth and breath of a child's knowledge base is minimized and predictably this results in minimizing the ability to learn the general concepts and vocabulary found in science texts. Simplified texts may produce a cumulative deficit in students' advanced verbal skills and general knowledge base that are a requirement to succeed in middle and high school science.

Errors in Science Texts

Perhaps even more egregious than the over-simplified writing style is the actual number of errors, fallacies, and myths perpetuated in K-12 science books. Since its inception in 1953, *The Physics Teacher* has published lists of errors found in a variety of science textbooks. This effort spearheaded by Mario Iona, who acted as a tireless watchdog, felt it imperative that textbook errors be eradicated so that students could learn meaningful science. It was his belief that student's misconceptions or " 'alternate conceptions' as they are sometimes called, seem to be due to the teaching and teaching materials that the students have endured" (Iona, 1987, p. 300) rather than some inherent natural or environmentally induced mental patterns. Iona (1987) goes on to say that,

> While it is not possible to monitor what goes on in every classroom, one can look at the textbooks that are being used. If the books present the

material incorrectly, I think it is unlikely that the classroom teaching is much better. Otherwise, one would expect that the teachers would complain and insist on better materials (p. 300).

One recent study regarding textbook accuracy was published in 2001 by John Hubisz[12]. In a two-year period Hubisz and his colleagues reviewed more than 32 middle school (grades 7, 8, 9) physical science textbooks published from 1991 to 2000. Each book was reviewed by at least two professionals (a total of 29 professionals created the review cohort) with the mandate to "consider scientific accuracy, adherence to an accurate portrayal of the scientific approach, and the appropriateness and pedagogic effectiveness of the material presented for the particular grade level" (Hubisz, 2001, p.304). They also noted the readability and attractiveness of the book and illustrations, and reviewed any ancillary materials (such as laboratory activities, suggested home activities, exercises to test understanding and resource suggestions) that were offered with the textbook.

This study found that "not one of the books we reviewed reached a level that we could call 'scientifically accurate' as far as the physical science contained therein. The sheer number of errors precludes such a designation" (Hubisz, 2001, p.306). The errors cited did not include typographical or grammatical mistakes (though numerous instances were found) rather; many were obvious scientific errors that could be easily corrected and others were subtle inaccuracies that would be difficult to ameliorate. These subtle errors included "misuse of technical words or phrases, the promulgation of ideas not validated by scientists, and the promotion of 'politically correct' views" (Hubisz, 2001, p.306). With regard to the accurate portrayal of the scientific approach, researchers found that “no text emphasized and reminded the reader that the scientific approach was something to be learned and applied, perhaps even outside the science classroom” (Hubisz, 2001, p.306). Many of the activities provided no clear understanding as to why the activity was to be done and follow-up questions tended to be trivial rather than questions that promoted further thinking and consideration of the concept at hand. Finally, the researchers determined that the appropriateness and pedagogic effectiveness of the material was also sadly lacking. “The net result is that students come away memorizing a great deal of material that they regurgitate on tests that emphasize recall and think that they know science” (Hubisz, 2001, p.306). An instance of this to which many teachers can relate, is the fact that in the drawings of the atomic model found in many science textbooks, the nucleus is drawn large and the electrons very small; yet nowhere is it noted that these drawings represent the mass and not the volume of an atom. Because of such illustrations without appropriate explanations students are often surprised to learn that nuclei are indeed very small.

In an effort to effect some change in the quality of the texts reviewed, the researchers in this study attempted to contact the authors. However, they found that the notion of ‘author’ was a foreign concept when linked to modern K-12 science textbooks. Researchers found that:

> None would claim to be an ‘author’ and some did not even know that their names had been so listed. Instead of authors, there is a collection of people who ‘checked’ parts or aspects of the text. Without a clear-cut author or pair of authors to ‘define’ the text or give it direction, the text fails miserably. Committees produce mush and it is very difficult to find

> anyone with the authority to make corrections. Instead of talking with authors, we dealt with 'editors', and to our concerns about inaccuracies got such responses as, 'Well, we have to make the science simple', 'We don't think that your qualifications are good enough', or 'Our experts disagree with you' (Hubisz, 2001, p.305).

When communication failed with the editors the researchers offered their support to the textbook publishers directly. They wrote letters in hopes of creating an avenue of communication to assist in eradicating errors and improving the quality of science texts; sadly no publisher responded to their offers.

A 2005 study conducted under the auspices of Project 2061 reviewed nine middle school science textbooks. They found that none of the nine texts rated a satisfactory on all criteria; in fact, most texts reviewed did not receive even a satisfactory overall rating. The study assessed curriculum materials to determine if the items met the following requirements: "their content primarily focuses on a coherent set of important age-appropriate student learning goals; their instructional design effectively supports the attainment of the specified student learning goals; and the teacher's guides supports teachers in helping students attain these goals" (Kesidou & Roseman, 2002, p.535).

Nine complete science programs were selected for evaluation based upon usage identified by the *1998 Education Market Research Report*. Three topic areas were selected from the two major sets of nationally recommended learning standards, *Benchmarks for Science Literacy* (AAAS, 1993) and the *National Science Education Standards* (NRC, 1996). The study focused on key concepts outlined in the standards that most middle school programs should cover. These concepts were: kinetic molecular theory, flow of matter, and energy in ecosystems and processes that shape the earth.

The reviewers in the study consisted of two member teams; one member - an experienced classroom teacher and the other member - a university science faculty member experienced in research and science learning and teaching. Each science program was evaluated by at least two teams and no team evaluated all nine programs. Before analyzing the materials all researchers participated in seven days of training to clarify and practice the procedures to be used in the review process. During the review process each team scored the materials using the same instructional criteria and was required to provide specific evidence from the materials to justify each ratings. After the analysis was complete reports from each independent team were compared and differences reconciled by the two teams through discussion using exemplars from their own data. Inter-rater reconciliation occurred 97% of the time in the area of kinetic theory, 100% in the area of ecosystems and 93% in the area of earth processes (Kesidou & Roseman, 2002, p.526-527).

The results concluded that, “eight of the nine programs reviewed did not differ greatly in their inclusion of the specific ideas. Each program addressed all (or nearly all) key ideas that served as a basis for the analysis. Although most key ideas were present in the programs, they were often buried between detailed, conceptually difficult, or even unrelated ideas, making it difficult for students to focus on the main ideas” (Kesidou & Roseman, 2002, p.527). Nineteen criteria were established to determine the extent of the instructional support offered by the design of each science program and the instructional material intended to help teachers guide students. “None of the programs received a satisfactory mean instructional rating (at least 2.0 points of a possible 3.0)" (Kesidou & Roseman, 2002, p.527) in each of the three topic areas. The highest score achieved by any science program for overall instructional support was a 1.42 (where 1.5 is considered a fair rating). The findings revealed that in the programs reviewed "instructional design does not support the attainment of key ideas, [and] support to teachers in helping students attain the key ideas is minimal" (Kesidou & Roseman, 2002, p.538).

Findings from this research are consistent with previous critiques of science programs which indicate an over-abundance of topics covered at a superficial level rather than few topics thoroughly investigated (Schmidt et al., 1997; Tyson-Berstein, 1988), materials focused on technical vocabulary and rote facts (Anderson & Roth, 1989), and content that does not address students' prior knowledge (Ciborowski, 1988; Eichinger & Roth, 1991).

These studies as well as many others (e.g. Pattis, 1988; Storey, 1989; Sanger & Greenbowe, 1999; Hurd, 2002), seem to be an affirmation of the thoughts of Mario Iona when he stated, "if the misconceptions of textbook authors are due to what they have learned, it seems safe to conclude that students studying from such texts will also learn misconceptions" (Iona, 1987, p. 300).

Content Analysis Studies

Communication is the basis of all human interaction. Kuhn asserts, "Communication is at the heart of civilization" (Kuhn, 1996, p. 151). As a consequence communication in all its forms has been studied from a variety of perspectives and disciplines. "Content analysis is a multipurpose research method developed specifically for investigating any problem in which the content of communication serves as the basis of inference" (Holsti, 1969, p.2). Despite the diversity of methods and definitions used to conduct content analysis, it is understood that the study must be objective, systematic, and generalizable. Objectivity implies that decisions made by the researcher are guided by an explicit set of rules that minimize (though never completely eliminate) the subjective predisposition of the researcher. Systematic implies that the inclusion or exclusion of content categories is done according to consistently applied rules, and generalizability requires that the findings have theoretical relevance. Purely descriptive information about content is of little value if it is unrelated to other attributes or foundational premises. To explore how these requirements are satisfied a summary of 24 content analysis studies is presented.

Summary of Content Analysis Research in the Past 15 years

Table 2.1 displays an overview of 24 content analysis studies conducted from 1995 to the present day. The studies were obtained through a search of the *ERIC* and *Wiley Interscience* databases and represent the latest studies published in respected research journals. These studies demonstrate a variety of approaches to content analysis. Table 2.1 presents the research purpose, data sources, instruments, reliability/validity techniques, and research results of each of the 24 content analysis studies.

Table 2.1 Content analysis studies published over the last 12 years.

Study	Study Purpose	Data Source/Instruments	Reliability of Protocol & Coding	Findings
Mayer, Sims & Tajika (1995)	Compare lessons regarding addition and subtraction of signed whole numbers between Japanese and U.S. mathematics texts	*3 Japanese and 4 U.S. elementary math textbooks *Quantitative - looking at frequencies, used partial text to analyze Illustrations & text *Analysis - 4 part inventory - examined exercises, irrelevant illustrations, relevant illustrations, explanations	*No reliability coefficient reported conflicts resolved by discussion/consensus *2 raters *Validity: Framework constructed by researcher (self-constructed). No discussion on validity of instrument.	*Japanese text devoted 81% of space to explaining solution procedure for worked-out examples compared to 36% in U.S. texts *U.S. text devoted more space to unsolved exercises (45%) and irrelevant illustrations (19%) than Japanese books (19% & 0% respectively) *Overall results consistent with classroom observations showing that Japanese math instruction emphasizes the process of problem solving more effectively than the U.S.
Moody (1996)	Ascertain how the topic of evolution functions in the overall structure of secondary biology textbooks	*8 purposefully chosen secondary biology texts *Quantitative - looking at frequencies, used whole books to analyze text *15 terms were selected, each text was inspected to determine the manner in which each of the selected terms functioned throughout - with regard to frequency, sequence & mutual proximity	*No reliability coefficient reported *Number of raters not reported *Validity: Framework constructed by researcher (self-constructed) and previous research *15 terms derived by consensus from several sources: published papers, preliminary text reviews & interviews with teachers *Used existing literature to present framework as reliable indicator - validity of instrument addressed insofar as selected terms functioned as reliable indicators of topics they would reveal overall shape, organization or structure of subject matter	*1980 texts did not cover the role of evolution throughout text but presented the topic later in the text *In 1990 texts evolution topics also presented at end of text but presented in a manner that indicated the importance and wide impact throughout the subject of biology *BSCS blue and green version presented the topic of evolution in a more pervasive manner throughout the texts

Shiland (1997)	Exploring the presentation of atomic theory to determine its acceptance as determined by a model of conceptual change	*6 secondary chemistry textbooks from the 1980's and 2 texts from the curriculum reform projects of the 1960s *Quantitative - looking at frequencies, used partial books to analyze text	*No reliability coefficient reported *Number of raters not reported *Validity: Framework constructed by previous studies The theory of accommodation (Posner et., al. (1982)) was operationalized and applied to the Bohr atomic model verses quantum model - only analyzed conceptual change in text not students - no discussion on validity of instrument	Results showed that the texts examined do not provide a sufficient basis to rationally accept the quantum mechanical model over the Bohr model based on the Posner et al., 1982 model of accommodation
Barbera, Zanon, Perez-Pla (1998)	100 years of Spanish biology curricula are reviewed to analyze the relationship between socially controversial biological issues and decision-making procedures in the construction of the national curricula	*9 Spanish national curricula at the secondary level published over the last 100 years *Qualitative analysis - narrative reporting from texts and overview of time frame referencing historical influences *Used partial documents to analyze text *Calculates average percentage of hours a week allocated to each subject in official timetables in relation to overall weekly schooling hours in each Spanish curriculum *Looks to biology books & Spanish social/political timelines to make statements about why & when content was presented	*No reliability coefficient reported *Number of raters not reported *Validity: Framework constructed by researcher (Self-constructed) *Validity of instrument addressed by comparing content of biology textbooks with curriculum content to confirm content followed published curricula	*Provides interesting perspective on possible pressures that influenced the when, how and why science content was introduced into the schools *By being aware of these influences we can be more mindful of how science education is created and distributed
Eide & Heikkinen (1998)	Determine how multicultural information relates to guidelines for science teaching	*21 purposefully chosen resource manuals for science textbooks *Quantitative - looking at frequencies - used whole book to analyze text *Percentage of page taken up by multicultural topics to nearest 10%; found topics were placed in categories; used a 3-Point Likert scale to assign relationship to science	*Average *Inter*-rater reliability 0.8; 3 weeks later *Intra*-rater reliability for each rater within range of 0.86 - 0.98 *4 raters *Validity: Framework constructed by previous research - used a matrix developed by Rodriguez (1992) and Lerner, Nagai & Rothman (1995) *Validity of instrument addressed by using a strategy that employed descriptors by this procedure as raters were not required to guess if a word or phrase was to be considered a multicultural descriptor	*Multicultural content usually 2-4 sentences per chapter and/or unit *purpose for inclusion not identified *Though material may have some relationship to science, in no instance did the material support the text's indicated learning objectives

Maria de Posada (1999)	Explore how metallic bonding is usually taught and the role textbooks play as agents of change in Spanish science pedagogical reform	*58 Spanish secondary chemistry textbooks from 1974 to 1998 *Quantitative - looking at frequencies, used partial books to analyze Illustrations & text *12 item questionnaire was used to analyze each text	*89% inter-rater reliability conflicts resolved by discussion/consensus *3 raters *Validity: Framework constructed by researcher (Self-constructed) - no discussion on validity of instrument	*Researchers noted a pervasive lack of integrative reconciliation among different topics *A disconnect appears between the definition, model and images of the metallic bonding - making it difficult for students to understand the concept *Only a few recent textbooks approach the topic with a constructivist orientation
Roth, Bowen & McGinn (1999)	This study wishes to discover what practices are required for reading graphs in journals and high school texts and what role do high school science textbooks offer in learning these practices	*6 eighth grade biology texts *5 ecology journals from the 10 most sited references *Mixed Qualitative & Quantitative - looking at frequencies, used parts of books and science journals books to analyze Illustrations & text. *Created 6 graphs categories counted frequency of graphs, provided narratives of general observations and experiences	*No reliability coefficient reported conflicts resolved by discussion /consensus *3 raters *Validity: Framework constructed by researcher (Self-constructed) and previous studies *Refined category scheme for graphs that researchers had used in previous studies (Roth & Bowen, 1994 Roth,1996) *Used anthropological approach employed by Livingston (1995) to establish ontology of graphs from the perspective of reader - no discussion on validity of instrument.	*Overall the same number of inscriptions or graphs was found in textbooks and journals dedicated to ecological issues *The nature of graphs were different - textbooks based all inscriptions upon pictorial metaphors - journals used more mathematical models *Textbooks featured fewer resources that assisted in interpreting data and linking to some theoretical framework
Jackson & Griggs (2001)	Compared textbooks to assist educators in finding a text to suit their needs	*26 full-length undergraduate research methods textbooks published in U.S. with copyrights between 1995 & 1999 *Quantitative - looking at frequencies - used whole book to analyze text. *Simple tabulation of textbook characteristics	*No reliability coefficient reported *Number of raters not reported *Validity: Framework constructed by researcher (self-constructed) - no discussion on validity of instrument	*Research produced 4 tables: 1 - demographic data for individual texts (# of authors, # of pages, chapters, etc.,) 2 - pedagogical aids in individual texts (outlines, advanced organizers, summaries, glossary, etc.,) 3 - Illustrative material in individual texts (# of figures, # of tables, # of boxes, etc.,) 4 - percentage of text devoted to specific topics for each textbook (Ethics, APA style, measurement, etc.,)

Kesidou & Sofia (2002)	Review middle school science texts for accuracy and adherence to 3 national standards	*9 middle school general science textbooks *Quantitative - looking at frequencies, used partial books to analyze text *Developed a 22 point code book for each standard analyzed, and a 5 point code book to evaluate each text	*Inter-rater agreement for three areas 93%, 97% & 100% - each team was required to provide evidence to justify ratings - conflicts resolved by discussion /consensus. *Reviewers consisted of two person teams (university and classroom teacher) a total of 6 teams: all researchers were trained in 7-day workshop to clarify practice and procedures *Validity: Framework constructed by previous research. Instrument developed through previous research and refinement processes within research team - developed highly detailed codebook - no discussion on validity of instrument	*Findings revealed that none of the 9 texts rated as satisfactory on all criteria, in fact most texts did not receive an over all rating of satisfactory
Leite (2002)	A study to validate checklist for analyzing history of science content in science textbooks	* 5 Portuguese secondary physics textbooks with different amounts of historical material were selected *Quantitative - looking at frequencies, used whole book to analyze text *Checklist developed by author to evaluate historical differences - frequency of items found on checklist were used to calculate historical topic presence	*No reliability coefficient reported conflicts resolved by discussion /consensus *2 raters *Validity: Framework constructed by researcher (self-constructed) *Check list validated by study itself. If analysis using checklist could reveal differences between textbooks that are known to be different with regard to the history of science content	*Checklist was validated by showing that texts were found to be different in how they handled the history of science *Overall the study found that textbooks seldom present the real evolution of a science concept or technological device and when they do so they rarely relate it to the diverse context in which it occurred

Dimopoulos, Koulaidis & Sklaveniti (2003)	Presents an in-depth analysis of the pedagogic functions of visual images included in science textbooks and daily press articles about science and technology	*6 mandatory science textbooks used in the Greek primary and secondary schools during the school years 1997-1999. [2 primary general science, 2 chemistry & 2 physics secondary science] *1,867 press articles found in 4 Greek newspapers of broad readership during 1996 to 1998 *Quantitative - looking at frequencies, used whole textbooks and whole newspapers to analyze text *Used coding matrix to analyze images - using three dimensions; syntactic construction (classification), social-pedagogic relationships (framing) and the degree of abstraction (formality)	*9% of images analyzed obtained a 90% inter-coder agreement *Two groups of educationalists- no report regarding how many were in each group *Validity: Framework constructed by researcher (self-constructed) and previous research *Follows work done by Kress & van Leeuwen (1996). Validation of instrument was addressed by having a group of researchers work with 9% of data to establish validity of matrix before applying to entire corpus	*Results show visual images are characterized by weak classification, meaning they tend to portray techno-science as being close to every-day knowledge *Both school science text and press articles do not expose their non-expert readers to the corresponding world of scientific conventions rather they mainly relate the content of science with the salient features of physical reality
Korfiatis, Stamou & Paraskevopoulos (2003)	Examines the environmental content of textbooks used in Greek primary schools for teaching natural sciences	*6 Greek textbooks from 1- to 6th grade *Quantitative - looking at frequencies, used whole textbooks to analyze text *Several categories: nature as metaphor, depictions of nature, types of nature, value of nature, representations of humans-nature relationship, representations of human activities, elements of environmental knowledge	*89% inter-rater reliability *3 raters *Validity: Framework constructed by researcher (self-constructed) - each category was described by citing previous research though the matrix itself and was designed by the researcher. No discussion on validity of instrument	*Textbooks characterized nature by stability and balance, while any change is not nature but rather a human-induced process *Humans held a position of dominance over nature, which had more a positive or a neutral rather than a negative impact *Nature was in oscillating balance, with things connected while humans had the absolute control over nature whose only value was its usefulness as a resource
Newton (2003)	Studies the extent that analogies in science texts are provided by authors	*80 elementary science books published in last 10 years *Quantitative - looking at frequencies, used whole textbooks to analyze text. *Used evaluation matrix to categorize analogies	*No reliability coefficient reported *Number of raters not reported *Validity: Framework constructed by previous studies *The categories used to classify analogies were taken from the work of Curtis and Reigeluth (1984) - no discussion on validity of instrument.	*45 of the 80 texts contained no analogies the remaining 35 books had a total of 92 analogies *These were predominantly structural, verbal and concrete. The researcher proposes that given the power of analogies in learning this study indicates that analogies were not used to full potential

Pozzer & Roth (2003)	*Investigate the prevalence, function & structure of photographs in high school science and how they assist in meaning making in relationship to subject matter	*4 Brazilian biology textbooks *Quantitative - looking at frequencies, used partial textbooks to analyze photos & text *Categorized and counted 4 types of photos; decorative, illustrative, explanatory and complementary	*No reliability coefficient reported conflicts resolved by discussion /consensus *Number of raters not reported *Validity: Framework constructed by researcher (self-constructed) *Employed precepts of Fourth Generation Evaluation (Guba & Lincoln, 1989) - monitored & recorded emerging understanding, enacted prolonged engagement, sufficient observation, revision of hypotheses through the analysis of negative cases and progressive subjectivity to construct audit trail. No discussion on validity of instrument	*Found that photographic images and captions are often inappropriately referenced from main text *Photos and captions usually function in a standalone mode from text * Photos were found to be: Decorative (5.4%) , illustrative (35.1%), explanatory (28.4%), complementary (31.1%)
Elgar (2004)	Looks at secondary science books to determine how equally females and males are represented in both illustrations and text	*3 secondary science textbooks (a series) published by the ministry of Education in Burnei Darussalam *Quantitative - looking at frequencies, used whole textbooks to analyze text *Counted frequency of male and female images in photos and illustrations, the number of male and female individuals named and the use of language and a grammatically male form used to refer to both sexes instead of neutral forms and specific male or female pronouns	*No reliability coefficient reported *Number of raters not reported *Validity: Framework constructed by researcher (self-constructed) - no discussion on validity of instrument	*The study revealed a clear gender imbalance in text and illustrations in favor of males in Bruneian science textbooks
Mesa (2004)	Investigate the nature of functions presented in selected textbooks	*24 7-8 grade mathematics textbooks from 18 countries chosen from the Third International Mathematics and Science Study [TIMSS] *Quantitative - looking at frequencies, used partial textbooks to analyze text *4 categories were created to identify the how functions were presented each had numerous subcategories to distinguish each type of pedagogy used	*First trial obtained an inter-rater agreement of 60-75%. The results were used to refine the coding system then retested for reliability and validity. Further tests produced 80-100% inter-rater agreement *3 raters *Validity: Framework constructed by researcher (self-constructed) *Constructed an instrument using Balacheff's theory of *conceptions* and *prototypical domains of application (*Balacheff & Gaudin, 2003). Validity of the instrument was tested by other raters using lessons and content that preceded each task	*Tasks that use symbolic rule where no context is involved is almost twice the percentage of tasks for practices that involve a context. Also, tasks involving physical phenomena seem to be more difficult to set up than social phenomena *As this study has highlighted the strategies for presenting the material further research is needed to determine the value of each of these approaches

Snyder & Broadway (2004)	Applies queer theory to analyze biology textbooks to analyze how sexuality outside the heterosexual norm is treated and if heteronomative attitudes are propagated	*8 secondary biology textbooks *Quantitative - looking at frequencies, used partial textbooks to analyze text *Using checklist looked to each of these sections of text to determine presence and type of sexuality discussion: genetics, behavior, nature of science, sexuality, AIDS, discussion of scientists' sexual orientation & inquiry.	*No reliability coefficient reported conflicts resolved by discussion /consensus. *2 raters *Validity: Framework constructed by previous research - no discussion on validity of instrument	*All 8 textbooks were completely void of any reference to sexuality outside of the heterosexual norm in all six categories *Only 3 textbooks explicitly mentioned homosexuality and this was in a discussion regarding AIDS
Wei & Thomas (2004)	Investigates the change of junior secondary school chemistry curriculum (JSSCC) in P.R. China over the period from 1978 to 2001.	* syllabi, textbooks, teachers' references, from 1978 to 2001 no reference to the number of books used not reported *Quantitative - looking at frequencies, used whole textbooks to analyze text *Books analyzed with 5-point checklist	*100% Inter-rater agreement *Number of raters unclear *Validity: Framework constructed by researcher (self-constructed) *Concepts of 'curriculum emphases' and 'companion meanings' were introduced to 2 specialists and they were asked to construct 'companion meanings' which would be applicable to JSSCC - the specialist formulated 5 themes *Next 20 recording units extracted from textbooks of JSSCC were given to each specialist to group into one of the 5 'companion meanings' themes they developed *Adjustments were made in the theme categories and validation exercise were carried out between specialists	*It was found that subject matter had been increasingly enlarged in its breadth but its requirements gradually decreased while companion meanings at different levels of curriculum had been increasingly added from 1978 to 2001
Brito, Rodriguez & Niaz (2005)	Study objectives: a) elaboration of history & philosophy of science framework based on a reconstruction of the periodic table; b) formulation of 7 criteria based on framework c) evaluation of textbooks with respect to framework historical framework constructed regarding the periodic table	* 57 freshman college-level general chemistry textbooks from 1966 to 2002 *Quantitative - looking at frequencies, used partial textbooks to analyze text *Each book was rated on a 3 point Likert scale for each of the 7 criteria (satisfactory -2, mention-1, no mention-0) - All textbooks were then evaluated on a scale of 0-14 and a mean was created for 3 groups: 23 books from 1966-1989; 21 books from 1990-1999; 13 books from 2000-2002	*90% Inter-rater agreement reported conflicts resolved by discussion /consensus. *3 raters *Validity: Framework constructed by researcher (self-constructed) and previous research - presents a detailed historical discussion on the development of the periodic table, construction, influences, assumptions and design - no discussion on validity of instrument.	*Results show almost all text recognize the importance of accommodation according to their physicochemical properties, the importance of contra predictions, and novel predictions *Very few textbooks attempt to explore possible cause of periodicity, the nature of Mendeleev's contribution viz., ordered domain, empirical law or theory, few text attempt to weave development of the periodic table as a sequence of heuristic principles

Kragler, Walker & Martin (2005)	Investigates ways in which comprehension strategy instruction is addressed primary-grade science and social studies texts	* 6 primary grade teacher addition textbooks - 3 social studies and 3 science books *Quantitative - looking at frequencies, used whole textbooks to analyze text	*No reliability coefficient reported *Number of raters not reported *Validity: Framework constructed by researcher (self-constructed) - no discussion on validity of instrument	*The texts contained few instances of teacher modeling and scaffolding comprehension strategies *The science text contained no teacher modeling and relied heavily on graphic organizers to help students comprehend the text
Ford (2006)	Trade books were examined for their explicit and implicit representations of science	*44 randomly chosen trade books selected from public library *Quantitative - looking at frequencies, used whole textbooks to analyze text *2 step process; books were read and those with explicit mention of the nature of science or science practices were in one category (33), those in the second category were placed in the implicit representations of science category (11)	*91% Inter-rater agreement reported conflicts resolved by discussion /consensus *Number of raters not reported *Validity: Framework constructed by previous research - used Helms and Carlone (1999) heuristic for coding scheme. Validation of instrument addressed by applying processes suggested by Lincoln & Guba (1985)	*Trade books reinforce science as facts not a process *There is little to no discussion of the production of knowledge or the tentativeness of science *Science is represented as only empirical in nature and holding to the 7 step scientific method
Orgill & Bodner (2006)	Presents an analysis of how analogs are used and presented in college level biochemistry textbooks and compares their use to those of other disciplines of science at the secondary level	*8 college-level biochemistry textbooks: 2 for non-majors; 4 used in undergrad & grad level classes; 2 used in medical school biochemistry classes *Quantitative - looking at frequencies, used whole textbooks to analyze text *Used modified classification schemes to analyze texts	*No reliability coefficient reported *Number of raters could be 4 *Validity: Framework constructed by researcher (self-constructed) and previous studies *Several classification schemes used; developed by Curtis and Reigeluth (1984), Thiele & Treagust, (1994) - no discussion on validity of instrument	*Overall, the manner in which biochemistry analogies are used and presented in biochemistry books is very similar to the secondary textbooks and does not differ greatly with the level of textbook
Ogan-Bekiroglu (2007)	Develop an instrument to identify characteristics of high school physics texts - then analyze Turkish science texts	*11 Turkish high school physics texts were analyzed *Quantitative - looking at frequencies, used whole textbooks to analyze text *131 criteria under 7 categories was created to analyze texts	*No reliability coefficient reported *Number of raters unclear 71-82 *Validity: Framework constructed by researcher (self-constructed) *Pre-service teachers developed the instrument through an iterative process, reviewing literature, interviewing teachers, using instrument over 3 semesters	*Ratings for the 11 Turkish physics texts ranged from 2-4 on a 1-5 scale in the 7 categories investigated

Selden (2007)	Traces the eugenic content in 73 U.S. science textbooks from 1914 to 1964 and compares patterns of content to science textbooks written by Moon published between 1921 and1963	*73 biology textbooks published between 1914 ad 1964 and compared to 10 biology textbooks published between 1921 and 1963 authored by Moon *Qualitative analysis - narrative reporting from texts and overview of historical influences	*No reliability coefficient reported *Number of raters not reported *Validity: Framework constructed by researcher (self-constructed) *Narrative reporting from texts and overview of decade referencing historical influences - No discussion on validity of instrument	*The Moon series of biology texts served as a conduit for eugenics reform movement - it was also reflected in other biology texts - provided readers with a specific life narrative where heredity should be accepted and one must adjust to the world as it is

The studies in this selection fall into several categories. Ten studies examine pedagogical issues to determine how content was presented or used to further student understanding or to establish best practices. Nine studies consider the social influences that directly affect the science content included in textbooks. One study falls into both of these categories by evaluating models of metallic bonding and also speculating on the role the Spanish reform movement played in the use of each of the models. Two studies provided descriptive information about the explicit content found in a selection of textbooks. Finally, two studies used content analysis to validate assessment instruments. The variety of studies indicates the wide applicability of content analysis to investigation and resolution of research questions.

Types of Research Conducted in Content Analysis Studies

“Content analysis is a research technique for making replicable and valid inferences from data to their context” (Krippendorff, 1980, p.21). Written documents are the most often analyzed media of communication (as opposed to art, music, or conversation). This is most likely due to the enduring nature of written communication, as the Chinese proverb states “the palest ink is clearer than the best memory”. All studies under consideration conducted research using printed educational materials. The majority of studies (21) used a quantitative method of analysis. This perspective focuses on frequency, number of pages or percentages of the page, chapter or book devoted to the topic of interest. By comparison, only two of the studies considered, Barbera et al. (1998) & Selden (2007), conducted their studies as qualitative analysis. This perspective uses a narrative approach, showing exemplars of specific findings and exploring relationships and influences that may impact the topic under investigation. One study by Roth, Bowen & McGinn (1999) used a mixed method approach to conduct their research.

Data Sources and Reliability in Content Analysis Studies

The Barber et al. (1998) study examines 100 years of Spanish *science curricula* as the primary data source, whereas all other studies use *science textbooks* as the primary source of analysis. Fourteen of the investigators (58%) chose to focus their study on data retrieved from entire textbooks while the remaining 10 investigators selected only parts of the textbook to examine. The decision to use a percentage of the text or the whole text relates closely to the decision of "who will be the raters" (Hershey, 1996, p.328).

Kerippendorff (1980) discouraged the use of a single rater as he felt it led to the least reliable content analysis; he suggested that content analysis should be performed by two or more raters. In addition, Krippendorff urged those who used multiple-rater techniques to strictly follow predefined protocols and maintain independent analysis with absolutely no communication between raters to assure the reproducibility of any content analysis. Intra-rater reliability is the agreement coefficient of two coding results (test and retest); inter-rater reliability is the agreement coefficient between two raters coding the same items. Maximum agreement is indicated by 1 and 0 signifies no agreement. “When the coefficient is only 10%...conclusions to which such data would lead are largely misleading or true only by chance. The fact that 60%... matched turned out to have no meaning” (Krippendorff, 1980, p.135). Cohen’s (1960) kappa takes agreement by chance into consideration when using nominal data and for this reason he proposed that a kappa greater than 0.75 indicates good agreement beyond chance; a kappa between 0.40 and 0.75 represents satisfactory agreement beyond chance; a kappa below 0.40 indicates poor agreement beyond chance (Rubenstein & Brown, 1984).

The 24 studies reviewed showed a surprising overall lack of information regarding the number of raters and the reliability of techniques used to gather data. Table 2.2 summarizes the reliability indicators in these studies. Half the studies did not mention the number of raters used to gather data and nine studies provided no discussion or information on the reliability of the data collected. Ten studies did provide information regarding inter-rater agreement, however, only the Eide & Heikkinen (1998) study provided an *intra*-rater agreement coefficient. The researchers who provided reliability coefficients often indicated that they discussed rater differences, which helped to “refine the coding system. They then retested for reliability and validity” (Mesa, 2004, p.263) ultimately increasing the reliability coefficients. In five studies, researchers did not provide reliability coefficients; rather, these investigators relied solely upon discussions between colleagues as a means of trustworthiness. “To achieve inter-rater reliability the results were collaboratively compared, discussed and finalized” (Snyder & Broadway, 2004, p. 624).

Table 2.2 Overview of Reliability Indicators of 24 studies

Number of Raters		Method of Data Reliability		
Indicated	**Not Indicated**	**Reliability Coefficients**	**Consensus**	**No Discussion**
12 studies	12 studies	10 studies	5 studies	9 studies

Instruments &Validity in Content Analysis Studies

The approaches to research found in these 24 studies varied widely. Some researchers counted images, words, or pages using a self-defined framework (13 studies) while others adopted frameworks and procedures developed through earlier studies (6 studies), and yet others developed their own criteria informed by previous studies (5 studies). However, as Krippendorff (1980) believes, constructing the conceptual framework or foundation is only the first step in establishing validity in content analysis. Researchers must ensure the instruments used actually measure what they intend to measure. The Leite (2002) study tested their instrument on texts with known variations in representing the history of science. When the instrument reflected the expected differences the researcher was satisfied that the developed checklist was accurately measuring the intended characteristic of science content. Additionally, to draw reliable inferences, guidelines or codebooks can help researchers obtain data *clerically*. When less judgment is required during coding the more likely the instrument is trustworthy (Krippendorff, 1980). The Eide & Heikkinen (1998) study is an exemplar of this manner of research. "Validity was addressed by using a strategy that employed descriptors (i.e., words, phrases, or groups of words used to identify content) or multiculturalism and multicultural education as identified by the *Thesaurus of ERIC Descriptors* (Houston, 1995) and the *Contemporary Thesaurus of Social Science Terms and Synonyms* (Knapp, 1992)…Objectivity was also controlled by this procedure as raters were not required to guess if a word or phrase was to be considered a multicultural descriptor" (Eide & Heikkinen, 1998, p. 184).

Table 2.3 Overviews of Validity Indicators of 24 studies

Source of Instrument Construction			Instrument Validation	
Researcher	**Previous Studies**	**Mixed**	**Discussion**	**No Discussion**
13	6	5	9	15

Lessons Learned from Content Analysis Studies

When attending to the issues of objective, systematic, and generalizable research design, it is clear that a valid and replicable analysis must be guided by a clear set of conceptual foundations. The 24 studies reviewed presented three approaches in establishing these foundations. The first approach looked to use prior studies to generate a framework and applied the analysis to different content, as found in the Korfiatis, Stamou & Paraskevopoulos (2003) study. The second approach explored, constructed and refined the theoretical framework during the process of content analysis, such as used in the Ford (2006) study. The third approach, employing a mixture of the two, used previous research as a starting point and then through an iterative process of discovery and discussion adapted the framework to suit the needs of the analyses at hand, as found in the Dimopoulos, Koulaidis & Sklaveniti (2003) study. Because of the lack of studies devoted to examining science content in textbooks over time, this study will apply the second method to construct and refine a framework during the processing of the content analysis.

All of the studies reviewed explained in detail the decisions made to create and conduct data analysis. However, a small percentage provided a discussion regarding the validity and reliability of their instruments. The importance of this information is undeniable. This study will document the process of data collection, attend to reliability issues by providing *intra* and *inter* rater coefficients, and develop a codebook to assist raters in consistently applying rules of analysis. The next chapter will describe these points in detail.

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[6] Included in this passage are references from two other sources; (Chall, 1967; Hockett, 1938).
[7] (U.S. Department of Ed: http://www.ed.gov/about/overview/fed/role.html?src=ln)
[8] Clark Kerr, former chancellor of the CA higher education system disputed the link between better education and economic growth. Citing studies by the MIT, Princeton, Brookings Institute, Kerr noted a weak correlation between productivity and improved education. Larry Cuban, former president of the American Educational Research Association also argued against the assumptions that through educational development economic development would follow. Larry Cuban, "The Corporate Myth of Reforming Public Schools," *Phi Delta Kappa*, October 1992, p.159.
[9] (http://www.uschamber.com/bclc/resources/newsletter/2005/0508newsletter.htm)
[10] Italics are original from the source.
[11] The mean LEX score for texts from 6th to 8th grade ranges between -25 to –30 for the years 1963 to 1991.
[12] This study was funded by the David and Lucile Packard Foundation which sought proposals for projects aimed at examining textbooks in schools. The full 500 page report may be downloaded at http://psrc-online.org/curriculum/book.html.

CHAPTER THREE – METHODOLOGY

Overview

This chapter provides a detailed discussion of the data analysis used in this study. The purpose of this study is to delineate specifically the science content found in 8th and 9th grade general science textbooks from the 1950's to the present, and to document the emergence of new topics over time. Textbook sampling in this study was based upon a convenience sampling. The books analyzed represent a sampling of all 8th and 9th grade science textbooks published from 1952 to 2008 and do not represent textbook usage or distribution. A pilot study was conducted using two textbooks. An initial content list and topic codebook were developed and exploratory data analysis conducted. Intra- and inter-rater reliability tests were also conducted using the pilot books to determine the trustworthiness of the content list development and the codebook.

Content Analysis

Content analysis relies upon the six basic elements of the communication process: "a *source* or sender, an *encoding process* which results in a *message*, a *channel* or transmission, a *detector* or recipient of the message, and a *decoding process"* (Holsti, 1969, p. 24). Figure 3.1 represents the relationships between these elements. Content analysis is always conducted on the message; the results, however, can be used to make inferences regarding all of the other elements. "Who says what, to whom, how, with what effect, and why" (Lasswell, Lerner, & Pool, 1952, p.12 from Holsti, 1969, p.24) is the classical formulation of the types of questions content analysis can answer. Research designs can analyze the message to make inferences about the quality, value or traits of the text, the origins or antecedents of the messages, or the results of communication. Each design differs in respect to the dimension of communication analyzed, the types of comparisons made, the questions asked of the data, and the research problem to be answered.

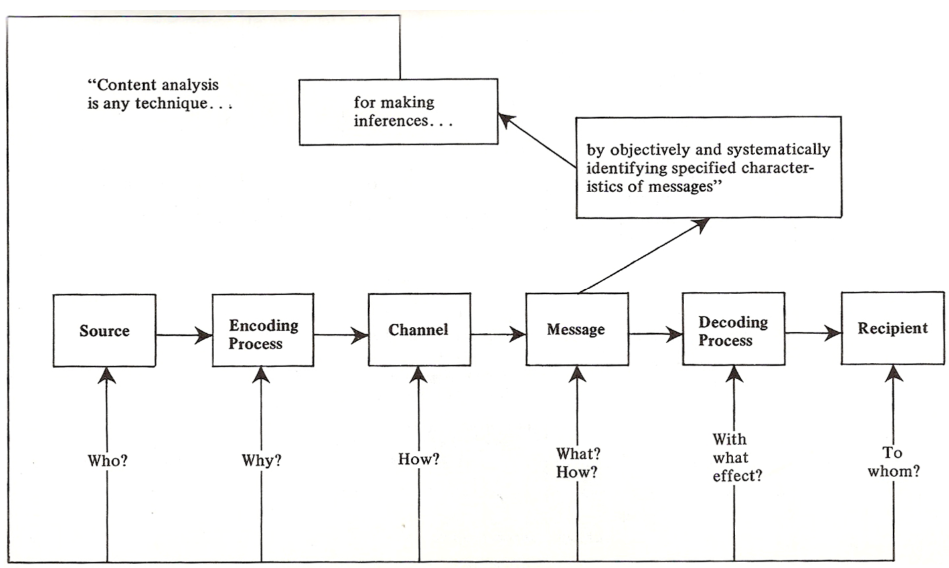


Figure 3.1 Content Analysis Elements & their Relationships

This study seeks to analyze science textbooks over time to describe trends in the communication (or message) content. The data obtained will illuminate the historical antecedents and the progression of science content offered to U.S. 8^{th} and 9^{th} grade students.

Sampling - Rational for Textbook Selection

Textbook selection was one of the first considerations in this study. Information about textbook sales is considered proprietary by most publishers, making sales information difficult and costly to obtain. Additionally, state adoption commissions do not keep historical records regarding textbook recommendations or usage. For these reasons textbook distribution statistics are not available. In the absence of distribution information, the *El-Hi Textbooks Serials in Print* (El-Hi textbooks and serials in print, 1947-2006) was used to create a listing of all 8th and 9th grade general science textbooks for the sample period. The *El-Hi* series first published in 1947 is a bibliography of all educational materials published annually in the U.S. To acquire the information necessary for this study the series was reviewed for each year from 1956 to 2006 to find title, author, and publisher information. Laboratory manuals, multi-media, workbooks, testing booklets, or book series were not included in the sample, only single volume textbooks designed for use in 8th or 9th grade general science classes were selected. Approximately 780 general or physical science textbooks have been published for use in the 8th and 9th grades during the past six decades. The number of books published each year ranged from 11 to 28. Not all books published were new texts; in fact only 120 unique titles were published over the past six decades with some editions reprinted annually for more than 25 years.

Most of the science textbooks published from 1956 to 1975 indicated use for a single grade, i.e. they were specifically written for the 8th or 9th grade. After 1984 *no* textbooks were being written for a single grade, rather grade ranges were indicated. For consistency, after 1984 only textbooks that indicated the grade range of 8th–9th or 7th–9th

were included. It is of interest to note that after 1985 publishers increasingly wrote single books intended for broader student audiences such as grades 1–8, 9–12, 7–12 and many instances of 5^{the}–12^{th} grade ranges. Some popular general science textbooks published between 1950 and 1999 were excluded because they did not meet the study criteria. For example, the *Prentice-Hall Physical Science* textbook first published in 1980 omitted a grade designation until 1987 when it was assigned for use in grades 6 through 9. In 2000 Prentice Hall began publishing a new series specifically for 7^{th}–9^{th} grade. Heath & Merrill science texts were designed for 6^{th} through 12^{th} grade and the Hewitt *Conceptual Physical Science* text indicated use for grades 7^{th} through 12^{th}. However, due to the fact that very few textbooks published after 2000 fit within the grade-range study parameters, exceptions to the grade delimitation rule was made in the case of books published after 2000. This study includes 12 current textbooks now in use throughout the U.S. and several that are specifically written for Florida, Texas and California.

The information derived from the *El-Hi Textbook Series* produced a list of published science textbooks that represents a sampling of all 8^{th} and 9^{th} grade textbooks used from 1956 to 2006. This list does not represent textbooks sales or distribution. To narrow the sample size and select texts that might have enjoyed a greater popularity, only those texts that have been published for five or more years were chosen for analysis. Table 3.1 displays the 37 selected textbooks.

Table 3.1 Thirty-seven 8th – 9th grade science texts published for 5 or more years between 1956 and 2006.

Year Pub	Author	Title	GR	Yrs Pub	Publisher
1956	Jacobson	Broadening Worlds of Science	8	8	American Book Co.
1956	Frasier	Our Scientific World	9	7	Singer Publishing
1956	Davis	Science Discovery & Progress	8	11	Holt, Rinehart & Winston, Inc.
1956	Davis	Science Experiments & Discovery	9	11	Holt, Rinehart & Winston, Inc.
1956	Smith	Science for Everyday Use	9	7	Lippincott, J.B. Co.
1956	Ames	Science for Progress	9	12	Nobel & Nobel Publishers, Inc.
1956	Ames	Science for Your Needs	8	13	Nobel & Nobel Publishers, Inc.
1956	Clark	Science on the March	8	7	Houghton Mifflin Co.
1956	Clark	Science on the March	9	9	Houghton Mifflin Co.
1956	Smith	Using Modern Science	9	6	Lippincott, J.B. Co.
1956	Burnett	World of Science	9	6	Silver
1956	Brandwein	You & Science	9	11	Harcourt, Brace & World, Inc.
1956	Brandwein	You and Your Inheritance	8	8	Harcourt, Brace & World, Inc.
1957	Frasier	Our Scientific Age	9	7	Singer Publishing
1957	Carroll	Science and Our Universe	9	6	Winston
1957	Carroll	Science and Our World	8	6	Winston
1960	Brandwein	You and Your Resources	8	6	Harcourt, Brace & World, Inc.
1967	Blanc	Modern Science Series	9	6	Holt, Rinehart & Winston, Inc.
1967	Blanc	Modern Science Series	8	9	Holt, Rinehart & Winston, Inc.
1968	Barnard	Science: A Key to the Future	9	5	Macmillan, Co.
1968	Barnard	Science: A Way to Solve Problems	8	5	Macmillan, Co.
1972	Heimler	Focus on Physical Science	7 - 8	11	Merrill, Charles E., Publishing, Co.
1972	Heimler	Principles of Science	7 - 8	12	Merrill, Charles E., Publishing, Co.
1975	Carter	Physical science: A Problem Solving Approach	7 - 8	29	Ginn & Co.
1976	Bernstein	Concepts & Challenges in Science	7 - 8	30	CEBCO Standard Publishing Co.
1977	no author	Exploring Physical Science	7 - 8	14	Allyn & Bacon, Inc.
1977	Atkin	Ginn Science Program	7 - 9	5	Ginn & Co.
1979	Ramsey	Holt Physical Science	7 - 8	14	Holt, Rinehart & Winston, Inc.
1979	Schneiderwent	Physical Science	7 - 8	26	Silver Burdett Co.
1981	Hill	Spaceship Earth: Physical Science	7 - 8	24	Houghton Mifflin Co.
1983	Boeschen	Foundations in Science: Physical Science	7 - 8	11	Benefic
1986	Magnoli	Experiences in Physical Science	7 - 8	17	Laidlaw Brothers
1988	Johnson	Addison-Wesley Physical Science	7 - 8	18	Addison-Wesley Publishing Co.
1988	Haber-Schaim	Introductory Physical Science	7 - 8	17	Prentice-Hall, Inc.
2000	no author	Prentice Hall Exploring Life, Earth, Physical Science	7 - 8	7	Prentice-Hall, Inc.
2002	no author	Exploring Creation with Physical Science	7 - 9	5	Hewitt Research Foundation, Inc.
2002	DiSpezio	Science Insights	7 - 8	5	Addison-Wesley Publishing Co.

Having completed the selection process, the next step was to acquire these books. Libraries are chronically short of space, most often retaining only the very old and most recent science texts. The corpus of texts published between 1919 and 1950 is fairly complete in most libraries but there are many omissions between 1950 and 2006. Of the 37 books published for five or more years, 30 of the textbooks were located. Multiple texts with the same title but different publication dates were included in the sample. The representative sample to be used in this study consists of 70 books as shown in Table 3.2.

Table 3.2 Science textbooks analyzed in this study (70). Cells with shaded backgrounds indicate textbooks that are outside the study's grade range. Cells with hatch backgrounds indicate textbooks that are outside the study's date range.

Title	GR	Books Years of Publication					
Addison-Wesley Physical Science	7-9	**1988**					
Broadening Worlds of Science	8	**1959**	**1964**				
Concepts & Challenges in Physical Science	7-9	**1978**	**1986**	**1991**	**1998**	**2003**	
Conceptual Physical Science	NGR	**2008**					
Experiences in Physical Science	7-9	**1985**					
Exploring Creation with General Science	8-9	**2002**					
Exploring Physical Science	7-9	**1973**	**1997**				
Focus on Physical Science	7-9	**1969**	**1977**	**1981**	**1989**	**2001**	**2007**
Foundations in Science: Physical Science	7-9	**1983**	**2005**				
Glenco Physical Science	NGR	**1991**	**2002**				
Ginn Science Program	8-9	**1988**					
Holt Physical Science	7-9	**1978**	**1986**	**1994**	**2001**	**2004**	**2007**
Introduction to Physical Science	NGR	**2006**					
Introductory Physical Science	8-9	**1972**	**1994**	**1999**	**2005**		
Modern Science Series	9	**1971**					
Our Scientific World	9	**1956**	**1960**				
Physical Science: A Problem Solving Approach	7-9	**1971**	**1979**				
Principles of Science Book2	8	**1966**	**1975**	**1986**			
Principles of Science Book3	9	**1975**	**1979**	**1986**			
Science Discovery & Progress	9	**1952**	**1957**	**1961**	**1965**		
Science Experience & Discovery	8	**1954**	**1958**	**1962**	**1965**		
Science in the Universe	9	**1958**					
Science for Progress	9	**1956**	**1961**				
Science for Your Needs	8	**1956**	**1961**				

Science Insights	7-9	**1994**	**1999**				
Science: A Key to the Future	9	**1963**	**1967**				
Science: A Way to Solve Problems	8	**1960**	**1966**				
Spaceship Earth: Physical Science	7-9	**1974**	**1981**				
Using Modern Science	9	**1956**					
You & Science	9	**1955**	**1960**				

Table 3.3 displays the number of books to be analyzed and categorizes them by decade.

Table 3.3 Texts categorized by publication date.

# of books	Decade of Publication
11	**1950s**
15	**1960s**
11	**1970s**
12	**1980s**
9	**1990s**
12	**2000s**
70	**Total**

As remarked earlier, since the late 1980s textbook publishers issue single volume science textbooks for broader audiences (e.g. 7^{th} – 12^{th} grades) resulting in fewer books published in the 1990's that are within this study's sample parameters.

Reliability - Process of Coding the Identified Units or What is Content?

This study focuses on the specific construct of science content as opposed to pedagogy, instructional support or the myriad other important constructs inherent in the development of curriculum material. To operationalize *content* we looked to the categories developed and used by other researchers (Chiappetta et al., 1991; Chiappetta et al., 1993; Lumpe & Beck, 1996) for analyzing science texts. The Chiapetta et al. (1991 & 1993) paper details four categories of information found in textbooks: 1) basic knowledge of science, 2) investigative skills of science, 3) science as a way of thinking, and 4) the interactions of science, technology and society. This study looks to the first category alone the basic knowledge of science.

> The knowledge of science presents, discusses, or asks the student to recall information, facts, concepts, principles, laws, theories, etc. This type of text reflects the transmission of scientific or subject matter [to be] learned by the reader. Textbook material in this category: (a) presents facts, concepts, principles, and laws, (b) presents hypothesis, theories, and models, or (c) asks students to recall knowledge of information. (Chiappetta et al., 1993, p. 790)

At the onset of this study, two textbooks were analyzed to establish the coding scheme and to begin gathering content topics. The initial content topic list was gathered in an iterative manner; as each textbook was analyzed new topics were added to the list as needed (Lincoln & Guba, 1985). As each of the remaining books was analyzed the content list expanded. Additionally, each textbook was scored individually, noting not only the topic covered but also the depth in which the topic was covered. A codebook was developed to ensure that the coding of depth of coverage was mutually exclusive, equivalent, and exhaustive. Each topic was unique to only one of the categories. Specific categories were mutually exclusive and every item was categorized. Four categories were created to meet these requirements

0 – None = Concept NOT represented

1 – Low = Low level of representation

2 – Mod = Moderate or adequate level of representation

3 – Hi = High level of representation

Zero indicates that the topic was not covered, 1 indicates little coverage of the topic, 2 indicates moderate or adequate topic coverage and 3 indicates in-depth coverage of a given topic. A detailed codebook can be found in Appendix A. This codebook was derived from analyzing two textbooks and provides detailed descriptions and examples of each category.

Clearly, content selection was dependent upon the interaction between the researcher and the science textbooks. Roman (from LeCompte, Millroy, & Preissle, 1992) alerts us to the tendency of researchers to overlook prior assumptions, knowledge and predilections that are inherent in all human endeavors and may impinge upon the process of selection. To ameliorate these concerns inter- and intra-rater reliability tests were conducted upon the content lists and the codebook to ensure commensurable results. Also, Appendix B details the author's experience and expertise to assist the reader in understanding the *lens* through which this analysis was undertaken.

Two outside researchers assisted in the content and codebook reliability check. The first researcher (Researcher **A**) has a BS in Biology and an MA in cognitive & neural science. This researcher taught high school Chemistry and Biology for 5 years and has taught both undergraduate and graduate level college classes for 10 years in basic science, research methods and science methods courses. She has published and presented papers at the national and international level in both science and education. The second researcher (Researcher **B**) has a BA, MA, and Ph.D. in General/Experimental Psychology. She has taught undergraduate and graduate statistics, research design and numerous courses in psychology. She has conducted numerous quantitative and qualitative studies and has published and presented papers at the national and international levels. She was co-director of a National Institute of Mental Health research center in New York and has been a PI and co-PI on several federally funded research grants.

Both Researcher A and B met individually with the primary investigator to review the task at hand. Approximately two hours of training was provided using one chapter from each textbook to clarify codebook rationales and practice coding. Researcher **A** was given nothing except the codebook and was asked to create a content list and to determine the depth of coverage for each topic. Researcher **A** used the codebook to analyze 60 pages (one chapter on Light) from one textbook. Researcher **B** was given the content list created by the author and asked to rate the depth of coverage for one chapter on Light from two textbooks (110 pages) using the codebook as a guide. In this way not only was the codebook validated regarding depth of topic coverage but also the consistency and quality of subject matter (science content) selection was verified. The inter-rater agreement with regard to the content list between the author and Researcher **A** was 98% and 96% regarding the depth of coverage. The inter-rater agreement between the author and Researcher **B** regarding depth of coverage for a chapter from each book was 91% and the inter-rater agreement between Researchers **A** & **B** for this same construct for one textbook was 93%. To demonstrate intra-rater reliability the author analyzed two complete textbooks and one month later analyzed one chapter from each of these same textbooks (the same chapters analyzed by Researchers **A** & **B**). The intra-rater reliability was 97% in duplicating the content list and 99% in identifying the depth of coverage. Table 3.4 displays the reliability results. These reliability indices adequately demonstrate dependability of the method of acquiring the content list and the trustworthiness of the codebook. The results provide reasonable evidence of the reliability of the codebook and content list for use in the analysis of the remaining textbooks. The analysis, as discussed later in Chapter Four, compares the degree of commonality of content and depth of coverage between texts and within each text over time.

Table 3.4 Inter & Intra rater reliability indices.

Inter-Rater Reliability – ***Content List*** (60 pages from Textbook 1)	**Inter-**Rater Reliability – ***Content Coverage*** (60 pages from Textbook 1)
98% - Researcher A and the author	96% - Researcher A and the author 93% - Researcher A and Researcher B
	Inter-Rater Reliability – ***Content Coverage*** (120 pages from Textbook 1 & 2)
	91% - Researcher B and the author
Intra-Rater Reliability – ***Content List*** (120 pages from Textbook 1 & 2)	**Intra**-Rater Reliability – ***Content Coverage*** (120 pages from Textbook 1 & 2)
97%	99%

One may question the value of utilizing sentence counts to indicate depth of coverage. It can be argued that a topic discussion, description, or explanation may still be superficial even if it extends over several pages; this justifiable concern is addressed by the process of content selection. Only those topics that are determined to be significant are added to the content list. What a researcher finds significant is not an entirely personal choice but is largely shaped by training and the community of science educators. The inter-rater test conducted using the content list shows agreement between two such science educators in determining significant content topics. An example may provide further clarification of the value of this approach. As shown in Table 3.5 the word model may or may not be used in a manner that indicates a significant discussion or explanation.

Table 3.5 Identifying significant topics.

Explanation	Example
Example sentences where the term *Model* is selected as a content topic. In this example scientific models are the topic of discussion and the text defines and explains the term.	A model is a simple system that reveals important properties of a more complex system that you wish to understand better. More than one type of model can be used to study the same complex system, each model shedding light on some different aspect of the complex system.
Example sentences where the term *Model* is **NOT** selected as a content topic. In this example the term model is not the topic of discussion, rather it is simply a term used to further explain or explore another topic.	An airplane model was used to help scientists to better understand how wing shape affected airflow around the plane. The model can demonstrate both Bernoulli's theory and Newton's third law in action.

Additionally, this research is concerned with acquiring information on the *basic science content* presented in the textbook and does not address pedagogical or cognitive levels of transmitting that content. Therefore a depth of coverage of 3 represents only the depth of information regarding the science content, not the rigor in which it was presented.

Validity - Issues of Quality Control

To ensure the validity of the content list and categories acquired from textbook analysis, a panel of six experts in the field of science education reviewed the content constructed by analyzing the first 30 books. These experts (credentials and experience of this panel can be found in Appendix C) reviewed a subject list containing 2,994 items in 53 categories. The panel reviewed the topics or categories developed by the author in the coding process. They rated the completeness of the category list and offered suggestions regarding using more appropriate category names, rearranging sub-items into more appropriate categories, and deleting extraneous categories. For instance, one of the 53 original categories was identified as Nature of Science (NOS), the panel suggested this category be subsumed under the larger category of Process of Science. After the panel review the content list contained 2, 900 items (it was suggested that itemizing science careers was unnecessary which resulted in fewer items) and 26 categories. Using the new content list the first 30 books were analyzed by the researcher once again to ensure agreement with the new content list structure and categories.

During the analysis of the *next* 30 books a list was created of new sub-items added to the content list that might have been covered in earlier books but not in depth. For instance, the Tydall effect (which is a characteristic of a colloid that has the ability to scatter light) was discussed at great depth in one textbook between books 30 and 60 and so this item was added to the content list. In earlier books the researcher may have overlooked this item due to small coverage or simply subsumed the item into the category of *colloid*. Concerned with accurate representation - a list of all such items was created (see Appendix D) and all books from 1 to 60 were reviewed to assess coverage of the newly added items. Not all new items found in textbooks 30 to 64 were added to this checklist, such as *quantum mechanics*, because this topic represented a new category and not a sub-item of an earlier created category. Only items that were subsets of earlier categories were subjected to this complete review. Analysis of books 65 through 70 produced no new items that required a reassessment of earlier texts. The final content list contained 3,533 items and 26 categories.

FLOW OF DATA COLLECTION

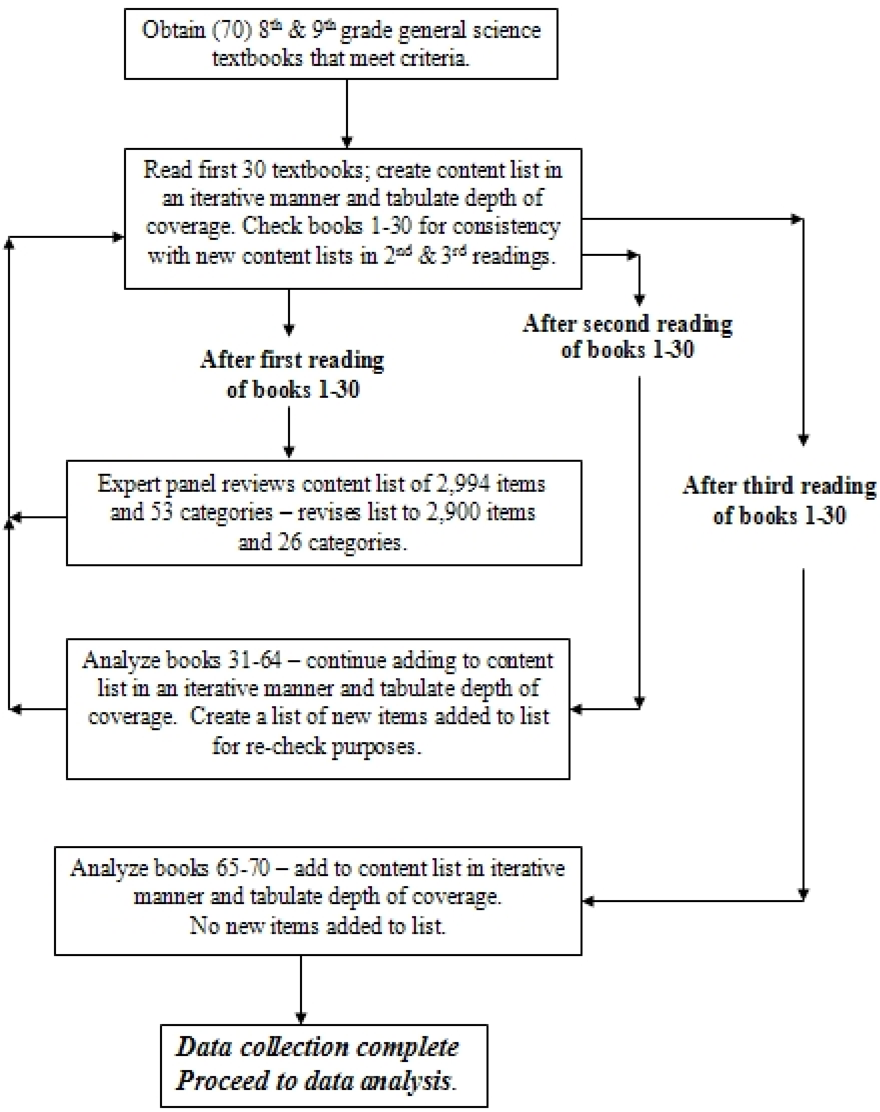


Figure 3.2 Flow of data collection

Issues in Data Collection

Data collection involved reading 70 complete science textbooks, creating a list of science content, and rating the depth of coverage for each content item. This section discusses the process of data collection, and the rational for and the manner of resolving exceptions to coding rules.

The content list was created to be inclusive of all topics found in the textbooks. Categories, organizing ideas, sub-categories, and items were created to assist the researcher in recognizing similar ideas across texts and to help identify new topics as they arose. Table 3.6 shows a portion of the content list that represents these groupings, with categories shaded in black with white lettering, organizing ideas in a larger black font with no shading, sub-categories shaded in green with black lettering, and items were indicted by black lettering and no shading.

Table 3.6 A category or theme from the content list representing a category,

Origins of Life	Category
Origins of life discussion	
proposed by Harold Urey-American scientist	
proposed by Stanley Miller-American scientist	
organic compounds amino acids, proteins create first living thing-virus	
Theory of Evolution	Topics that organize ideas
Natural Selection	Sub-category
survival of the fittest - examples of natural selection	
gradualism & punctuation models of change	Items
Fossils - as data and support - over 600mil yrs	
trilobites & brachiopods	
Extinct species	
Evolution - Decent & change	
Age of earth - about 5 billion yrs - Life about 2 billion yrs	
Main points of Darwin's theory:	
every living organ descended from another live organism	
More offspring are produced than required to replace parents both PL & AN	
a variety of traits among individuals & species	
conditions on earth change and will continue to change	

natural selection occurs each generation of plant and animal species
natural selection cause some species to become extinct
Natural causes some species to evolve into new different species
Comparative biochemistry and embryology support theory of E

The organizing ideas were not used in the data analysis; rather these items were simply to help the researcher find topics within the content list. Each sub-category was given a value of zero to three, depending upon the depth of coverage. The items identified the type of information or details that were covered under that topic and were also given a score between zero and three. The items are indicators of the discussion and may be covered superficially, in depth or not at all. For instance, book 52 (as shown in Table 3.7) discussed the *Gas Laws* in depth but did not cover any of the items listed, indicating perhaps a thorough but conceptual discussion of the topic.

Table 3.7 Data indicating thorough coverage of the sub-category [book 52]

Gas Laws	3
Charles Law Pressure Const & Temp UP then Vol UP	0
Boyles law - temp const & Pressure UP then Vol Down	0
Gay-Lussac's Law - Vol const & pressure UP then temp UP	0
Brownian motion	0
Ideal gas law - PV =nRT	0
vacuums - cause and effects	0
siphons	0
water pumps	0
compressed air - uses of	0
compressed C02 - uses of	0

Book 34 (shown in Table 3.8) illustrates in-depth coverage of a sub-category and in-depth coverage of several of the items in that category.

Table 3.8 Data indicating thorough coverage of the sub-category [book 34]

Gas Laws	3
Charles Law Pressure Const & Temp UP then Vol UP	0
Boyles law - temp const & Pressure UP then Vol Down	2
Gay-Lussac's Law - Vol const & pressure UP then temp UP	0
Brownian motion	0
Ideal gas law - PV =nRT	0
vacuums - cause and effects	3
siphons	3

water pumps	3
compressed air - uses of	3
compressed C02 - uses of	0

Exception 1 – Item Unrelated to Sub-category or Category

On several occasions an item was covered but without mention or discussion of the sub-category in which it was situated. An example of this can be found in books 61, 56 and 55 (shown in Table 3.9), where these books discussed S and P waves without any discussion on the subject of Earthquakes under the category of Geology.

Table 3.9 Data gathered indicating a discussion on an item without [books 55,56,61]

	BK61	BK56	BK55
Earthquakes	0	0	0
seismograph	0	0	0
epicenter, focus, fault lines	0	0	0
discussion on S-waves & P-waves	3	1	3
discussion on Love & Rayleigh waves	0	0	0
Richter scale	0	0	0
Mercalli scale - measures effects on local environment	0	0	0
causes of earthquakes	0	0	0

When this occurred, the item was evaluated and the sub-category heading remained zero and shaded blue to indicate this condition. 237 occurrences of this exception were noted. Considering that there were more than 3,500 items over 70 books, these types of exceptions account for approximately .096% of the data. The data analysis looks to organize the data into 26 categories from the aggregate scores of the sub-categories and portray commonalities and differences between books via these specific categories. Because these discarded items (S & P waves in the above example) did not contribute to the discussion regarding the sub-category (Earthquakes) or the category (Geology) in which the item was located these items were disregarded in the final analysis.

Exception 2 – Scientific Terms Not Used to Describe Concepts

In several books a topic was discussed but no mention of the scientific name or conceptual framework was mentioned. For instance, books 5, 11 and 12 thoroughly discuss inertia and action/reaction pairs without mentioning Newton or his laws. When this occurred, the item was evaluated and the sub-category heading was also evaluated and shaded pink to indicate this condition (shown in Table 3.10). There were 129 occurrences of this exception noted. All such occurrences were evaluated and included in the final analysis, because the topic in the sub-category (Newton's first law in this case) and category (Motion) was covered, even though the scientific designation was not used in the text.

Table 3.10 Data showing topic covered but no explicit mention of topic/ sub-category name.

Newton's first law	3	3	3
inertia	3	0	0
friction (static or kinetic)	3	3	3
coefficient of friction	0	0	0
sliding	1	0	0
rolling	1	0	0
fluid	1	0	0
Newton's second law	0	0	0
Newton's third law	3	2	2
action reaction forces	3	2	2
action reaction forces on different mass objects	0	0	0

Exception 3 – New Terminology

Over time, the name of a topic or idea may change in textbooks, although the description of the concept – what is referred to here as content - does not. An example of this is the hydrologic cycle. This term came into usage after 2006. Before this time all textbooks analyzed referred to this concept as simply the water cycle. New or different terminology for a single concept was added to the content list as an additional item under a sub-category, but this addition had no overall effect on the sub-category depth of coverage rating. These items are there to reveal differences in texts when conducting fine-grained analysis of textbook changes over time.

Exception 4 – Textbook Errors

As discussed in Chapter 2, textbooks are often rife with scientific, grammatical, and conceptual errors. During data collection, textbook errors were included in the data collection if, even though erroneous, they contributed to the depth of coverage. Sub-categories or items with no basis in fact were included in the content list, but were not included into the category average. The investigator noted errors in the physics, earth science and astronomy portions of the text. Due to her lack of background and experience in biology, geology and environmental science, errors in these areas were not ascertained and were most likely included in the content list.

Analysis of the Data

A descriptive analysis of the data was conducted in response to each of the research questions. A statistical analysis using mixed-design repeated measures ANOVA and Tukey tests were then performed to uncover significant changes between decades and themes. Finally a qualitative look at the textbook sample is offered to provide a context for discussion of the data findings.

FLOW OF DATA ANALYSIS

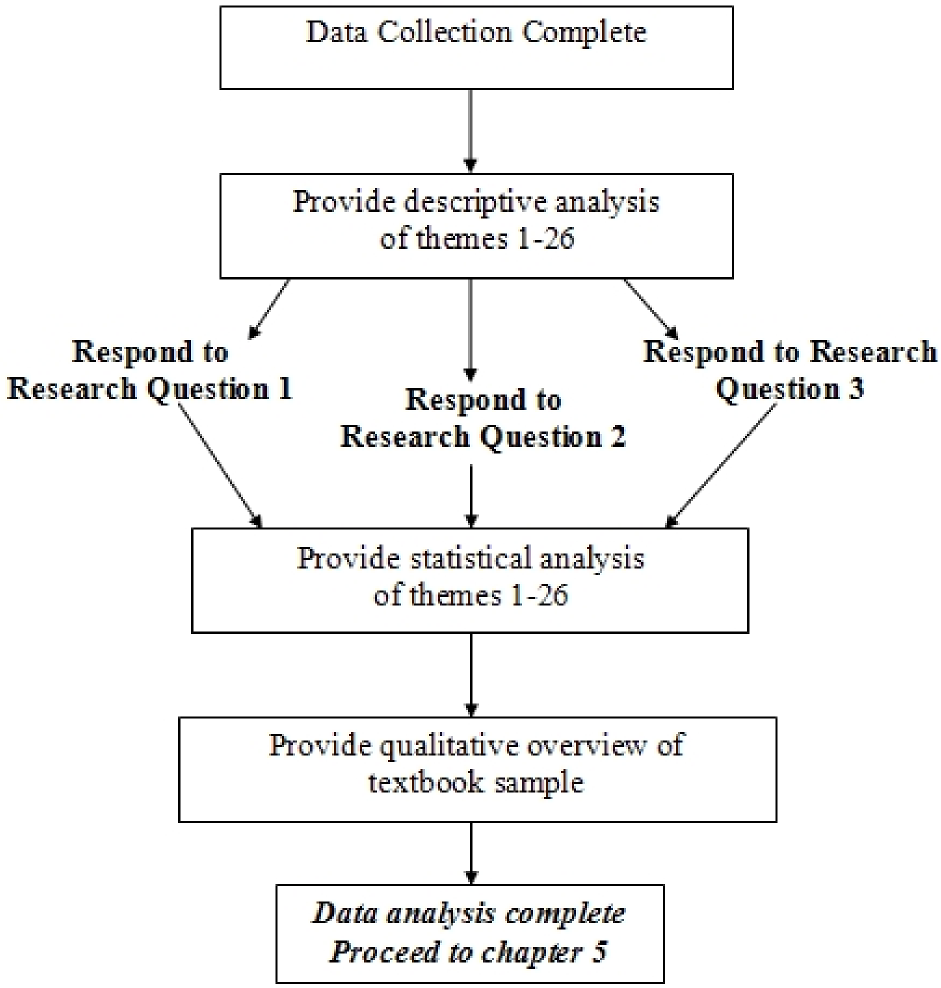


Figure 3.3 Flow of data collection

Summary

The purpose of this study is to examine 8th and 9th grade science textbooks over time to illustrate and analyze the science content expectations of the U.S. educational system. Seventy textbooks published over the past six decades were analyzed to investigate science topics and depth of coverage. The analysis cannot claim to know what science content children have learned during this period nor can it claim that children have been exposed to the exact science content revealed in these textbooks. However, this analysis shows the foundational science content expectations for 8^{th} and 9^{th} grade students as established by this representative sample of science textbooks. The next chapter will present graphic, qualitative, and quantitative representations of the data to reveal the areas and depth of science content coverage found in these texts.

CHAPTER FOUR – FINDINGS

Overview

The purpose of this study is to delineate the science content found in 8th and 9th grade general science textbooks from the 1950's to the present, and to document the emergence of new topics over time. In pursuit of these goals, this study addresses the following research questions: 1) what *specific science content* is presented in the selected 8th and 9th grade U.S. general science textbooks from the 1950s to the present day; 2) in what way has the *science content changed* in each of the selected 8th and 9th grade U.S. general science textbooks from the 1950s to the present day, 3) are new scientific findings reflected in 8th and 9th grade U.S. general science textbooks? The procedures and methods of data collection were discussed in the previous chapter. This chapter presents and describes the data found from the analysis of seventy 8th and 9th grade general science textbooks.

Descriptive Analysis

The dependent variables (specific content) in this study are categorical and ordinal. An examination of 70 books produced more than 3,500 discrete content items. The items for each book were given a value between 0 and 3 indicating the depth of coverage. Though the reliability of each variable is high, the number of Type I (false positive) errors arising from over 3,500 dependent variables would erode the credibility of any analytical outcomes. Therefore the 3,533 items were placed into 26 categories, as decided by an expert panel, to represent a logical and consistent overview of the science content. Table 4.1 lists all 26 themes. The total for each theme or category was calculated by taking the aggregate scores of the sub-categories in each section. Appendix D lists the subcategories under each theme.

Table 4.1 Twenty-six themes/categories used to organize science topic items.

Theme / Category List		Theme / Category Description
1	Process of Science	Discusses how science is conducted. Examples of sub-categories are: observations, hypothesis, experiments, scientific method, measurements.
2	Characteristics & Structure of Matter	Discusses the classification and basic structure of matter. Examples of sub-categories are: physical & chemical properties, periodic table, heat transfer, kinetic theory.
3	Chemical Interactions	Includes the process, types and effects of chemical interactions. Examples of sub-categories are: chemical equations, reaction rates, oxidation, acids and bases.
4	Organic Compounds	Includes carbon chemistry. Examples of sub-categories are: isomers, hydrocarbons, structural formulas.
5	The Atom & Nuclear Reactions	Includes topics regarding the size and understanding of atoms and nuclear reactions. Examples of sub-categories are: radioactivity, detecting radiation, changes in the nucleus.
6	Fluid & Gases	Discusses the properties of fluids and gases. Examples of sub-categories are: gas laws, buoyancy, pressure in fluids.
7	Motion	Describes the physics of motion. Examples of sub-categories are: Newton's laws, momentum, gravity.
8	Energy	Describes the nature and types of energy. Examples of sub-categories are: kinetic, potential, energy transformation.
9	Work, Power & Machines	Discusses the meaning of work and power and simple machines. Examples of sub-categories are: mechanical advantage, compound machines, efficiency.
10	Mechanical Waves & Sound	Includes information about the nature of waves in general and specifically discusses the nature of sound waves. Examples of sub-categories are: reflection, refraction, wave model of sound.
11	Electromagnetic Waves & Light	Includes information on radiant energy and the nature of electromagnetic waves. Examples of sub-categories are: index of refraction, lasers, and models of light.

12	Electricity	Discusses the nature and production of electricity. Examples of sub-categories are: electric currents, resistance, electric circuits.
13	Electromagnetism & Magnetism	Describes the nature of and uses of magnetism. Examples of sub-categories are: earth as a magnet, electromagnets, and magnetic fields.
14	Astronomy	Describes the heavenly bodies and our understanding of them. Examples of sub-categories are: sun, moon, black holes, and galaxies.
15	Geology	Includes information regarding the structure and features of the earth. Examples of sub-categories are: volcanoes, erosion, rock types.
16	Weather	Discusses weather on earth. Examples of sub-categories are: weather maps, air pressure, wind, precipitation.
17	Ecology	This category not only discusses types of climates and environments but also includes information regarding conservation of resources. Examples of sub-categories are: ecosystems, food chain, food resources, air pollution, water conservation.
18	Diversity of Life	Discusses classification of life on earth. Examples of sub-categories are: biological classification and living things discussion.
19	Origins of Life -	Includes information regarding the origin and evolution of life on earth. Examples of sub-categories are: natural selection, fossils, evidence to support theory of evolution.
20	Characteristic of Living Things	Discusses processes and nature unique to living things. Examples of sub-categories are: photosynthesis, specialized cells, diffusion.
21	Animal Organ Systems	Describes the anatomy and function of animal organ systems. Examples of sub-categories are: muscles, bones, digestion.
22	Genetics	Includes information describing the nature and function of genetics. Examples of sub-categories are: inheritance, genes & chromosomes, DNA, RNA
23	Human Health	Describes ways in which humans become sick and methods to become and stay healthy. Examples of sub-categories are: microbe carriers, poisons, nutrients, emotions.
24	Technology	This section describes how specific machines work as discussed within the body of the text and presents discoveries and products of science –documenting standalone information unrelated or disconnect to the body of the text – usually side bar, end of chapter or end of unit narratives. Examples of items in this category: parts and function of internal combustion motor, or nano technology
25	History of Science	This section looks at the history of science via the scientist and historical narratives. Examples of items in this category are: Robert Boyle, the history of flight.
26	Scocioscienific Issues (SSI)	This category presents topics that were socioscientific in nature. Either two sides of the topic were presented or a moral was to be extracted from the narrative. Examples of items in this category are: pros and cons of gasohol, Industry and the power and function of industry in society.

The categories are arranged in loose groupings; categories 2-4 are classic chemistry topics, categories 5 & 6 bridge both chemistry and physics, categories 7-13 are classic physics topics, categories 14-16 are often covered in earth science, 17-23 are biology topics and categories 24-26 are not science themes, per se, but represent outcomes, products, qualities or descriptions of science. All sub-category scores for each theme were averaged and used to represent that theme or category for each book. Each of the 70 textbooks had a value between 0 and 3 for each of the 26 categories. Table 4.2 shows the highest, lowest and mean values in each category array, showing 70 values representing the degree of content coverage for every text. Unlike all other themes listed, Technology, History of Science and SSI categories all have high values below 0.40 and mean values below 0.01.

Table 4.2 - Each category has 70 values representing all textbooks analyzed. This table displays the max, min, and means in each category.

Theme	process	matter	chem_int	organic	motion	fluid_gas	energy	wrk_pwr	mechwave
H	1.65	2.48	2.64	3.00	2.28	2.86	2.57	2.30	2.58
L	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M	0.74	1.55	1.09	1.12	0.95	1.30	1.24	1.33	1.04
Theme	Electro wave	electricity	electromag	atom	astronomy	geology	weather	ecology	diverslife
H	2.43	2.84	3.00	2.69	2.20	2.17	3.00	1.78	3.00
L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M	1.05	1.40	1.58	1.29	0.65	0.64	0.97	0.63	0.66
Theme	Origins life	charactliving	animalsys	genetics	humhealth	technol	history	ssi	
H	3.00	2.00	2.08	2.20	1.97	0.34	0.40	0.38	
L	0.00	0.00	0.00	0.00	0.00	0.11	0.12	0.10	
M	0.16	0.65	0.60	0.43	0.42	0.00	0.01	0.00	

These differences in values are due to the differences in number of the sub-categories. Categories 1-23 encompass specific scientific areas (e.g., Motion, Chemical Interactions, etc.), which have numerous dimensions and avenues of exploration and discussion but each sub-category must be held within the parameter of the thematic topic;

because of this, the number of sub-categories is bounded. Categories 24-26, however, have an *exponentially greater* number of possible sub-categories, since these categories are not bounded by a single theme but rather a characteristic or quality of science. When comparing books across categories this becomes an important issue, as can be seen in the values in Table 4.3. To maintain an equitable assessment of the scientific content, frequency tables were employed to analyze the sub-categories for themes 24-26.

The independent variables (books) are continuous interval scale data ranging from 1952 to 2008. This study analyzed 70 general science books spanning more than six decades, as shown in Table 3.2 and the textbook bibliography.

Research Question One

1.) What *specific science content* is presented in each of the selected 8th and 9th grade U.S. general science textbooks from the 1950s to the present day? To address the question as the depth of presentation, graphs were constructed to display this information for each decade investigated. To do this, sub-categories for themes 1-23 were averaged to obtain a depth of coverage value for each theme for every book. The scores for each book were then used to create a box and whisker plot that displays the depth of coverage for each of the first 23 categories for each decade investigated. These graphs show the median, 1st and 3rd quartiles, highest and lowest values, outliers; the red dot indicates the mean value in each array. Additional tables for each decade were constructed to display the frequency of items covered fully (3), moderately (2), slightly (1) and not at all (0) in categories 24-26 for each decade. These frequency charts display all non-zero values for depth of coverage in each decade from the possible 241 sub-categories in category 24

(Technology), 348 sub-categories in category 25 (History of Science) and 109 sub-categories in category 26 (SSI).

Content Coverage in the 50s

As seen in Figure 4.1, eleven books from the 1950s were evaluated in this sample. All themes were represented in this decade. Theme 19 had a mean score of 0.9 derived from two books. Theme 16 (Weather) was the category with the highest mean score of 1.88 derived from contributions from all eleven books reviewed in that decade. Theme 8 (Work, Power & Machines) and theme 18 (Diversity of Life) were the second and third highest categories with mean scores of 1.56 and 1.50. The short boxes for themes 1 (Process of Science), 4 (Organic Compounds), 5 (Motion), and 17 (Ecology) show very small variability in the representation of these topics, indicating that books reviewed in this decade were in agreement upon the depth of coverage assigned to these themes. The greater variability shown in the other themes indicates that though there was agreement that the topics should be represented there was no consensus on the optimal depth of coverage. Frequency charts, Figure 4.2, show that every book reviewed in this decade discussed theme 24 (Technology) at least 4 times in depth (scored a 3); the highest number of in-depth discussions found in one book was 36. All books reviewed touched upon theme 25 (History of Science) a minimum of 9 times. The highest number of historical discussions in one book was 57. Though each book discussed at least one social issue, theme 26 (SSI) was found an average of 4 times per textbook for this decade.

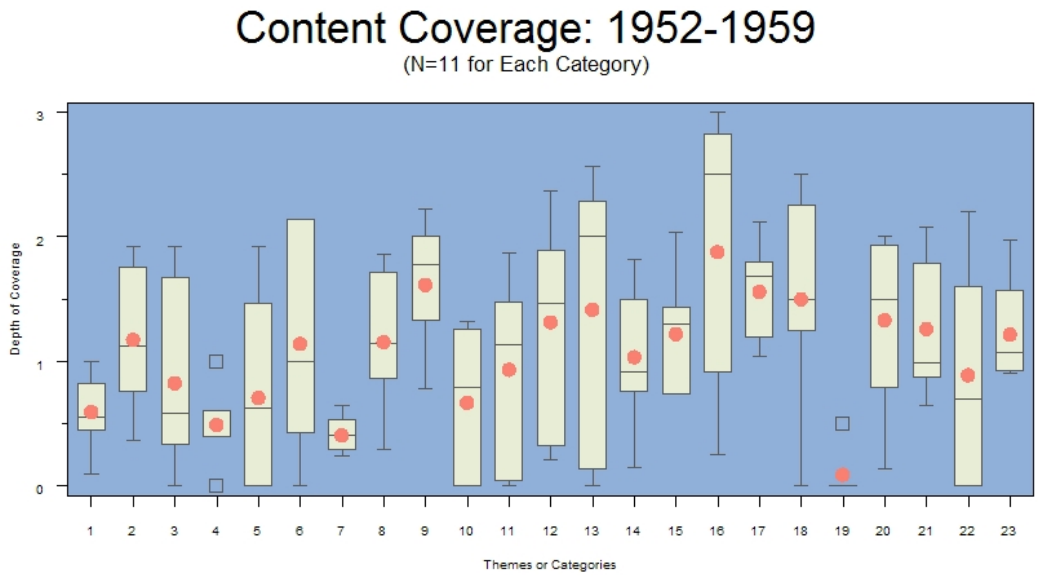
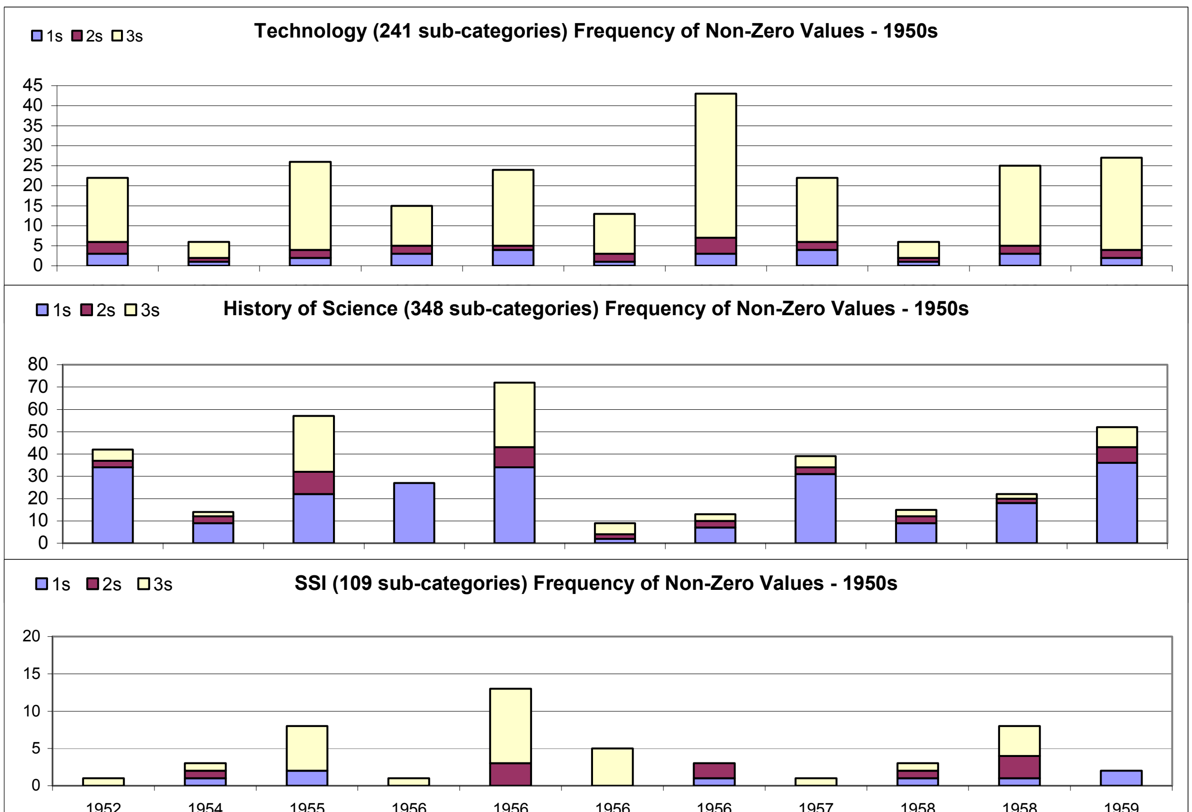


Figure 4.1 - Content coverage for 11 books from 1952-1959



These charts indicate the number and the freqeuncy of non-zero sub-categories in themes 24-26. There were 11 books reveiwed published from 1952 to 1959.

Figure 4.2 Frequency charts for categories 24-26 - 11 books from 1952-1959

Content Coverage in the 60s

As seen in Figure 4.3, fifteen books from the 1960s were evaluated in this sample. In this decade all themes are represented and as in the previous decade theme 19 (Origins of Life) is the least represented category, as shown in Figure 4.3. Three books contributed to theme 19 with one book covering the topic in depth (score of 2.5). Theme 16 (Weather) had the highest mean score of 1.65. Themes 13 (Electromagnetism & Magnetism), 12 (Electricity) and 9 (Work, Power & Machines) were the next categories with the highest mean scores of 1.5, 1.44 and 1.43. As seen in the last decade, the themes 1 (Process of Science), 4 (Organic Compounds), 6 (Motion), and 17 (Ecology) show relatively small variability, indicating agreement on the depth of coverage devoted to these themes. The greater variability shown in the other themes indicates agreement on the topics to be covered but no consensus on the depth of coverage. Figure 4.4 show frequency charts for the content coverage provided in categories 24-26 in books reviewed from 1960 to 1969. During this time all books presented theme 24 (Technology) a minimum of 4 times in depth (score of 3) with the highest number of discussions of any depth for a single book being 28. Books in this sample that discussed theme 25 (History of Science) ranged from a low of 7 and a high of 72 references in a single book (inclusive of all levels of coverage). One book provided 13 topics on theme 26 (SSI); two books did not cover the theme at all and the remaining books provided fewer than 7 non-zero scores each on this theme.

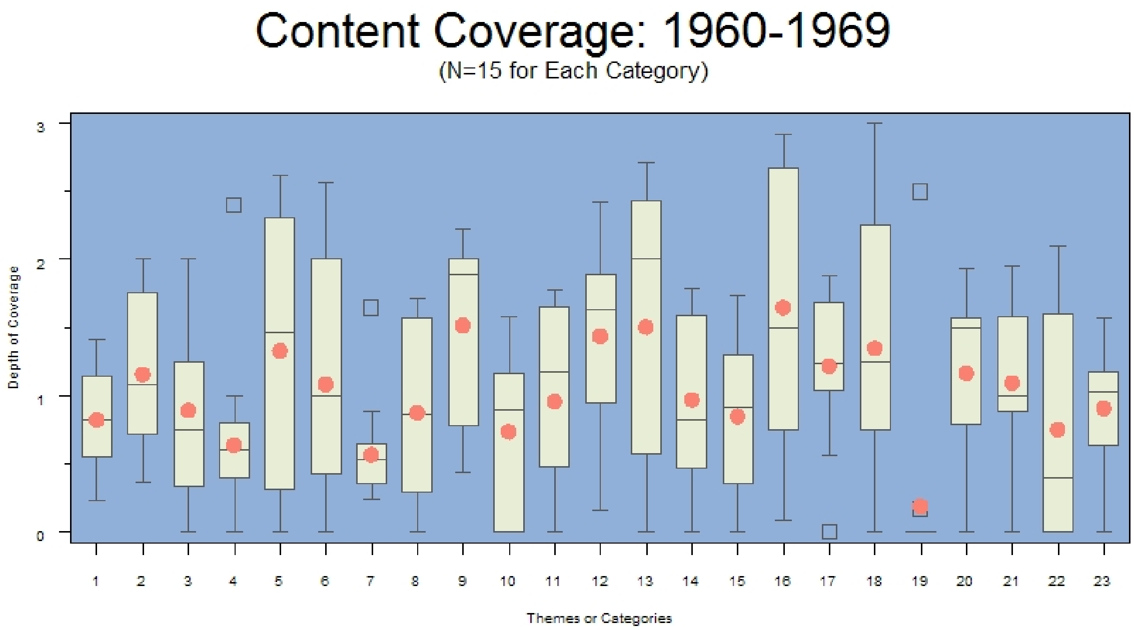


Figure 4.3 - Content coverage for 15 books from 1960-1969

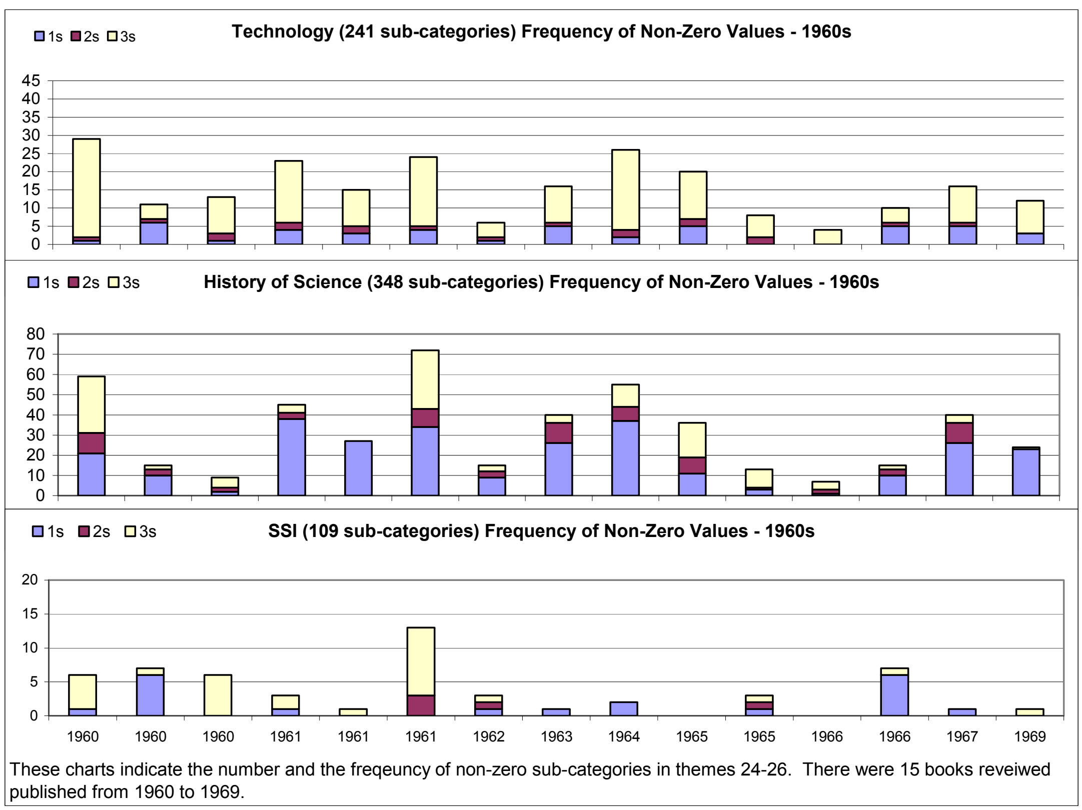


Figure 4.4 - Frequency charts for themes 24-26 in 15 books from 1960-1969

Content Coverage in the 70s

As seen in Figure 4.5, eleven books from the 1970s were evaluated in this sample. During this time a shift in the importance of topics is apparent. In the previous decades themes 14-23 (see Figure 4.3) had means that were near or above a depth of coverage of 1 (excluding theme 19); in the 70s the means of these themes gather around a depth of 0.5. Theme 16 (Weather), 15 (Geology), 14 (Astronomy) have waned in coverage during this decade. The opposite appears for themes 2-5 which had means close to 0.5 in previous decades and in this decade those means rose to 1. Both theme 19 (Origins of Life), which continues to have an average coverage of 0.0, and theme 18 (Diversity of Life) were represented by only two books for this decade (the same books covered both themes). Theme 12 (Electromagnetism & Magnets) displayed large variability in coverage in the earlier decades; however, in this decade theme 12 as well as theme 4 (Organic Chemistry) seem to exhibit even larger variability than any other topic presented, indicating perhaps a diverse assessment of the value of coverage of these topics. Themes 24-26 are displayed in the frequency chart shown in Figure 4.6. Theme 24 (Technology) was presented in depth (score of 3) 22 times in one book; the next highest occurrence was 15. The remaining books reviewed included this theme less than 9 times. The History of Science (theme 25) was also not evenly discussed in the sample for this decade. In one book 70 historical references were made, in another 41 and the remaining books made less than 20 references to historical figures or past scientific endeavors. With regard to social issues in science (SSI - theme 26) 4 books in this sample did not introduce this theme at all and the remaining books presented the topic less than 6 times.

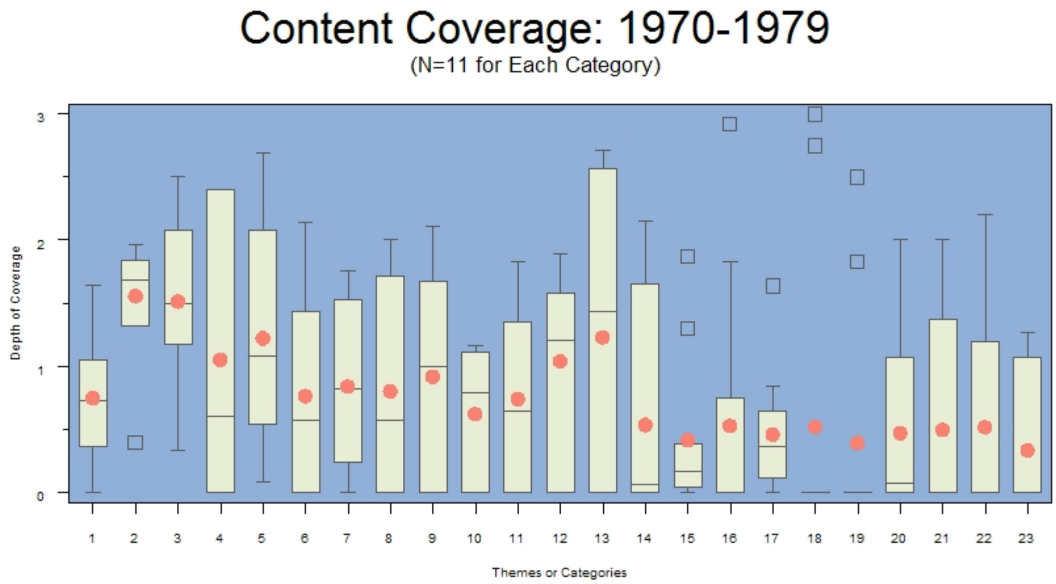
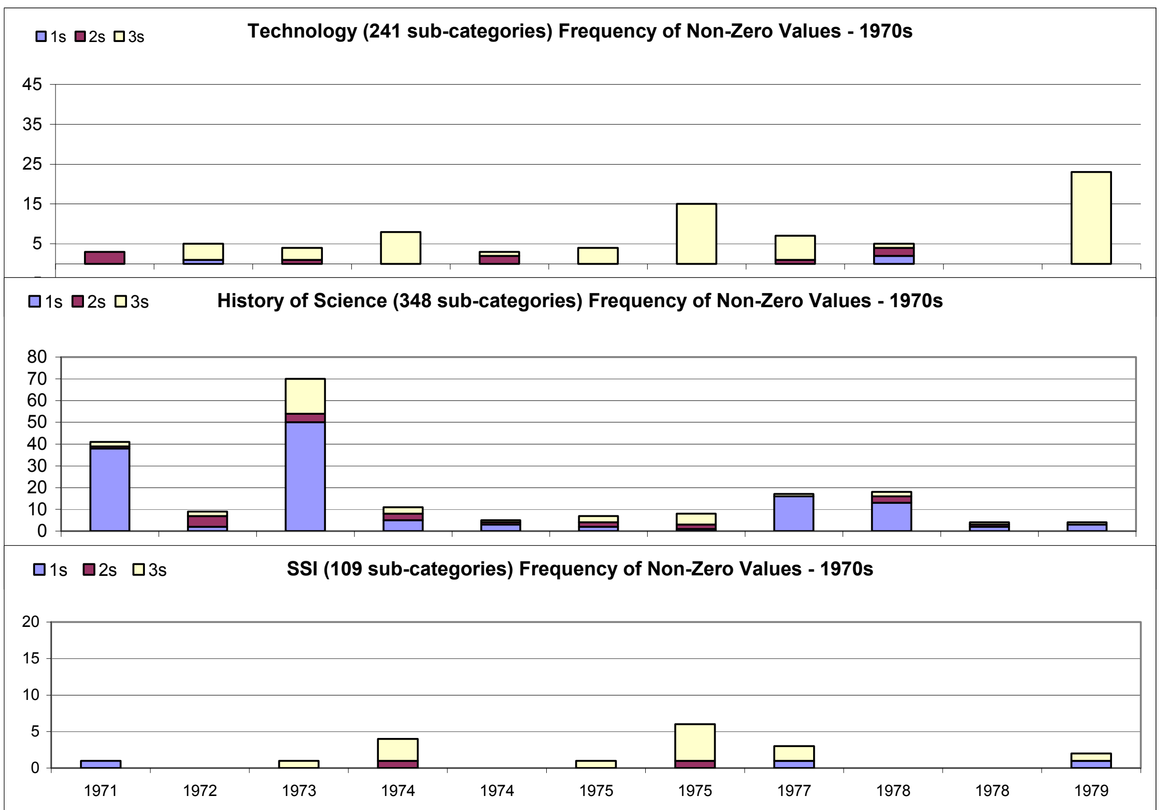


Figure 4.5 - Content coverage for 11 books from 1970-1979



These charts indicate the number and the freqeuncy of non-zero sub-categories in themes 24-26. There were 11 books reveiwed published from 1970 to 1979.

Figure 4.6 - Frequency chart for categories 24-26 for 11 books from 1970-1979

Content Coverage in the 80s

As seen in Figure 4.7, twelve books from the 1980s were evaluated in this sample. The trend of declining coverage in themes 14-23 and increasing coverage of themes 1-5 as seen in the sample from the 70s became more pronounced in the 80s. Themes 14 to 23 are barely represented with average depth of coverage on or near 0.0; the exception being theme 17 (Ecology) that had an average coverage of 0.5. The remaining themes have relatively smaller variability than seen in earlier decades, however; the exception to this trend is theme 4 (Organic Compounds) which continues to be a contested topic with regard to depth of coverage. Because of the agreement among the majority of authors in this sample there are more outliers than in previous decades. Theme 12 (Electricity and Magnetism) enjoys the highest mean (2.06) for books reviewed in the 80s. . The ambiguity of the previous decades regarding the value of this topic seems to have resolved itself. Theme 2 (Matter Characteristics & Structure) has the second highest mean (1.86), with 11 (Electricity) following closely with a mean of (1.78). Only one book covered themes 18 (Diversity of Life) and 19 (Origins of Life) and it does so in depth (2.25 and 3.0 respectively). On the subject of Technology (theme 24) frequency charts (Figure 4.8) show that there were more in depth (score of 3) coverage than minimal (score of 1) coverage; however, the number of overall non-zero scores averaged 12 per book. Theme 25 (History of Science) had more minimal coverage than in depth coverage and averaged 19 instances per book. Not all books in this sample addressed theme 26 (SSI). One book addressed social issues in science 17 times; all other books in the sample addressed this topic less than 10 times.

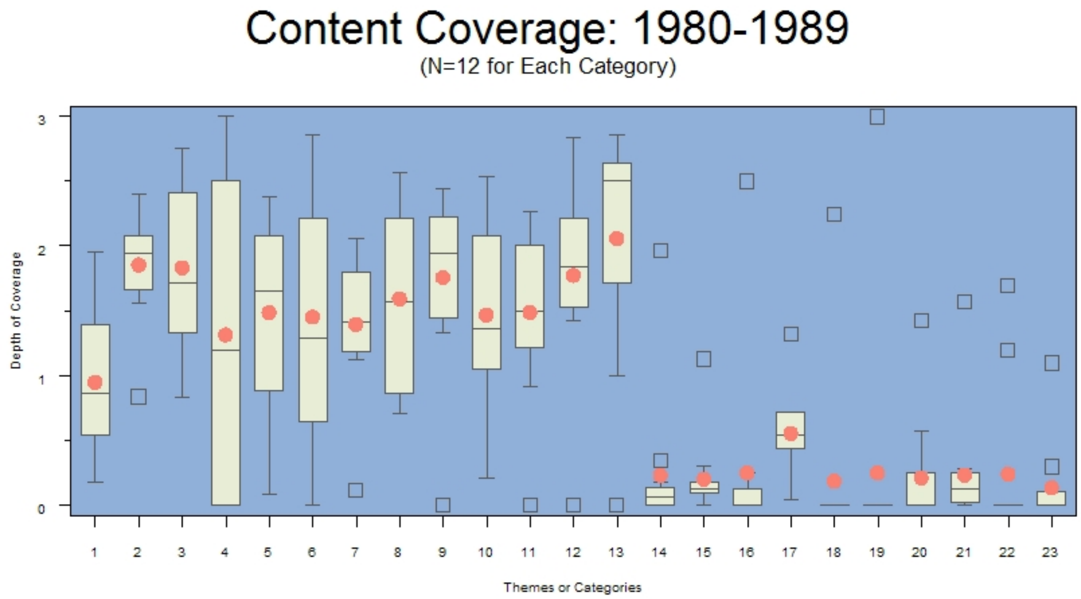
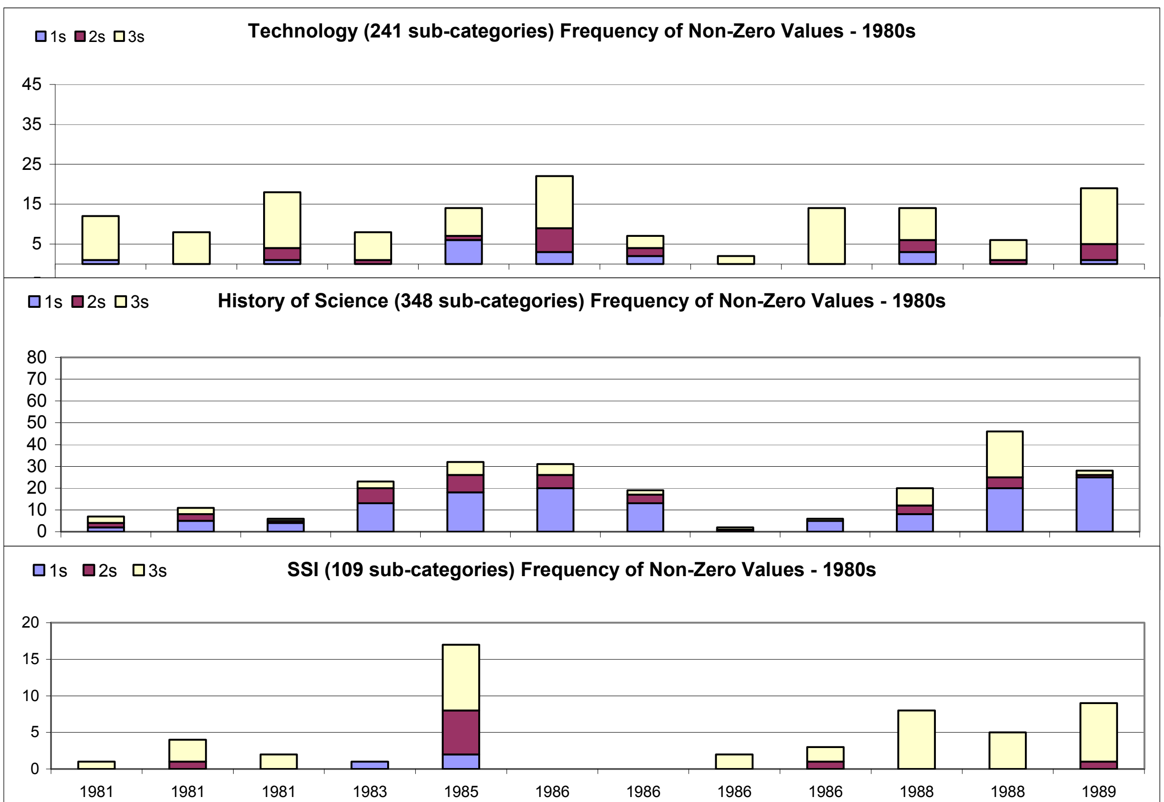


Figure 4.7 - Content coverage for 12 books from 1980-1989



These charts indicate the number and the freqeuncy of non-zero sub-categories in themes 24-26. There were 12 books reveiwed published from 1980 to 1989.

Figure 4.8 Frequency chart for categories 24-26 for 12 books from 1980-1989

Content Coverage in the 90s

As seen in Figure 4.9, eleven books from the 1990s were evaluated in this sample. The textbooks in the sample reviewed during this decade display a greater consensus on the treatment of many of the themes represented. The reduced number of outliers and smaller box sizes in this section indicate greater agreement on the depth of coverage. The consensus appears to be that very little attention is warranted for themes 14 (Astronomy), 15 (Geology), 16 (Weather), 18 (Diversity of Life), 19 (Origins of Life), 20 (Characteristics of Living Things), 21 (Animal Organ Systems), 22 (Genetics) and 23 (Human Health). The indecision of earlier decades regarding theme 4 (Organic Compounds) seems to have been resolved in the 90s when most textbooks covered the topic in some depth. With one exception, all outliers are 0.0, indicating there was close agreement on the depth of coverage for this theme. Figure 4.19 shows the frequency charts for themes 24-26. There is almost double the average number of non-zero scores appearing in the category of Technology (theme 24) compared to the previous decade (21 in the 1990s, 12 in the 1980s) and an equal number of non-zero scores compared to the 1950s (21 in the 1950s). Under this theme an average of 15 non-zero scores per book were covered in depth (score of 3). The History of Science (theme 25) was represented in all textbooks during this decade; the lowest and highest number of references per book was 10 and 36. Theme 26 (SSI) was not represented in all books in this sample. However, the average number of non-zero scores per book in this sample doubled compared to earlier decades. This decade also had the highest average number of non-zero score per book for this theme (8 items) compared with all the decades reviewed (50s – 4, 60s – 4, 70s – 2, 80s – 4, 90s – 8, 00s – 6).

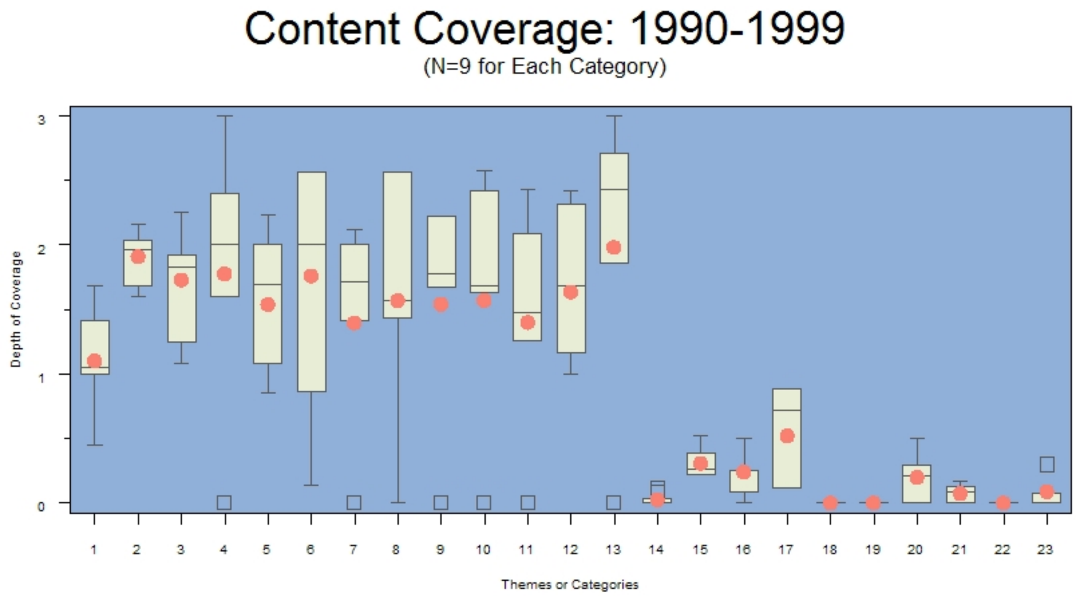


Figure 4.9 - Content coverage for 9 books from 1990-1999

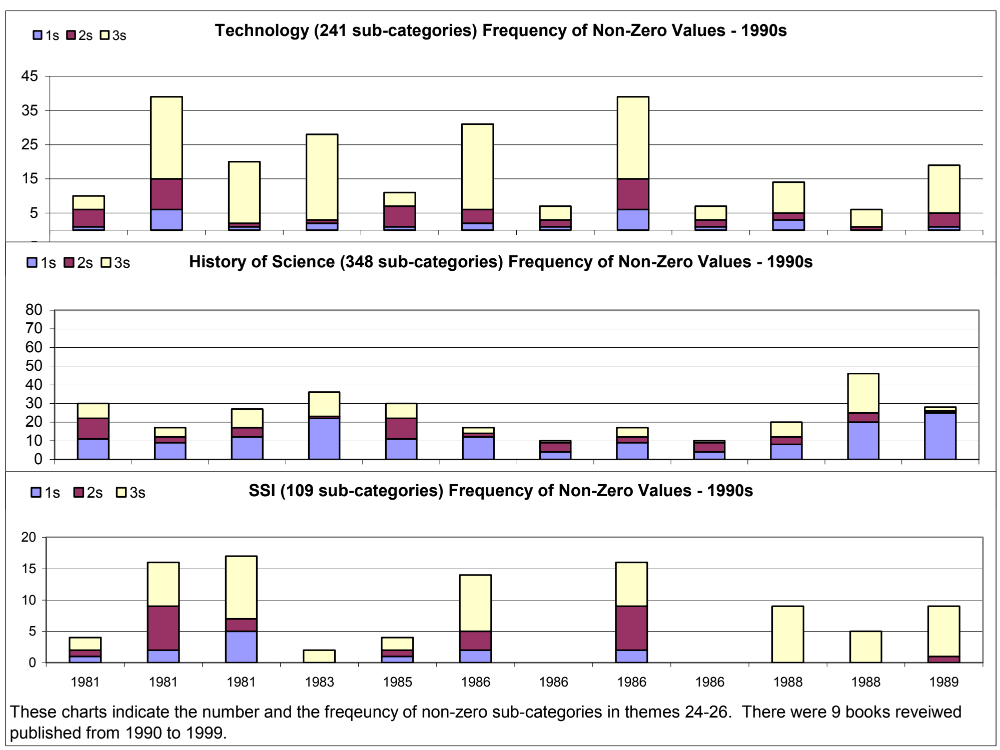


Figure 4.10 - Frequency chart for categories 24-26 for 9 books from 1990-1999

Content Coverage in the 2000s

As seen in Figure 4.11, twelve books from the 2000s were evaluated in this sample. The consensus regarding depth of coverage enjoyed in the previous decade is no longer evident in content coverage for the present decade. Theme 19 (Origin of Life) was not represented by any of the books in the sample and theme 18 (Diversity of Life) was discussed in only 1 book; theme 22 (Genetics) was represented in 2 books out of the 12 books in this sample and theme 8 (Energy) appears to be the category with the least agreement on the appropriate depth of coverage. Theme 13 (Electromagnetism) was also a category that displayed little agreement on depth of coverage. Theme 1 (Process of Science) appears to be the category with the least variability and no outliers, suggesting agreement that this topic should be represented and given a depth of coverage close to 1. Theme 2 (Characteristics & Structure of Matter) has the highest mean in this decade and also displays a small variability suggesting agreement that this topic deserves a high depth of coverage. Frequency tables for themes 24-26 are shown in Figure 4.12. Coverage for theme 24 (Technology) in this sample ranges from a high of 29 total non-zero scores in one book to a low of 4 non-zero scores. Almost all books cover this theme in depth (score of 3). All books reviewed for this decade address theme 25 (History of Science). The book with the most coverage provided 69 references to this theme, the book with the least coverage made a total of 6 references. Theme 26 (SSI) averaged 6 references to social issues per book in the sample reviewed.

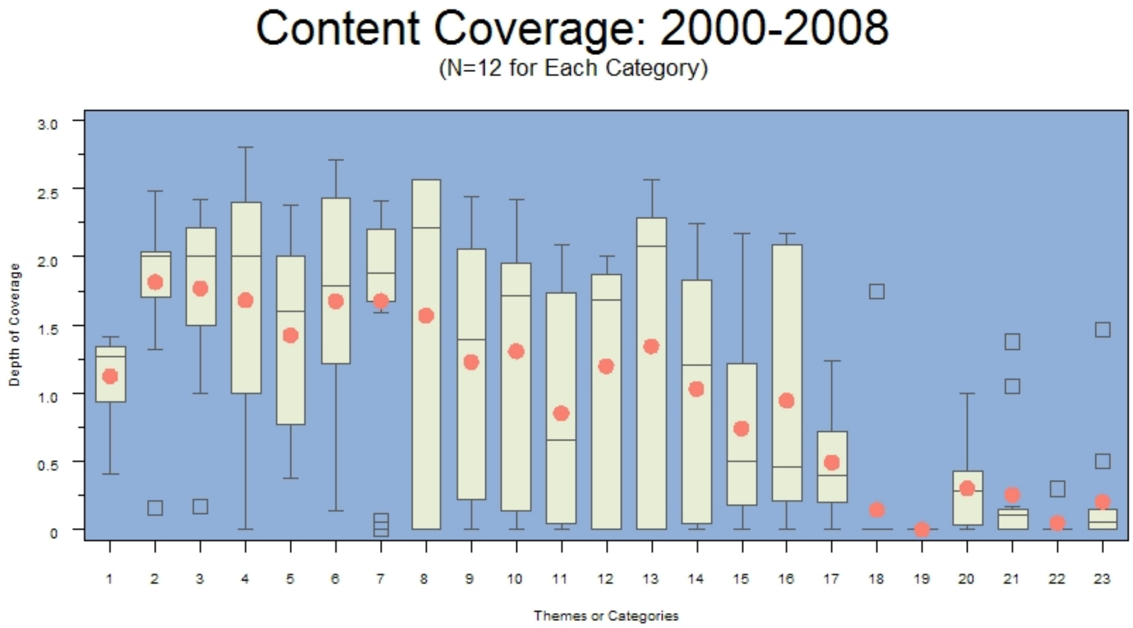


Figure 4.11 Content coverage for 12 books from 2000-2008

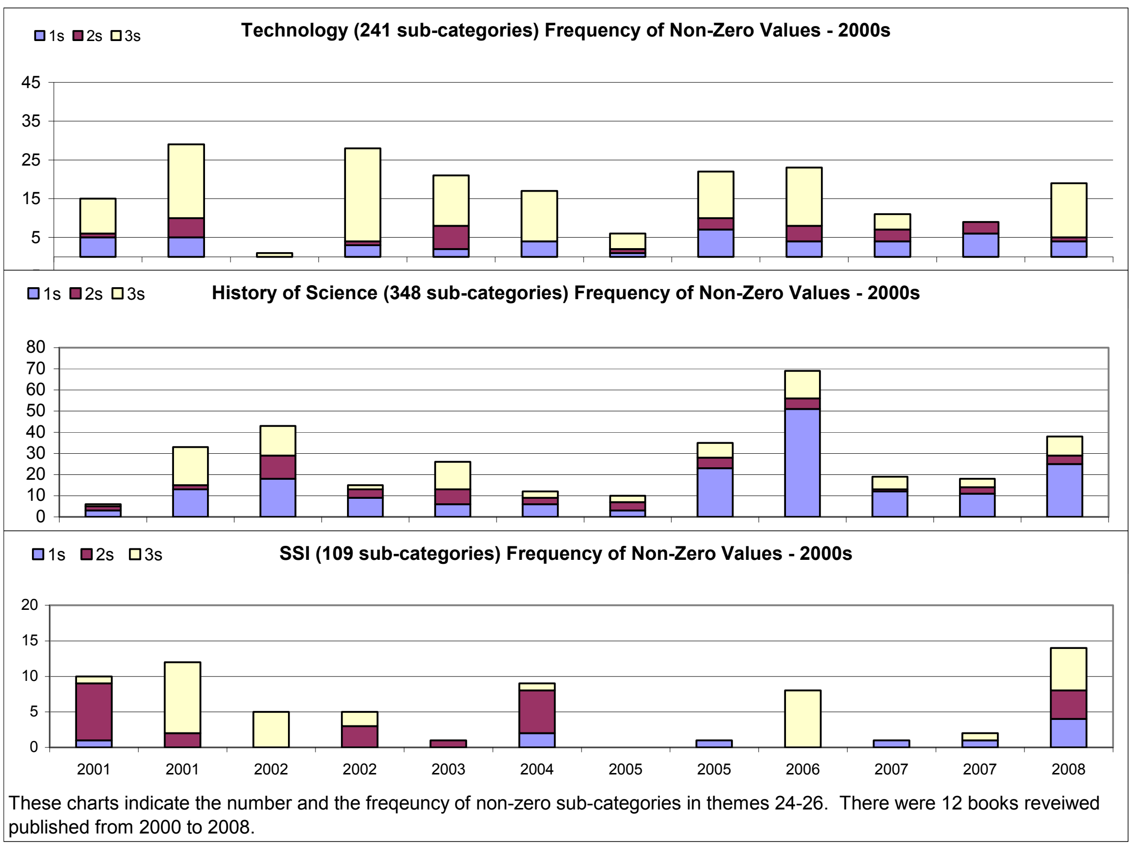


Figure 4.12 Frequency chart categories 24-26 for 12 books from 2000-2008

Research Question Two

2.) In what way has the *science content changed* in each of the selected 8th and 9th grade U.S. general science textbooks from the 1950s to the present day? To examine this question, separate scatter plots were created to reveal relationships or associations that may be perceived between depth of coverage and textbook publication year. Such relationships manifest themselves by any non-random structure in the plot. In the review of these plots a fairly even distribution within 2 blocks or 1 point is operationalized as a low or small variability, a distribution over 3 blocks or 1.5 points is operationalized as a moderate variability, and a distribution over 4 blocks or 2 points is operationalized as a high distribution. Although causality implies association, association does not imply causality: these plots are simply used as diagnostic tools to better inform our understanding of these themes over time. Each plot investigates one theme (from 1-23) for all books (70) in the sample. For themes 24-26 the mean of frequencies were calculated for each level of coverage over each decade. Three themes (24-26) over six decades are displayed together in Figure 4-36.

Processes of Science

As seen in Appendix D, the Process of Science encompass sub-categories that describe how science is conducted, the characteristics of those who carry out scientific endeavors and the tools of science such as observations, experiments and measurements. Figure 4.13 shows how this theme was portrayed within the textbook sample. There is no great variability within each decade and the plot appears to remain relatively flat around 0.75 depth of coverage. This graph indicates a consistent and fairly even (minimal) representation of this theme over time.

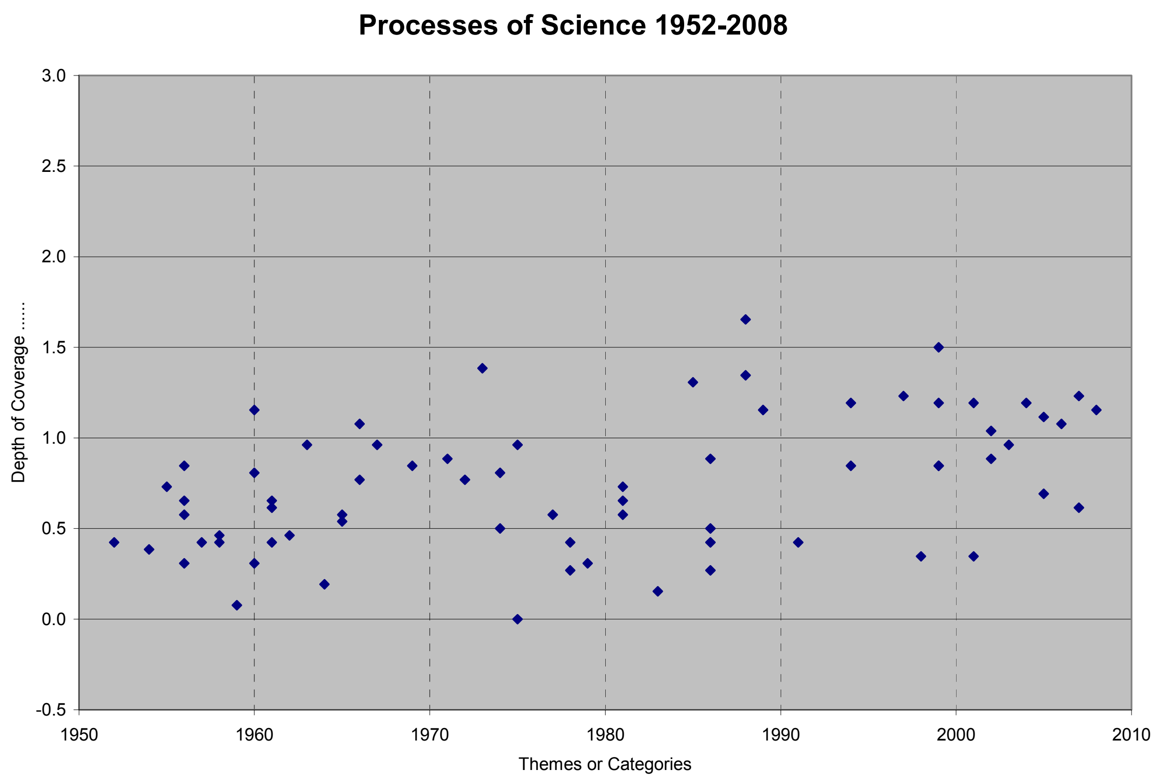


Figure 4.13 Depth of Coverage for Category 1 – Process of Science - for all books (70) - 1952-2008

Matter Characteristics & Structure

This theme describes the physical properties of matter. The concept of elements, compounds, and mixtures are discussed as well as the effect of temperature on matter and the theories of molecular energy and movement. (see Appendix D) Figure 4.14 shows how this theme was portrayed within the textbook sample. The scatter plot shows a greater variability in the 50s and 60s and a decreasing variability in depth of coverage over time. Not only does the variability decrease but also the average depth of coverage increases over time. These factors seem to indicate a more consistent valuing of this topic after the 70s than seen in the 50s and 60s.

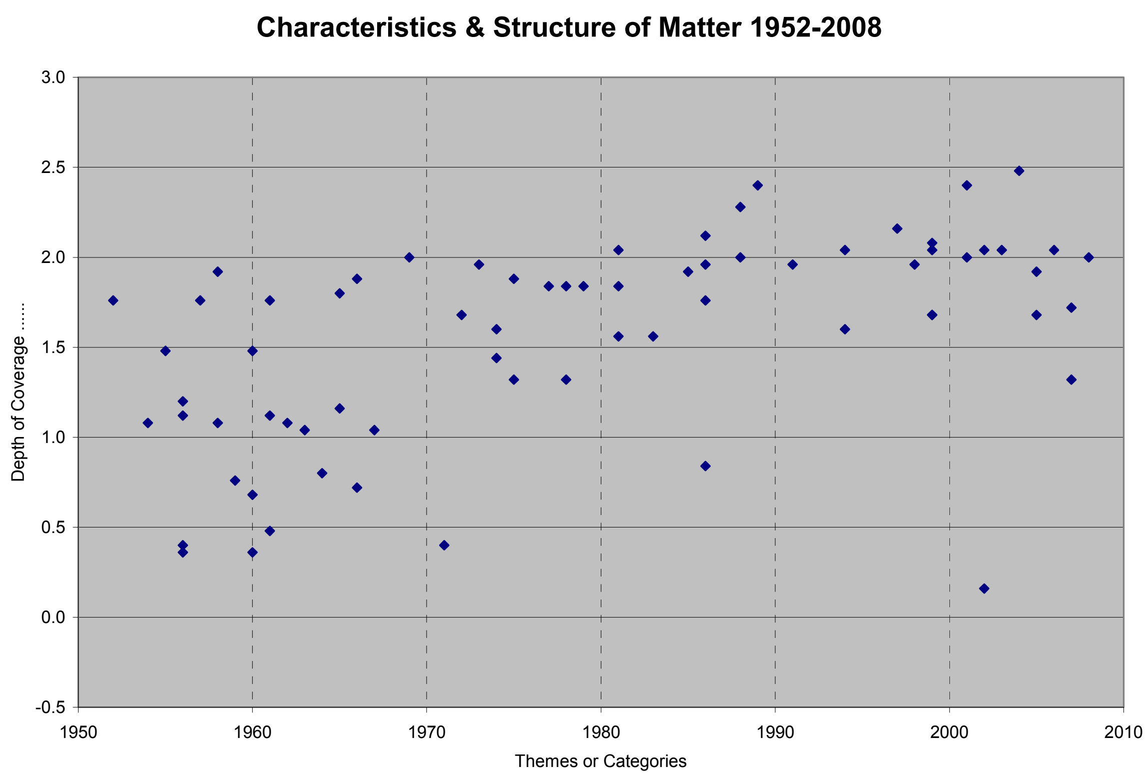


Figure 4.14 Depth of Coverage for Category 2 –Characteristics & Structure of Matter - for all books (70) - 1952-2008

Chemical Interactions

The theme 'Chemical Interactions' includes topics such as chemical properties, equations, reaction and bonds as well as discussions regarding acids and bases (see Appendix D). Figure 4.15 shows how this theme was portrayed within the textbook sample. The graph exhibits a highly variable depth of coverage for this topic. Although the degree of coverage has increased over time the variability of in depth of coverage has stayed consistently high. This graph indicates an increase in coverage in later decades as compared with earlier decades.

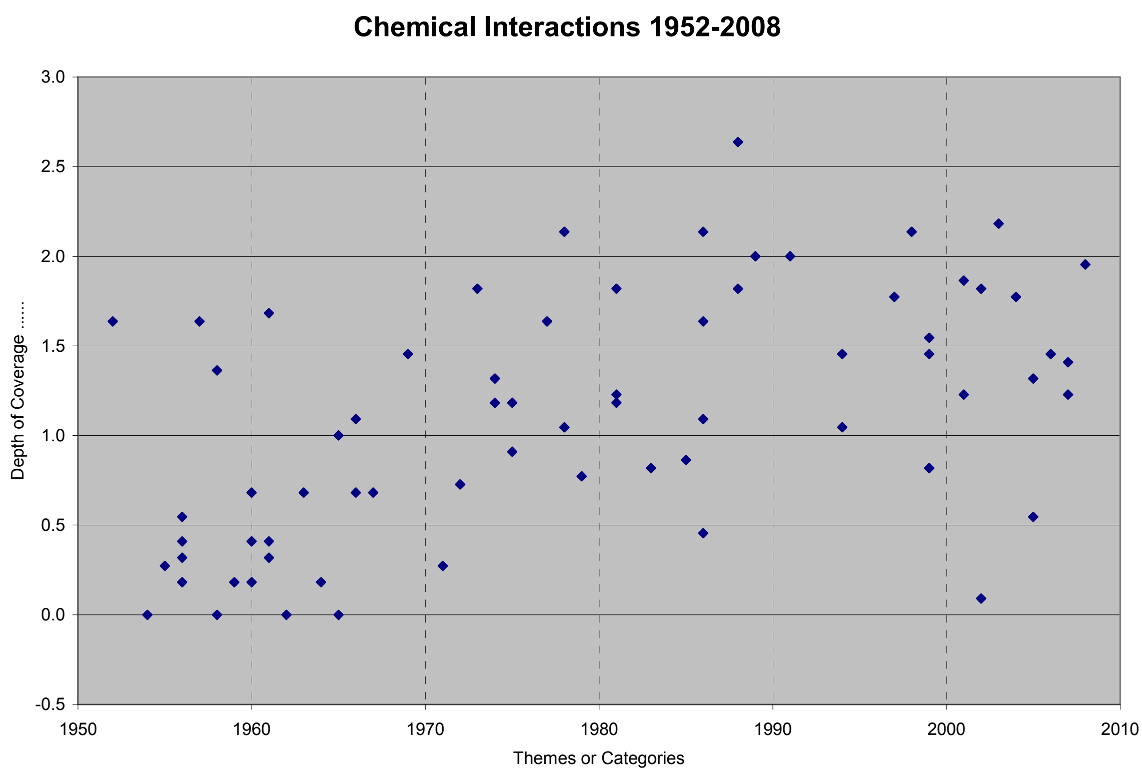


Figure 4.15 Depth of Coverage for Category 3 – Chemical Interactions - for all books (70) - 1952-2008

Organic Compounds

Organic Compounds is a topic that describes the structure, nature and uses of carbon compounds (see Appendix D for sub-categories). Figure 4.16 shows how this theme was portrayed within the textbook sample. The plot shows small variability and low depth of coverage in the 50s and 60s. The variability of coverage in the 70s and 80s is extremely high; after the 80s there is less variability and greater depth of coverage. In the last 20 years more than 80% of textbooks represented this theme in some depth (1.5 or higher). This graph indicates increased (minimal-high) representation of this theme over time.

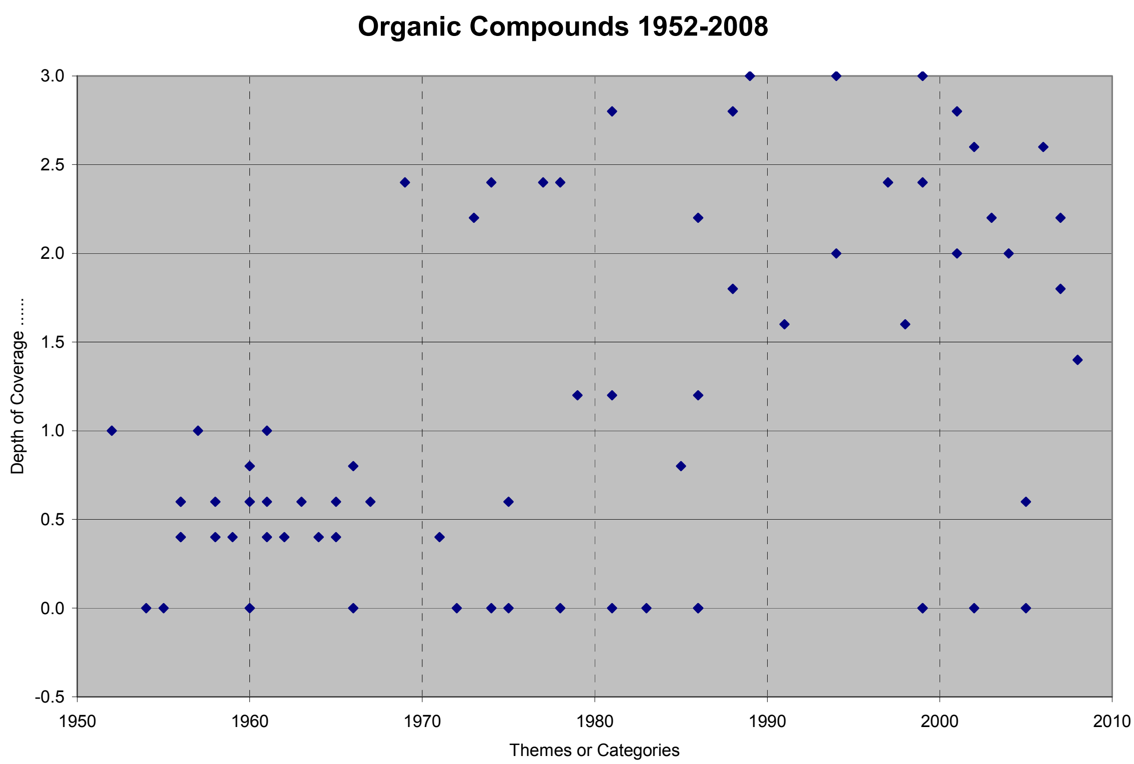


Figure 4.16 Depth of Coverage for Category 4 – Organic Compounds - for all books (70) - 1952-2008

The Atom & Nuclear Reactions

This category covers topics such as descriptions of atomic models, radioactivity and changes in the nucleus (see Appendix D). Figure 4.17 shows how this theme was portrayed within the textbook sample. The graph shows high variability of coverage over each decade with no consensus on depth of coverage. There has been no agreement or change in agreement on representation of this theme over the past 60 years.

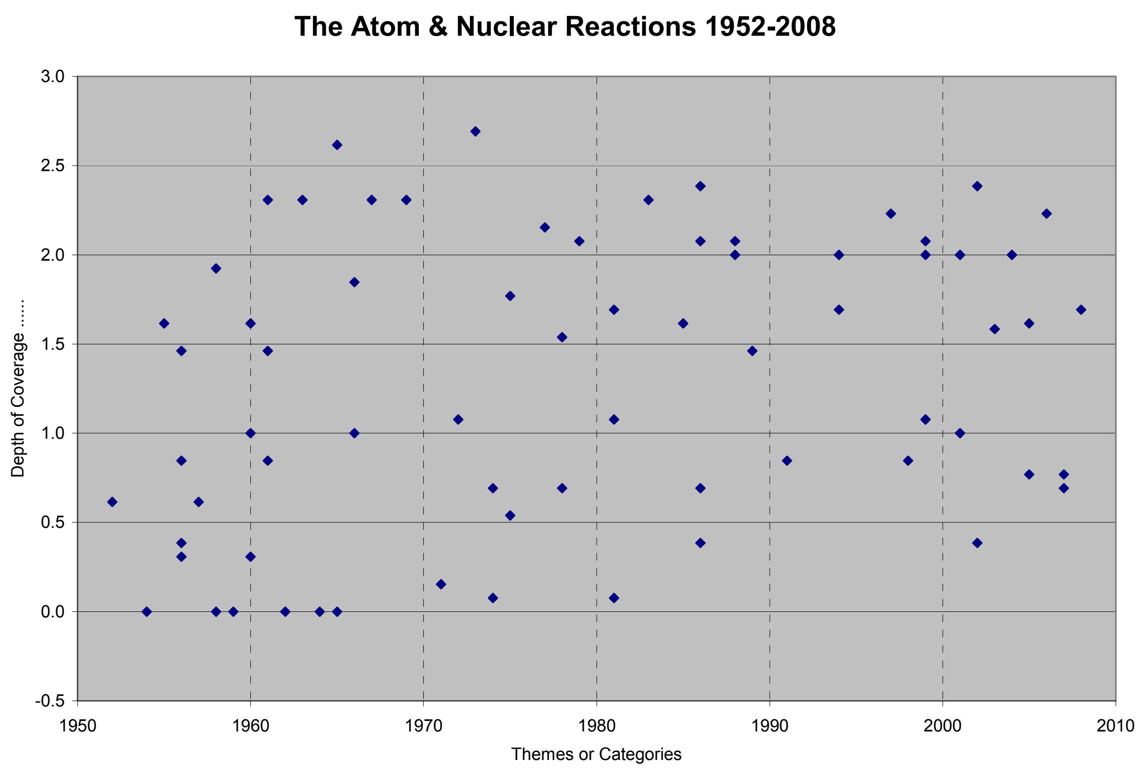


Figure 4.17 Depth of Coverage for Category 5 – The Atom & Nuclear Reactions - for all books (70) - 1952-2008

Fluids & Gases

The theme 'Fluid & Gases' is comprised of topics such as pressure, gas laws, buoyancy and the general characteristics of fluids (see Appendix D). Figure 4.18 shows how this theme was portrayed within the textbook sample. Much like the previous graph, theme 5 (The Atom), Figure 4.17 displays a range of variability in each decade with no consistent pattern or consensus on depth of coverage. Almost every square on the graph has a data point, suggesting no agreement or change in agreement regarding this topic over the past 60 years.

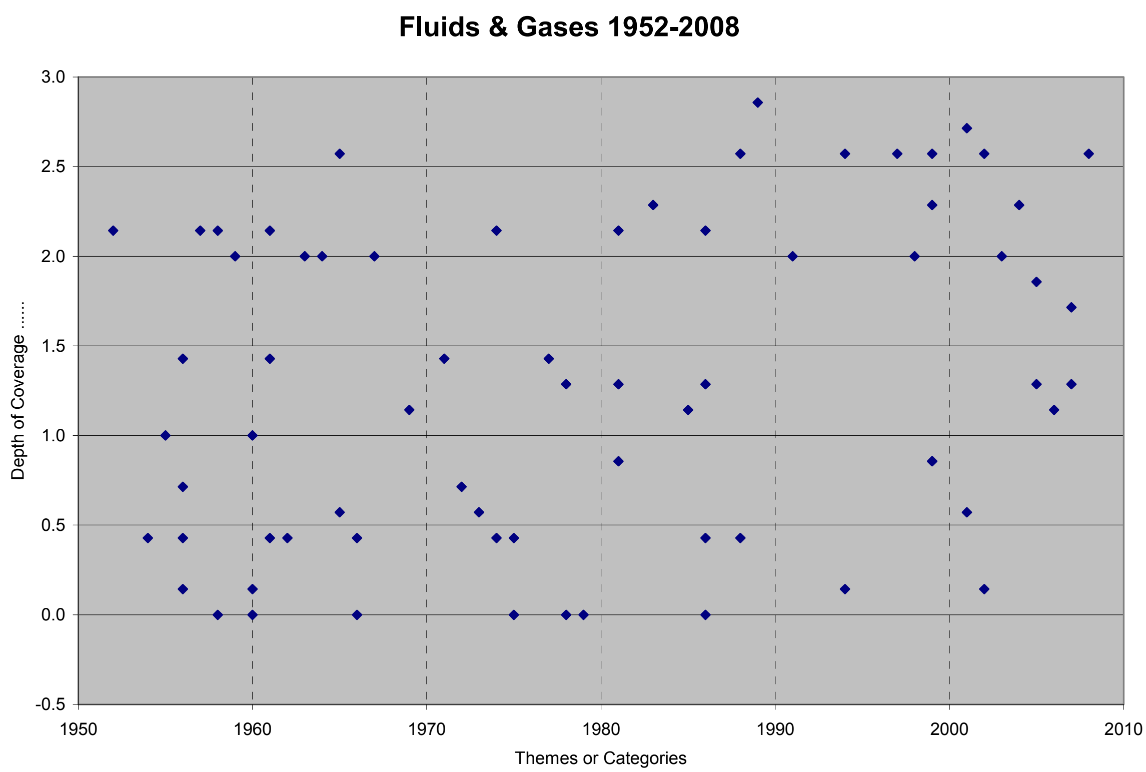


Figure 4.18 Depth of Coverage for Category 6 – Fluids & Gases - for all books (70) - 1952-2008

Motion

This theme describes the laws and theories regarding the movement of matter (see Appendix D). Figure 4.19 shows how this theme was portrayed within the textbook sample. Except for the 70s, the graph displays relatively little variability of coverage and increasingly greater depth of coverage over time. This plot indicates agreement within each decade regarding this theme and displays increasingly higher coverage over time.

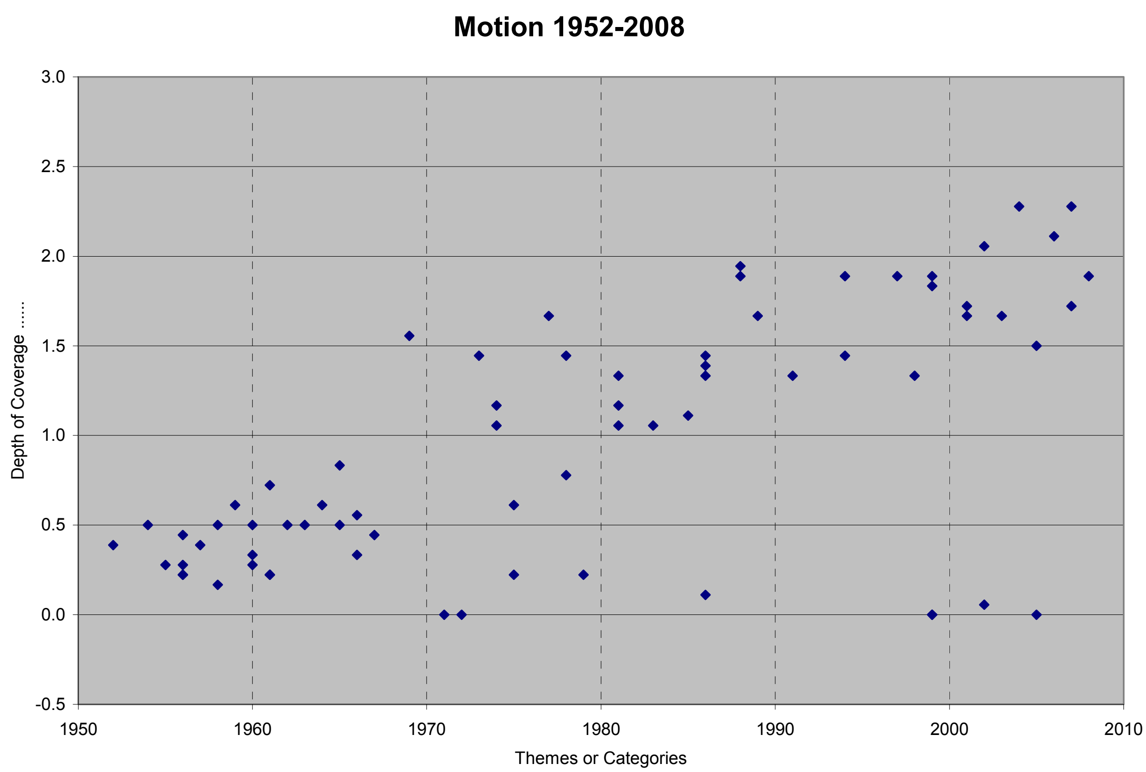


Figure 4.19 Depth of Coverage for Category 7 – Motion - for all books (70) - 1952-2008

Energy

This theme discusses the definition of energy and the many different forms of energy and energy conversion (see Appendix D). Figure 4.20 shows how this theme was portrayed within the textbook sample. The most interesting aspects of this graph are the top six left squares and bottom four right squares. In the 50s, 60s and 70s this theme was not covered at a depth above 2.0. During the 90s and 00s this theme was represented in consistently higher coverage and less variability. In the last 20 years this theme was either *not* covered or covered in some depth.

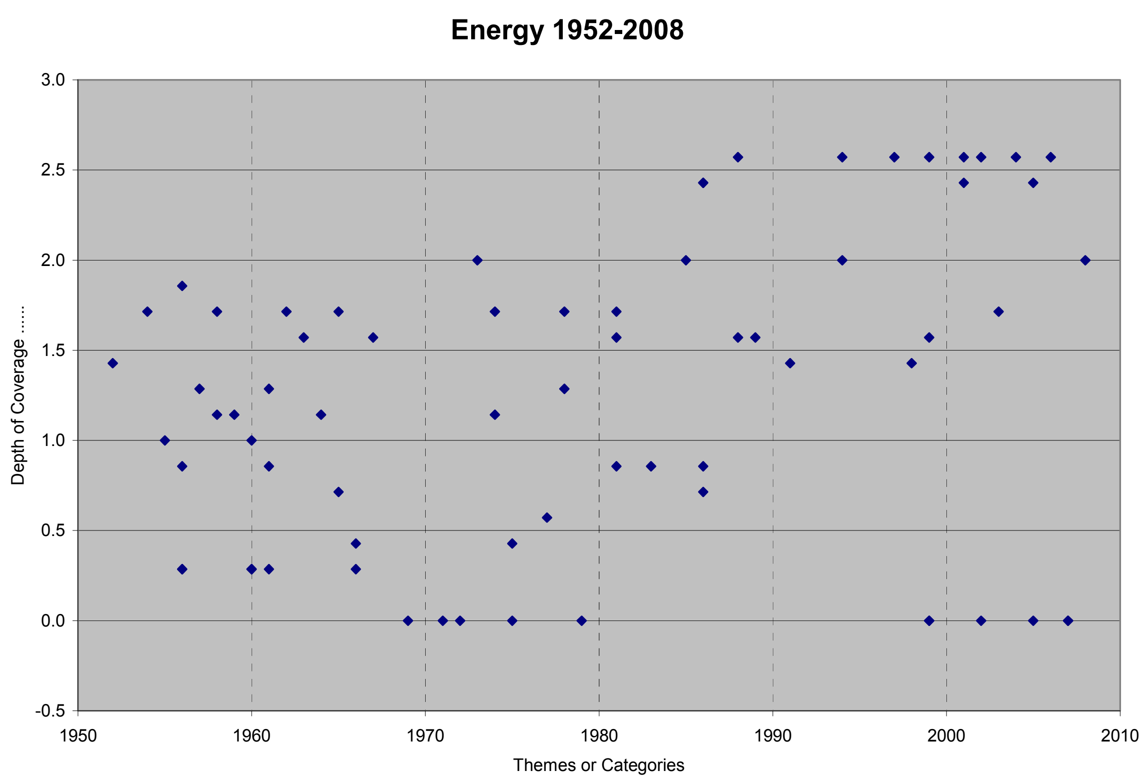


Figure 4.20 Depth of Coverage for Category 8 – Energy - for all books (70) - 1952-2008

Work, Power & Machines

This category presents the definitions and equations for topics such as work, power, efficiency and mechanical advantage and discusses simple and compound machines. Figure 4.21 shows how this theme was portrayed within the textbook sample. In this graph the variability of coverage and depth of coverage remains fairly consistent from decade to decade indicating consistent and above minimal coverage of this theme over six decades.

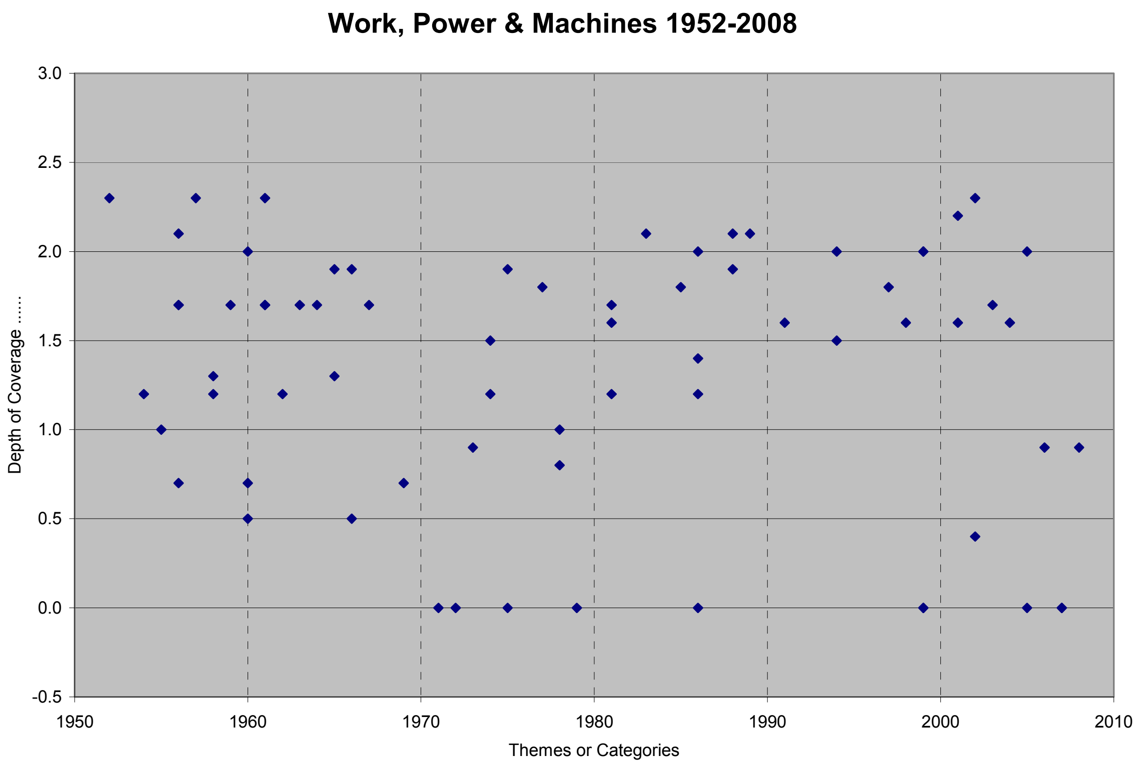


Figure 4.21 Depth of Coverage for Category 9 – Work, Power & Machines - for all books (70) - 1952-2008

Mechanical Waves & Sound

As seen in Appendix D this category includes topics such as the types, descriptions and interactions of waves and specifically discusses the properties and attributes of sound. Figure 4.22 shows how this theme was portrayed within the textbook sample. As shown in plot, except for the 80s we see a decrease in variability of coverage and an increase in the depth of coverage for this topic over time. In the 50s, 60, and 70s this theme was covered minimally. In the 80s variability of coverage is large. In the 90s and 00s variability is smaller and the theme is covered in greater depth than in earlier decades. In the last 20 years this theme was either covered in above minimal depth (above 1.5) or close to or at zero depth of coverage.

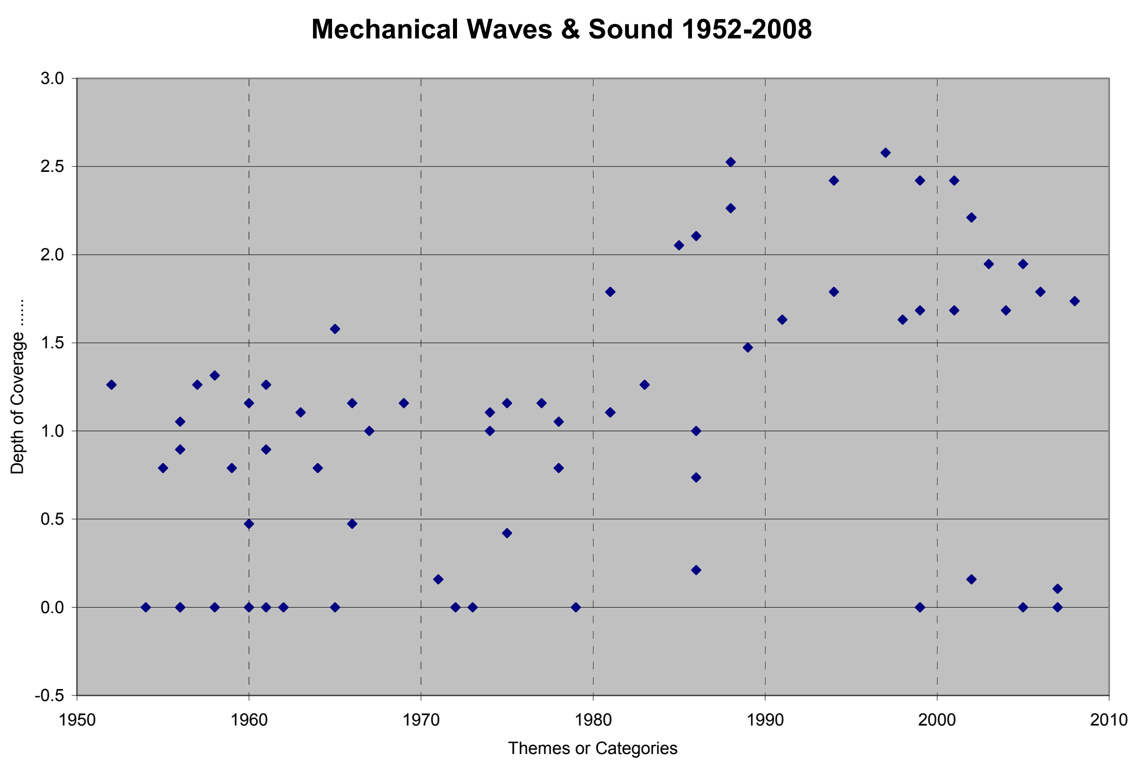


Figure 4.22 Depth of Coverage for Category 10 – Mechanical Waves & Sound - for all books (70) - 1952-2008

Electromagnetic Waves & Light

This theme encompasses topics such as the production and sources of light, reflection, refraction and the electromagnetic spectrum (see Appendix D). Figure 4.23 shows how this theme was portrayed within the textbook sample. As the graph indicates, variability of coverage was greater in the earlier decades than later decades and depth of coverage for this theme was slightly elevated in the 80s and 90s. Once again a familiar pattern of theme coverage is found in the last 20 years. During this time, coverage of this theme is either above 1.0 or close to zero.

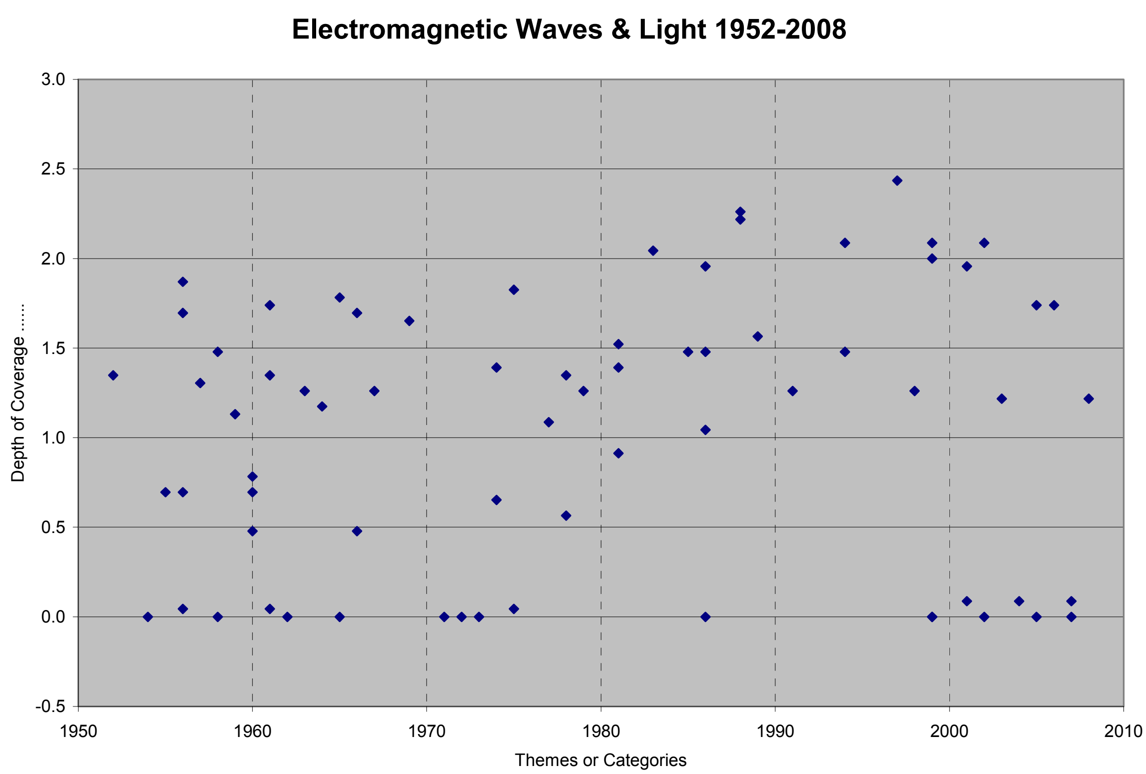


Figure 4.23 Depth of Coverage for Category 11 – Electromagnetic Waves & Light - for all books (70) - 1952-2008

Electricity

Electricity covers a variety of topics from electric charges and fields to generating electricity (see Appendix D). Figure 4.24 shows how this theme was portrayed within the textbook sample. The plot displays large variability of coverage in the 50s and 60s. From 1970s to the present the graph shows that this topic was covered at a depth above 1.0 or not at all. This indicates that when the topic was represented there was agreement that a depth of coverage above minimal (1.0) was preferred.

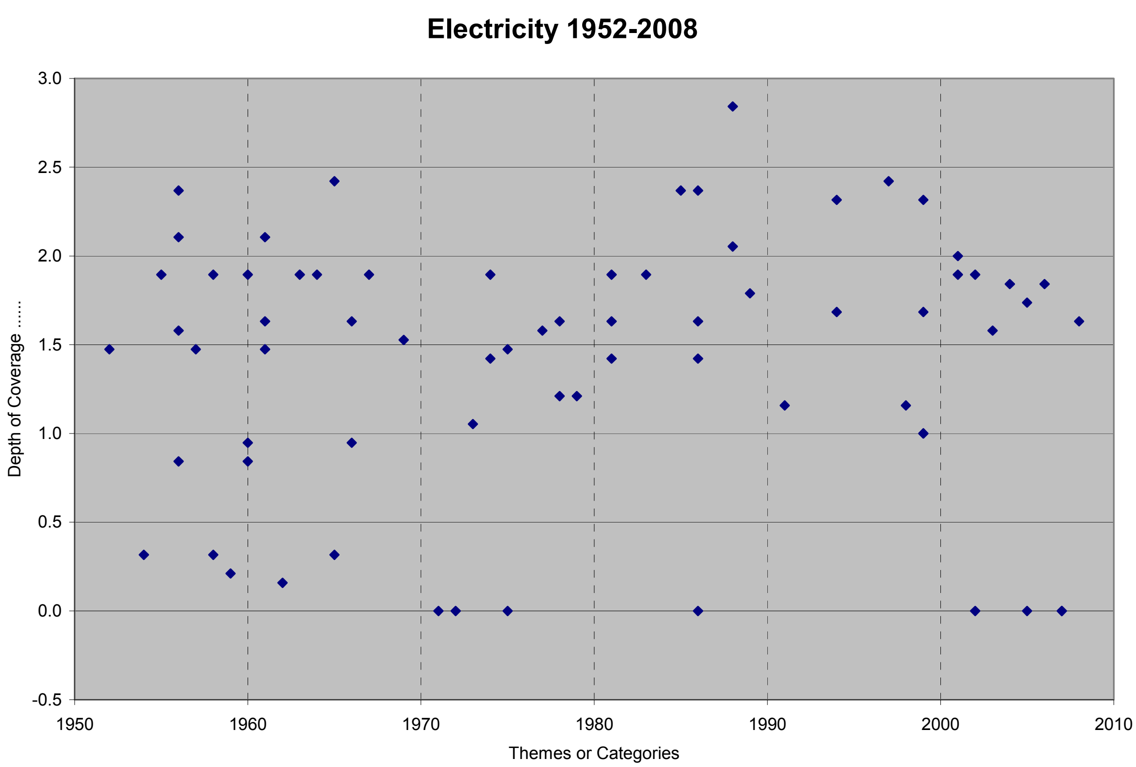


Figure 4.24 Depth of Coverage for Category 12 – Electricity - for all books (70) - 1952-2008

Electromagnetism & Magnetism

This theme includes sub-categories such as magnetic fields, electromagnetism, and electromagnets (see Appendix D). Figure 4.25 shows how this theme was portrayed within the textbook sample. In this graph there are distinct groups of variability. The middle of the graph is noticeably more sparsely populated than the upper and lower regions, suggesting divided agreement on representation of the topic over the last 60 years. From 1980 to the present decade this theme is either *not* covered or has a depth of coverage above minimal (above 1.5).

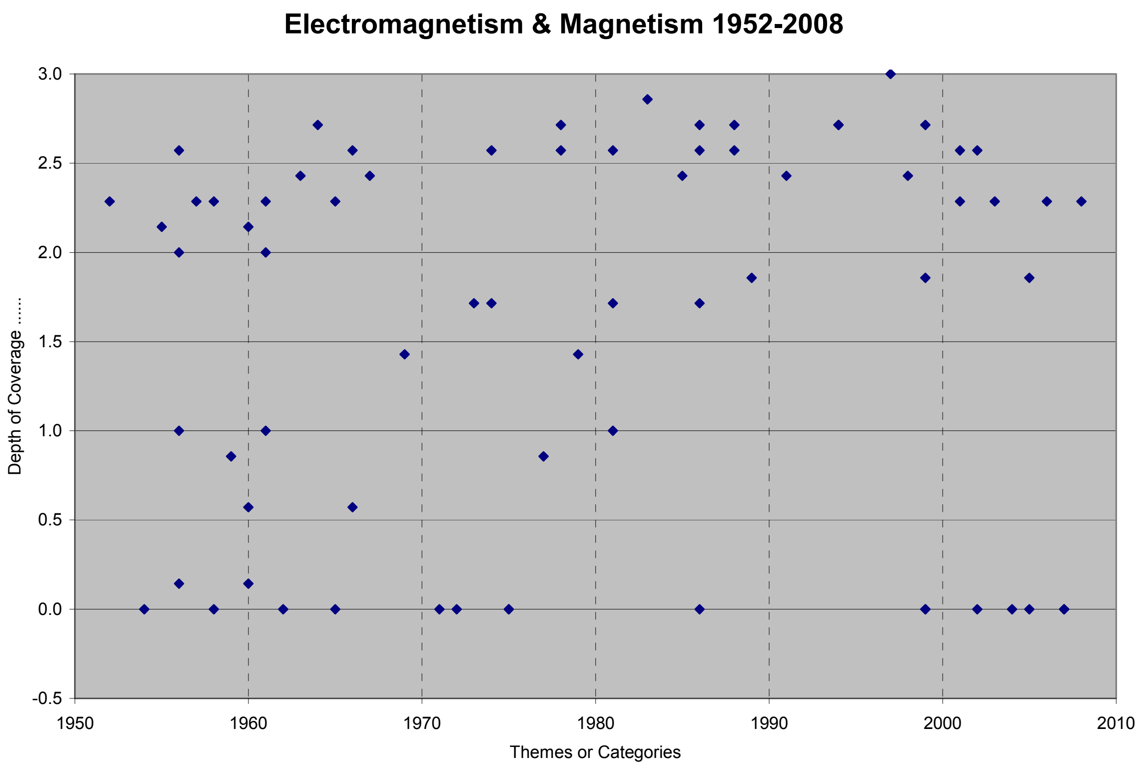


Figure 4.25 Depth of Coverage for Category 13 – Electromagnetism & Magnetism - for all books (70) - 1952-2008

Astronomy

The Astronomy category includes subjects such as the moon, sun and planets. There are also discussions regarding space travel, training and programs (see Appendix D). Figure 4.26 shows how this theme was portrayed within the textbook sample. In the 50s and 60s there was varied coverage. In the 70s to the 90s variability was quite narrow and resides close to zero with only a few outliers. In the present decade this theme experienced resurgence and displays a depth of coverage above 1.0 when the theme is represented.

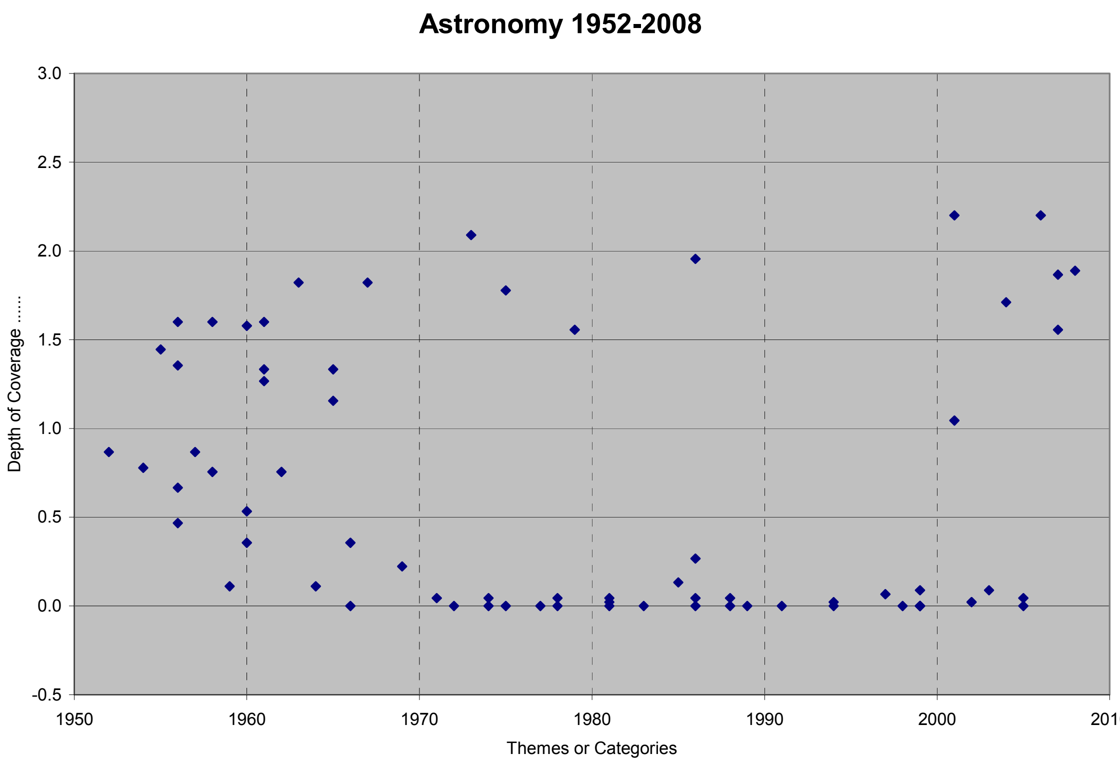


Figure 4.26 Depth of Coverage for Category 14 – Astronomy - for all books (70) - 1952-2008

Geology

This theme includes areas such as the origin and shape of the earth, earth process and geologic time (see Appendix D). Figure 4.27 shows how this theme was portrayed within the textbook sample. The variance in this plot is quite similar to the previous plot that represents the Astronomy theme (Figure 4-26). In the 50s there was less variability and greater average depth of coverage than in the 60s. Once again, from the 70s to the 90s variability is quite narrow and resides between 0.0 and 0.5 with only a few outliers. In the present decade there is a resurgence of interest but no consensus regarding this theme as seen by the large variability in depth of coverage.

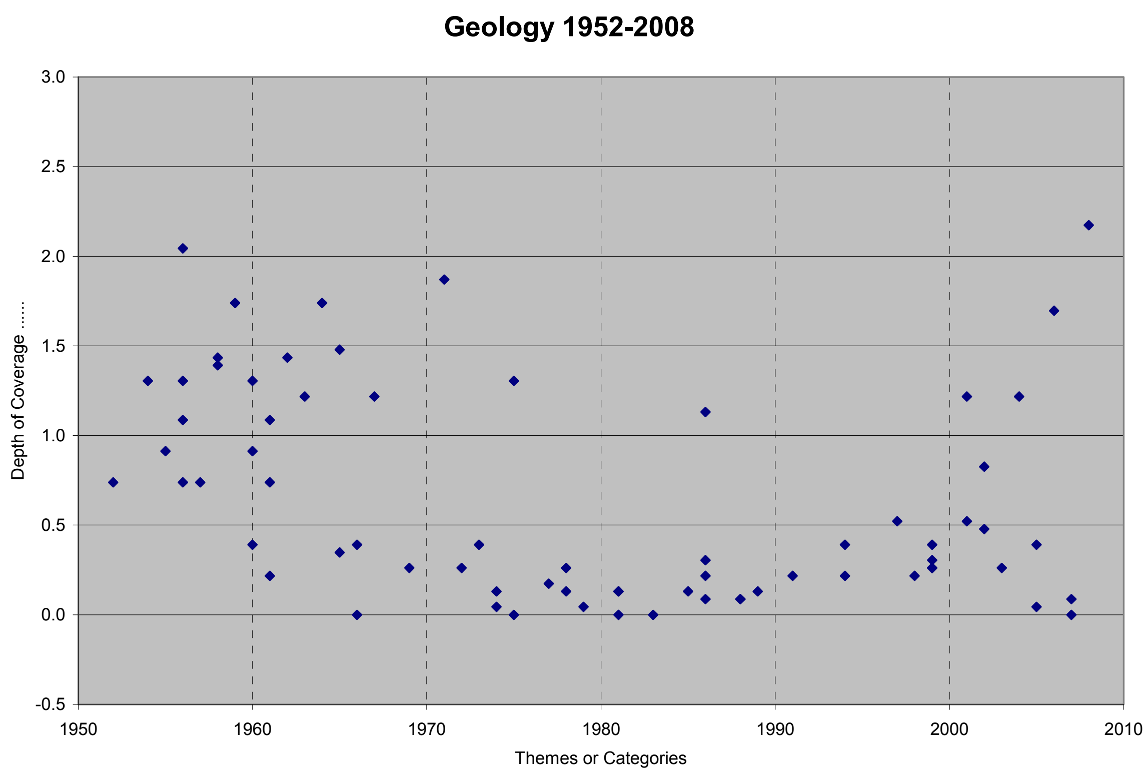


Figure 4.27 Depth of Coverage for Category 15 – Geology - for all books (70) - 1952-2008

Weather

As shown in Appendix D the category 'Weather' covers subjects such as clouds, precipitation, weather maps and weather forecasting. Figure 4.28 shows how this theme was portrayed within the textbook sample. Again, coverage shown for this theme is similar to the previous themes, Astronomy (Figure 4.26) and Geology (Figure 4.27). In the 50s and 60s there were two distinct groups; one group with depth of coverage at 2.5 and above and another group with coverage at 1.5 or below. During the 70s to the 90s variability is quite narrow and resides between 0 and .5 with only a few outliers. In the 00 decade there are again two distinct groups; one shows little variability around 0.0 and 0.5 and another group with little variability above 2.0.

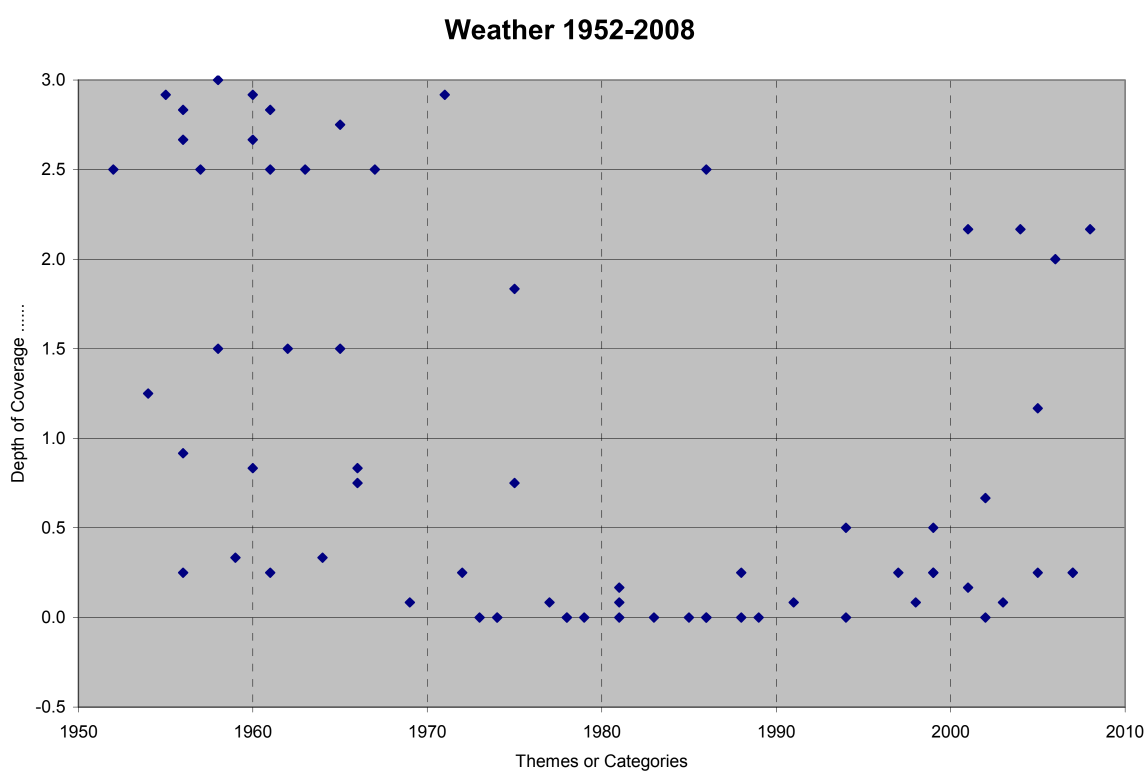


Figure 4.28 Depth of Coverage for Category 16 – Weather - for all books (70) - 1952-2008

Ecology

Ecology covers topics such as climate, natural resources and conservation (see Appendix D). Figure 4.29 shows how this theme was portrayed within the textbook sample. This graph shows the variance across six decades is constant; however, the depth of coverage decreases over time. The scatter plot indicates agreement in depth of coverage and a decrease in the representation of this theme over time.

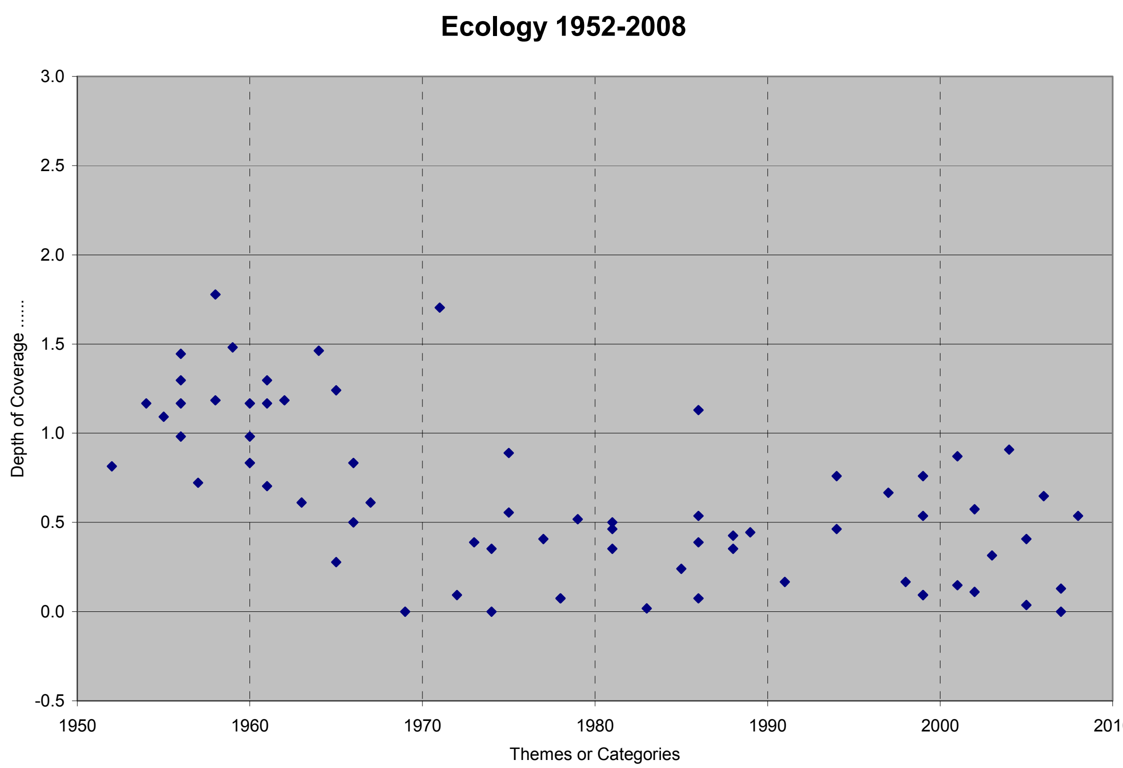


Figure 4.29 Depth of Coverage for Category 17 – Ecology - for all books (70) - 1952-2008

Diversity of Life on Earth

This theme represents the topics of biological classifications and descriptions of living things (see Appendix D). Figure 4.30 shows how this theme was portrayed within the textbook sample. The plot shows little consensus during the 50s and 60s regarding this topic as indicated by the large variability in coverage. After 1970, with the exception of a few outliers – this topic was not represented. The graph shows an obvious decline in the representation of this topic over the past 60 years.

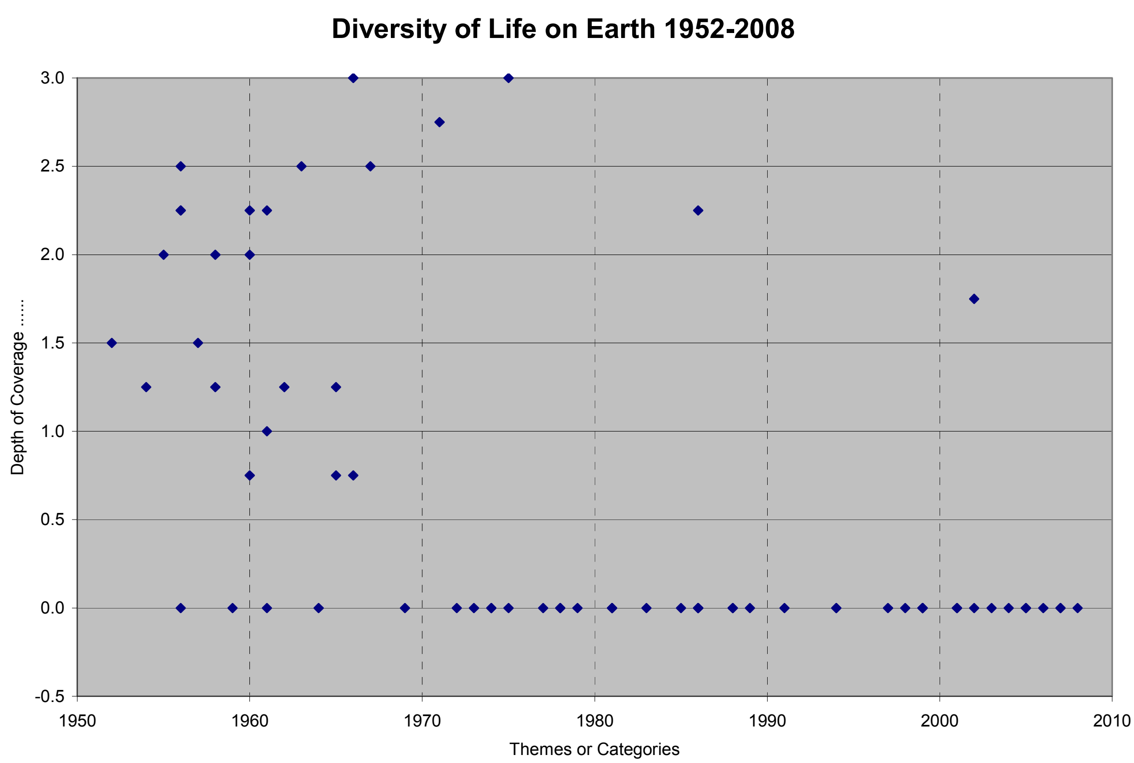


Figure 4.30 Depth of Coverage for Category 18 – Diversity of Life on Earth - for all books (70) - 1952-2008

Origins of Life

The 'Origins of Life' category discusses natural selection and theories of evolution (see Appendix D). Figure 4.31 shows how this theme was portrayed within the textbook sample. The graph consisting of one group around zero and a few outliers shows very little variability. The plot displays a clear and consistent consensus in depth of coverage for this theme (0.0) over the last six decades.

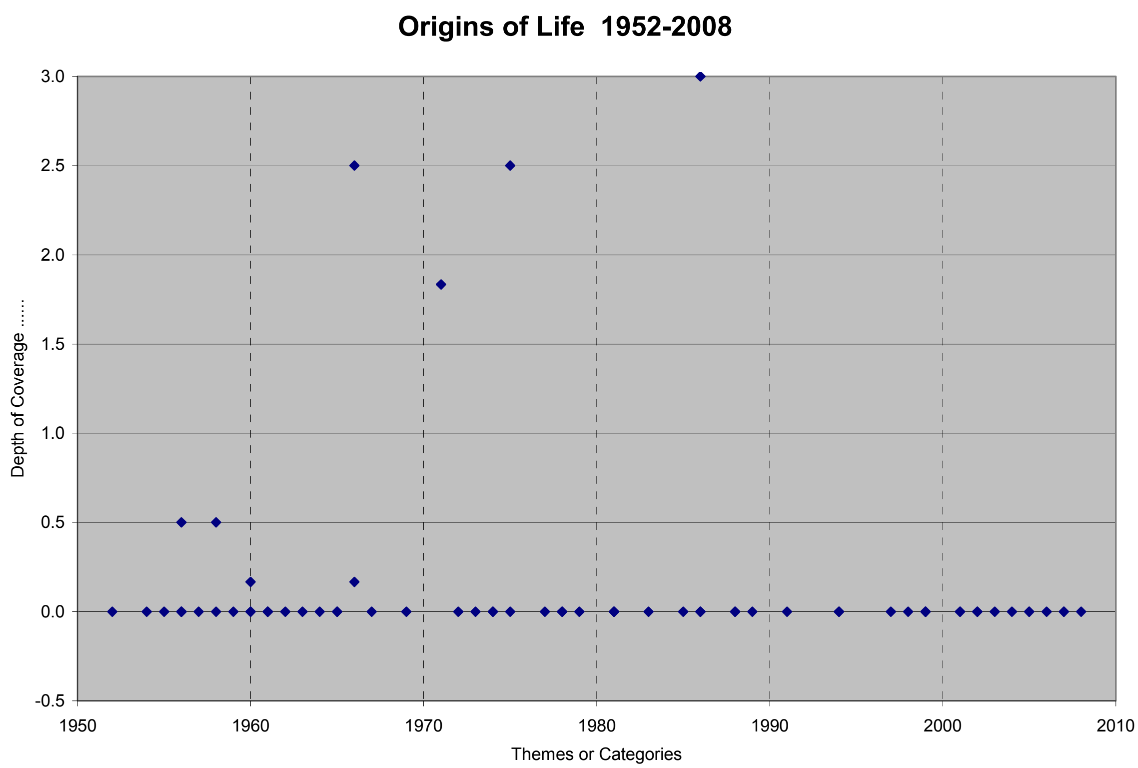


Figure 4.31 Depth of Coverage for Category 19 – Origins of Life - for all books (70) - 1952-2008

Characteristics of Living Things

This theme includes topics such as the cell, photosynthesis and the cycles of life (water cycle, nitrogen cycle, oxygen-carbon cycle). Figure 4.32 shows how this theme was portrayed within the textbook sample. The graph displays larger variability in the 50s and 60s than in later decades. Variability decreases and the depth of coverage ranges from 0.0 to 0.5 from the 70s to the 00s. During the last 40 years this topic has not lost all representation but has certainly been reduced in coverage.

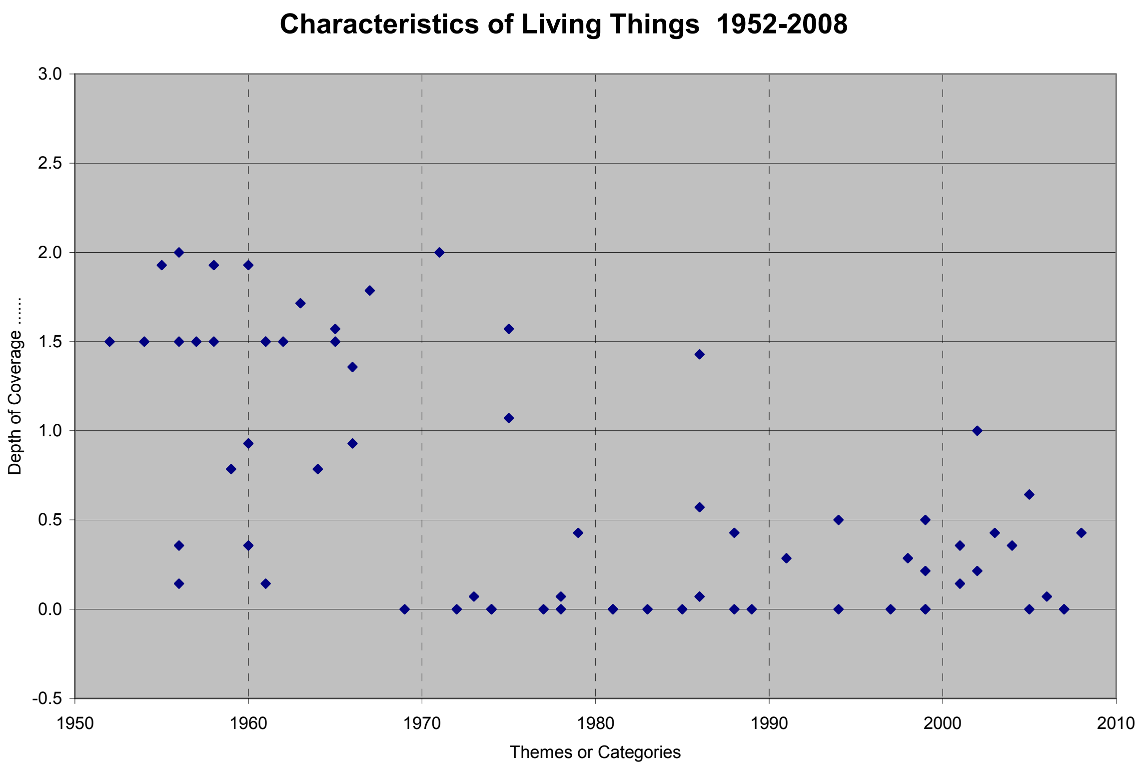


Figure 4.32 Depth of Coverage for Category 20 – Characteristics of Living Things - for all books (70) - 1952-2008

Animal Organ Systems

Animal Organ Systems includes body systems such as the respiratory, digestive and endocrine systems (see Appendix D). Figure 4.33 shows how this theme was portrayed within the textbook sample. This graph shows a pattern similar to previous graphs. Variability and depth of coverage in the 50s and 60s is greater than in later decades. After 1970 there is a decrease in variability and depth of coverage close to zero with several outliers. This plot illustrates a de-emphasis of this theme over the past 40 years.

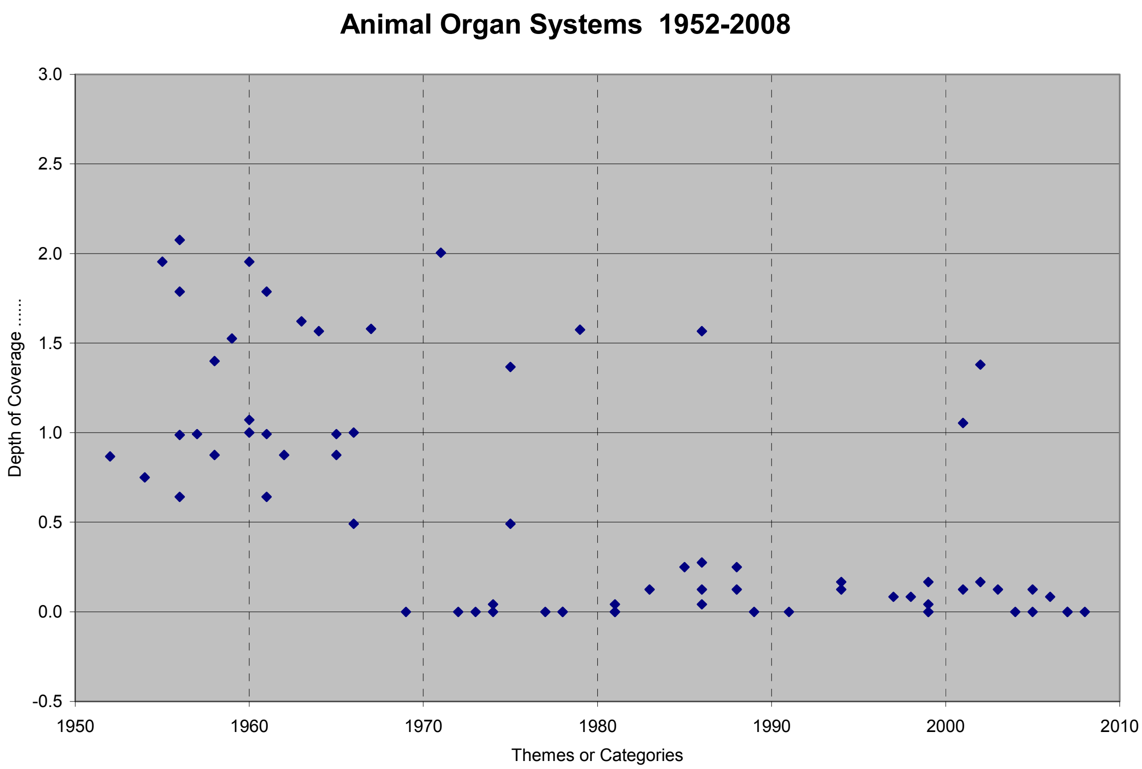


Figure 4.33 Depth of Coverage for Category 21 – Animal Organ Systems - for all books (70) - 1952-2008

Genetics

As can be seen in Appendix D, this category encompasses inheritance, traits, and genes. Figure 4.34 shows how this theme was portrayed within the textbook sample. This graph displays a pattern similar to that seen in earlier themes. The plot shows high variability in the 50s and 60s with decreasing variability and depth of coverage over time. Once again, this graph reveals a de-emphasis of this theme over time.

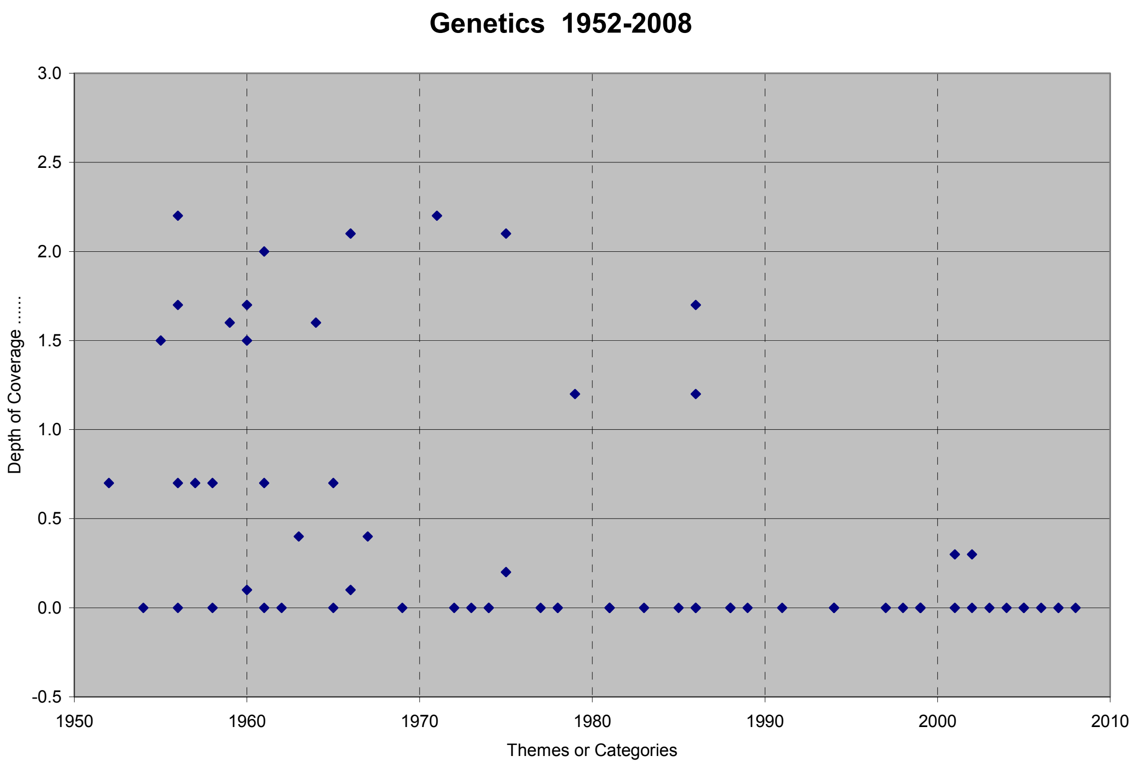


Figure 4.34 Depth of Coverage for Category 22 – Genetics - for all books (70) - 1952-2008

Human Health

The theme of 'Human Health' covers information regarding nutrition, disease, disease prevention, and behavior (see Appendix D). Figure 4.35 shows how this theme was portrayed within the textbook sample. In this plot a small range of variability is seen in the 50s and 60s that hover near 1.0. The range of variability and depth of coverage decreases after 1970. Much like several of the previous themes this graph shows a de-emphasis in this topic over the last 40 years.

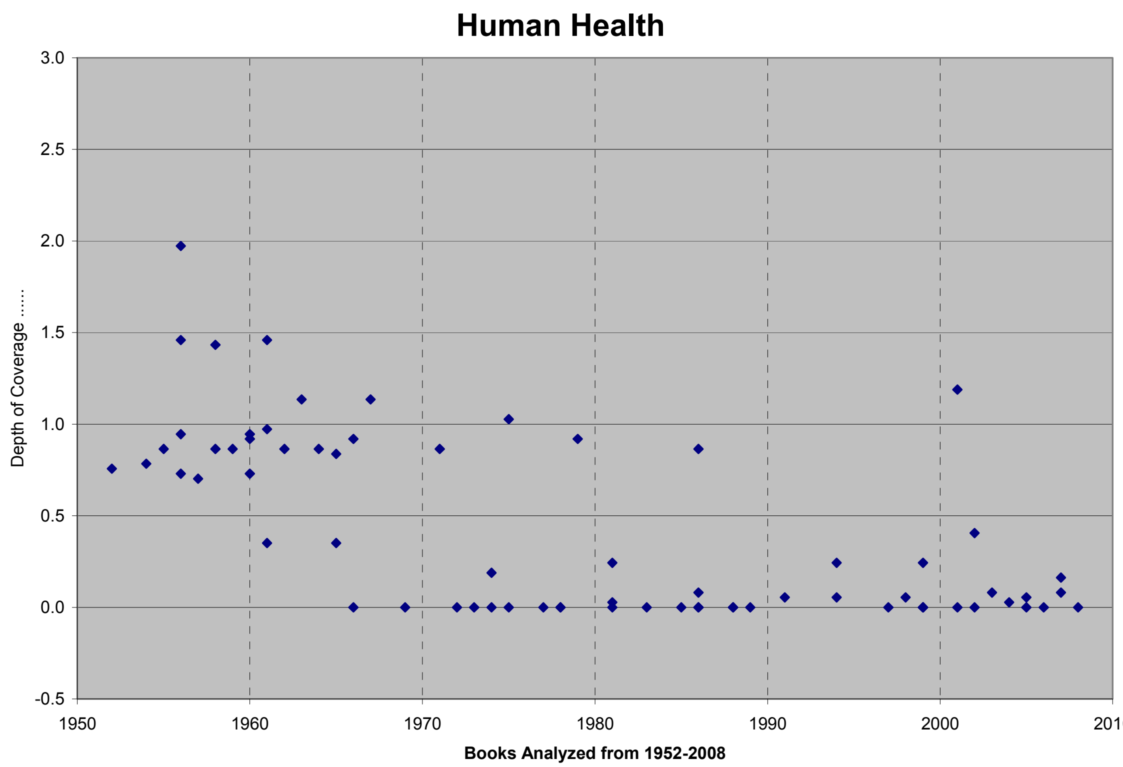
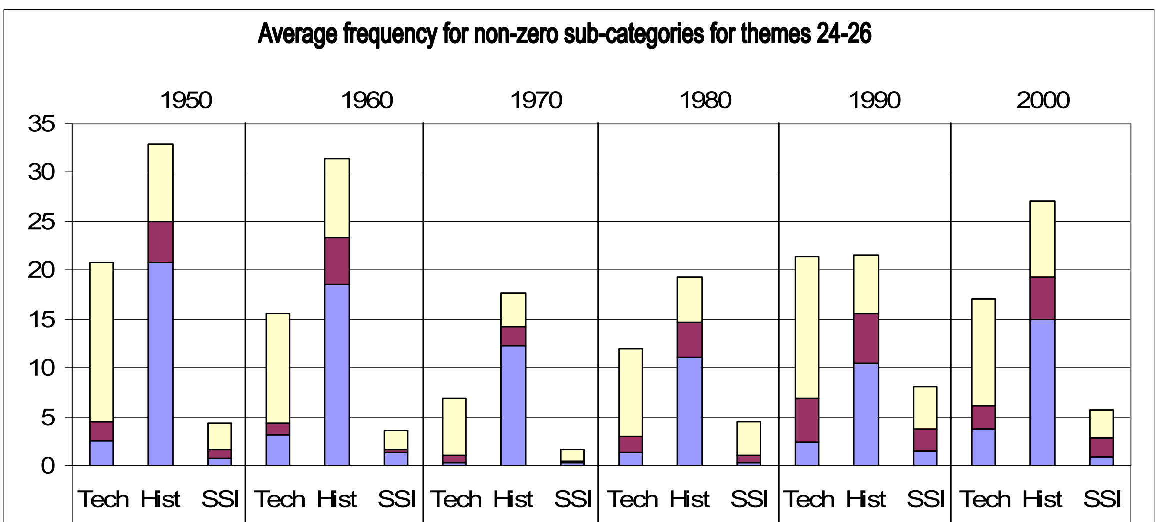


Figure 4.35 Depth of Coverage for Category 23 – Human Health - for all books (70) - 1952-2008

Technology, History of Science, and Socioscientific Issues

One can find in Appendix D that the categories of Technology, History of Science and SSI cover a range of science information. Figure 4.36 shows how these themes were portrayed within the textbook sample. This chart below shows the average *depth of* frequency *coverage* for each theme and compares the coverage by decade. The chart also reveals that the 90s and the 50s introduced the highest number of technology items per textbook in the samples reviewed. The 50s and 60s presented the highest number of Historical items, while the 70s and 80s presented the least number of both Technology and Historical items in the textbooks reviewed. For instance, books in the 50s averaged 21 technology items, 33 historical items and five social issues per book. Social issues in science were not highly represented in any decade; however, books in the 90s averaged seven social issues and the present decade averaged 6 social issues per book.



	1950 Tech	1950 Hist	1950 SSI	1960 Tech	1960 Hist	1960 SSI	1970 Tech	1970 Hist	1970 SSI	1980 Tech	1980 Hist	1980 SSI	1990 Tech	1990 Hist	1990 SSI	2000 Tech	2000 Hist	2000 SSI
3s	16	8	3	11	8	2	6	3	1	9	5	3	15	6	4	11	8	3
2s	2	4	1	1	5	0	1	2	0	2	4	1	5	5	2	2	4	2
1s	3	21	1	3	19	1	0	12	0	1	11	0	2	10	1	4	15	1

Figure 4.36 Depth of Coverage for Category 24-26 – for all books (70) - 1952-2008

Data Review - Themes 1-23

A review of the data in this sample reveals that all themes 1-23 were represented at least minimally in the 50s and 60s. In the 1950s there are 16 topics whose mean depth of coverage was between 1.0 and 2.0 and three themes whose mean coverage was at 0.5. In the 1960s there are 12 topics whose mean depth of coverage was between 1.0 and 2.0 and only one theme with a mean coverage at 0.5. Theme 19 (Origins of Life) was consistently lacking in representation over the time period studied. Only six of the 70 books reviewed over all six decades covered this topic. Three of these books covered the topic in a depth greater than 2.5 and two of the books presented the theme with a depth of coverage of 0.5. The remaining 64 textbooks reviewed did not present this topic at all.

In the 1970s we begin to see a de-emphasis in many topics in this sample. During this decade only two themes were represented with a mean depth of coverage between 1.0 and 2.0, while ten themes were given a mean coverage of less than 0.5. In this decade, theme 18 (Diversity of Life) lost the representation that was shown in the 50s and 60s and was represented by only two books in this decade, each with a depth of coverage over 2.5. From 1970 to 2000 this theme was represented in a total of four books.

In the 1980s another shift de-emphasized certain themes. Twelve themes are covered at a mean depth between 1.0 and 2.0 and nine themes receive a mean coverage of less than 0.5. In this decade the data display tighter agreement between textbook authors and less variability in depth of coverage for each theme. Although the variability between scores is smaller in the 1980s this decade has a higher number of outliers (19) than in any other decade.

The 1990s represent the greatest consensus among textbooks in this study sample. There are the fewest number of outliers in this decade and smallest variability in depth of coverage. No outlier is above zero, which indicates that those who choose to cover the topic did so at approximately equal depth of coverage. In this decade there are 13 themes with a mean depth of coverage between 1.0 and 2.0 and ten themes with a mean depth of less than 0.5. In the present decade there appears to be greater variability in depth of coverage for each theme. Fourteen themes have a mean coverage between 1.0 and 2.0, and seven themes have a mean coverage below 0.5. Figure 4.37 shows the mean depth of coverage for themes 1-23 over the past six decades.

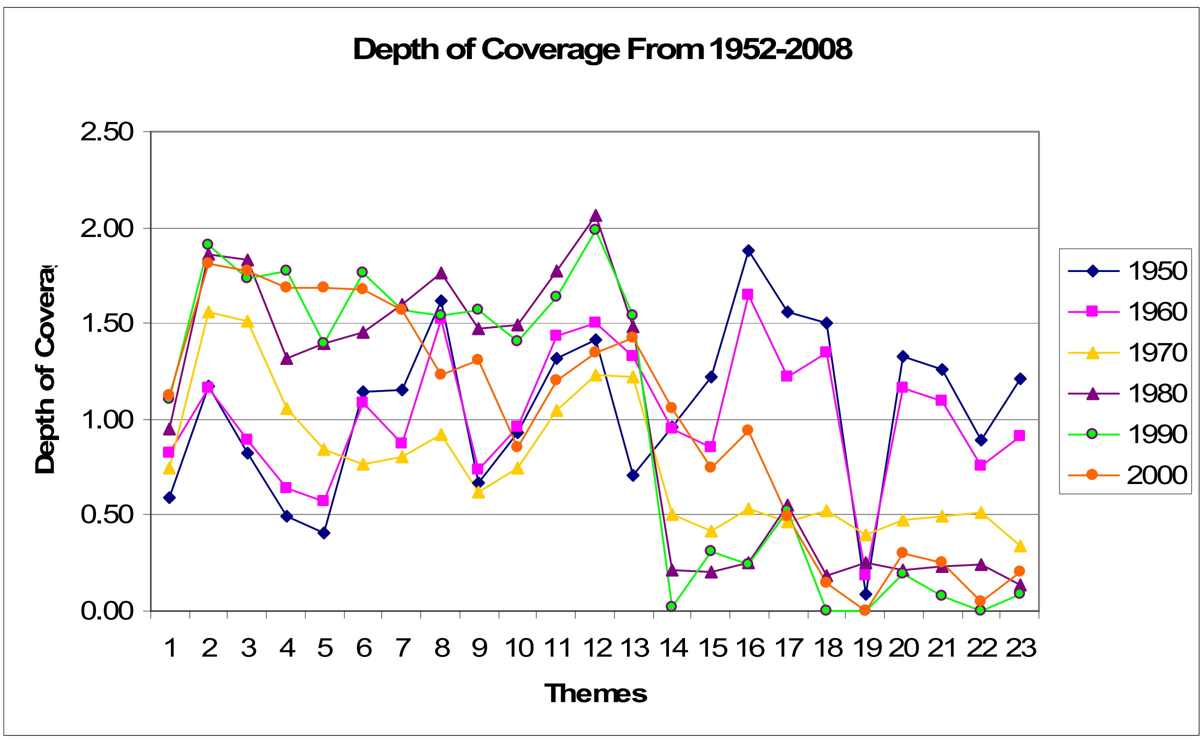


Figure 4.37 Depth of coverage for themes 1-23 for all decades

Research Question Three

3.) Are new scientific findings reflected in 8th and 9th grade U.S. general science textbooks? In this study the researcher noted two types of 'new information' or scientific findings within the developed content list. The first type of 'new information' introduced scientific concepts and ideas that were 'new to the world'; theories and applications that have been developed or discovered in the last six decades, such as telecommunication satellites, cell phones, and microwave ovens. In this study this type of information is labeled *Discoveries*.

The second type of 'new information' is concepts that have *not* been developed or discovered over the past six decades, however, these concepts had not been presented in earlier books. In essence these ideas are scientific concepts that were not presented in books published in the earlier decades but appear in later decades; this type of information is labeled *Deepening*. Examples of this are the introduction of Plank's constant, Tyndall effect, black holes, angular momentum and bioluminescence. As noted earlier, science textbooks grew in page number but not in the number of chapters or units covered. An increase in the breadth of science coverage within themes is a partial explanation of this phenomenon. For instance, under the Motion category is the sub-category 'Reference Objects'. No book examined in the 1950s sample set discussed this sub-category, however, in the 1960s one book referred to 'Reference Objects', two books in the 1970s, five books in the 1980s, three books in the 1990s and eight out of twelve books in the present decade discussed 'Reference Objects'. This was also true of items such as the Laws of Thermodynamics, Heisenberg uncertainty principle, and de Broglie waves. This second type of 'new information' that deepens student's understanding of a topic, though important, is not germane to this particular research question. Data from this type of 'new information' has been subsumed in the appropriate theme and has added weight to the theme in which it was placed. For instance discussions regarding the Plank's constant was placed in theme 5 (The Atom) in the sub-category of Quantum Physics.

To examine the occurrence of 'new information' or *Discoveries,* the researcher reviewed the entire 3,533 item content list and tagged any item that was a new science concept developed after 1952. Only those items that were discussed in the body of the text were considered relevant. Items in sidebars or ending narratives were not tagged. Information presented in these locations is offered to spark interest in a science topic, to motivate or to entertain the student. This is evidenced by the lack of questions pertaining to the content provided in these 'info boxes' and the absence of any reference to the content found in these boxes from the main body of text. Sidebars and science narratives that acted as stand-alone information bytes unconnected to the science theme under discussion were noted in the Technology category under Discoveries and Products of Science.

There were 16 different *Discoveries* found within the text in this sample of 70 books spanning 60 years. Table 4.3 displays the 16 *Discoveries* and indicates the publication year of the textbook(s) in which it was found and the depth of coverage. The most often mentioned new discovery was the Laser. It was discussed in 22 textbooks from 1963 to 2006 and usually covered in depth. Computer Enhancements was the second most often mentioned. They were discussed in 21 textbooks from 1959 to 2005 and usually covered in depth. The third most often discussed new discovery was Fiber Optics, which was covered in depth in 16 textbooks. The remaining 14 topics were mentioned in 10 or fewer textbooks with varying degrees of coverage. Sixty-three percent of all new topics were covered in four or fewer textbooks with an average depth of 2.4.

Table 4.3 Discoveries found in the sample textbooks spanning 60 years.

Lasers																						
	63	67	69	78	81	81	86	86	88	89	91	94	94	97	98	99	99	01	02	03	05	06
	3	3	3	1	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Computers																						
	59	60	63	67	69	77	81	85	86	88	88	89	91	94	97	98	99	99	01	04	05	
	3	1	3	3	3	3	3	3	3	2	2	3	2	3	3	2	3	3	3	3	3	
Fiber Optics																						
	81	81	86	88	88	89	94	94	97	99	99	01	02	03	05	06						
	2	3	3	3	1	3	3	3	3	3	3	3	3	3	2	1						
Telecommunication																						
	89	94	94	97	99	01	01	02	04	05												
	2	3	3	2	3	3	3	3	3	2												
Scanning Tunneling Microscope																						
	89	99	03	06	07	07	08															
	3	1	1	2	1	1	1															
Cell phones																						
	97	01	01	02	03	04																
	1	2	3	1	3	2																
Communication Satellites																						
	01	01	02	04																		
	3	3	3	3																		
Microwave Ovens																						
	94	99	06	08																		
	3	3	3	3																		
Kuiper Belt																						
	06	07	08																			
	2	1	3																			
Pluto - no longer a planet																						
	07	08																				
	1	1																				
Fullerenes																						
	01	06																				
	1	2																				
2003UB1313 larger than Pluto, orbits sun 560 yrs																						
	07																					

Discovery found in text
Yellow boxes indicate year book published
Blue boxes indicate depth of coverage

1
CDs
94
3
Dark energy
08
3
Maser
69
3
Smoke Detectors
81
3

Discovery found in text
Yellow boxes indicate year book published
Blue boxes indicate depth of coverage

Statistical Analysis

The last section presented the description of the data set. The next step is to review the data and describe the broader picture that these data represent. To help us better understand the results of this study from a macroscopic perspective let us first take a look at the categories represented in the textbook sample. Table 4.4 displays each of the themes as suggested by the expert panel. The first category (Process of Science) looks to how science is conducted and the characteristics of the scientific endeavor.

Table 4.4 Themes / category list – [1- Process of Science; 2-5 – Chemistry; 6-13 Physics; 14-16 Earth Science; 17-23 Biology]

Theme / Category List	
1	Process of Science
2	Characteristics & Structure of Matter
3	Chemical Interactions
4	Organic Compounds
5	The Atom & Nuclear Reactions

Process of Science

Chemistry

6	**Fluid & Gases**
7	**Motion**
8	**Energy**
9	**Work, Power & Machines**
10	**Mechanical Waves & Sound**
11	**Electromagnetic Waves & Light**
12	**Electricity**
13	**Electromagnetism & Magnetism**
14	**Astronomy**
15	**Geology**
16	**Weather**
17	**Ecology**
18	**Diversity of Life**
19	**Origins of Life -**
20	**Characteristic of Living Things**
21	**Animal Organ Systems**
22	**Genetics**
23	**Human Health**

Physics

Earth Science

Biology

The next three categories (Characteristics & Structure of Matter, Chemical Interactions, and Organic Chemistry) can be subsumed under the subject of Chemistry. Both categories 5 and 6 (The Atom & Nuclear Reactions and Fluids & Gasses) are usually discussed in both Chemistry and Physics and cannot be ascribed to only one domain. However, in this study because details of the Atom and Nuclear Reactions were most often found in relation to Chemistry with discussions that used atomic theory to explain oxidation and chemical bonding this theme has been placed in the Chemistry category. Fluids and Gases were most often discussed from a physics perspective, providing discussions regarding the gas laws and pressure (its effects in different states of matter) therefore, this theme was placed in the category of Physics. Categories 7 through 13 (Motion, Energy, Work, Power & Machines, Mechanical Waves & Sound, Electromagnetic Waves & Light, Electricity, Electromagnetism & Magnets) are Physics subject matter. Categories 14 -16 (Astronomy, Geology, Weather) are found in the context of Earth Science. Category 17 (Ecology) is a theme that may be found in the domain of either Earth Science or Biology. In this study Ecology is grouped with Biology. Categories 18 – 23 (Diversity of Life, Origins of Life, Characteristics of Living Things, Animal Organ Systems, Genetics, and Human Health) are all Biology topics. It is important to note here that these broad subject areas arose naturally from the data and were not imposed from the onset of this analysis. The content list created during data collection dictated the 26 categories and in the same manner dictate what areas of science are represented in this study.

Analysis of Themes 1-23

By reducing the number of dependant variables from 23 to 5 subject areas (Process of Science, Chemistry, Physics, Earth Science and Biology) an analysis of the differences between decades and themes becomes more manageable, and allows the broader implications of the data to be revealed. In addition, the reduction in the number of dependant variables lends itself to decreasing the number of Type I errors, making this analysis more reliable than if conducted across all 23 themes as seen in Figure 4.37.

The question to be answered by a statistical analysis is; are the changes in depth of coverage that have occurred in these subject areas from 1952 to 2008 statistically significant? To address this inquiry, depth of coverage across 5 themes of subject areas were compared and contrasted over 6 decades. A mixed-design ANOVA was conducted, as this type analysis is appropriate for studies that include both repeated-measures factors and between-group factors. The 6 decades in this study are the between-group factors, while the 5 themes are the within-group or repeated-measure factors. All assumptions were met for conducting a multivariate test of this kind, as described in Appendix E.

The results of the factorial ANOVA with repeated measures showed that the Group x Theme interaction was significant ($F(20,256) = 8.79$, $p < 0.0001$) warranting contrast comparisons and further investigation to test simple effects. Next the mean depth of coverage for each subject area over each decade was graphed. Figures 4.38 and 4.39 show two different perspectives, which assists in viewing different aspects of what this data sample had to reveal. Figure 4.38 presents the data in a manner that shows trends for each decade and permits a visual comparison of subject area coverage *between* each decade. Figure 4.39 presents the data in a manner that reveals general trends of coverage for each subject area and permits a visual comparison of subject area *within* each decade.

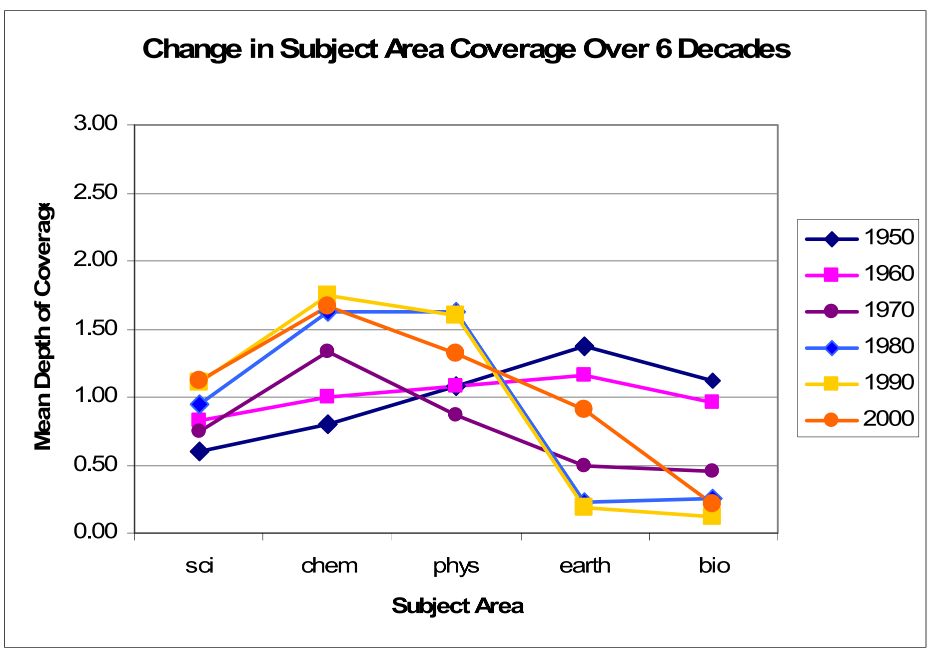


Figure 4.38 Mean depth of coverage over 6 decades – comparing subject areas for each decade

HSD Tukey tests were conducted to discover any simple effects between decades for each subject area. Confidence levels were adjusted from 95% to 99% ($\alpha < 0.05$ to $\alpha < 0.01$) to account for the 5 Tukey tests conducted. Under these conditions three subject areas were found that displayed significant differences in depth of coverage across decades. As seen in Table 4.5, the Process of Science and Physics showed no significant change in depth of coverage over the past 6 decades. As Table 4.6 illustrates, Chemistry showed a significant *increase* in depth of coverage between 1950 and 2000. Earth science and Biology showed a significant *decrease* in coverage from the early decades to the later decades.

Table 4.5 Subject areas that displayed significant differences in depth of coverage over 6 decades are shaded ($\alpha < 0.01$).

Subject	F(5,64)	p
sci	2.93	0.020
chem	5.62	0.0002
phys	2.77	0.025
earth	10.26	<0.0001
bio	13.5	<0.0001

Table 4-6 Decades comparisons exhibiting significant differences in depth of coverage for subject areas indicated in Table 4.5.

decade comparison		diff in means	99% Confidence Limits	
Chem				
1950	1980	0.8241	0.0102	1.638
1950	1990	0.9403	0.0639	1.8167
1950	2000	0.875	0.0611	1.6889
Earth				
1950	1970	0.8836	0.1022	1.6651
1950	1980	1.1506	0.3856	1.9156
1950	1990	1.1872	0.3635	2.0109
1960	1980	0.9293	0.2195	1.6392
1960	1990	0.9659	0.1932	1.7386
Bio				
1950	1970	0.6632	0.0807	1.2457
1950	1980	0.8611	0.2909	1.4314
1950	1990	0.9952	0.3811	1.6092

1950	2000	0.9135	0.3432	1.4838
1960	1980	0.6948	0.1657	1.2239
1960	1990	0.8288	0.2528	1.4049
1960	2000	0.7472	0.218	1.2763

To determine effects *within* each decade or subject matter trends another HSD Tukey test was conducted. Six tests were run, therefore adjustments were made to significance level comparisons (α < 0.05 changed to α < 0.0083) to assist in reducing Type I errors. Figure 4.39 displays this comparison and Table 4.7 indicates significant differences found in each decade.

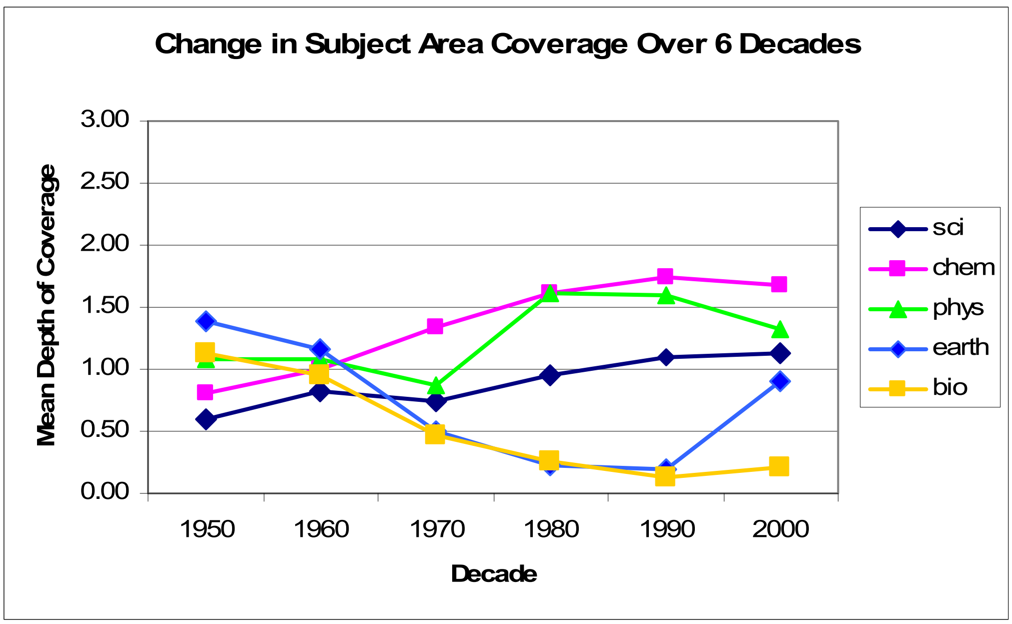


Figure 4.39 Mean depth of coverage over 6 decades – comparing subject areas over decades

Table 4.7 shows that in 50s and 60s there were no significant differences in depth of coverage in any subject area. However, there are differences in depth of coverage in later decades. Table 4.8 indicates that in the 70s Chemistry was covered in significantly *greater depth* than Physics, Earth Science and Biology, and that Physics was covered in statistically *greater depth* than Biology. In the 1980s Chemistry and Physics were covered in a statistically *greater depth* than Earth Science and Biology. In the 1990s Process of Science, Chemistry and Physics were all covered in a statistically *greater depth* than Earth Science and Biology. The present decade indicates that Biology was covered with statistically *less depth* than any other subject area and that Chemistry was covered in statistically *greater depth* than Earth Science.

Table 4.7 Decades that displayed significant differences in depth of coverage over 5 subject areas are shaded (α < 0.0083).

Subject	F(4,18)	p
1950	1.13	0.372
1960	0.29	0.8837
1970	21.91	<.0001
1980	68.24	<.0001
1990	95.54	<.0001
2000	38.46	<.0001

Table 4-8 Subject comparisons exhibiting significant differences in depth of coverage for decades as indicated in Table 4.7

subject comparison		diff in means	99% Confidence Limits	
1970				
chem	sci	0.4659	0.0817	0.8501
chem	earth	0.8418	0.3625	1.3211
chem	bio	0.8795	0.4863	1.2728
phys	bio	0.4136	0.0888	0.7383
1980				
chem	earth	1.39488	0.81759	1.97217
chem	bio	1.36352	0.88977	1.83728
phys	earth	1.3962	0.88448	1.90791
phys	bio	1.36484	0.97365	1.75603
1990				
sci	earth	0.90899	0.09786	1.72012
sci	bio	0.9751	0.22414	1.72606
chem	earth	1.54769	1.01117	2.0842
chem	bio	1.6138	1.17351	2.05409
phys	earth	1.41684	0.94127	1.8924
phys	bio	1.48295	1.11939	1.8465
2000				
sci	bio	0.9174	0.0122	1.8226

chem	earth	0.7681	0.1213	1.4148
chem	bio	1.4668	0.9361	1.9975
phys	bio	1.1509	0.7127	1.5892
earth	bio	0.6988	0.1144	1.2831

Analysis of Themes 24-26

As can be seen in Table 4.9 the mean averages of frequencies of depth of coverage for non-zero sub-categories for themes 24-26 is not a satisfactory method of showing possible differences between each decade. However if we simply look at the mean sum of non-zero scores offered in each decade a more accurate representation is portrayed as shown in Figure 4.40.

Table 4.9 Non-zero score - sums and means – do not show real differences between decades.

	1950	1960	1970	1980	1990	2000	
N	21	16	7	12	21	17	**24 Tech**
Sum	55	39	19	31	55	41	
MEAN	2.62	2.50	2.39	2.68	2.52	2.38	
N	33	31	18	19	22	27	**25 History**
SUM	53	53	26	32	39	47	
MEAN	1.59	1.72	1.68	1.72	1.76	1.76	
N	4	4	2	4	8	6	**26 SSI**
SUM	11	8	4	12	19	13	
MEAN	2.39	1.74	1.54	2.23	1.88	1.91	

Once again the question arises; are the changes in mean frequency depth of coverage seen between themes 24-26 from 1952 to 2008 statistically significant? To address this inquiry, depth of coverage across these 3 themes were compared and contrasted over 6 decades. A mixed-design ANOVA was once again employed, and all assumptions were met for conducting a multivariate test of this kind, see Appendix E.

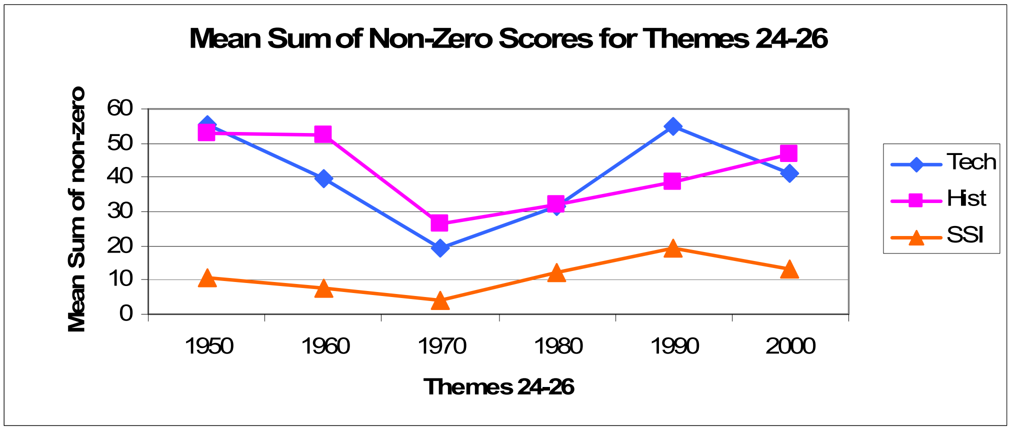


Figure 4.40 – Mean sum of non-zero scores for each decade

The analysis revealed that the Theme x Decade interaction was *not significant*, F (10,128) = 1.57, p=0.1219 at an ($\alpha < 0.05$). This analysis revealed that the main effect of decade was *significant*, F (5, 64) = 2.78, p=0.0246 ($\alpha < 0.05$). The main effect for theme was also *significant*, F (2,128) = 47.88, p<0.0001 ($\alpha < 0.05$). Post-hoc HSD Tukey tests found only one significant difference ($\alpha < 0.0167$) in theme 24 (Technology) between decades 1950 and 1970 (diff in means=36.00, 98.33% confidence limits min=1.754, max=70.246). Contrast repeated measures tests indicated that there was a significant difference ($\alpha < 0.0167$) between SSI & History of Science (F (5,64) = 71.36, p <.0001) and for SSI & Technology (F(5,64) =119.54, p <.0001) over all decades.

A Qualitative Look at the Textbook Sample

Before addressing the specific questions in this study it is of interest to note the qualitative characteristics of the textbooks analyzed. These include the look and feel of the textbooks, size of books, prose, and pedagogical differences. In identifying pervasive qualities found in the textbook sample the researcher hopes to convey a sense of the task undertaken and the characteristics of the books reviewed.

Look and Feel of Textbooks

Many of the earlier textbooks published in the 1950s and 1960s consisted of black and white text and pictures or black and white with a single color to highlight images and texts. In contrast, books in the 1970s to the present day have many color images, multi colored text, and glossy pages. The feel and presentation of textbooks reflect the significant improvement in printing technologies and practices that have occurred over the past six decades.

Size of Textbooks

Books became more sophisticated, more colorful, and more attractive over time and increased in the number of pages. Table 4.10 shows the number of pages, chapters and units averaged over each decade. There is a noticeable dip in the 1970s but over the last 30 years textbooks have steadily increased the number of pages though not the number of units covered. As illustrated later in this chapter, this is a noteworthy development in science textbooks.

Table 4-10 - Number of pages, units and chapters in textbooks – averaged over each decade. (These numbers do not include glossaries, indexes, appendixes or sections beyond the numbered chapters for each text)

decade	#pages	#of units	#of chapters
1950	486	12	52
1960	494	11	45
1970	416	7	31
1980	501	7	43
1990	511	11	73
2000	591	8	44
MEAN	500	9	48

Figure 4.41 displays a comparison between the number of pages and number of chapters for each text, which reveals individual differences between the books reviewed. The shaded area on the graph denotes the number of pages (y axis to the left – scale is 0 to 800) and the bar graph (y axis to the right – scale is 0 to 400) indicates the number of chapters. The graph indicates that several books have approximately twice as many pages as chapters –suggesting very short chapters. Five books, *Challenges in Modern Science,* published from 1978 to 2003 contribute to the short chapters, as the format for this book was to present very specific information in a few pages. The graph also displays books that have a much greater difference between the number of pages and the number of chapters, representing longer chapters.

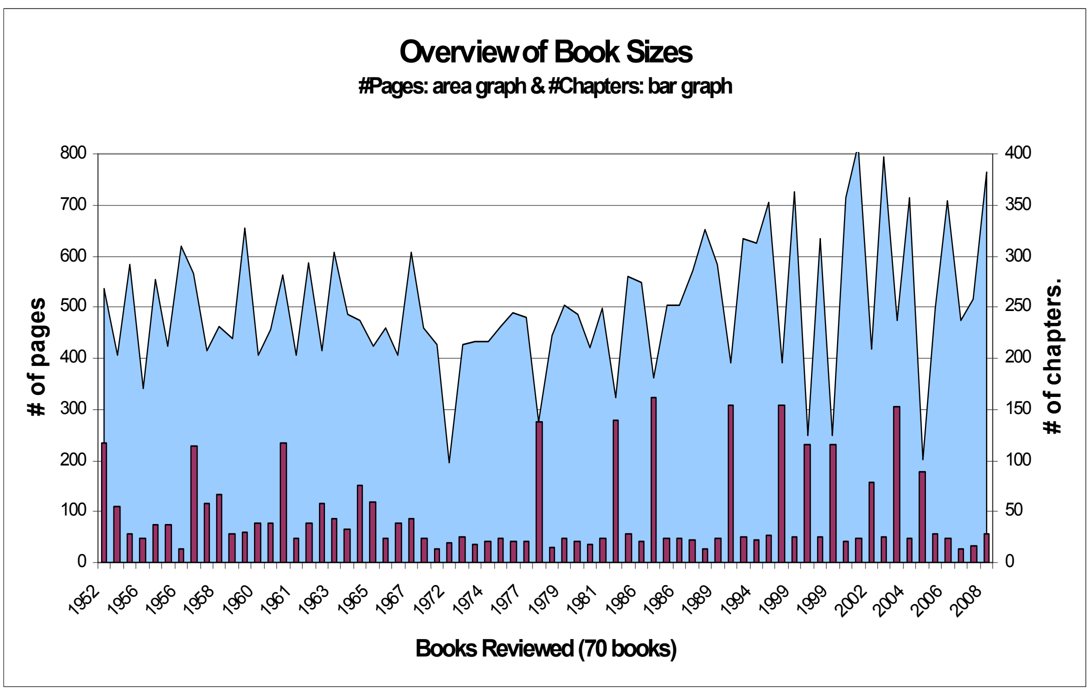


Figure 4-41 Overview of 70 books reviewed – comparing number of pages and chapters for each book

Scientific Prose

One of the most notable features of the books reviewed was the type of writing employed. In the 1950s and 1960 most books were written in a conversational prose. Discussions often crossed science content boundaries and themes, not adhering to specific science topics as the prevalent manner of communicating ideas. Book 35, chapter titled "Machines of Modern Living" (1956, page 318) can be used to illustrate this point. From this central topic the author discusses not only the topics of work, simple machines, mechanical advantage, and efficiency but he also presents detailed discussions of how specific machines work (windmills, paddlewheels, washing machines, vacuum cleaners, refrigerators/freezers, steam engines, internal and external combustion engines, gas and diesel engines, turbo and jet engines, to name a few). In these discussions the author branches off into different science topics. For example, while explaining how piston and cylinder machines function there is a discussion of centripetal force, pressure in liquids, resistance, and friction. In the discussion regarding how refrigerators and freezers work there are explanations of evaporation, heat absorption, and the effects of changing pressure in fluids. All topics and ideas, including those tangential to the main chapter theme, are discussed directly in the body of the text. In comparison, textbooks after 1975 presented specific topics in a more direct and narrowly defined manner. Books published after 1975 presented topics considered tangential to the chapter theme in sidebars and end of chapter or unit science highlights and not within the body of the science text.

Book 67 presents the science topic 'Work' in a manner that is quite common to the textbooks reviewed from 1975 to the present. An example can be found in the chapter titled "Work and Machines" (2001, page, 96). The authors define and calculate, if applicable, the terms work, mechanical advantage, efficiency, and simple machines and give examples of simple machines. There is a timeline displaying buildings that have been constructed using simple machines and another small section that addresses the issue of automation in the workplace. However, unlike earlier books, neither of these tangential topics is discussed nor referred to in the body of the text. The writing style employed after 1975, presented concepts in bulleted form, highlighted statements and words that described the main concept quite directly without embellishment. This style of writing did not require any work on the part of the researcher to locate the science content nor require much thought to grasp the meaning of the material presented. However, the prose in the books written before 1975 required a much slower and more thoughtful reading by the researcher to extract the science content.

Pedagogical Differences in Science Textbooks

An in-depth discussion of pedagogical differences between texts is not part of this study. However, some general observations may provide depth to the content analysis described in the next section. The pedagogical proclivities of textbook authors influence how any science book is written; the prose, as noted above, is one example of this. Textbooks written in the 1950s and 1960s provided the reader with what might be considered by today's standards 'extraneous' information. However, the questions asked at the end of sections, chapters or units were quite similar to the questions posed in books written after the 1970s, such as short answer questions: "What is the difference between temperature and heat?" (Book 35, p.245), Fill in the blank questions: "Light rays are ____ when bent by a surface through which they do not pass (Book 35, p.186)", vocabulary definitions, matching and further research questions. Textbooks in the last 20 years and especially in the last 10 years focused on exposing students to very specific science information in the main text, with little digression in the supporting topics. Evidence for this can be found in the seemingly obsessive reference to the science standards and objectives that each unit, chapter and section is to convey.

Book 68 published in 2007 is an example of how very specific science content is being communicated to the students through the textbook. Each chapter of this book begins with an overview of key concepts to be learned, an activity to explore a key concept and an internet activity. Next a 'getting ready to learn section' reviews the science standards and science content presented in the previous chapter and displays the new science standards and vocabulary to prepare the students for what they are about to learn. Each chapter is then interspersed with reading comprehension questions, reading tips, skill builders and activities with notations as to which standard applies to each item. At the end of each section is a review in three parts: key concept questions, critical thinking questions and a challenge question; these questions also have notations indicating the standard is being addressed. At the end of the chapter is a review of key concepts, vocabulary questions, matching, multiple choice questions, thinking critically, and short answer questions. Once again each question is attending to a specific science standard and is labeled as such. Finally, a standards-based assessment test is offered – each question indicating the standard being tested. It is not the intention of this research to qualify these practices as valuable or not but the awareness of these practices informs this particular study and provides some rationale for the results found in the following analysis.

Summary

This chapter presented and summarized the findings of data collection for this study. It was found that emphases on certain themes have waned over time (earth science and biology) and others have increased in depth of coverage (chemistry). The research also showed that in the main text only 16 items in a list of over 3,500 science content items were newly introduced science findings discovered or developed since 1950. The next chapter looks to explore this data, discuss possible factors contributing to these findings and examine the implications of these results to education today and in the future.

CHAPTER FIVE – CONCLUSION

Overview

The intent of this research was to ascertain the specific science content in 8th and 9th grade U.S. general science textbooks from the 1950s to the present and to document the emergence of new topics over time. Earlier chapters discussed the rationale for this study, the background literature, the methodology and the findings. This chapter reviews and discusses the findings to examine the implications for education today and in the future.

Discussion of Data Findings - Trends in the Data

As discussed in the previous chapter, Table 5.1 displays the 26 themes that were selected by an expert panel (see Appendix B), and the subject areas that each theme represents. Chemistry encompasses themes 2-5; themes 6-13 are included in the Physics subject area; themes 14-16 are in Earth Science, and themes 17-23 are in the Biology subject area. Themes 24-26 (Technology, History of Science, and Socioscientific Issues, SSI) are characteristics, qualities, or products of science. Because these themes attend to how science is conducted, thought about, and practiced in society, they will be considered together with theme 1 (Process of Science) in the following discussion.

Table 4.1 Themes in each subject area

Theme / Category List	
2	Characteristics & Structure of Matter
3	Chemical Interactions
4	Organic Compounds
5	The Atom & Nuclear Reactions
6	Fluid & Gases
7	Motion
8	Energy
9	Work, Power & Machines
10	Mechanical Waves & Sound
11	Electromagnetic Waves & Light
12	Electricity
13	Electromagnetism & Magnetism
14	Astronomy
15	Geology
16	Weather
17	Ecology
18	Diversity of Life
19	Origins of Life
20	Characteristic of Living Things
21	Animal Organ Systems
22	Genetics
23	Human Health
24	Technology
25	History of Science
26	Socioscientific Issues (SSI)
1	Process of Science

Chemistry

Physics

Earth Science

Biology

Process of Science

Innumerable patterns can be found in such a large data set and selection requires a purposeful basis. Therefore, trends will be viewed along subject areas and historical timelines to better understand the answers posed by the questions in this research. These questions are:

1. What *specific science content* is presented in the selected 8th and 9th grade U.S. general science textbooks from the 1950s to the present day?

2. In what way has the *science content changed* in each of the selected 8th and 9th grade U.S. general science textbooks from the 1950s to the present day?

3. Are new scientific findings reflected in 8th and 9th grade U.S. general science textbooks?

Subject Area Trends

The Subject of Chemistry

The data reveal a steady increase in the mean depth of coverage for all Chemistry topics (themes 2-5) in the textbook sample from the 50s to the 80s and a slight, but not significant, decline to the present decade.

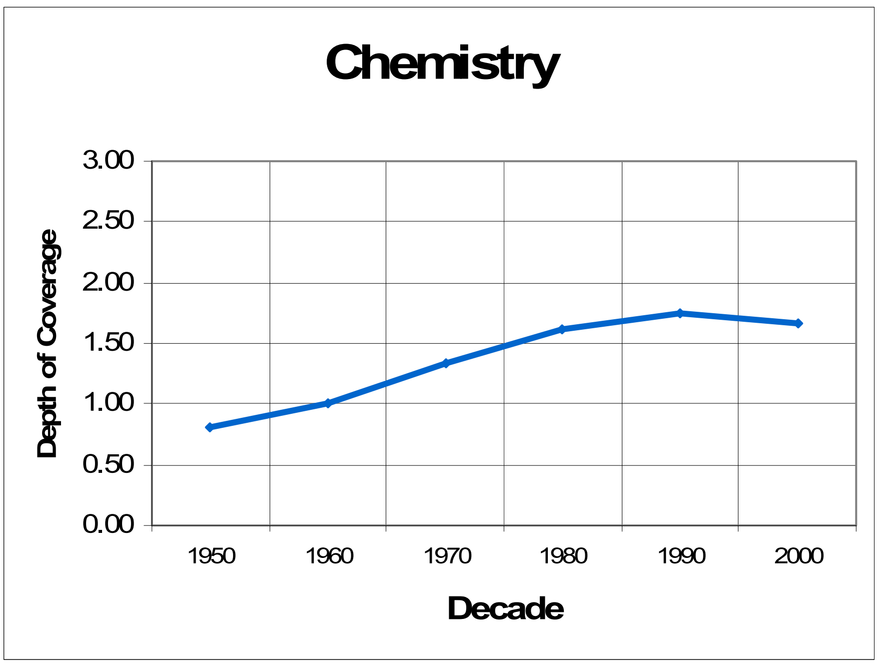


Figure 5.1 Chemistry trends over 6 decades

Figure 5.1 shows the general trend in Chemistry over six decades; zero indicates no coverage and three indicates maximum topic coverage. During the last 30 years mean depth of coverage was significantly greater than coverage in the 1950s, but not significantly different from the 1960s.

The Subject of Physics

The data revealed no statistically significant change in the mean depth of coverage in the subject area of Physics over the past 60 years.

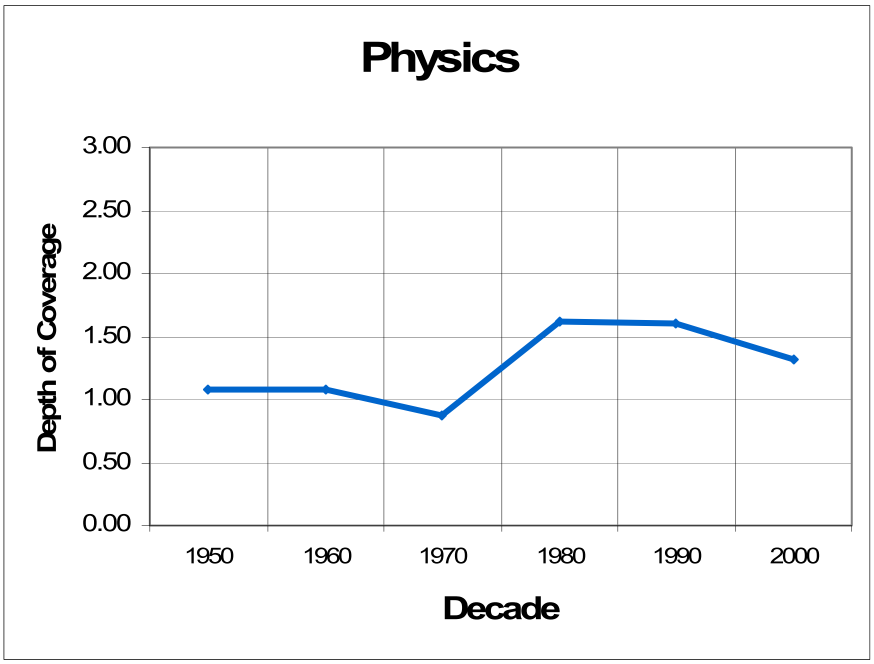


Figure 5.2 Physics trends over 6 decades

Figure 5.2 shows the general trend in Physics over six decades; zero indicates no coverage and three indicates maximum topic coverage. Descriptive graphs displayed in Chapter 4 depict localized differences in individual themes, yet when considered together there was no significant difference. Mean depth of coverage in Physics peaks in the 80s and after that time declines slightly, although none of these differences are significant.

The Subject of Earth Science

In Earth Science we see an opposite trend to that shown in Physics. Instead of an increase and a decline, we see a decline and then an increase in mean depth of coverage.

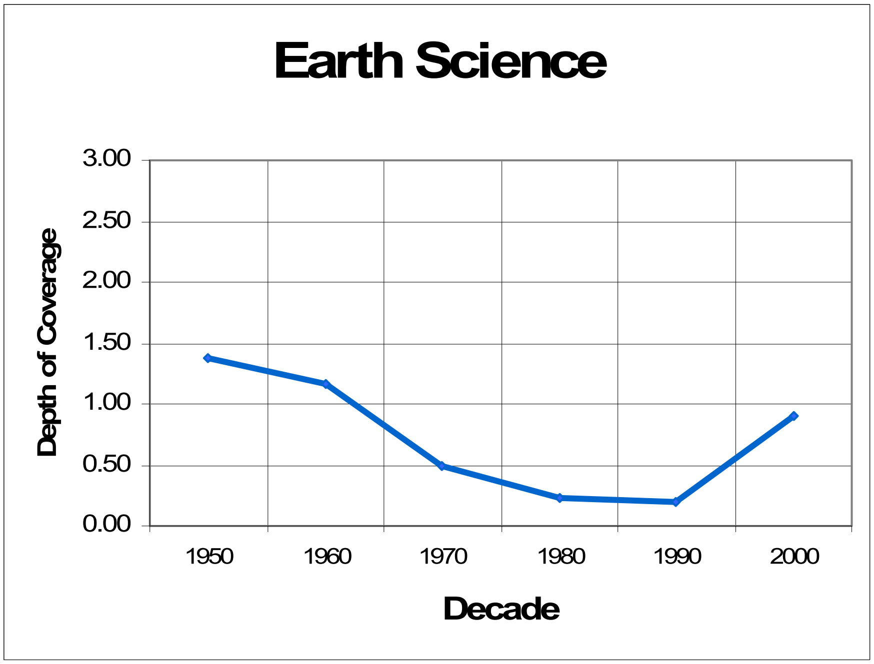


Figure 5.3 Earth Science trends over 6 decades

Figure 5.3 shows the general trend in Earth Science over six decades; zero indicates no coverage and three indicates maximum topic coverage. The decline in content coverage is statistically significant between the early (50s and 60s) and the latter (70s, 80s and 90s) parts of the study time frame. Although there is an increase in coverage in the present decade it is not statistically significant. The rise in Earth Science can be attributed to the renewed coverage of Astronomy (theme 14) in the present decade. This theme (Astronomy) displays a steady decline in coverage from 1950 to 1990 when the mean depth of coverage was 0.0. However, in 2000 this topic was revived almost to the levels seen in the earlier decades.

The Subject of Biology

In biology there is a statistically significant decline in depth of coverage from the 50s and 60s to all of the following decades.

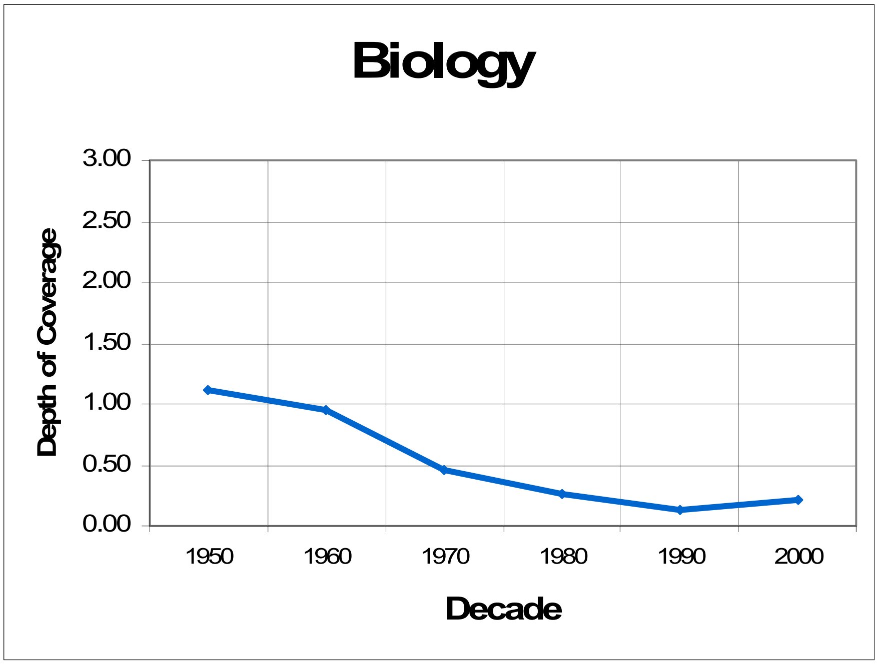


Figure 5.4 Biology trends over 6 decades

Figure 5.4 shows the trend in Biology over six decades; zero indicates no coverage and three indicates maximum topic coverage. In 1970 the mean depth of coverage decreased to below 0.5. From 1980 to the present, the mean depth of coverage clustered around 0.15 indicating almost no coverage in this subject area. Surprisingly, Ecology (theme 17) experienced a similar trend. Ecology, which includes topics regarding conservation, pollution, and alternative energy resources, had the highest mean coverage in the 50s and 60s. Since then the mean coverage of this topic decreased and remained constant around 0.5 for the past 40 years. With an increased interest in the environment, renewable energy resources, and conservation in the last 20 years one might have expected this topic to have been given greater coverage.

The Process, Products & Characteristics of Science

The data show no statistically significant change in depth of coverage for the Process of Science (theme 1), Historical Discussions (theme 25), or Social Issues in Science (theme 26), and no statistically significant change after 1970 in Technology (theme 24).

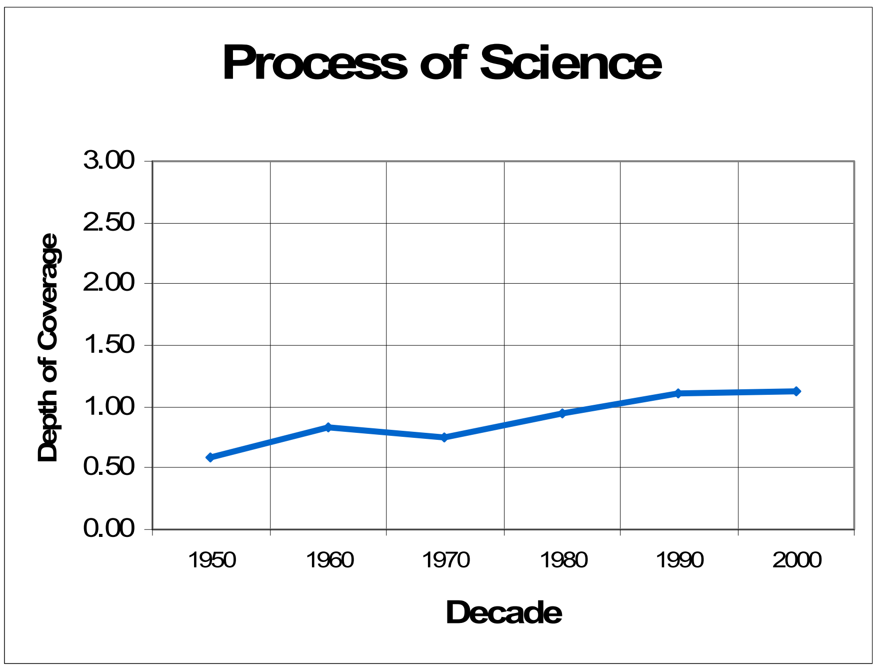


Figure 5.5 Process of Science trends over 6 decades

Figure 5.5 shows the trends in Process of Science over six decades; zero indicates no coverage and three indicates maximum topic coverage. There was a statistically significant decrease in Technology (theme 24) sub-categories between 1950 and 1970 (not shown on Figure 5.5, see Figure 4.40). However, no other decade exhibited any statistically significant differences. Sixteen new discoveries were found. More than half of these items were found in books published in the present decade (see Table 5.2).

Table 5.2 New discoveries mentioned in main text for each decade in the sample

Year	**1950 (N=11)**	**1960 (N=15)**	**1970 (N=11)**	**1980 (N=12)**	**1990 (N=9)**	**2000 (N=12)**
# of new Discoveries discussed each decade out of a total of 16 new topics	1 item was found	3 items were found	2 items were found	6 items were found	8 items were found	13 items were found

Although not many new discoveries were found during the 1950s or 1990s, books during these decades showed on average the highest mean frequency of Technology (theme 24) items (see Figure 4.40).

Summary of Subject Area Trends

The general trends in science content in U.S. 8th and 9th grade general science textbooks, as revealed by this data sample, indicate no statistically significant change in depth of coverage in Physics or Process of Science in the last six decades; no significant change in depth of coverage in Earth Science and Biology in the last 4 decades and no significant change in coverage in Chemistry over the last 3 decades. Only two individual themes, the Atom & Nuclear Reactions (theme 5) and Astronomy (theme 14) displayed higher (though not statistically significant) mean depth of coverage in the present decade than any other decade. In the last six decades 120 8th and 9th grade science textbooks have been published; 37 of those titles have been published for more than five years; 30 of those 37 books were included in this study. These facts lend support to the notion that this study closely reflects the reality of a static educational system.

Possible Explanations of Trends

There are several possible reasons for the trends seen in this sample. As discussed in the Limitations section in chapter one, the absence, or in this case, the decline of a topic may be the result of an intentional movement to transfer some topics to another grade level. This suggests that the subject area is simply moved from the 8th and 9th grade general science curriculum to another grade in the K-12 curriculum. Biology and Earth Science are often offered as separate courses in high school which may explain the decline in these subject areas. It must be noted, however, that many high schools require only one science course for graduation (see Table 5.3), suggesting that those students who take only the minimum science requirements may leave school without a foundation in one or more science areas (National Center for Education Statistics, 2004).

Table 5.3 High school graduation requirements in science for 50 states plus D.C.

High School Graduation Requirements in Science for 50 States and D.C.	# of States
One science course required out of bio/phys/earth	21
One science course in bio required	3
Two science coursed required out of bio/phys/earth	7
Three classes required one each bio/phys/earth	8
Science courses in Technology/life skills required	3
Math and Science requirements together	1
Science only required for college prep	1
No State requirements – up to each local district	7

Another reason for the trends seen in these subject areas may be found in the nation's focus on very specific science *outcomes*. As discussed in chapter two, since the mid 80s the U.S. Department of Education has been promoting education by encouraging state standards, mandating standardized tests, and enforcing sanctions for non-performance (U.S. Department of Education, 1991). These actions affect the selection of science content and the depth of coverage provided. The unvarying content found in the five-subject areas as depicted by the data may be a natural consequence of attempts to attain and maintain specified achievement standards. As noted in the previous chapter, textbooks written in the last decade focused on presenting specific facts and relating those facts to testable outcomes.

It is interesting to reflect on the Project 2061 research conducted by Kesidou & Roseman (2002) as highlighted in chapter two. This study concluded that "eight of the nine programs reviewed did not differ greatly in their inclusion of the specific ideas. Each program addressed all (or nearly all) key ideas that served as a basis for the analysis. Although most key ideas were present in the programs, they were often buried between detailed, conceptually difficult, or even unrelated ideas, making it difficult for students to focus on the main ideas" (p. 527). This critique suggests that information tangential to the specific science content is considered confusing to the student and should be excluded from the main text. In response to this type of critique textbook authors and publishers may have moved towards less detailed coverage of individual science themes; a paring away of any topic, concept, or idea that did not relay the science content to be tested.

Historical Trends

1950s & 1960s

The textbook sample from the 1950s and 60s represented 21 of the first 23 *themes* with a depth of coverage greater than 0.5; the exceptions are Origins of Life (theme 19) in both decades and Motion (theme 7) in the 1950s. In the 50s 13 of those themes were covered at a depth greater than 1.0 and, in the 60s 11 themes were covered with a depth greater than 1.0 (see Table 5.3). All *subject areas* (Chemistry, Physics, Biology, Earth Science, and Process of Science) were represented during both decades and there was no significant difference in depth of coverage between subject areas during these decades (see Figure 4.39). These findings reflect the educational reform movement of the time. As noted in chapter two, by the mid 1950s progressive education had lost its momentum and administrative and political support was being drawn in a new direction (DeBoer, 1991). In the 1950s scientists became involved with creating a more rigorous curriculum intent on increasing the number of students taking science classes and presumably lead to greater numbers of citizens choosing careers in science and technology. These projects were influenced by scientists from diverse disciplines resulting in a wide variety of topics offered within several subject areas. This was reflected in the data which showed that all content areas were represented and no one area was covered to any significantly greater depth than another. As seen in Table 5.4, breadth of coverage appeared to be emphasized over depth of coverage in these decades. More *themes* were covered minimally (0.5 to 1.5) than the number of themes covered at average depth (1.5 to 2+). This is most likely due to the intent of reformers to help students understand the structure of science before proceeding to the specific details and disciplines of science. In attempts to make science more attractive and relevant to the lives of students, scientists created courses that contained a significant amount of material that dealt with technological applications. Attention was also given to presenting the changing nature of scientific knowledge by including the historical development of topics (DeBoer, 1991). These objectives were reflected in the data from this study. Textbooks from the 1950s had the highest frequency of Technology (theme 24) and History of Science (theme 25) items; textbooks from the 60s also displayed a comparatively high frequency of items in these areas (see Figure 4.40).

Table 5.4 Frequency of themes for each decade in 0.5 increments of depth of coverage score

	≤ 0.5	0.5 - 1.0	1.0 - 1.5	1.5 - 2.0	≥ 2.0
1950	2	8	11	2	0
1960	1	11	8	3	0
1970	10	7	4	2	0
1980	9	2	2	9	1
1990	9	1	5	7	0
2000	7	4	6	6	0

1970s

By the 1970s attention in education moved from national security and keeping pace with the Soviet Union to concerns about equitable education opportunities. An unpopular Vietnam War aroused discontent with many facets of life in the U.S. Public attention focused on overt racial prejudice, gender inequity, and poverty in urban areas. During this era legislation was passed in an effort to provide educational equity to compensate for perceived economic, racial and social imbalances. In the late 70s "the call for intellectual rigor for excellence, and for disciplinary study, that had been made little more than a decade earlier sounded strangely anachronistic… the new need was for an enlightened citizenry, not an educational elite" (DeBoer, 1991, p.173). The data from this study reflects this de-emphasis on science content. Results show that no *subject area* in this decade has a significantly higher mean depth of coverage than earlier decades and the areas of Earth Science and Biology are covered in significantly lower depth than in the 50s and 60s (see Figure 4.38). If individual *themes* are explored, we find themes 2-5 (Chemistry content areas) and theme 19 (Origins of Life) are the only categories out of 26 in which the decade of the 70s scored higher means than in the 1950s and 60s (though not significantly higher, see Tables 4.37 and 4.40). Only 13 themes were covered at a mean depth greater than 0.5 and six of those themes were covered at a depth greater than 1.0 (see Table 5.4). In this decade we also see 10 themes (14-23 in Earth Science and Biology subject areas) are all covered at a depth *less than* 0.5. Surprisingly, given the focus on the social and relational aspects of science during this decade, the 1970s also displayed the lowest mean scores in the areas of History of Science (theme 25) and Socioscientific Issues (theme 26 – see Table 4.40).

1980s

School reform in the early 80s was initiated by the Department of Education based upon the report, *A Nation at Risk* (National Commission on Excellence in Education, 1983). Reforms were based on existing organizational structures that did not require a restructuring or upheaval of current operations. The initiatives recommended quantitative increases such as lengthening the time students spend in school and establishing tougher disciplinary measures. There was also a refocusing of the curriculum on mathematics and science (Beyer, 1985). These reforms also refined educational goals and linked those goals to testable outcomes (Murphy, 1990). The significantly higher coverage seen in Chemistry in this research can be clearly linked to the initiatives enacted during this period. Textbooks published in this decade displayed a significantly higher depth of coverage than in all earlier decades in the *subject area* of Chemistry, while the areas of Biology and Earth Science have a significantly lower mean depth of coverage compared to earlier decades. In spite of the initiatives implemented in this decade the Process of Science and Physic areas did not show any change in depth of coverage from earlier decades. The reason for this may be that these areas are equally valued across decades. It is also important to note that in the statistical analysis discussed in chapter four, a significant difference in depth of coverage was found in Process of Science and Physics, with p values of 0.020 and 0.025 respectively however, due to the Bonferoni adjustments for multiple tests, the acceptable p value was modified to 0.01 leading to an interpretation of no significant differences. As discussed earlier, the decrease in coverage in Biology and Earth Science may indicate that these subject areas were moved to other grade levels.

If we explore the individual *themes*, this decade provides a mean depth of coverage above 0.5 for 14 themes. Nine of these themes are covered at a depth between 1.5 and 2.0 and theme 13 (Electromagnetism & Magnetism) is covered at a depth greater than 2.0 (see Table 5.4). There are six themes in this decade with a higher depth of coverage than found in any other decade; five of these themes are in the area of Physics (see Figure 4.37). There are nine themes in the area of Earth Science and Biology that have a mean depth of coverage below 0.5. The data show the shift from an emphasis on breadth of coverage in the early decades to an increased depth of coverage of several *themes* within the *subject areas* of Chemistry and Physics and an overall decline in coverage of *themes* within the *subject areas* of Earth Science and Biology.

1990s & 2000s

By the 1990s accountability was defined in relation to standards of excellence (Snauwaert, 1993). Corporate collaboration increased and by 1995 the Business Roundtable, composed of 200 of the most influential chief executive officers (CEOs) in the nation, proposed nine essential components to improve schools; the first four were state standards, state tests, sanctions, and the transformation of teacher education programs (Business Roundtable, 1995). The influence of corporate partnerships continued throughout the 90s and into the present decade, as can be seen in the No Child Left Behind (NCLB) Act of 2001. This Act promotes education by encouraging state standards, mandating standardized tests, and enforcing sanctions for non-performance, as well as providing flexibility in choice of schools. The Act assumes educators can specify and measure what all children should know and learn. Further, it assumes that accountability for assuring that children will have the expected grade-level knowledge and skills can be established on the basis of these measures. Data from this research study show no significant change in depth of coverage in the five *subject areas* from the 1980s to the present. Additionally, only 14 new science content items were introduced from 1990s to the present. As noted earlier in this chapter, textbooks in the present decade focused attention on ensuring science content was closely aligned with specified state standards (each state and district maintaining their own version of science content standards). As was found in the 80s, content coverage was focused on fewer *themes* in greater depth than found in the 50s, 60s and 70s. Table 5.4 shows that theme coverage in the last 20 years was not provided at the depth provided in the 1980s. These findings may be due to the shift in thinking and practice of accountability in education. More attention is paid to assessing specific content than to broadening or expanding science content; therefore, no significant changes across subject areas can be discerned. In fact small declines in coverage are seen as compared with the 80s when one looks to individual *themes*. There are 12 themes above 0.5 in the 90s and 16 themes above 0.5 in the present decade (see Table 5.3). In the 1990s there were five themes (in the areas of Chemistry and Physics – see Table 4.37) that had the higher mean depth of coverage than any other decade. The table also shows two themes (theme 5 – Atoms and theme 14 –Astronomy) receiving their highest mean depth of coverage in the present decade. It is not evident why the depth of coverage would increase (though not significantly) for these themes.

Perhaps a more pragmatic explanation of the similarities seen over the last 30 years may be offered when one looks to the publishing industry. Over the last 30 years Pearson Education has acquired a predominant share of the educational publishing market. To date the following publishers fall under the Pearson Education umbrella:

> Putnum, Prentice-Hall, FT Knowledge Financial Learning, Penguin, Viking Press, Grosset and Dunlap, HarperCollins Educational Publishing, Penguin, Silver, Scott Foresman, Allyn and Bacon, Addison-Wesley,

Burdette and Ginn, Longman, Benjamin Cummings and Macmillan Publishing, Macmillan Reference, Peachpit Press, New Riders, Cisco, Adobe Press and Dorling Kindersley.

Pearson Education leads in every major sector of educational publishing, including elementary and secondary school, higher education, professional education, English Language Teaching (ELT), and educational technology, both in the U.S. and internationally. These realities imply that Pearson Education controls not only what is being taught but also how it is assessed. The company has acquired National Computer Systems (NCS, the largest educational testing and data management company in the US), eCollege® (a provider of eLearning and enrollment services to post-secondary education), and Harcourt Assessment and Harcourt Education International (largest international testing company). Therefore the findings from this study regarding the last 30 years may be the natural outcome of the consolidation of educational materials under one publishing company. This obviously raises the question as to whether U.S. educators, administrators, and teachers have abdicated control over science content, curriculum, and testing. Does Pearson act as a willing agent in the service of education, responding to the needs, concerns, and philosophy of educators, or is the U.S. educational system merely a recipient of the educational content and curriculum deemed appropriate by major publishing houses. This question is beyond the scope of this study however, it merits closer examination by all interested in any level of school reform.

Summary of Historical Trends

If we take a wide view of the findings from this study we see a progression of change in science content from broad coverage of many inter-related themes in the 50s and 60s to a more focused and in depth coverage of fewer isolated themes after the 70s. In the earlier decades, scientists were the main architects of the general science content. They espoused the theory that before students could conduct science properly and engage in authentic scientific activities they must first understand the structure and function of science (Elliott and Woodward, 1990). To this end scientists constructed unifying themes that crossed discipline boundaries and provided students a variety of experiences in multiple science content areas in order to shape an appreciation for the underlying principles of scientific practice (Goodlad, 1966). The data from this research reflect this effort; textbooks published in the 50s and 60s displayed equal coverage of multiple themes crossing science disciplines. Data from this time period showed the highest instances per textbook of technology and historical discussions, providing students a context in which to place their newly acquired understanding of science. Textbooks in the research sample from these decades were written in a style that demanded attention and thoughtful consideration to successfully navigate the science content. Scientists attempted to engage students in the processes of connecting ideas and concepts that would lead to a broader understanding of how science is put into practice and developed from inquiry to scientific theories (Elliott and Woodward, 1990).

In the 70s the nation's attention was focused on more equitable education rather than the content of science education (DeBoer, 1991). This de-emphasis on science is evident in the data from this period. For the majority of science *themes* the average depth of coverage decreased in this decade from the levels found in the earlier decades. Surprisingly, themes relating to social issues and historical perspectives showed a decline; one would assume these themes would have provided an excellent avenue to incorporate equity issues into science education.

In the 1980s the shifts in science content that began in the 1970s become more pronounced and defined. What was seen as a general decline in all themes in the research data in the 1970s becomes a general decline in Earth Science and Biology in the 1980s. The report initiated by the Department of Education, *A Nation at Risk*, acted as a catalyst to refocus attention on the math and science curriculum (National Commission on Excellence in Education, 1983). The de-emphasis of Earth Science and Biology in general science textbooks may have been an effort to differentiate subjects so that each area could be approached in a more purposeful manner. It was during this decade that corporations became involved in education. Reforms enacted during this time were built upon existing structures that enabled schools to act quickly to link new science goals to testable outcomes (Murphy, 1990). The data from this research shows significant increases in the *subject area* of Chemistry and increases in depth of coverage in nine *themes* in both Physics and Chemistry subject areas.

Over the next two decades corporations became more heavily involved in education. Legislation was passed allowing business leaders with no prior experience in education to act as school administrators, to serve on local, state, and national educational policy panels, and to testify on federal education legislation (DeBoer, 1991; Celis, 1993; Berube, 1994). Inevitably corporate involvement in the schools influenced school policy to mirror corporate interests in profit, choice, and the bottom line. The data from this study showed no significant change in any *subject area* over the last 30 years. There are minimal increases in some theme coverage, though not significantly so. This may be due to educators' preoccupation with mandating standardized tests, encouraging standardized and measurable outcomes for each grade as well as providing flexibility in school choice (U.S. Department of Education, 1991). It is more economical to create, distribute and test students on science content that has been in place for more than 30 years than to continually modify, update, and revise materials that reflect science innovations. It is also more cost-effective to expect and enforce the notion of uniform outcomes than to support the unique talents, skills and abilities of all students. Finally, the option of school choice allows those who can afford the high cost of learning science in the 21st century to achieve their educational goals in an environment most conducive to their learning needs. However, vouchers eliminate equity in education for those of lower socioeconomic levels and perpetuate stratification of the system.

What was *not* in the Data

Perhaps as interesting as what was found in this sample of general science textbooks is what was not found. There was very little, if any, reference to other countries or parts of the world outside of the U.S., even when the opportunity to do so flowed naturally from the content. For instance, many books discussed the seasons, and in doing so, mentioned the northern and southern hemispheres. However, no book mentioned or depicted what countries might be located in the northern and southern hemispheres. Sidebars and end chapter narratives touched upon topics relating to locations outside of the U.S., such as how the pyramids were built using simple machines, and the Tsunami in Thailand, but did not include a discussion of these types of issues in the body of the text. Interestingly, many books published in the last decade discussed global warming in the main text but did not discuss the global implications, nor did they offer perspectives on the factors and causes of global warming beyond *human activities*.

As noted in chapter four, few cross-discipline discussions were included in the main text in books published in later decades. In earlier decades, discussions often crossed science boundaries (e.g., Biology, Chemistry and Physics) although few books crossed discipline boundaries (such as English and Social Science). Books published in later decades made references to other disciplines (Writing, Literature, History, etc.) but only as sidebar or end of section narrative.

Implications

The Selection of Science Content

This study noted that in an era of exploding scientific advancements in technology (e.g., wireless technology, genetic engineering), in our understanding of the universe (e.g., climate change and string theory), and in our scientific thinking (e.g. science is about relationships between systems not simply a process of isolating systems to understand local interactions) few of these areas are reflected in the science textbook. It is understood that educators must make choices and in the process may place more emphasis on some content over others. This is a natural outcome, just as a mapmaker, in order to produce a useful reference must first flatten and distort the shape of the earth and then select from countless geographical features to produce a meaningful orientation to a geographical area. One cannot dispute the need for selection, simplification, and emphasis, which is inevitable to produce meaningful science education. However, the mapmaker's selections are a technical necessity for the production of a purposeful diagram. The educational system's selections are more than a mere technical necessity; they also involve an ideological construct. In a world of competing interests, the fact that much of the science content has remained virtually unchanged for 4 decades, uninfluenced by the reality of advancements in science, suggests that we are entrenched in a single ideological construct. This research shows that we have lost the interconnecting thread that binds various subjects together. In the 50s and 60s science content was presented in a cross-discipline manner; however, in the last 40 years science content has been presented in a vacuum, insulated from other disciplines within and outside of science. Textbooks offer knowledge from each subject in separate compartments, creating fragmented knowledge factoids to be accumulated and restated on standardized tests. As a result, unlike the most current systemic view (Minati, Gianfranco & Pessa, Eliano, 2006), science is presented in textbooks unrelated to or at odds with religion, philosophy, art, history, etc. Given this reality, the modern science educator's conundrum can be appreciated. One may accept the current system or attempt to transform it. The data from this study sheds light on both possibilities; the short term implications of this study accept the current system as it is and offer suggestions on how it may be improved; the long term implications of this study provide a foundation from which transforming the current system may take place.

Short Term Implications for Educators, Administrators & Policy-Makers

For those who value the existing system, the fact that we have been covering the same science content decade after decade is an effective argument for the implementation of a single science standard for all states. Opponents of a national science standard have voiced numerous concerns regarding this notion, such as: 1) National standards and assessments do not increase the achievement gap between minority and nonminority students; 2) National standards do not improve achievement because most teachers will ignore them and teach as they always have; 3) National standards do not take into account the uniqueness of all students; 4) National standards take away school autonomy and impose mandated subject matter ((Ravitch, Brookings Institution & Brown Center on Education Policy, 1995; Ohanian, 1999). All of these concerns are valid and worthwhile considerations, however, when the issue of standards is discussed standard content and standard curriculum are often mistakenly considered to be the same. The data from this study cannot and does not attend to science curriculum (which address the concerns of the first 3 objections) only science content (which addresses the last concern).

A single *science content* standard does not suggest a unification of the *science curriculum* or suggest specific *science outcomes*, as advocated by current policy-makers. Nor does this suggest an intervention from the federal government to organize a science content standard and provide incentives through funding or other resources to achieve cooperation from state governments. Rather, the data from this study addresses the argument against a standard science content based upon the reasoning that national science standards would take away school autonomy. Data from this study show that schools that have been enjoying autonomy in choosing science content over the last six decades have basically chosen to provide the *same science content*. After reviewing 30 of the 37 textbooks that have been published for five or more years over the last six decades, and taking into account that 92% of all 5^{th} through 12^{th} grade classrooms use commercially published textbooks, and that 66% of U.S. public school teachers complete 75% or more of the text (NCES, et al., 2005), it can be concluded that U.S. schools are teaching the same science content. The same science content has been distributed via the textbooks in the U.S. public school system for almost half a century, which makes the argument for autonomy in selecting science content a moot point. A single science content standard would provide a codification and delineation of what is already in place. The drafting of a science content standard would be an acknowledgement of what is already in effect. The U.S. is perceived as a world leader in standards-based science reform yet, unlike other countries, U.S. science education has no organizing principle that can be conceptualized as more than thematically bundling of science topics and related learning opportunities (Schmidt, 2002). The acknowledgement and articulation of common science content would provide cohesion between states, districts and local schools. Use of a common K-12 science content standard would not only allow for communication between schools but also within schools throughout the United States. Each grade would know incoming and outgoing science content expectations, assisting teachers in maintaining cohesion between grade levels, independent of where the student was coming from. It would provide a cost effective national tool for clarifying educational goals. It would diminish redundancy of effort and resources expended yearly at every level of education (more than 15,000 school districts with their own versions of science standards) and the role of government in crafting, refining, distributing, and marketing science standards. It would provide a foundation on which to create a standard model for professional development for principals and teachers that could be distributed nationwide. In this way professional development could move away from distributing random lesson plans and classroom activities that teachers attempt to integrate into the existing curriculum, to a model that provides targeted lesson plans and classroom activities that assist in creating cohesive curricula that meet the unique needs of their learning environments.

A nationwide (not necessarily federally mandated) unified public school science standard could:

1) Improve achievement by clearly defining expectations,

2) Ensure equal access to information and learning opportunities by providing uniform content goals across the nation allowing teachers to focus on the unique needs of the child to help each student meet those goals,

3) Provide a means of coordinating content and assessments nationally and a more meaningful dialogue internationally,

4) Provide consumer protection to parents, teachers and students (everyone knows what is expected),

5) Conserve resources of time and money. (Ravitch, Brookings Institution & Brown Center on Education Policy, 1995, p.27)

A national science content standard could also alleviate the problem of numerous errors found in textbooks. With a single common standard, accurate science information could be transmitted with ease and greater consistency.

Additionally, a single science content standard would allow for more time and resources to be directed toward creating multiple curricula that meet the needs of diverse student populations.

Finally, a single science content standard would provide common ground in which to communicate and discuss science in a global community. As recent TIMSS (The International Math and Science Study, 2003) results shows, the U.S. has fallen in rank from fourth to twelfth in math and science in the international community. One may question the validity of this test and other similar tests conducted nationally, is there alignment between what is being tested and the content offered; is there consistency between nations in the TIMSS testing and states in national testing? Test-makers attempt to create valid tests and provide measures of validity; however, the number of variables involved makes this a difficult and arduous process which can produce imprecise results. These very concerns could be addressed with greater certainty if the U.S. created a single national science standard. A standard would allow educators to create rigorous curricula and devise tests that could accurately assess the intended science content.

Unlike other countries "the picture of the U.S. system that emerges from the TIMSS data is that the U.S. does not have a coherent, focused and rigorous science curriculum" (Schmidt, 2002, p. 3). To stay abreast of the international community and collaborate meaningfully on global educational initiatives, those educators who wish to maintain the current system must develop and implement a coherent science content standard that can be used to represent science education throughout the U.S. and not piecemeal frameworks that represent different areas of the country.

Short Term Implications - Global Considerations

In the early part of the 20th century it was in the national interest to educate future scientists to produce technology; since 1982 the emphasis shifted to educating all citizens in the use of highly mechanized and technical environments, creating a stronger workforce. During this time there was a dramatic increase in the use of technology and a corresponding decrease in costs for the use of these tools. For instance, owing to satellite communication technology, the price of a three-minute phone call from New York to London fell from approximately $250 in 1930 to $30 in 1970 and is now less than 20 cents (Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, 2006, p.17). These technologies are rapidly changing the nature of how we work, learn, play, and socially interact with one another. Not only can we share images, information, data, and entertainment but this can occur without the constraints of time or space. Instantly we connect and download from any location in the world that is *on-line*. Therefore, in addition to the deficiency in coverage of bourgeoning technical and scientific innovations, educators must attend to the increasing availability of instantaneous global interactions.

The world population has grown from 2.5 billion to more than 6.5 billion since 1950. "Managing differences is becoming one of the greatest challenges to multicultural countries" (Orozco & Qin-Hilliard, p.4). Children growing up in these times, more than any other, must navigate through numerous social, cultural, political, and moral differences encountered by the variety of people they interact with. Immigrants are no longer inclined to *assimilate* to mainstream standards to survive in a new country. This includes assimilation of *traditional western* *scientific or classical* ideologies as compared to their own cultural or native explanations for how the world may be viewed and mediated. Inexpensive communication and travel allow immigrants to communicate and keep in close contact with family and friends in their native homeland. In previous eras divided national loyalties might have been construed as almost treasonous, whereas in the twenty-first century such qualities represent valuable human capital as the global market place rewards intercultural sophistication (Coatsworth, 2004, p.53). Children of immigrant families must come to terms with their own mixed cultural identities. These children are asked to navigate the U.S. school system attempting to make sense of traditional western scientific or classical concepts within the framework of their own cultural, religious, and familial frameworks. Therefore, the dearth of international, global, or multi-cultural topics in the sample texts is a critical issue to be addressed by science educators. For classroom teachers, this information can alert them to the necessity of going beyond the textbook in preparing students for life in a global society. This is not to suggest that local, place-based science content and curricula are not important or useful, rather this is a call to include the wider perspective and relate local issues to global realities. The intention is to help students not only understand science concepts but to help them relate those concepts to their own lives, their own nation and the world they live in.

It also underscores the need to help students make connections between classic science and cultural explanations of natural phenomenon. In educational practice, this research supports and reinforces the need for inquiry learning and socioscientific curricula.

Long Term Implications for Educators, Administrators & Policy-Makers

For those who wish to transform the system, this is an opportunity to explicate the under-pinning or ideological construct that holds science education content in stasis. Education stands out as one of the main social institutions for the transmission of knowledge, culture, and values, items that are perennially in dispute. As Gardner (2004) commented "in the United States in 2000, how could we possibly create an educational system that would please the three Jesses – conservative North Carolina senator Jesse Helms, charismatic African American leader Jesse Jackson, and flamboyant Minnesota wrestler-turned-governor Jesse Ventura" (p. 236). However, as indicated by the data, we are in accord about science content. Why? What is this ideology that has our implicit if not explicit agreement? Once identified, educators, administrators, and policy makers can begin questioning the value and relevancy of this ideology or constructs that dictate science content.

Considering the historical background, one might reasonably argue that economics is the basis for our present educational system. The capitalistic ideology permeates the educational system as seen by the importance that is given to outcomes or products in education rather than manner and means of education. The bottom line has taken precedence over the development of the whole child to find and articulate a unique and personal place in society. At what point does society decide that economics is no longer an adequate basis for education? Such a decision must follow from the recognition that income alone is not sufficient to define one's quality of life. Pollution, over-crowding, noise, and resource depletion involve social costs that cannot be conceptualized if we rely only on established economic models. Knowledge of ecosystems and of urbanism, for example, can be considered relevant organizing themes for science education. There is nothing new in this suggestion, scholars and educators have been advocating this perspective since the early 1970s. Hofstein and Yager (1982) challenged the assumptions of the classic science model?

> Rather than including information merely because it is basic to the discipline, the decisions should be made on the basis of relationship to real-life problems… There needs to be a cultural validity to school science as well as a scientific validity. Courses in science should be bounded not by discipline lines, but by a specific context, or relation to current issues and concerns (p.542).

This perspective offers a compelling alternative to the classic science model. It places science in relation to important aspects of contemporary life, provides motivation to learn, as selected topics would be relevant to students' lives, and teaches science in a truly interdisciplinary manner, not isolated bodies of knowledge. This type of thinking embodies a world-view that implies the foundation for understanding lies in interpreting interrelationships rather than focusing mainly on the constituents that make up a system, as seen in the classic science model. In the systemic view of science it is the interrelationships that are responsible for the manner in which systems operate and it is interrelationships that result in the patterns of behavior and events we perceive. The systemic view provides a perspective that more accurately reflects how the universe works. It moves beyond the linear economic model of present science education with its production and consumption of knowledge bites. It is a fundamental shift in perspective that invites educators and students alike to go beyond events to seek underlying systemic interrelationships that are responsible for the patterns of behavior and the events observed.

This study provides a rationale for policy-makers, administrators and teachers to look for new and more effective ways of presenting science. This research has shown that U.S. schools have consistently provided science content via the textbook in the traditional manner without realizing the hoped for results. We have not maintained nor improved our international standing but have fallen from forth to twelfth on the 2003 TIMSS. As discussed in Chapter One, students have not shown gains in science skills. This proposed shift in organizational structure of science content would have an impact on the vast numbers of students who do not have aspirations to become scientists. It would allow science to become accessible and meaningful for all students and move beyond the belief that "the only rightful domain of science education is that of helping people learn what scientists know" (DeBoer, 1991, p.189). Admittedly, those who wish to transform science education will find this a challenging endeavor.

Future Research

Now that we have a better understanding of what science content has been taught and when, we are in a better position to discuss the relevancy of this content to the teaching and learning of science. The next step may be to correlate the *youthscape* of U.S. students with data from this research. Maira (2004) describes youthscapes as how students see themselves and the world around them as opposed to the traditional conceptions of students as seen and conceptualized by adults. In correlating student perceptions, science content, and achievements in science, educators may find unique relationships to generate science programs that reflect the interests and goals of the student.

This research provides empirical evidence indicating that the science content of the classroom text for 8^{th} and 9^{th} grades has not changed significantly over the past 30 years. How can this knowledge be used to launch further educational research, development and practice? These data provide the impetus to ask fundamental questions about the classic science content that has been and continues to be offered today. For instance, does this type of content, which has been relatively unchanged for almost half a century, meet the needs of students of today, and will it meet the needs of the students of tomorrow? There is a dearth of new science content in science textbooks. How does this affect students' interest, motivation, and enthusiasm for the subject? Is the classic science subject matter the best platform for learning science? How does the classic science content subject matter assist students in facing a complex world? For those who value the classic science content model, further research might lead one to explicate and clarify organizing principles that can be used to better communicate science content within the national and international community. Additionally, we live in a global economy and culture, yet there were few references in the sample textbooks relating this reality to science content. Research may also be conducted to explore how science may be used to help students understand and adapt to more inclusive and international perspectives? Do the countries that excel in science education have a different approach to science content? Studies investigating sidebar and chapter or unit end narratives may be conducted to better understand how these items are used to extend teacher pedagogy, student motivation and overall usefulness of this material. Answers to these questions can provide invaluable insight and assist educators in designing and implementing appropriate and meaningful science education.

Conclusion

In this study we have shown that over the past six decades 8^{th} and 9^{th} grade general science textbooks have provided science content in the areas of Process of Science, Chemistry, Physics, Earth Science and Biology. This research provided empirical evidence via 70 textbooks published from 1952 to 2008 that indicates these areas of science content have not significantly changed since 1970. Since 1980 the subject of Biology lost coverage in general science textbooks. Earth Science was barely represented from 1970 to 1990, but recovered representation in the present decade. Only 16 new scientific discoveries were found in the main text of the 70 books in this sample. These results suggest that students are presented with a narrow unchanging view of the universe. The visible spectrum is only $1/50^{th}$ of the entire electromagnetic spectrum yet humans who perceive the world from this vantage point believe they know the world around them, when in reality it is only a very narrow view. In the same manner, the classical science content of the past six decades presents students with only a fraction of the possible science content, perspectives, and philosophies.

In contrast, the systemic view provides a perspective that more accurately reflects the multi-dimensional reality of our world. It provides a perspective that reflects not only how the universe works but also a means by which to view the world. Systemics is a perspective for going beyond events to seek underlying interrelationships that are responsible for the patterns of behavior and events (Bertalanffy1927, Senge, 1990). Future generations face a succession of choices. To successfully navigate national and global challenges they will have to mediate between the traditional ways of thinking, acting, doing, and the creation of fresh responses to new and relevant material. It is imperative that we offer more contemporary and relevant content to help students understand science and their relationship to science in a local and global environment.

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APPENDICES

APPENDIX A – CODE BOOK

Table A-1 Code book developed to analyze textbooks

Topic Code Book

Exclusions
1)Questions at the end of chapter 2) Questions at the end of sections 3)Vocabulary lists, or simple vocabulary definitions in sidebar 4)Experiments or procedures to help students understand information 5)Sidebar callouts eliciting responses to: main topic, critical thinking, further analysis, cognitive bridging **ALL EXCLUSIONS ARE NOT PROCESSED** and may be coded as a 0 - see Code 0 for examples
Code 0 - Concept Not Represented - Descriptors
1) No mention of topic 2) 10 words or less 3) 1 sentence 4) 1 picture with no connection to text
Code 1 - Low Level Representation - Descriptors
1) 2-8 sentences 2) May have 1 picture or table with some connection to content in main text
Code 2 - Moderate Level Representation - Descriptors
1) 9-14 sentences 2) May have 1 picture or table with some connection to content in main text **OR** 1) 2-8 sentences AND has one or more of the following: 1) 1+ worked out examples with solutions 2) Historical background regarding topic 3) 2+ pictures and/or tables with some connection to content in main text 4) Link or reference to additional information (such as appendix, table, charts not in main text)
Code 3 - High Level Representation - Descriptors
1) 15+ sentences **OR** 9+ sentences AND has one or more of the following: 1) 1+ worked out examples with solutions 2) Historical background regarding topic 3) 2+ pictures and/or tables with some connection to content in main text 4) Link or reference to additional information (such as appendix, table, charts not in main text)

Table A-2 Examples of codes taken from sample textbooks

Code 0 - Examples	Book & Pages
area in sidebar: The amount of surface within a given set of lines; measured in squared metric units(m2,cm2, mm2, etc). *This is considered a Code 0 because it's a definition in the sidebar and not discussed in the text itself.*	B2, p.8
levers, resistance arm, effort arm: *These terms are only single sentence definitions given in the text. Though the pictures indicate where these are for each type of lever - there is no further discussion or mention.*	B1, p.206
Code 1 - Examples	**Book & Pages**
direct observations: *5 sentences & 1 picture.*	B1, p.5
indirect observations: *6 sentences & 1 picture.*	B1, p.5
scientific method steps: *2 sentence and definition of steps*	B1, p.9
controls: *5 sentences*	B1, p11
theories: *4 sentences*	B2, p.8
laws: *4 sentences*	B2,p.8
matter phases: *Only 1 sentence but research topic sidebar on next page moves it to a code 1*	B1, p56-57
periodic table description nonmetals: *4 sentences and image but doesn't go into great depth.*	B1, p.106
chemical changes, chemical equations reactants, products & balancing: *a single sentence definition is given in the text for each of these terms and then the term is used repeatedly while discussing chemical equations however there is no further discussion of these terms only the proper use of the terms which is educational but does not count towards in-depth discussion of these topics.*	B1. p113-115
Code 2 - Examples	**Book & Pages**
predictions: *12 sentences, no images*	B1,p.9
variables: *Variables are defined and used in the discussion but not discussed in depth of themselves but rather as a means to better understand experiments.*	B1,p.10-11
axis, labels & scale: *These sub topics of graphing are covered but and as a whole create a 3 rating for graphing but each of these topics separately are not covered in depth. Yet images help to convey meaning to these topics.*	B1, p.26
periodic table description alkali metals: *10 sentences and an image to illustrate text discussion*	B1, p.103
acid & cases *ph:* *10 sentences and one image showing the pH scale. Also the first image in the first chapter showed a pH change.*	B1, p.124-125
average speed: *a section is devoted to this topic - 10 sentences and an image - but not enough depth to warrant a code of 3*	B1, p.144
Code 3 - Examples	**Book & Pages**
observations: 11 sentences & 2 pictures. However the book comes back to this and reinforces these concepts in helping to understand science content throughout the rest of the book.	B1, p.5, 83, 86
hypothesis: *Page and a half discussion (14+ sentences), provides examples and relevant image linked to text. Later in text also uses the term to help understand other concepts*	B1, p.8-9, 83
experiments: *Page and a half discussion, provides an example and relevant image linked to text*	B1, p.10-11
models: *Page discussion, historical information & relevant image. Later in book models are referred to over and over again and how scientist use models to help understand the world around them by using familiar things to describe unfamiliar things.*	B1, p.12-13, 89, 94,107, 113
graph: *Page and a half discussion, provides examples in the text linked to 3 images and 1 data table.*	B1, p.26-27
steps in solving and approaching problems: *One page discussion with itemized steps provides an example of how to sketch out a problem and an example in the text with answers and step by step procedure. Not a question at the end of the section.*	B1, p.35-36

classifying matter by order: *Full page discussion (14+ sentences), related images*	B1,p.55
matter phases: *Only 1 sentence but research topic sidebar on next page moves it to a code 1 - the topic is brought up again later in the chapter and presents a discussion in greater detail along with relevant pictures.*	B1, p56-57 & p.64-69
combustion: *More than 8 sentences plus a historical discussion regarding lavoisier and his contribution to understanding the process of combustion.*	B1, p.74-75
compounds: *When first coded in chapter two compounds was given a code of 1, however chapter 3 delves into the topic at much greater depth and is given a code of 3.*	B1, p.61, 91-93
atomic models electron cloud model: *Full page discussion, 3 images to illustrate text discussion*	B1, p.108-109
speed, s=d/t: *Gives a 9 sentence description of the equation but provides 3 examples with solutions.*	B1, 141-142

Two books were used to begin creation of the content list and code book. B1 and B2 as indicated in the examples table are shown below.

Table A-3 Books used to developed codebook and initial content list

BOOK1 = Physical Science;
Barr & Leyden;
Addison-Wesley; 1988

BOOK2 = Physical Science;
Ramsey, Gabriel, McGuire, Phillips, Watengaugh;
Holt Rinehart & Winston;1978

APPENDIX B – BIOS OF EXPERT PANEL

The experts engaged in this study come from a variety of backgrounds and experiences. Below are short bios of the six panelists who provided their assistance in refining the content list used in this study.

Panelist 1 has a BS in Biology and an MA in cognitive & neural science. This researcher taught high school Chemistry and Biology for 5 years and has taught both undergraduate and graduate level college classes for 10 years in basic science, research methods and science methods courses. She has published and presented papers at the national and international level in both science and science education.

Panelist 2 has J.D. and a DDS. He has taught high school for 9 years and continues to teach traditional, AP and IB anatomy, chemistry and biology at a local school. He has published and presented papers at the national and international level in science education.

Panelist 3 has a B.S. and M.S. in Zoology. He teaches college level courses: General Biology I, II with lab; Ecology Lab, Anatomy & physiology I, II - lecture and lab courses; General Biology for non-science majors - lecture and lab courses; Elementary Methods science education.

Panelist 4 has a B.S. Fisheries & Wildlife and an M.S. in Science Education. He has taught high school physical science, biology, anatomy & physiology, astronomy, marine biology for 8 years. He also teaches college level Elementary Science Methods.

Panelist 5 is the Supervisor of Secondary Science Education for Hillsborough County Public Schools, in Tampa, FL. He earned a Bachelors degree in Biological

Sciences and Master's in Biological Sciences and Specialist's degree in Educational Leadership. In 2007, he was recognized as a Teacher of Excellence in Science by the Hillsborough County Public Schools. He was elected by his peers as Robinson's Teacher of the Year in 2005 and B.E.S.T. Mentor Teacher in 2004. Also in 2004, he was recognized as the Sigma Xi Science Teacher of the Year for Hillsborough County. He has been published on numerous occasions in peer-reviewed journals and has presented at national and international conferences.

Panelist 6 has a B.S. in Marine Science, M.A. in Journalism and an M.S. in Marine Biology. He has taught college level Elementary Science Methods. He also edited teacher training materials based on the Sunshine State Standards for math and science.

APPENDIX C – BOOKS 30-64 ITEM CHECK

Table C-1 Topic review items after analysis of 60th book.

What is critical thinking - why important
Matter characteristics
Physical Properties of matter
thermal conductivity, ductility, state, mallealbility, solubility, density
physical change
Metals & Nonmetals
doping - add impurities to increase conductivity
luster, ductile, shine, thermal conductors
Mixtures
calculating concentrations/ ration of solvant to solute
titration
tyndall effect - abiltiy to scatter light
emulsion
separating mix - distillation, magnet, dissolving, filter, ceterifuge, evap
Compounds
hydrates - anhydrides & hydrides
Periodic table
Lanthanides 58-71
Synthetic elements -
radioactive elements - radioactive
actinides - radio active elements 90-103 - unstable
transuranium elements
Matter Phases
amorphous solids -
pieszoelectric
Specific heat / heat energy
Change in Thermal E   Q = mass (Temp2 - Temp1)
Chemical Interactions
Chemical properties
physcial vs chemical changes
Chemical Equations
coefficients
collision theory
making alloys
example of alloy - steel, new aluminum, titanium

Chemical Bonds
ionic compound/bond - lost/received
covalent compound/bond - shared
polyatomic ions - have both ionic and covalent bonds
metallic bonds
Van der Waal bonding
dipole-dipole
Organic Compounds
cyclic hydrocarbons - aromatics
esters
Motion
Momentum
Force & changing Momentum   F = (mvf - mvi)/t
electromagnetic
Energy
EP electric power   EP = current x voltage diff
Electromagnetic Waves & Light
Sources of light
Producing light - heat causes e- to jump orbit give off radition
flourescent light
incandescent light
neon light
phosphorous light
sodium - vapor light
tungsten - halogen light
producing shadows - umbra, penumbra
mirror
plane
parabolic
Production and transmission of electromagnetic waves
electromagnetic spectrum
microwaves are a type of radio wave with highes frequ & energy
Electricity
power of E transformation   PE = energy/time

Atom
nuclides -
Atomic models
dalton - solid spheres
thompson - cookie of protons with chocolet chip electrons
Rutherford's peach pit model
Detecting Radation
nuclear emulsion
Applications
Balance device for measuring mass / calabrating / use
equal arm balance
unequal arm balances
electronic balances
sesnitivity of a balance
Rockets
thrust / exhaust velocity [as example of 3rd law]
Discoveries
bucky balls - carbon 60
ceramics - how made - uses
perpetual motion

Gas Laws
ocean pressure -

APPENDIX D – CATEGORY & SUB-CATEGORY LIST

Table D-5 Below is a list of categories and sub-categories used to derive the category depth of coverage scores.

Content List	1950 N=11	1960 N=15	1970 N=11	1980 N=12	1990 N=9	2000 N=12	ALL Years
	Next to each sub-category is the percentage of books for each decade that covered the specified sub-category. For instance 36% of 11 books covered the 'Fields of Science', 40% of 15 books in the sample in 1960 covered this same topic and so on. *All Years* shows the percentage of *all* books in the sample that covered the sub-topic. Each category shows the MEAN percentage of books that included coverage of the indicated category. These numbers represent frequency of coverage NOT depth of coverage.						
Process of Science	28%	37%	35%	42%	48%	49%	40%
Discussion on science as a process & products	82%	87%	45%	25%	44%	67%	60%
Fields of science	36%	40%	36%	50%	56%	83%	50%
Importance of physical science - why study	0%	13%	18%	25%	67%	42%	26%
Observations	73%	67%	73%	75%	67%	58%	69%
Hypothesis	55%	73%	64%	67%	78%	75%	69%
Scientific Method	73%	80%	27%	50%	67%	83%	64%
Experiments	82%	87%	73%	67%	78%	92%	80%
Characteristics of Scientists	91%	93%	18%	25%	44%	58%	57%
Models	0%	20%	36%	58%	78%	75%	44%
Theories	18%	33%	64%	67%	56%	67%	50%
Laws	9%	27%	55%	50%	56%	58%	41%
Analogies	0%	0%	18%	0%	22%	8%	7%
Measurements	27%	53%	73%	75%	44%	50%	54%
Metric system/ standards discussion / need in science for standards	45%	73%	82%	100%	100%	83%	80%
Unit Conversation	0%	13%	27%	33%	22%	50%	27%
Estimating	0%	0%	0%	17%	0%	0%	3%
Mathematics the language of science	0%	0%	0%	0%	0%	17%	3%
Measurement Errors - including averaging	18%	27%	27%	58%	56%	42%	39%
Graphing	0%	20%	27%	42%	67%	67%	36%
Steps in solving and approaching problems	0%	0%	0%	17%	33%	0%	9%
Unit analysis	0%	0%	0%	8%	0%	0%	1%
Dimensional analysis	0%	0%	0%	8%	22%	0%	4%
Matter Characteristics & Structure	47%	47%	55%	64%	60%	61%	56%
Physical Properties of matter	82%	87%	82%	100%	100%	83%	89%
Properties of substances	27%	40%	45%	50%	33%	58%	43%
mechanical properties - how acts when force applied- fracture, creep,	0%	7%	0%	0%	0%	0%	1%
Classifying matter	18%	13%	45%	42%	33%	0%	24%

Mixtures	73%	80%	100%	100%	100%	92%	90%
Solubility	36%	20%	82%	75%	78%	83%	61%
Compounds	73%	80%	82%	92%	89%	92%	84%
compound formulas	55%	67%	73%	92%	78%	83%	74%
Molecules	55%	67%	82%	75%	100%	100%	79%
Water	45%	33%	64%	50%	78%	75%	56%
spectrograph - each element unique signature	55%	53%	73%	58%	44%	75%	60%
Elements 92 natural elements - the rest person-made!	82%	73%	91%	92%	89%	92%	86%
Periodic table	0%	7%	73%	75%	78%	83%	50%
Oxidation numbers	0%	0%	0%	42%	44%	33%	20%
Activity of metals	0%	13%	18%	17%	0%	8%	10%
Temperature effects volume of substance - causes phase changes	82%	80%	91%	83%	100%	83%	86%
Matter Phases /physical change/ states of matter	73%	60%	73%	100%	100%	92%	81%
Stages of physical change from affects of temp	73%	60%	82%	83%	100%	83%	79%
heat discussion	64%	60%	55%	83%	22%	25%	53%
Temperature changes / discussion	64%	60%	73%	100%	56%	75%	71%
Discussion on superconductors/ semiconductors	0%	20%	18%	42%	78%	67%	37%
Specific heat / heat energy	64%	60%	73%	83%	67%	67%	69%
Heat transfer	91%	80%	64%	83%	67%	75%	77%
Heating systems	64%	47%	18%	50%	44%	50%	47%
Products of burning fuels	45%	40%	0%	8%	0%	8%	19%
Cooling Systems	64%	53%	18%	42%	33%	33%	44%
Laws of thermodynamics	0%	0%	9%	0%	11%	42%	11%
Kinetic theory of matter	45%	53%	45%	75%	56%	58%	56%
Chemical Interactions	35%	43%	58%	67%	63%	63%	55%
Chemical properties	18%	13%	27%	42%	11%	50%	27%
Chemical Changes	45%	53%	82%	100%	67%	75%	70%
Chemical Equations	27%	53%	73%	100%	78%	83%	69%
Conservation of mass /matter	27%	47%	73%	67%	89%	92%	64%
Chemical Reactions	9%	40%	73%	83%	100%	92%	64%
Reaction rates	36%	33%	82%	75%	100%	83%	66%
Examples of everyday chemical reactions	64%	53%	45%	42%	78%	33%	51%
Fuels discussion	64%	67%	18%	17%	0%	0%	30%
Chemical Bonds	27%	53%	73%	92%	78%	83%	67%
Mole - Avogadro's constant	0%	13%	27%	42%	33%	50%	27%
Acid Base discussion	36%	33%	73%	92%	78%	83%	66%
Electricity to produce chemical changes - and visa versa!	64%	53%	55%	58%	44%	33%	53%
Organic Compounds	5%	15%	35%	48%	58%	58%	35%
Organic or Carbon Chemistry	27%	33%	55%	58%	78%	67%	53%
Isomers	0%	7%	18%	42%	44%	50%	26%
Structural formulas	0%	7%	27%	42%	33%	42%	24%
Hydrocarbons	0%	13%	45%	67%	56%	67%	40%
Biochemical compounds	0%	13%	27%	33%	78%	67%	34%
Motion	19%	27%	35%	56%	52%	61%	41%
Describing Motion	18%	20%	18%	42%	44%	67%	34%
Reference Objects	0%	7%	18%	42%	33%	67%	29%
Distance - length of path /displacement - discussion	0%	0%	0%	25%	0%	33%	10%

Speed	0%	7%	55%	83%	78%	83%	50%
Velocity	0%	7%	27%	58%	78%	75%	39%
Acceleration	0%	20%	45%	67%	78%	83%	47%
Forces	45%	40%	45%	92%	78%	92%	64%
Types of forces	0%	0%	27%	42%	67%	50%	29%
Springs - measures weight not mass	0%	0%	18%	17%	44%	8%	13%
Newton's first law	73%	87%	73%	92%	78%	83%	81%
Newton's second law	9%	33%	55%	83%	78%	83%	56%
Newton's third law	45%	87%	64%	100%	78%	83%	77%
Using Newton's three laws to predict motion	0%	0%	0%	0%	0%	8%	1%
Momentum	9%	20%	18%	50%	33%	67%	33%
Centripetal force - towards the center	27%	33%	36%	58%	33%	50%	40%
general theory of relativity	0%	0%	9%	0%	0%	25%	7%
Gravity	100%	100%	82%	100%	78%	83%	91%
Fluids & Gases	40%	38%	29%	48%	65%	61%	47%
Discussion of fluids	55%	27%	36%	33%	22%	58%	39%
Pressure / concept /discussion / force over area	0%	7%	27%	42%	67%	58%	34%
Pressure in Fluids	55%	53%	18%	25%	67%	58%	46%
Gas Laws	45%	47%	36%	67%	67%	50%	54%
Density / discussion of density as well /specific gravity	36%	40%	45%	75%	100%	92%	64%
Buoyancy	55%	53%	36%	58%	67%	67%	57%
Bernoulli's principle	36%	40%	0%	33%	67%	42%	37%
Energy	64%	50%	42%	73%	71%	57%	59%
Energy definition - the capacity to do work	91%	73%	45%	83%	78%	67%	73%
Kinetic	73%	53%	64%	92%	78%	67%	70%
Potential	73%	60%	64%	92%	78%	67%	71%
Energy conversion - the law of conservation of E	45%	53%	36%	92%	78%	67%	61%
Energy transformations - what it is/calculations/ processes	0%	0%	45%	50%	78%	67%	39%
Mechanical energy & friction	64%	33%	9%	42%	44%	8%	33%
Types of Energy	100%	80%	27%	58%	67%	58%	66%
Work, Power & Machines	61%	58%	36%	64%	57%	46%	55%
Work	100%	87%	64%	92%	78%	67%	84%
Mechanical advantage	55%	53%	45%	83%	78%	58%	61%
Ideal Mechanical advantage	0%	0%	18%	33%	0%	33%	16%
Efficiency of machines	64%	73%	45%	92%	78%	58%	69%
Torque	0%	0%	9%	8%	0%	8%	4%
Simple machines	100%	87%	55%	92%	78%	58%	79%
Compound machines	64%	60%	27%	58%	78%	42%	56%
Machines that burn fuel for work	82%	80%	27%	50%	44%	25%	54%
Power	82%	80%	36%	67%	78%	67%	70%
Mechanical Waves and Sound	25%	29%	31%	56%	60%	52%	42%
Mechanical waves - produced by the vibration of matter	36%	20%	55%	75%	78%	67%	53%
Longitudinal/Compression - sound & water waves	45%	33%	55%	92%	78%	67%	60%
Transverse waves - light & electromagnetic radiation	0%	27%	55%	67%	78%	67%	47%
Wave - description/definition	27%	60%	27%	75%	78%	67%	56%
Frequency	27%	53%	45%	75%	78%	67%	57%
Wavelength - discussion/calculation	18%	53%	27%	42%	0%	42%	34%

Wave speed - discussion/calculation	0%	7%	9%	50%	78%	58%	31%
Reflection (echoes) (standing waves)	18%	27%	27%	58%	67%	50%	40%
Refraction	0%	7%	27%	58%	67%	50%	34%
Absorption	0%	0%	0%	0%	0%	8%	1%
Diffraction	0%	0%	18%	42%	44%	50%	26%
Interference	0%	0%	27%	50%	56%	58%	30%
Producing sounds - discussion on sound	64%	40%	55%	75%	78%	50%	59%
ear - attending to sound - parts of ear	55%	40%	18%	17%	78%	42%	40%
speed of sound	64%	73%	55%	83%	78%	50%	69%
Music	55%	47%	27%	75%	67%	50%	54%
properties of sound	64%	53%	27%	58%	56%	50%	53%
Wave model of sound	0%	13%	0%	17%	11%	25%	11%
Doppler Effect	0%	7%	27%	50%	78%	67%	36%
Electromagnetic Waves and Light	43%	41%	32%	59%	59%	37%	45%
Producing light - heat causes e- to jump orbit give off radiation	18%	20%	9%	25%	11%	8%	16%
Sources of light	73%	73%	27%	67%	78%	42%	60%
producing shadows - umbra, penumbra	45%	20%	9%	17%	22%	17%	21%
Transmission of light	55%	40%	36%	50%	67%	33%	46%
Reflection	73%	67%	55%	83%	78%	50%	67%
mirror	45%	53%	55%	92%	78%	50%	61%
image	45%	33%	55%	92%	78%	50%	57%
ray	55%	60%	45%	75%	78%	50%	60%
Refraction	64%	60%	55%	92%	78%	50%	67%
Lenses	73%	67%	64%	92%	78%	42%	69%
EXAMPLES to help relate info	73%	67%	64%	83%	78%	42%	67%
Speed of light - electromagnetic waves	55%	60%	36%	75%	33%	58%	54%
Index of refraction	0%	7%	18%	33%	11%	33%	20%
internal reflection /total internal reflection	0%	0%	0%	25%	56%	25%	17%
brightness & distance - measurement of light energy	64%	53%	27%	25%	33%	0%	34%
Laser	0%	7%	0%	58%	78%	42%	29%
Production and transmission of electromagnetic waves	0%	7%	0%	0%	33%	25%	10%
electromagnetic spectrum / radiant energy - higher the freq the more energy	36%	67%	36%	67%	78%	67%	59%
Polarizing light & filters	27%	20%	27%	42%	56%	42%	36%
Models of light	27%	33%	55%	75%	78%	33%	50%
Color - description/discussion - absorption/reflection of colors	64%	53%	18%	67%	78%	42%	53%
color light -	64%	47%	45%	67%	56%	25%	50%
color pigment -	36%	27%	9%	50%	56%	33%	34%
Electricity	54%	60%	44%	68%	68%	50%	57%
Electric Charges/ Forces	55%	80%	64%	75%	67%	50%	66%
What is an electric charge - fields	45%	60%	73%	75%	89%	67%	67%
Static electricity	64%	67%	45%	83%	56%	58%	64%
1. Charging by friction	55%	80%	55%	58%	44%	33%	56%
2. Charging by contact or conduction	36%	53%	45%	83%	89%	42%	57%
3. Charging by induction - also electrical discharge	45%	40%	64%	75%	67%	58%	57%
Coulomb's law	0%	0%	9%	25%	0%	17%	10%
Electric currents	64%	80%	73%	92%	100%	58%	77%

batteries	64%	60%	55%	75%	100%	58%	69%
Measuring currents	73%	73%	64%	75%	78%	50%	69%
Direct current	64%	80%	36%	67%	78%	67%	66%
Resistance	55%	60%	55%	83%	78%	67%	66%
Electric Power P=V x I	64%	60%	18%	75%	56%	50%	56%
Electric circuits	73%	80%	64%	92%	100%	67%	79%
circuit safety devices	64%	67%	45%	75%	78%	67%	66%
complex circuits	55%	60%	9%	42%	44%	25%	40%
Generating Electricity converts mechanical e into electrical e	82%	67%	18%	58%	67%	58%	59%
other types not electromagnetic	27%	33%	9%	17%	33%	8%	21%
transporting electric energy	36%	40%	27%	58%	78%	50%	47%
Electromagnetism - Magnetism	61%	61%	44%	75%	75%	51%	61%
Magnets	64%	60%	55%	92%	78%	58%	69%
earth as a magnet	36%	53%	45%	58%	67%	42%	50%
Magnetic fields	64%	53%	45%	75%	78%	50%	60%
Electromagnetism	73%	60%	36%	67%	67%	50%	59%
Electromagnets	73%	67%	55%	92%	78%	58%	71%
Electromagnetic Induction	55%	53%	36%	67%	78%	42%	56%
Alternating current	64%	80%	36%	75%	78%	58%	66%
The Atom & Nuclear Reactions	38%	56%	50%	57%	62%	59%	54%
Atoms	73%	80%	64%	83%	100%	92%	81%
Energy in an atom	27%	20%	18%	25%	33%	50%	29%
particles in an atom	73%	80%	73%	92%	78%	83%	80%
Quantum Physics / mechanics	0%	0%	9%	0%	0%	25%	6%
Atomic models	36%	47%	91%	92%	100%	83%	73%
Matter can be changed into energy	45%	60%	27%	42%	0%	67%	43%
Radioactivity	55%	73%	55%	58%	78%	33%	59%
uses of radio active materials / peaceful uses of atomic energy	55%	73%	55%	58%	100%	75%	69%
Radiation	18%	60%	55%	67%	56%	67%	56%
Detecting radiation	64%	73%	64%	67%	100%	50%	70%
Changes in nucleus	9%	47%	36%	33%	33%	25%	31%
Nuclear changes	36%	73%	45%	67%	56%	50%	57%
Rate of nuclear decay	0%	40%	55%	58%	78%	67%	49%
Astronomy	43%	40%	21%	9%	1%	43%	28%
Astronomy discussion	55%	47%	18%	8%	0%	17%	26%
Astronomical observations	45%	27%	9%	8%	0%	17%	19%
Radio Astronomy	18%	27%	27%	8%	11%	0%	17%
Moon	73%	60%	27%	8%	0%	58%	40%
tides	64%	60%	36%	8%	0%	42%	39%
moon origin	18%	20%	27%	8%	0%	50%	21%
moon phases	55%	53%	18%	8%	0%	58%	36%
eclipses	73%	60%	27%	8%	0%	58%	40%
Motion of the planets	45%	47%	27%	8%	0%	58%	33%
Kepler's laws	18%	47%	27%	8%	0%	25%	23%
Sun dist, size, comp, energy	91%	80%	27%	17%	11%	58%	50%
conditions necessary for life on Earth	9%	13%	9%	0%	0%	25%	11%
Latitude & Longitude	55%	53%	9%	8%	0%	25%	29%

Time Zones	64%	60%	18%	8%	0%	8%	30%
Earth motion (any heavenly body motion)	82%	60%	18%	8%	0%	25%	36%
Earth Seasons	64%	47%	18%	8%	0%	42%	31%
Planet discussion	73%	60%	27%	8%	0%	58%	40%
Kuiper belt - ring of bodies beyond Pluto	0%	0%	0%	0%	0%	25%	4%
Asteroids / planetoids	36%	47%	27%	8%	0%	58%	31%
Meteors	73%	60%	27%	8%	0%	50%	40%
Comets	55%	47%	27%	8%	0%	50%	33%
Origins of the solar system - Earth	45%	20%	18%	8%	0%	50%	24%
Stars and stellar distances discussion	91%	80%	36%	8%	0%	58%	49%
Classification of stars	55%	47%	27%	8%	0%	58%	34%
Formation of stars	0%	0%	0%	17%	0%	58%	13%
neutron star or pulsars	0%	0%	18%	17%	0%	67%	17%
black holes	0%	0%	9%	8%	0%	67%	16%
quasars	0%	0%	9%	0%	0%	42%	9%
Interstellar space	55%	47%	18%	8%	0%	50%	31%
Galaxies	55%	53%	27%	8%	0%	58%	36%
Origins of the Universe	27%	7%	18%	8%	0%	58%	20%
predicting the future of the universe	0%	0%	0%	0%	0%	42%	7%
Space Program (Apollo and earlier)	45%	67%	27%	33%	0%	25%	36%
Satellites	27%	80%	36%	25%	11%	33%	40%
Space Training & survival	36%	40%	18%	8%	11%	17%	23%
Geology	48%	32%	17%	7%	12%	29%	25%
Origin of the earth	36%	40%	9%	0%	0%	17%	19%
Shape & size of earth	82%	60%	18%	8%	0%	33%	36%
Evidence of earth facts - how determined	9%	13%	18%	0%	0%	33%	13%
Glaciers	73%	27%	9%	0%	0%	17%	21%
theories of rock movement isotasy	27%	13%	9%	8%	0%	33%	17%
Earthquakes	91%	53%	18%	8%	0%	33%	36%
Volcanoes	82%	47%	18%	8%	0%	33%	34%
Rocks & Minerals discussion	55%	27%	18%	8%	0%	50%	27%
Methods of finding and extracting minerals	36%	20%	9%	0%	0%	8%	14%
Earth process that produced petroleum - crude oil	45%	27%	18%	8%	67%	42%	33%
Earth process that produce coal	55%	27%	9%	0%	11%	25%	21%
Earth process that produced precious metals	18%	13%	9%	0%	0%	17%	11%
Methods for finding extracting petroleum / hydrocarbons	45%	47%	18%	33%	78%	25%	40%
Separating minerals from ore - processes	18%	7%	9%	0%	0%	0%	6%
Methods for mining/ extracting / finding precious rocks / metals	27%	13%	9%	0%	0%	0%	9%
Weathering & erosion	91%	67%	27%	17%	33%	58%	50%
Rock Types - discussion	73%	53%	9%	8%	0%	42%	33%
Caves - where / how formed	36%	40%	45%	25%	56%	83%	47%
Rocks and plants as earth history discussion	73%	40%	18%	8%	11%	42%	33%
time discussion	18%	13%	18%	0%	0%	17%	11%
Measuring time	27%	20%	27%	8%	0%	8%	16%
Geologic Time	45%	40%	18%	8%	0%	25%	24%
Weather	65%	59%	20%	9%	9%	35%	36%
Weather discussion - diff between weather and climate	82%	67%	27%	8%	0%	17%	37%

Weather changes along cold Fronts	55%	47%	18%	8%	0%	33%	30%
Weather changes along warm fronts	55%	47%	18%	8%	0%	25%	29%
Weather maps	36%	27%	18%	8%	0%	25%	20%
Affect of Sun on Earth's weather	82%	73%	9%	0%	22%	42%	41%
Weather forecasting	55%	47%	18%	8%	0%	17%	26%
Air pressure	64%	60%	45%	17%	89%	83%	60%
Effect of temp & pressure on weather - different around land/water/mts etc	82%	87%	27%	8%	0%	25%	41%
Wind	73%	67%	18%	8%	0%	42%	37%
Clouds	36%	40%	9%	8%	0%	33%	23%
Precipitation	82%	80%	18%	8%	0%	42%	43%
The Atmosphere	82%	73%	18%	17%	0%	42%	43%
Ecology	60%	46%	18%	22%	18%	21%	32%
Climate	64%	47%	9%	8%	0%	17%	27%
Biomes discussion	45%	47%	18%	0%	0%	0%	20%
Habitat - adaptations to weather/climate/environment	55%	67%	18%	0%	0%	0%	26%
human habitat - homes and buildings /designing structures	73%	47%	0%	33%	44%	8%	34%
Life Zone	9%	13%	18%	0%	0%	0%	9%
Ecosystems	0%	0%	0%	0%	0%	17%	3%
Community	64%	33%	18%	8%	0%	17%	24%
Food Chain	64%	53%	18%	8%	0%	8%	29%
Food web - interdependence of living things	73%	47%	9%	8%	0%	17%	29%
Energy/food pyramids	45%	40%	0%	17%	0%	0%	19%
Resources	100%	87%	45%	58%	33%	42%	64%
Present Energy Resources discussion	64%	67%	36%	75%	56%	58%	60%
Present Energy Resources	82%	73%	27%	50%	44%	50%	56%
American Farming	64%	47%	0%	0%	0%	0%	20%
Pollution	100%	73%	45%	92%	100%	67%	79%
Discussion on pollution moving through the food chain	0%	0%	0%	0%	11%	0%	1%
Disturbing the balance or cycle of life - examples	64%	40%	9%	8%	11%	17%	26%
soil erosion and mineral loss	91%	60%	18%	17%	0%	0%	33%
Forest destruction	55%	27%	18%	8%	0%	0%	21%
Wild life resources - losses	64%	40%	18%	17%	0%	17%	27%
radiation - distance is best, underground shelters next	27%	27%	0%	17%	22%	50%	24%
Food production - increasing quality and quantity	91%	60%	9%	0%	11%	0%	30%
Conservation	100%	67%	27%	17%	33%	17%	44%
Alternative Energy Resources - Energy conservation	91%	80%	64%	83%	56%	75%	76%
Ways to conserve resources	18%	0%	27%	33%	33%	42%	26%
Diversity of Life on Earth	34%	40%	16%	6%	0%	6%	19%
Living things discussion	18%	27%	18%	0%	0%	0%	13%
Biological Classification	9%	27%	18%	8%	0%	8%	13%
Plant kingdom	55%	53%	9%	8%	0%	8%	24%
Animal Kingdom	55%	53%	18%	8%	0%	8%	26%
Origins of Life	5%	8%	17%	8%	0%	0%	6%
Origins of life discussion	9%	20%	18%	8%	0%	0%	10%
Natural Selection	18%	7%	18%	8%	0%	0%	9%
Fossils - as data and support - over 600 mil yrs	0%	7%	18%	8%	0%	0%	6%
Evolution - Decent & change	0%	7%	18%	8%	0%	0%	6%

Main points of Darwin's theory:	0%	7%	18%	8%	0%	0%	6%
Comparative biochemistry and embryology support theory of E	0%	0%	9%	8%	0%	0%	3%
Characteristic of Living Things	56%	50%	19%	10%	10%	14%	28%
Characteristics of Living Things discussion	64%	53%	18%	17%	0%	8%	29%
Diffusion	36%	33%	36%	17%	0%	0%	21%
Osmosis - diffusion through a membrane	45%	27%	27%	17%	0%	8%	21%
Cell discussion	91%	87%	36%	17%	0%	8%	43%
Specialized Cells	55%	60%	36%	17%	0%	0%	30%
Bodies and Energy	73%	73%	27%	8%	33%	42%	44%
Plants and Energy	73%	67%	9%	0%	44%	8%	34%
photosynthesis	91%	87%	18%	25%	44%	67%	57%
Anatomy of Plants	91%	80%	9%	0%	0%	8%	36%
Symbiosis	18%	20%	0%	8%	0%	8%	11%
Chemosynthesis - energy produced without sunlight in ocean bottom	0%	0%	0%	8%	0%	0%	1%
Oxygen-carbon dioxide cycle	45%	40%	18%	0%	0%	0%	20%
Nitrogen cycle	45%	33%	18%	0%	22%	0%	20%
water cycle	55%	47%	18%	0%	0%	42%	29%
Animal Organ Systems	52%	48%	21%	12%	6%	13%	27%
Human Body discussion	55%	53%	27%	8%	0%	0%	26%
Skeletal System	55%	60%	27%	8%	0%	17%	30%
Muscles (650)	55%	60%	27%	8%	0%	17%	30%
Cardiovascular System	18%	20%	9%	8%	0%	8%	11%
Respiratory System	82%	60%	27%	33%	0%	17%	39%
Lymphatic System	18%	27%	18%	8%	0%	8%	14%
Digestive System	82%	73%	27%	8%	0%	17%	37%
Appendix	0%	0%	0%	0%	0%	0%	0%
Excretion system	82%	73%	27%	8%	0%	8%	36%
Skin	64%	33%	9%	0%	33%	17%	26%
Nervous system	82%	73%	27%	8%	0%	8%	36%
Sense Organs	64%	60%	45%	58%	56%	50%	56%
Endocrine system	73%	73%	27%	8%	0%	17%	36%
Reproduction	0%	0%	0%	0%	0%	0%	0%
Genetics	36%	31%	20%	8%	0%	2%	17%
Inheritance	73%	47%	18%	8%	0%	0%	26%
law of dominance - Mendel	55%	33%	27%	17%	0%	0%	23%
law of segregation - Mendel	18%	7%	9%	0%	0%	0%	6%
law of independent assortment - Mendel	0%	0%	9%	0%	0%	0%	1%
law of Unit Characteristics (or Law of independent assortment) - Mendel	73%	60%	27%	17%	0%	0%	33%
Traits	55%	47%	27%	17%	0%	0%	27%
Genes & Chromosomes	55%	47%	18%	8%	0%	0%	23%
DNA - found in nucleus of cell	18%	33%	27%	0%	0%	8%	16%
RNA - found throughout cell	9%	27%	27%	0%	0%	0%	11%
Genetic disease and disorders	9%	7%	9%	8%	0%	8%	7%
Human Health	47%	36%	13%	6%	3%	8%	20%
Nutrition discussion	82%	73%	36%	25%	0%	17%	41%

Nutrients	82%	80%	36%	25%	22%	25%	47%
Testing for nutrients	9%	7%	0%	0%	0%	0%	3%
Calories and health -	64%	47%	9%	0%	22%	25%	29%
Nutritional deficiency / malnutrition	73%	47%	9%	0%	0%	0%	23%
Balance Nutrition	73%	53%	9%	0%	22%	17%	31%
Food preservation	100%	73%	9%	8%	22%	17%	43%
Feeding cats and dogs good nutrition for pets	9%	7%	0%	0%	11%	0%	6%
Exercise keeps you healthy along with proper nutrition and rest	55%	40%	0%	0%	0%	8%	19%
Characteristics of a healthy person	45%	20%	0%	0%	0%	0%	11%
How to get dependable docs /health info	9%	0%	0%	0%	0%	0%	1%
How doctors find and cure disease - modern medicine	27%	20%	0%	0%	0%	0%	10%
Disease discussion - infectious	100%	67%	27%	17%	0%	17%	40%
Koch's Postulates	18%	20%	18%	8%	0%	8%	13%
microbe carriers	100%	60%	27%	8%	0%	8%	36%
Infectious diseases	73%	40%	9%	0%	0%	8%	24%
Diseases not caused by germs - noninfectious	82%	47%	27%	8%	0%	8%	30%
Poisons - may be breathed, eaten, through skin	18%	13%	0%	0%	0%	0%	6%
Defense against disease	100%	67%	27%	8%	0%	17%	39%
Community Health	91%	60%	18%	17%	0%	8%	34%
First Aid	36%	13%	0%	0%	0%	8%	10%
Classification of drugs discussion long-range effects & Use	0%	0%	18%	8%	0%	8%	6%
long-range effects of drugs	0%	0%	18%	8%	0%	0%	6%
uses of drugs	73%	67%	27%	8%	0%	8%	33%
Drug Addiction	27%	40%	27%	8%	0%	8%	21%
Behavior discussion	18%	40%	18%	8%	0%	8%	19%
Changes in behavior as we grow infant to adolescent	18%	13%	0%	0%	0%	8%	7%
psychology	0%	13%	18%	8%	0%	0%	9%
Emotions	27%	33%	0%	0%	0%	0%	13%
Four parts of learning	0%	13%	0%	0%	0%	0%	3%
Technology - Applications in our world	Percentages are not given for each decade for themes 24-26 – as this type of coverage is shown in the frequency charts discussed in Chapter 4.						
Energy/technology and how it relates to your standard of living today							33%
Buying home appliances - how to							9%
Airplane							26%
Automobiles							23%
Balance device for measuring mass / calibrating / use							14%
Bunsen Burner / Stove - works the same							4%
Cameras							41%
CDs - how made and read from							4%
Computers							31%
Conveyers							1%
Cranes							1%
Doorbell - electric							3%
Dryer -							4%
Factories - automation of tasks							3%
Faucets and water flow/traps/air vents/why U shaped							6%
Floor polishers							3%

Electric stoves, mixers, toasters, sewing machines, garbage-disposal							6%
Electron Eye - used as door openers, alarms, production lines							4%
Grinding machines							1%
Harvesters							1%
Hearing - Aids - how they work							3%
Helicopters							7%
Iron & ironers							7%
Jet propulsion - how it works							23%
Lasers - discussion							21%
Lathe							1%
Lighting							30%
Maps							7%
Maser - amplification by stimulated emission of microwaves							1%
Microscope - parts, magnification, how made, how to choose one - how it works							46%
Microwave ovens - theory behind how they work							6%
Milking machines							1%
Milk separators							1%
Motors converts electrical e into mechanical e							30%
Navigation tools / aids							20%
Plumbing - indoor and meter reading							6%
Phonograph - Record Player! How it works							3%
RADAR							36%
Radio							49%
Refrigerator							24%
Roads							6%
Rockets							44%
Septic Tanks							4%
Ships							4%
smoke detectors - how they work							1%
Soil cultivators							1%
Sound recorders							26%
Submarines -							7%
Telecommunication							16%
Telegraph							29%
Telephone							37%
Telephotograph							6%
Telescope							49%
Teletype Messages							7%
Television							51%
Trains							10%
Toilets							6%
Vacuum cleaner							13%
Washing machine							7%
Water wheel , different types and how they works							19%
Discoveries & Products of Science							
Acid rain - solutions to, trends in technology							6%

Acoustics - considerations in building music halls							1%
Antacids - chemical interactions and how they work							3%
Air bags - safety feature in cars							4%
Airplanes traveling at Mach speeds							1%
Airplanes - different types - aircrafts, airplanes, helicopter							4%
Alloys - the uses of different types							4%
Alternative Pain Relief treatments (EOC)							1%
Anticorrosion coating							4%
Antifreeze - properties, uses, how it works and how made							1%
Antiviral grapes - wine							1%
Archaeology & History - using historical documents to prove science theory [creation]							1%
Arctic fish to study antifreeze properties							1%
Artificial body parts - how built and used							1%
Astronomy as a hobby - using telescopes							9%
Automobile - future of / what scientists are working /hybrid/bio-fuels etc.							1%
Batteries - differences between A, AA, AAA, C, D, etc.							1%
Beaufort scale - a scale for describing wind speed							1%
Beaumont, William - studied digestion from a person whose stomach wound didn't heal							1%
Bends - from diving - what it is/how happens/how to prevent							6%
Bionics - high tech prosthetics using electronics							3%
Blood Substitutes - creating artificial blood							1%
Bloodless surgery							1%
Breathing hydrogen gas							1%
Bridges - engineering behind them - types of							1%
Bubbles - how they relate to study and science							1%
Carbon dioxide - frozen=>dry ice/ uses / making pure CO2							36%
catalytic converters							10%
Cells that make up your body							0%
Ceramics - what it is, how made - some uses							11%
Ceramics - new type is being used in car engines							6%
Cermets - mixture of metal & ceramics							1%
Chemistry as a hobby - acid and base experiments							6%
Chimps learning to talk							0%
Chromatography - what is it/ how to do/ uses of							11%
Circus - the physics of circus acts							1%
Coal gasification							1%
Color - how animals use color and are different colors							1%
Comet caught by passing Stardust space probe brought home pieces for study							1%
Communication satellites - trends in technology							9%
Composites 2+ substances combined - making newer better materials cars, airplanes, etc							6%
Computers - supercomputers uses and potential							1%
Computer chips made of silicon / uses and break through							6%
Corn - Growing - detailed discussion from start to finish							1%
Cryogenics - refrigeration to the max							14%

Cryosurgery - freezing to destroy tissue							1%
Cubism art - what it is and why it is used - shows object in both time & space							6%
Day study - length of day - different ways to measure							1%
Deep-sea vents - how made/what lives there							1%
description of snake venom studies							0%
diesel engine							1%
Dinosaurs - K-T Event - boundary between when dinos were around and not							1%
Dolphins used to detect underwater mines							1%
domestication of animals							4%
Dry cleaning - not really dry! Stain removal							7%
dyes							1%
Earthquake prediction							1%
Earthquake proof structures - how to make buildings withstand earthquakes							3%
Electricity - animals that produce and use their own							1%
Elements - creating new							10%
El Nino & la Nina - types of storms							3%
Fire retardant materials							1%
Fireworks - how made, how to get different colors							7%
Fluorine compounds - medical uses of							3%
Food additives							4%
Food gathered from the ocean							6%
Fossil finds - archeological digs							1%
Fourier Analysis - reduction of wave motion to a sine wave							1%
Fruit - fabricated							1%
Genetic engineer on plants - increasing crop yields							3%
Glow sticks and how they work							1%
Glues - making better glues							4%
GPS (global positioning device) uses							4%
Grain and wood alcohol - how they are made							6%
Graft two fruit trees - how to guide							1%
Hairless mice for testing							1%
Hang time - the physics of - best standing jump 1.25m and 1 sec							1%
Hazards Mobile lab - cleans up environmental waste							1%
Heart patients - how we are helping							1%
Heliox - divers use mix of He & O2 when depths of 60m +							1%
Holograms - overview of and uses							6%
Hubble space telescope							6%
Human Powered vehicles - airplane (Gossamer) , bike cars							3%
Hydrogen - process of obtaining pure H2							7%
Ice Core studies in geology							1%
Ionized bracelets - shown to be placebos with experiments							1%
Kevlar - how it was discovered and uses							3%
Kites - use							3%
Lasers and optical fibers							20%
Lasers & Measurement							9%

Lasers used to create fusion reactions							3%
Lasers on satellites - track motion of tectonic plates to warn of earthquakes							6%
Lasik - eye surgery with lasers							9%
Light pollution - overcoming at Lick observatory in San Jose - low-pressure Na lamp							3%
Locks and how they work (water locks for transportation)							1%
Lone Star facts - lots of info about the state of Texas							1%
Manometers - instrument used to measure pressure							6%
Mars - two moons of							1%
Medicine - finding new drugs using natural sources and mimicking							1%
Medicine - time-released capsules - how does it work/what is it							1%
Memory research using cats							1%
Meteors - viewed crashing into Jupiter in 1994							1%
Meteors and asteroid tracking - what's being done and how							1%
Micro aquarium - starting and keeping a							1%
Microbes to fight disease							6%
Milankovitch effect - distribution of solar rad over the earth over millions of years							1%
Mixing oil and water							1%
Model airplanes - building							4%
Model rockets - building							3%
MRIs - what are they and how they are used to diagnose							6%
naming Hurricanes							1%
Nanotechnology and Bucky balls							13%
Nature - a discussion on how it informs scientist to create newer/better technology							1%
Nuclear Reactor - details about controlling/using							20%
Ocean thermal energy - how and practicality							1%
Optical scanners - scan bar codes and such - also in copiers and printers							1%
Oxygen - process of obtaining pure O2, uses of pure O2, properties of O2							23%
Pacemakers							1%
Perpetual motion machines							6%
PH - importance for good function of the body							7%
Pheromones - used in animal studies - honey bees use to navigate							3%
Photography - Kirlian							1%
photography as a hobby							13%
Plants and animals that produce poisons/toxins							1%
Plastics - conducting							4%
Polymers - quick setting							3%
Printers - four color printing - how it works							4%
Radiation helping heart patients/ cancer patients							6%
Radio active implants to track and study animals							4%
Radon - detecting in homes - originates from earth and gets trapped in basements							9%
Rattlesnakes and their rattles							1%

Recycling Plastics - how sorted/ by type/ what types							7%
Recycling Tires/rubber							1%
Refrigeration - refrigerants - toxic and non toxic							1%
Restoration of artifacts							1%
Robot in spacecrafts to investigate Jupiter and Saturn / and other uses							4%
Rock collecting as a hobby							6%
Roller Coasters - physics of motion - energy trans from pot to kinetic energy							3%
Rubber - vulcanized => heated with sulfur and cooled							1%
SAD - seasonal affective disorder - relieved by light exposure							3%
Satellites - communication, Landsat satellites							7%
Seat belts - anti-inertia belts							13%
Self-heating metals - add H20 to metal vigorous corrosion raises temp - cook food							4%
Shock absorbers - how they work and importance of							3%
Shot-crete - a mixture used to stabilize tunnels							1%
Siamese twins							1%
Skid marks to determine a vehicle's velocity							3%
smart cards - credit cards with microchip							3%
soap - how works, made - make your own soap							1%
Space sickness - treatments							1%
Space Materials - products made in space - different from those made on earth							1%
Spectroscopy - different types- Infrared, x-ray, nuclear magnetic and uses of							1%
sports medicine							1%
Star - luminous blue variable LBV 1806-20 brightest discovered to date							1%
Stoves - more efficient designs							1%
Submarines - advancements in that allow them to stay under H20 longer							3%
Submarines - powering with atomic energy							3%
Super bulb							1%
Superconductor - uses such as create new ways of transportation - trains							13%
superglue - cyanoacrylates - uses and function							1%
Synthetic fibers - how nylon is made							4%
Thermography - detecting heat from objects							11%
Torino Scale - used to assess potential damage of asteroids or comets							1%
Tower of Pisa - shifting and stopping the probably fall - engineers fixed							1%
Transistors - how they are made and their function							1%
Transportation - via h2o, air, and on land - auto, train, electric, care of bridges and roads							6%
Tsunami - what they are/where it's occurred							9%
TV - difference between High-Def and ordinary TV							3%
TVs - sending waves through the air for use in TVs							0%
TVs - hundreds of scientists contributed over many years - not just one person							3%

Ultrasound / ultrasonic - medical, echolocation and other use of							16%
Uranus - rings of							1%
Vaccine - hepatitis							1%
Viruses - slow-acting							1%
Wasps in south America							1%
WETF - weightless environments for space training							1%
Wind chill temperature index - uses							1%
Wood distillation - the many products produced from distillation							1%
Xerox machines - inventor and how works							6%
Velcro - another polymer							1%
video tape							3%
Virtual reality developed for many uses -							1%
History of Science							
Adams, John - predicted the location of Neptune with leverrier							7%
Agassiz, Louis - Swiss zoologist studied glacier movements - many theories proved true							3%
Alexander, Claudia - 7th project manager of the Galileo mission to Jupiter							1%
Alvarez, Luis - discovered 2 types of atomic particles							6%
Ampere, Andre - found that coil carrying an elec current acted as a magnet with poles too							14%
Anaxagoras - proved air was a substance - filled goat bag							3%
Anaximander - student of Thales proved air was substance [creation book]							1%
Appert, Nicolas - 1809 French chief preserved food for French army							7%
Archimedes - invented calculus, calculated pie, buoyancy							17%
Aristarchus - 310-250 BC - earth moves around sun							6%
Aristotle - great thinker and teachers whose ideas where sometimes wrong							20%
Arrhenius, Svante - first to explain acids and bases							0%
Audubon, John James - naturalist painter							1%
Avogadro, Amedeo - defined # or particles in a mole							6%
Bacon, Francis - philosopher who is said to have helped launch the scientific age							3%
Baekeland, Leo - first synthetic polymer							1%
Bardeen, John; Shockley,William; Brattain, Walter; - invented the transistor							1%
Barton, Clara - founded the American Red Cross							1%
Beaumont - studied a man who's stomach didn't heal - describes the digestive process							1%
Becquerel, Henri 1986 - research in radioactivity and work with uranium							36%
Bednorz, J.G with Muller created first ceramic superconductor							1%
Beebe, William - created bathysphere - device to descend deep into the ocean							1%
Bell, Alexander - created first successful telephone							24%
Bennett, Jean - physics studying light and making smooth surfaces to reflect light							1%
Bently, Wilson - photographed snowflakes - studied them							3%

Bernoulli, Daniel - showed connection between pressure and flow of fluids							13%
Berthollet, Claude - thought substances could combine in any proportion he was wrong							6%
Berzelius, Jons Jkob, created chem sym, disc, Se,Ce							9%
Bessel, Frederic - first to observe parallax with telescope							1%
Bessemer, Sir Henry - created steel from pig iron							6%
Bichat, Francois - described different tissues that were essential materials of body							1%
Black, Joseph-same energy taken in and given off as state changed							3%
Bluford, Guion - first black man in space							1%
Bode, Johann - devised easy way to calculate astronomical unit							1%
Bohr - e orbits around nucleus							30%
Boyle, Robert - used atoms to explain why chemicals combine in simple proportions							17%
Bradley, James - observed movement of Draconis - proposed aberration of light theory							1%
Bradwardine, Thomas disputed Aristotle's ideas of motion [creation]							1%
Branca - 1629 constructed steam engine in shape of man							4%
Brand, Hennig - discovered phosphorus							1%
Brown, Robert - discovered motion due to molecular activity							4%
Brache, Tycho - record careful observations of the planets for over 20 yrs							9%
Buckminster, Fuller							1%
Burbank, Luther, plant breeder created many hybrids							7%
Byrd, Admiral Richard E - explorer of Antarctic and South pole							4%
Carothers, Wallace - developed nylon							1%
Carver, George Washington - introduced many uses for peanuts							4%
Cassini, Giovanni - discovered Saturn							1%
Caballo, invented the electroscope							1%
Cavendish, Henry - found the universal gravitational constant							9%
Celsius, Anders - developed temperature scale							10%
Chadwick, James - discovered the neutron 1932							11%
Chang-Diaz, Franklin - designed the ion rocket engine, also an astronaut							1%
Charles, Jacques - studied the affects of heat on gases							7%
Christy, James - found Pluto's moon charon							1%
Clerk-Maxwell, James - said differ between elect & light is frequency of vibr							6%
Cockcroft, John & Walton, Ernest - built first linear accelerator							4%
Congreve, William - developed military rockets early 19th century							6%
Copernicus - 1543 - proves earth and planets move around the sun.							23%
Cori, Geri - solved how cells covert glucose to glycogen							1%
Coulomb, Charles - derived relationship for mag of electrostatic force between 2 things							6%
Cox, Herald - developing a better vaccine than previous methods							6%

Crookes, William - suggested presence of e-							1%
Curie, Marie or Madame and husband P. - discoveries polonium & radium							51%
Curie, Irene - method to make artificial radioactive eleme							6%
Cusa, Nicholas of - first to break with Ptolemy's geocentric ideas - believed heliocentric							1%
Cuvier, George - mapped rock layers and fossils which became basis for paleontology							1%
Daguerre - created method of pictures on plate of silvered-copper							7%
Dana, James - described thousands of minerals with properties, shape & formula							1%
Darwin, Charles - naturalist proposed evolution and community cooperatives							7%
Dalton - each element is composed of atoms							51%
Davy, Humphrey - invented the first electric light - the arc lamp, found chlorine - did a lot							17%
Davenport, Thomas 1834 - invented first electric motor							4%
Da Vinci, Leonardo - flying machines /art / anatomy							10%
Dawson, Thomas - invented devices that are used at NASA							4%
de Broglie - waves associated with moving particles							6%
De Forest, Lee - created the triode							13%
Democritus - 2,400 in Greece came up with concept of atoms							36%
Deville, Henri - 1859 - discovered a process to extract aluminum							4%
De Vries - added mutation theory to Darwin's original theory of natural selection							1%
Diesel, Rudolf - created more efficient motor							7%
Dowd, Charles - American educator first proposed time zones in 1883							1%
Dufay, - discovered two kinds of electricity -,+							1%
Duryea brothers - built first automobile in 1892							3%
Easley, Annie - improved operation of electric-powered vehicles by NASA							1%
Eastman, George - developed film that could be wound and other advancements							6%
Edison - building the first light bulb - our bulbs are different from what he first made							44%
Eijkman, Dr. - cures beriberi							7%
Einstein - relativity, photoelectric effect, e=mc2, etc							40%
Emerson, Gladys - isolated vit E and studied the effects of B complex vitamins							1%
Empedocles - claimed all matter made up earth, air, water, fire							4%
Eratosthenes determined circumference							1%
Evans, Oliver, - 1st automated flour mill powered by water wheel							4%
Fabre, Jean Henri - wrote one of the first insect encyclopedias							6%
Fahrenheit, Gabriel - developed temperature scale							9%
Faraday, Michael - used magnetism to make electricity - same time as Henry							40%
Farrel, Airman Donald G. - human gini-pig for space environment							1%
Fermi, Enrico - bombarding particles with neutrons							13%

Fleming, Alexander - found a mold which killed bacteria - called it penicillin							23%
Fleming, J. Ambrose - developed diodes							6%
Florey, Howard - isolated penicillin to produce the drug penicillin							3%
Forest fires - pros and cons of							1%
Formaldehyde - pros and cons of use dangers and virtues							1%
Franklin, Ben - experiments with electricity - key & lightening							34%
Freiberg, Dietrich Von - offered explanation on rainbows [creation]							1%
Fraunhofer, Joseph - 1814 noticed lines in dark lines in spectra gave import info							1%
Fulton's, Robert - created first steam engine ship							6%
Gagarin, Yuri - first person to orbit Earth - Russian - 1961							4%
Galen - roman physician precepts about anatomy followed for 13 centuries							7%
Galilei, Galileo - 1564-1642 - 2 objects fall at same rate in vacuum							50%
Galton, Francis - introduced the term eugenics, inherits traits from parents							3%
Galvani - study of frogs found frog legs twitched when two metals placed on either side							14%
Gell-Mann, Murray - discovered subatomic particles							6%
Ghiorso, Albert - discovered new chemicals 95,106,99,100							1%
Gilbert, William - found materials that acted like amber(attracted things) called it electricity							17%
Glaser, D.H - devised the bubble chamber							1%
Glenn, John - orbit earth 3 times - US 1963							6%
Goddard, Proff Robert - first liquid rocket fuel							10%
Goldberger, Dr. - cures pellagra							6%
Goodyear, Charles - created latex from vulcanized rubber							3%
Grosseteste, Robert - devised the scientific method [creation]							1%
Gutenberg, Beno - using s & p waves discovered moho boundary							1%
Guth, Alan - inflationary model of the big bang							4%
Haber, Fritz - developed process for producing ammonia							4%
Hale, Ellery - built telescope on Mt. Wilson in CA							1%
Hall, Charles - cheep production of AL - same time as Heroilt							7%
Hahn, Otto & strassmann, Fritz - same studies as Fermi - found that U split in two							6%
Harvey, William - study blood circulation							11%
Hawking, Stephen - proposed the existence of black holes							9%
Heisenberg, Wener - can't now where and how fast at same time							6%
Helmholtz, Hermann - introduced the idea of elementary charges							4%
Henry, Joseph - along with Faraday credited with generating elec in coil							14%
Hero of Alexandria - the first steam engine							7%
Herodotus - 425 BC studied the Nile and recorded changes							1%
Heroult, Paul - cheep production of AL using elect - same time as Hall							4%

Herschel, sir William - discovered Uranus, other contributions to astronomy							9%
Hertz, Heinrich - found a suitable wave for transmitting - radio waves							23%
Hertzsprung, Ejnar - created H-R diagram with Russell							6%
Hess, Harry - found shifting sea floors contributed to continental drift theory							1%
Hiller, James - developed the electron microscope							3%
Hippocrates, Greek physician 4th century							4%
Hodgkin, Dorothy - analyzed shape of compounds using x-ray							4%
Hooke, Robert - 1665 - examined cork under microscope - came up with the name cells							13%
Hopper, Admiral Grace Murry - pioneers in computer science, oldest office on active duty							1%
Hubble, Edwin - proposed galaxies moving away - found Andromeda galaxy							7%
Hutton, James - geologist proposed theories of rock and Earth formation							3%
Huygens, Christian - hypothesized light was a wave not particle							6%
Hyatt, John - first produced celluloid plastic in 1869							6%
isbister, Jenefir - developed micro organism to eat sulfur from coal							1%
Jackson, Shirley - low-energy physics							7%
Jansens, Zacharias - developed first compound microscope							7%
Jenner, Edward - first vaccine against small pox							9%
Joule, James - found how much mechanical work was needed to produce heat energy							20%
Karle, Isabella - developed method for analyzing crystal structures							9%
Kelvin - Kelvin temp scale based on absolute zero							9%
Kepler - laws of elliptical motion							24%
Kirchhoff, Gustav - said total of all the voltage drops must add up to total bat supply							1%
Koch, Robert - discovery of germs							13%
Langley, Samuel P. - first plane to fly under own power 'Aerodrome' in 1896							6%
Latimer, Lewis - assisted bell with the phone, and Edison with light bulb							3%
Lavoisier, Antoine - what happens when material burns							34%
Lawrence, Earnest - developed /build first cyclotron 1929							9%
leucippus - claims this guy is father of atomic theory and not Democritus [creation]							1%
Leverrier, Urbain Jean - predicted the planet Neptune with Adams							6%
Lewis , Gilbert - created electron dot structures to describe atomic compounds							4%
Lind, Dr. - cures scurvy							4%
Linnaeus, Carolus - Swedish biologist started the general system for naming living things							9%
Lippershey invented telescope in 17th century							10%
Lister, Dr. Joseph - ordered docs in hospital to sterilize hands and instruments							10%

Long, Crawford - first to use ether in surgery to remove tumor - 1842							4%
Lowell, Percival - predicted Pluto, thought mars was inhabited							6%
Lyell, sir Charles - first geologists proposed the earth took millions of yrs to form							1%
Maxwell, James - proved electric waves travel through air							10%
Malphighi, Marcello - invented first microscope 1628-1694							6%
Marconi, Guglielmo - used radio waves to send signals farther							16%
Mayer, Maria Goeppert - explained proton/neutron arrangement							9%
Mayer, Julius - first to come up with conservation of energy							1%
Meitner, Lise - devised mathematical precise explanation for the process of fission							6%
Mendel first studied laws of heredity with pea plants							24%
Mendeleev - proposed organization of periodic table							37%
Milikan , Robert - drop experiment - charge of e							1%
Miller, Stanley - provided evidence of the production of H2,O2 in dawn of life							1%
Mo Ching - 2,300 ys ago first proposed if no opposing force motion never stops							4%
Montoya, Patrick - biochemical engineer that build artificial heart/lung machine							1%
Morgan, thomas - found evidence for existence of genes which make up chromosomes							4%
Morton, William - first dentist to use ether in surgery -1846							4%
Michelson, Albert - discovered exactly how fast light travels							16%
Morse, Samuel - invented the telegraph and of course Morse code							26%
Moseley, Henry - improved periodic table based it on atomic # instead of atomic mass							11%
Muller, Herman - found that radiation can cause mutations in living organisms							1%
Muller, K.A. - with Bednorz created first ceramic superconductors							1%
Muybridge - 1872 first moving pictures to solve a bet if horse lift all 4 hoofs when run							3%
Newcommen, Thomas - improved on Savery's pump							7%
Newton - the scientist - what didn't he do?							66%
Niecpce, Nicephore - made 1st picture with asphalt on metal plate							4%
Nobel, Alfred - created more efficient means of using gunpowder, explosives etc.							3%
Oberth, Herman - explained how to shoot rocket away from earth's gravity							6%
Oersted, Hans - found electric currents produce magnetic fields							43%
Ohm, George, Simon - investigated resistance in e- circuits							11%
Oldham, Richard - using s & p waves discovered nature of earth's core							1%
Onnes, Heike - materials lose resistance when get close to absolute zero							3%
Ostwald , Wilhelm - developed process producing nitric acid							4%
Paracelsus - introduced use of chemicals in medical treatment							3%

Pare - 1533 advance surgery							3%
Parsons, Charles parson turbine - more efficient steam engine than others							3%
Pascal, Blaise - devised fluid laws							17%
Pasteur, Louis & Robert Koch - discovery of germs							26%
Pauling, Linus - devised the shell model							3%
Perey, Maguerite - discovered francium							4%
Perkin, Henry - first synthetic dye - mauve							3%
Piccard, August - invented the bathyscaphe - sub that can go to bottom of ocean							4%
Pinel, Philippe - began research in mental illness - during French Revolution							4%
Planck,, Max - atoms could exist only in certain distinct quantities - quanta							14%
Priestley - discovery of O2 Scheele, Karl - independently discovered O2							19%
Proust, Joseph - disagreed with Berthollet and came up with law of const proportions							6%
Ptolemy - 100-171 AD earth centered universe							17%
Redi, Francesco - showed maggots did not come from dead meat.							11%
Reed, Walter 1900 experiments showed yellow fever caused by mosquitoes							4%
Rey, John - improved Galileo's thermometer							1%
Richards, Ellen - first women accepted at MIT - chemist worked on H20 pollution							1%
Richards, Theodore - measuring atomic weights - found isotopes							4%
Ritter, Johann - discovered ultraviolet rays							1%
Roemer, Olaus 1675 - first established speed of light verified by Michelson							11%
Roentgen, Wilhelm - discovered x-rays							24%
Rumford, Count-heat caused by friction not the flow of caloric sub - Ben Thompson							14%
Russell, Henry Norris - created the H-R diagram with Hertzsprung							1%
Rutherford e- exist - plum pudding experiment							33%
Sabine, Albert - developed live virus vaccine							9%
Salk, Jonas E. - discovered a vaccine against polio							9%
Savery, Thomas - created steam engines that pumped H2O - miner's friend							1%
Schaefer, Vincent - first to seed clouds with dry ice and make it rain							3%
Scheele, Karl - independently discovered O2 Priestly - discovery of O2							4%
Schiaparelli, Giovanni - astronomer who collected data on mars							3%
Schleiden, Matthias & Schwann, Theodor - everything is made up of cells							7%
Schrodinger, Erwin - proposed electron cloud model of the atom							6%
Semmelweiss, Ignaz - advocate of the use of antiseptics in hospitals to prevent disease							4%

Smith, William - laid foundation of study of sedimentary layers - stratigraphy							6%
Spallanzani - showed life only comes from living things/cannot from dead							7%
Steno, Nicholas - crystal forms of rocks reveal past earth history							1%
Stephenson, George - created first steam engine train							10%
Talbot, first to use paper not metal for recording pictures							4%
Tereshkova, Valentina - first woman in orbit							4%
Tesla, Nikola - inventor and scientist who worked with electricity							6%
Thales - 600 BC showed when bodies rubbed together they attract/repel objects							11%
Thompson, Ben- also known as count Rumford							3%
Thompson, William - established a lab to study dry-climate plants							3%
Thomson, J.J. - built a mass spectrograph that sorted atoms according to mass							29%
Torricelli,Evangelista - measured the weight of air, constructed first barometer							14%
Tyson, Neil DeGrasse - served on presidential commissions on future of US exploration							1%
Urey, Harold - discovered deuterium							6%
Vesalus, Andreas - 1543 - illustrated first book on human anatomy							7%
Volta, Alexandra - made first battery							24%
Von Behring - developed cure for diphtheria							3%
Von Braun, Wernher - developing better rockets							4%
Von Guericke, Otto - created air pump in 1650s - also no sound in vacuum							11%
Von Helmholtz, Hermann - contributions in optics, chemistry, hydrodynamics, bio and more							10%
Von (van??) Helmont-weighing willow to deduce that growth was due only to H20							7%
Von Leeuwenhoek - many say he invented first microscope 1975							20%
Wang, An - created electronic equipment - Wang Laboratories - changed the world							1%
Watt, James - improved Newcommoen's pump to build 1 steam engine for useful work							27%
Wegener, Alfred - fit the contents together, evidence for continental drift							4%
Wilson, C.T.R. - devised cloud chamber							1%
Wright brothers - first flight 1903							16%
Wu, Chien-Shiung, designed experiments to prove theory of beta particles							11%
Yalow, Rosalyn - discovered technique to identify radioactive mat in blood							3%
Young, Thomas - showed the property of light was wavelike - diffrac exper							9%
Yukawa, Hideki - proposed the strong nuclear theory							4%
Zilkovsky, Constantine - Russian mathematician proved space travel possible							1%
Historical Discussions [like newspaper articles]							11%

Alchemy - first process/purpose of chemistry and how it changed over time							9%
Aluminum - process of extraction							6%
Astronomy - beliefs about the heavens and earth and Sun origins through time							9%
Atomic bomb - Explosion of first atomic bomb - first hand accounts from observers							6%
Atomic bomb - scientists involved in the project, history							33%
Atoms - first definitions and further refinement of understanding							3%
Ball bearing used to decrease friction in machines							4%
Boats through time							1%
Bridges - golden area of brides - description of types of brides created through history							1%
Brides - Brooklyn bridge - history of and newspaper clipping							4%
Calendars - starting with the moon Babylonians - roman calendars to present							1%
Christianity and science - historical perspectives [creation]							3%
Combustion - the process of discovery around what it involves							3%
Communication - history of through ages, alphabet, printing press…							1%
Compass - the development of the compass							11%
computers - brief history of the progression and advancements							1%
Daylight savings - history, who uses, benefits							3%
Earthquakes - history of international							6%
English measure - background history							1%
Electricity - why 120V in homes - brief history							6%
Electricity - the historical background to discovery and use of							9%
Electricity history of blackouts							6%
Elements - brief history of symbols and naming/ finding							7%
Energy - "man's" progressive use of energy from animals to machines							4%
Fire - history of it's use to improve home heating							9%
Flight - history of air flights - starting with balloons							4%
Flight - myths and stories about flight/ Mercury, Daedal us & icarus							1%
Force - history of the development of our understanding of force							4%
Gold rush							4%
H2 bomb - Explosion of first							3%
Heat - understanding of heat							3%
Home heating - in the 1600 native Americans and settlers							4%
Horses - background, man's use, evolution through time							19%
Horsepower - background of							3%
Instruments for making music - historical notes							3%
Kinetic theory - development of							7%
Koch's theory - historical background							6%
Light - first calculations and refinements of the speed							3%
Lightning rod use through history							7%

Magnetic currents/magnets development/ refinement of understanding							3%
Manhattan project - details and players							20%
Measurement - history of							4%
Medical developments throughout history							9%
Metric measure & simply measurement - background history							1%
Metric mishaps - orbiter crashed/ plane almost because of British/Metric convers probs							6%
Microscope - development of							3%
Motion - Mo Ching stated 1st law-Aristotle ideas held sway until Galileo proved Mo Ching							0%
Music							1%
Nobel Peace Prize							1%
Optical instruments - history of from microscopes - Hubble space telescope							3%
Penicillin - discovery and production							27%
Periodic Table - historical background and development							3%
Pharmacies - historical look at how people got their drugs							1%
Photography - instant							1%
plate techt / continental drift - interdisciplinary history of the progress of acceptance							3%
Polar Path Gyro - Langewiesche talks about flight over the pole using this instrument							3%
Polio vaccine - development of							3%
Polymers history of development of synthetic							6%
Radioactivity - Radium and first discoveries							3%
Reproduction - Old ideas about reproduction - life can come from nonliving things							6%
Resonance - Bridges destroyed by harmonics - wind, marching bands							6%
Satellites - history of US space program's first satellites							4%
Science - historical progression of science through the ages - modern science around 1800							4%
SCUBA Diving - how it works							1%
SETI - history and future of [Search for extra-terrestrial Intelligence]							1%
Ship building through history							6%
Simple machines in building - use through time - pyramids, pagoda, Gk theaters,							1%
Soap - development of							1%
Solar heated hot-air balloons							1%
Solar system - geocentric to heliocentric models and all the players							10%
Sound barrier - breaking it							13%
Steam engine - Steam engines herald the industrial revolution							7%
Telescopes - quick historical overview							3%
Thermometer - development of							1%
Transportation - history of how speed has increased with newer machines							1%
Volcanoes - historic eruptions							3%

Water use through history to serve our needs - waterwheels, dams, turbines							1%
Weismann - tails on mice proved acquired traits not inherited							1%
Wireless communication - history of - timeline							1%
Wood stoves - historical look							1%
You and Science							
13- part series describing the ascent of man							1%
Accidents - accident prevention							29%
Acid Rain - conflicting reports on cause of whom to believe how to resolve issue							1%
Airbags in cars - should they be required - should we be able to disconnect them?							3%
Airplanes - should they be forced to use life-saving inventions (i.e. fire-retardant material)							3%
Animal production - pros and cons of hybrids							1%
Atomic and H2 bombs - controversy over the use and proliferation of							1%
Atomic fuel - will it replace coal/oil fuel cars?							4%
Atomic bombs - Hiroshima ,Nagaski Japan - helped stop the war, folly of science							4%
Atomic bombs - Bikini island tests effects of radiation -							3%
Automobile - how they affect modern living - our dependency on them							4%
Biblical authority and science - [creation]							1%
Bike helmets - should they be required?							3%
Breakwaters & wave barriers - pros and cons for environment							3%
Bridges - what are the social effects of -							1%
Buildings - tradeoffs between insulation E conserve & air quality spread of disease							1%
Burglarproof vault in GA - time capsule for 82nd century - 6000yrs!							1%
Cell phones and driving - safety issues - laws against?							1%
Chemicals - how they harm and help us - restrict the use? - transportation?							4%
Chernobyl - one year after the explosion - three mile island - NR accidents							9%
Coal as fuel controversy							3%
Cogeneration - sharing energy pros & cons							6%
Conservation - which animals should live?							3%
Communication satellites - trends in technology directions for future							1%
Common Cold - Spitzbergen in the Arctic - cold free 7 months of the year							3%
Computers - are they helpful or harmful?							0%
Computers to reconstruct biblical synagogue							1%
Computer security - internet dangers							1%
Driving the speed limit controversy							1%
Dirty air and health							6%
Discussion on careers in science							0%
Droughts in Texas and Oklahoma - dust bowls created by improper land use							7%

Earth's future discussion							11%
Earth origin/fossils - two views - [creation]							1%
Electric Cars - pros and cons - may be the future							10%
Electricity - our dependency on it in every aspect of our lives - how to safely produce							13%
Electricity - it's superiority over the use of steam							3%
Electromagnetic spectrum - should the gov't auction off sections to private corps?							1%
energy production - pros and cons of a variety of resources							1%
Environment - humans domination over for better or worse- humans right to control							1%
Environment - humans striving for balanced interactions with nature and progress							9%
Expectations are what a person realizes							6%
Evolution and why it's not a very good theory [creation]							1%
Farming in America							7%
Fast cars - making safe - safety issues							1%
Fluoridation of public water - pros and cons							3%
Food - Genetically engineered - is it safe?							1%
Future research							14%
Gas - use and consumption large cars vs. small cars							3%
Gasohol - pros and cons of							3%
Graphs & data - how same data can be displayed in diff ways give diff impression							4%
Greenhouse effect - CFC pollution - is it a real problem or not							7%
Gypsy moth - illustrates web of life							4%
Hazardous House Materials (paint batteries) should they be regulated sale, use, disposal							1%
Herron irradiation - illustrates web of life							0%
Industry and automation - effects on jobs, who should pay society -							1%
Industry - Ode to the greatness of industry - production from factories/mines							7%
Industry-Responsible Care - pledged to manufacture without causing environ damage							1%
Industry - take 2 - 6% of world pop - produce 40% world good - all through machines							4%
industry - thermal & other pollutions - should they be regulated and forced to adhere							1%
Information privacy, identity theft							4%
Information - government access to personal information							1%
irradiation of Food - is it safe?							3%
Lake Monster - CO2 released understand but lack funding to take care of problem							1%
Land use and private property							1%
Mars - face on mars - canals - alien controversy - proof of life on mars							3%
Maintain pipes in power plant - considerations in							0%
Metric System controversy - why use it?							7%
Microwave controversy - safe or not?							3%

Noise pollution - who decides what is noise and is it right to regulate?							3%
Nuclear fusion as a future source of energy							19%
Nuclear power - controversy regarding producing / safety							27%
Oriental Fruit Moth							3%
ozone hole - International concern, causes, effects							1%
Paper of Plastic at the grocery store - lists various student perspectives on this issue							4%
Past comets cause of ice age - perhaps will happen again							1%
Pets - medical care/costs/benefits/risks - should people spend money on their pets							1%
Pollution in environment - causes of , pros and cons of cleanup							21%
Pollution and poisons in the work place - who's responsible?							1%
Pollution and batteries - types of batteries - disposal of pros and cons							1%
Pollution - plastic disposal - environmental impact, poisons found in plastics,							11%
Pollution - biodegradable plastics							6%
Pollution - should zero-emission be required							3%
Pollution and regulations are they fair? Practical? Who should pay?							1%
Pseudoscience - fake science astrology, ads on TV, wrong info abounds							1%
Pseudoscience -magnetic theory - disproven by Franklin & Lavoisier - used today again							1%
Public water services - historical notes on providing clean water to communities							6%
Radiation - are medical uses of safe or not?							7%
Radiation - how much radiation is safe - when are levels too dangerous							7%
Railroads - our dependency on them - from horses to electric locomotive							3%
Robots - uses and how they will affect society?							6%
Robots - replacing jobs in the workplace how this might be a problem?							1%
Science - examples of how it has been wrong in the past so it must always be tentative							1%
Science - it's potential/ pros and cons - our responsibility - need for public awareness							1%
Seat belts/air bags - should there be laws to make us wear/have them?							6%
Smog - where its found, what it is, effects to humans							7%
Smog - should there be laws to regulate zero-emission cars/							3%
Snake venom effects entire body - scientist dies in detail							1%
Space travel - the possibility of							11%
Space Travel - beyond the moon to Venus and mars							9%
Space travel/exploration - is it worth the cost? Pros and cons							1%
Splitting atoms - what will the future hold							4%
Sports technology - pros and cons							1%
Starlings introduction to NY - illustrates web of life							3%
Steroids - the use /danger of/ why people use them /abuse of							1%

Sweeteners - natural/artificial - pros cons possible dangers							1%
Technology - the pros and cons - good and deadly uses of what is our responsibility?							10%
UV light - dangers of exposure - health risks of tanning							1%
Water ph adjustments in bodies of water - pros and cons							3%

APPENDIX E – ASSUMPTIONS FOR ANALYSIS

A mixed-design ANOVA assumes that the analysis will include:

- at least one nominal-scale predictor variable that is a between-groups factor
- plus at least one nominal-scale predictor variable that is a repeated-measures factor (Hatcher & Stepanski, 2003, p. 334)

In both repeated measures analyses conducted in this study the 6 decades are the between-group factors, while the 5 subject areas created from the 23 themes and the 3 themes (24-26) are the within-group or repeated-measure factors. There are several assumptions that must be met when conducting a multivariate test of this kind.

1. **Level of measurement**. The criterion variable should be assessed on an interval- or ratio-level of measurement. Depth of coverage is the criterion variable based upon a 0-3 point scale. The predictor variables both should be nominal-level variables (categorical variables). One predictor codes within-subject factors and the second codes between-subject factors. The 5 subject areas in the first analysis and the 3 themes in the second analysis are the categorical within-subject factors and the 6 decades are the between-subject factors in both tests. The six decades used in this study are ordinal in nature however we may treat them as categorical for the purpose of this analysis. Just as pre, post and follow-up categories are used in this manner so too is the decade variable.
2. **Independent / Random observations**. The 70 textbooks were not analyzed in any particular order. The criteria used for the order of book review was textbook

due date. Books that had short lending intervals were analyzed first those books that could be kept longer were analyzed last.

3. **Multivariate normality**. As seen earlier in this chapter in most themes do not display normal distribution. However theme 1 (Process of Science) and the combined themes forming subject areas conform to normality specifications. Each of these distributions displays skewness less then 1.0 or -1.0 and an acceptable kurtosis. Table G.1-3 displays the depth of coverage statistics of the distributions used in both multi-variate analyses.
4. **Homogeneity of covariance matrices**. Tests were conducted across all decades for all themes to discover any significant differences between matrices. The tests for homogeneity resulted in a χ^2 (1755) =116.42, p =1.00. This indicates that there are no significant differences between matrices and the assumption is met.
5. **Sphericity**. This assumption was met as indicated by a Huynh-Feldt Epsilon of 0.72 in the first analysis and a Huynh -Feldt 0.91 of in the second analysis.

Table E.1 Assumptions for multivariate tests – normality of distributions

	Proc Sci	Chemistry	Physics	Earth Sci	Biology
Mean	0.89	1.33	1.25	0.76	0.55
Median	0.86	1.36	1.41	0.56	0.25
Std Dev	0.43	0.64	0.66	0.67	0.54
Skew	0.18	-0.09	-0.23	0.50	0.65
Kurtosis	-0.57	-1.13	-0.98	-1.28	-0.83

Table E.2 Assumptions for multivariate tests – normality of distributions

	1950	1960	1970	1980	1990	2000
Mean	1.06	1.03	0.77	1.00	0.97	0.99
Median	1.16	0.97	0.74	1.32	1.40	1.13
Std Dev	0.43	0.35	0.35	0.71	0.77	0.61
Skew	-0.37	-0.26	0.91	-0.05	-0.19	-032
Kurtosis	-0.11	0.18	-0.04	-1.82	-1.87	-1.30

Table E.3 Assumptions for multivariate tests – normality of distributions

	Tech	History	SSI
Mean	39.70	42.23	10.79
Median	35.00	28.50	6.00
Std Dev	26.16	32.33	11.97
Skew	0.72	1.37	1.20
Kurtosis	-0.6	1.41	0.28

ABOUT THE AUTHOR

Anna Lewis has a BS in Physics (1982) and a MS in Instructional Technology (2003). After receiving her BS she worked for six years at the Marshal Space Flight Center in Alabama. She also spent time at MIT, programming the navigational system for the Galileo space satellite. She lived in India for two years working in various social programs. When she returned to the U.S. she began her own business in adaptive technology.

In 2003 Ms. Lewis began her doctorial program in science education, that same fall she began teaching high school physics and physical science. It was at this time that Ms. Lewis became interested in the use, the reliability, and the appropriateness of science textbooks. During her summers Ms. Lewis assisted in several science-book and curriculum selection committees. The Sarasota school district reviewed several integrated science curricula to be implemented in the local district. While serving on these committees Ms. Lewis discovered that no 'integrated curriculum' that was offered to the district at that time (2003-2005) was truly integrated. Rather textbooks and curricula simply provided differentiated sections and chapters in physics, chemistry, biology, earth science and astronomy.

During this period, Ms. Lewis worked in collaboration with three other science teachers to write the high school science standards for the Sarasota district. These standards were then given to another committee to write test questions based upon the devised standards. Neither the standards nor the test questions were ever used by the district, which illustrates the often puzzling action of educational systems to spend time, funds, and resources on activates that serve no real purpose.

Ms. Lewis anticipates that this research will explore the differences and commonalities among textbooks used in the U.S. The results of this study will assist our educational system in making common sense decisions regarding science standards, reducing multiple efforts at the local, district, and state levels, and conserving education dollars and resources. It is also hoped that this research will provide a foundation on which to begin discussion about the value and worthiness of truly integrated and systemic science programs.