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Alignment Between Secondary Biology Textbooks and Standards for Teaching English Learners: A Content Analysis

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ABSTRACT

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The goal of the most recent science education reform movement in the U.S. is science literacy for all Americans. Science literacy among U.S. students remains low, however, as compared with students in other industrialized countries, and is lowest among English Language Learner (ELL) students. Although there are barriers to developing science literacy for all adolescent students, ELL students often experience additional barriers that make developing science literacy even more challenging without support. Because textbooks are often heavily relied upon by secondary science teachers, the opportunity for many ELLs to develop science literacy may depend upon the support for these students included in science textbooks. Many textbook publishers have included textual tools for teaching ELLs in the teacher's editions of science textbooks they claim will help teachers support the learning of ELLs in the ways that are recommended by national standards, which describe appropriate science content, pedagogy, and language supports. These standards, referred to in this study as ELL standards, include the *Benchmarks for Science Literacy*, the CREDE standards, the WIDA standards, and the TIMSS standards. The purpose of this descriptive qualitative content analysis was to determine how the textual tools for teaching ELLs found in three widely used secondary biology textbooks in the U.S. are aligned with the ELL standards. All textual tools were read, reread, and coded using the ELL standards as a priori coding categories. The results indicate that some of the textual tools in the biology textbooks align with the ELL standards. However, the frequency of alignment between the textual tools and the ELL standards is not high. Further, many of the instances of alignment between the textual tools and the ELL standards are implicit, rather than explicit, indicating that the alignment between them is weak. Finally, many of the textual tools that are aligned with the ELL standards are only aligned with one of the categories within a given standard and ignore other, important, categories. It is recommended that textbook publishers update the textual tools for teaching ELLs in future editions of their textbooks to make them more aligned with the ELL standards. It is further recommended that secondary science teachers be better prepared so they will not have to rely on the textual tools for teaching ELLs in their instruction.

Keywords: science literacy, science textbooks, ELLs, science education reform

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Chapter 1

Introduction

The science education community emerged from World War II determined to reform the way science was taught in the United States in order to ensure continued U.S. global economic, technological, and military dominance. The ensuing era of reform consisted of two separate movements. The first of these movements, often called the *Curriculum Reform Movement*, focused almost exclusively on the creation of future scientists. This effort reflected a view of the purposes for science education that excluded the majority of the K-12 school population (DeBoer, 2000). Eventually, having attempted to update the science content, increase the rigor, and introduce the process of science as actually performed by scientists in science courses (Yee & Kirst, 1994), the reform efforts of the 1950s through the 70s failed to significantly change the way science was taught in schools. "General education in science was relatively little aided by the curriculum reform efforts" (Klopfer & Champagne, 1990, p. 151), and by 1975 government funding for all curriculum projects was withdrawn (Duschl, 1990).

The second reform movement in science education, which officially began in the 1980s and continues to the present day, has focused on developing science literacy for all U.S. students, defined as both the ability to use scientific content knowledge to think, reason, and problem-solve as well as the ability to speak, read, write, and communicate within the field of science (Norris & Phillips, 2003). Achieving scientific literacy is now considered "a necessity for everyone," not just future scientists (American Association for the Advancement of Science [AAAS], 1990, p. xvi). This is because U.S. citizens live in a global society that presents them with an ongoing set of science-related political, social, economic, environmental, and personal issues about which they need to be able to form their own intelligent, rational choices (AAAS, 1990, 1993; Hand, Prain, & Yore, 2001; National Research Council [NRC], 1996, 2012; Norris & Phillips, 2003; Schleicher & Stewart, 2008).

To this end, three documents were created by science education reformers and widely adopted as the definitive articulation of the science "understanding," "reasoning," "knowledge," and "skills" that all adults in the United States should have acquired during their public school education (p. 1). These publications, referred to in this study as the science education reform documents, include *Science for All Americans: Project 2061* (AAAS, 1990), *Benchmarks for Science Literacy* (AAAS, 1993), and the *National Science Education Standards* (NRC, 1996), comprise the foundational texts of the current science education reform movement. They act as a framework for instruction for teachers of science, guiding their practice as they strive to ensure that all American students, "regardless of their social circumstances" (AAAS, 1990, p. xviii), reach a standard level of science literacy. They also serve a useful function by defining what that standard level is, providing specific recommendations regarding "what all students should know and be able to do in science, mathematics, and technology by the time they graduate from high school" (AAAS, 1993, p. xi).

Significantly, however, even with the adoption of these reform documents, educators have experienced difficulties in achieving the aim of science literacy for all. Students in the U.S., who have long performed more poorly than their cohorts in other industrialized nations on international assessments of science achievement (Mayer, Sims, & Tajika, 1995; National Commission on Excellence in Education, 1983; Robitaille & Garden, 1989), continue to do so (Petrilli & Scull, 2011; Tsao, 2004), with U.S. English Language Learner (ELL) students achieving the lowest scores among all student groups (Janzen, 2008).

As crucial as the science education reform documents have been to restructuring science education in the United States, they clearly were not, in and of themselves, sufficient to help teachers meet the science literacy needs of all learners (Gross et al., 2005). This is, perhaps, because the documents do not attend to all of the aspects of what teachers must consider and do on a day-to-day basis (e.g., pedagogy, linguistics, cognition, content) in order for at-risk students to be supported sufficiently in their development of science literacy (DeBoer, 2000; Gross et al., 2005). That was never their purpose. Rather, they are policy documents intended to communicate what is valued in science education and to promote further research in a given area (Hiebert, 1999; Woodward, 2004). Thus, the documents "are guideposts, not blueprints" (Wheelock, 1996, p. 3), and given the diversity of students in classrooms in the U.S., they could not be anything more. The creators of the standards documents could not, and do not claim to have "analyzed the terrain in which such standards will be utilized" (Kyle, 1996, p. 1044). It is, rather, "the responsibility of individual teachers" (DeBoer, 2000, p. 14) to know the needs of their own students and to identify and implement the instructional strategies that will be most effective at helping them achieve science literacy.

In order to assist educators in these efforts, a separate group of documents was created. These documents were not necessarily designed to address just the needs of any one group of students, or just science literacy. Instead, the emphasis of some of these documents is on at-risk learners in general. However, because they address all of the relevant instructional dimensions required for the development of the content-area literacy of all students, for the purposes of this study these documents will be referred to as the ELL standards. These include the *Center for Research on Education, Diversity, and Excellence* (CREDE) standards (University of California Berkeley Graduate School of Education, 2002), the *World-Class Instructional Design and*

Assessment (WIDA) standards (Board of Regents of the University of Wisconsin System, 2007), and the *Trends in International Mathematics and Science Study* (TIMSS) standards (National Center for Education Statistics, 2011). The WIDA standards address the linguistics and language aspects of curricula. The CREDE standards inform the pedagogical aspect of curricula. The TIMMS standards facilitate the evaluation of the cognitive aspects of curricula. *Benchmarks for Science Literacy* (AAAS, 1993), which was revised in 2009, has been added to this list for the purposes of this study because the benchmarks, as they will be referred to hereafter, emphasize the acquisition of an aspect of content-area literacy that the other three standards do not directly address: the science content itself.

Challenges to Achieving Science Literacy

There are many factors that combine to create challenges in achieving the goal of science literacy for all. For teachers of secondary students, many of these challenges derive from the nature of adolescent learners. Such challenges include the way adolescent learners cope with the realities of culture, identity, and the nature of science literacy (Aikenhead, 2000, 2001; Alvermann, 2001; Brickhouse & Bodner, 1992; Mount-Cors, 2008; Norris & Phillips, 2003). These challenges are often further exacerbated for ELL students because of characteristics that tend to be inherent within ELL populations (Mount-Cors, 2008). Such characteristics include a variety of fundamental socio-cultural differences between ELLs and native speakers of the school language (Pitoniak et al., 2009), a lack of the kinds of parental support for secondary schooling among ELL families that school personnel typically expect (Rivera & Waxman, 2011), the challenges faced by ELL students in navigating the overall school culture in the U.S. (Harklau, 1994), the English language barrier (Watts-Taffe & Truscott, 2000), and a lack of effective content-area reading strategies for ELL students (Alvermann & Phelps, 1994). The cumulative effect of these challenges has been the prevalence of low levels of science literacy for large numbers of ELL students in a U.S. society in which science "permeate[s] every aspect of modern life" (NRC, 2012, p. 7).

The classroom teacher is expected to overcome these challenges by employing effective teaching methodologies (Carrasquillo & Rodriquez, 2002; Thier & Daviss, 2002; Tobin, Briscoe, & Homan, 1990). It becomes significant, then, that teacher-related factors also pose challenges to the development of high levels of science literacy among all students, particularly in schools with large ELL populations, wherein disproportionately high levels of underprepared teachers are employed (Darling-Hammond, 1987, 2006; Haycock, 1998, 2000; Hollins & Guzman, 2005; Ingersoll, 2002, 2004). There are many reasons for this phenomenon, including teacher supply deficits; variable quality of teacher preparation; and school organizational factors (e.g., school district regulations, quality of principal leadership, strategies used in teacher recruitment and hiring, employment and utilization policies enacted by administrators, school funding, and average class sizes), all of which tend to lead to high levels of out-of-field teaching in ELL-dominated schools (Darling-Hammond, 1999, 2000, 2006; Ingersoll, 1997, 1999, 2002; Quartz, 2003). Whatever the specific reason or reasons, ELL students in the U.S. are much more likely than their mainstream counterparts to be taught by secondary science teachers who are inexperienced or under-prepared to implement the kinds of teaching methods and strategies that ELL students need in order to develop science literacy (Gersten, 1999; Lankford, Loeb, & Wyckoff, 2002; U.S. Department of Education, 1996; Ravitch, 2004).

Reliance on Science Textbooks as Curriculum

One consequence of this phenomenon is that a large number of science teachers rely heavily on course textbooks rather than their own expertise for the curricular framework and instructional strategies of their teaching (Garner, 1992; National Assessment of Educational Progress, 2000). Indeed, the powerful, central role that textbooks play in the U.S. education system has been well established (Armbruster and Ostertag, 1993; Bednarz, 2004; Driscoll, Moallem, Dick, & Kirby, 1994; Li, Chen, & An, 2009, Oakes & Saunders, 2004), with Garner (1992) noting that “textbooks serve as critical vehicles for knowledge acquisition in school” (p. 53). Kesidou and Roseman (2002) concur, pointing out that textbooks

> have a major role in teaching and learning. Many teachers rely on them to provide some or all of their content and pedagogical content knowledge . . . especially . . . when the teacher is a novice or is teaching outside his or her area of expertise. (p. 522)

In many science classrooms, textbooks also provide a "blueprint for classroom instruction" and "set the scope of what is to be taught and learned in the classroom" (Li, Chen, & An, 2009, p. 809). This means that science textbooks in the U.S. often constitute a sort of de facto national curriculum, leading some researchers to make virtually no distinction between the terms *curriculum* and *textbook* (Radcliffe, Caverly, Peterson, & Emmons, 2004). It has even been suggested that the most "accessible way of documenting how teaching and learning are likely to proceed for a large population and over a large period of time" would be through "an analysis of textbooks" (Li, Chen, & An, 2009, p. 809).

In response to the reform documents and the ELL standards, and out of an awareness of the reliance of teachers on textbooks, many textbook publishers have augmented their publications in recent years. These additions, according to publishers, incorporate suggestions put forth by the science education reform documents as well as many aspects of the ELL standards in a series of resources they claim will assist science educators in making the science content in each chapter more accessible to ELL learners than ever before (Biggs et al., 2009;

Miller & Levine, 2010; Postlethwait & Hopson, 2006). Although these resources, which typically consist of instructional recommendations described in a paragraph, have different titles in different textbooks, for the purposes of this study they will be called *textual tools for teaching ELL students*.

Due to the addition of these textual tools for teaching ELL students to recent editions of their textbooks, textbook publishers claim that science teachers (specifically, for this study, biology teachers) are adequately supported in their efforts to make the content of their curriculum accessible to ELL students (Biggs et al., 2009; Miller & Levine, 2010; Postlethwait & Hopson, 2006). In fact, publishers assure teachers that by using their textbooks, and especially the textual tools for teaching ELL students found in the textbooks, as the primary vehicle for delivering instruction, they "can address the needs of all students in the biology classroom" (Biggs et al., 2009, p. 13T).

Statement of the Problem

Whatever the claims of textbook publishers, it can be argued that if these textual tools are to be successful at aiding in the achievement of science literacy for ELL students, it is essential that they conform to all of the ELL standards. However, a search of the literature indicates that no in-depth examination of textual tools for teaching ELL students has been made to determine if such conformity exists. It is unclear how the instructional procedures and practices promoted by the textual tools for ELL students in secondary biology textbooks are aligned with the ELL standards.

Purpose and Question of the Study

The purpose of this study was to determine how the recommended instructional practices and procedures for teaching science to high school English language learners (ELLs) found in the textual tools for teaching ELL students in three secondary biology textbooks align with the ELL standards. The research question that guided this study is: How do the recommended instructional practices and procedures in the textual tools for teaching ELL students found in three secondary biology textbooks align with the ELL standards?

Chapter 2

Review of Literature

The purpose of this study was to determine how the recommended instructional practices and procedures for teaching science to high school English language learners (ELLs) found in the textual tools for teaching ELL students in three secondary biology textbooks align with the ELL standards. In order to better understand this issue, this chapter will consider four bodies of literature. The chapter begins with a review of the literature that establishes the importance of having a scientifically literate society (i.e., science for all Americans). This will be followed by a description of the major issues impacting the achievement of science literacy for adolescent learners. The next section of the chapter will discuss the rise of the various laws, reform documents, and standards intended to facilitate equal access to learning for all U.S. students, including the population that provides the context for this study, adolescent ELLs. Finally, the chapter will conclude with a description of issues associated with the resources that are necessary and available for the development of science literacy, including, and especially, textbooks.

Science for All Americans

For nearly three decades the generally acknowledged goal in science education has been that all students, regardless of their "cultural or ethnic background...should have the opportunity to attain high levels of science literacy" (NRC, 1996, p. 20; see also NRC, 2012). This widely held ideal has been the focus of the most recent reform movement in science education, the second reform effort since World War II. This movement, together with the reform effort that preceded it, represents attempts to improve K-12 science education in the United States.

A history of science education reform in the United States. Two major reform movements, the *Curriculum Reform Movement* of the 1950s through the 1970s and the more recent emphasis on *Science for All Americans,* have sought to shape science education in the United States over the past 60 years. This section of the chapter will provide a brief description of these movements, including an explanation of the implications that the outcomes of these movements have for this study.

The first reform movement: **The Curriculum Reform Movement.** It is widely believed that the launch of the *Sputnik I* satellite by the Soviet Union was the impetus for the first science education reform movement in the U.S. (National Commission on Excellence in Education, 1983). As significant as that event was, however, the reform movement was well established by October 4, 1957, when the launch occurred. It was, instead, the events surrounding World War II that led to the call for changes in the way science was taught in the U.S. (DeBoer, 1991). Indeed, it was specifically "because of the impressive technological successes of World War II" (Duschl, 1990, p. 16) that the National Science Foundation (NSF) was created in 1950, with the charge of, among other things, realizing "our nation's potential in . . . science education" (Duschl, 1990, p. 16). At that time it was thought that in order for the U.S. to maintain the dominant economic, technological, and military status with which it emerged from the war, it was necessary to emphasize high achievement in science, mathematics, and technology among the nation's students. This led to unprecedented involvement by the federal government in the way science was taught (Shymansky, 1992; Welch, 1979). The most overt manifestation of this involvement was the decision to involve government agencies, specifically the NSF, in setting curriculum standards in science (Welch, 1979).

The decision to take the step, "unparalleled in our nation's history" (Welch, 1979, p. 282), of intimately involving the federal government in school curriculum funding, design, and implementation was a response to the perceived weaknesses of the science education of the day.

The American tradition of individual schools setting their own curricula to meet perceived local needs was now deemed to be inadequate to meet the scientific and technological demands of a post-war world (DeBoer, 1991; Frandsen, 2006). In addition, declining numbers of students enrolled in accelerated science and math courses, as well as complaints by university science professors that college students were being insufficiently prepared by their secondary science classes to take college science courses, led to the fear of a shortage of scientists and mathematicians (DeBoer, 1991; Frandsen, 2006; Yee & Kirst, 1994). Thus, pressure began to mount from the various stakeholders in science education (e.g., state legislatures, business leaders, science educators, interest groups) to improve secondary science curricula in order to ensure that the U.S. would continue to produce large numbers of scientists.

It was at this critical moment in the national debate over how to improve science instruction that the Soviet launch of Sputnik 1 galvanized the nation to action. This technological leap forward by the nation's main international competitor convinced many that the U.S. had fallen behind the Soviets in scientific and technological progress (Yee & Kirst, 1994). In fact, some insisted that science education had actually compromised national security because the Soviets "had the capacity to deliver the [nuclear] bomb on an intercontinental ballistic missile" (Wolfe, 1979, p. 57); the U.S. did not. Science education was blamed for not generating enough scientists for the U.S. to keep up with the Soviets (Yee & Kirst, 1994). A crisis was declared. Demands to improve science curricula became strident and science education reform was forced to the forefront of national priorities (Frandsen, 2006).

Thus began the curriculum reform movement of the 1950s through the 1970s, the purpose of which was to make science instruction more rigorous and more authentic in the sense that students would be learning and doing science the way actual scientists do science (Yee & Kirst, 1994). This objective was deemed too important, however, to be entrusted to teachers. Instead, it was scientists and university faculty who designed and developed the multitude of curriculum development projects on which billions of dollars of government and private funds would eventually be spent (DeBoer, 1991; Frandsen, 2006; Prather, 1993). The goal was to increase the numbers of scientists in the U.S. by creating a wide array of literature, materials, and experiments that would prepare students for college science courses and future science careers (Bybee, 1993; Klopfer & Champagne, 1990). This was not to be science for the average American, but science for scientists.

By the 1970s, a variety of criticisms had been leveled at the Curriculum Reform Movement, which caused public support to "[decrease] progressively" (Shymansky, 1984, p. 54). Congress held hearings to ascertain the effectiveness of the NSF's science education policy, determining that it was not accomplishing the goals of the reform movement (Kraus, 2010; White, 2010). This led to the withdrawal, in 1975, of all funds for developing science education curricula from NSF and other organizations (Duschl, 1990; Frandsen, 2006; Prather, 1993), and in 1982 the Science Education Directorate of NSF "came perilously close to extinction" (Shymansky, 1984, p. 54).

As researchers have examined the criticisms that led to the demise of the first reform movement, three main factors have emerged as significant. First, because it was believed that teachers lacked sufficient scientific knowledge to participate in the development of improved science curricula, reform leaders made the decision to marginalize teachers during the process of new curriculum design. They also suggested that teachers were insufficiently prepared to implement the new curricula without specific guidance (Prather, 1993). The new curricula, designed by scientists and university faculty with little involvement from K-12 classroom teachers, were scripted so as to be teacher-proof, so that teachers “could not mess them up” (Yager, 1992, p. 905). Many members of the education community resented this imposition of what was perceived to be a federally mandated national curriculum that violated the traditional American local approach to schooling (Welch, 1979; White, 2010). As a result, many teachers felt no need to implement the new curricula, ensuring that reform efforts would not succeed (Klopfer & Champagne, 1990).

The second factor that prevented lasting change in science education was the failure of the new science curricula to meet the needs and interests of a majority of students. Instead, schools had become "sorting and selecting agencies" (Tyack, 1974, p. 272) in which the curricula included very few relevant applications to daily life that would catch the interest of the average student and lead to engagement with the content (Yee & Kirst, 1994). Although “many scientists, mathematicians, and engineers were produced . . . the informed citizenry needed to maintain a science and technology-dependent civilization had not followed” (Prather, 1993, p. 55); many students perceived the curricula as elitist, too difficult, and, ultimately, not for them (Duschl, 1990; Frandsen, 2006). This belief was shared by many of their teachers, who refused to use the materials as designed (Bybee, 1993; DeBoer, 1991; Frandsen, 2006; Yager, 1992; Yee & Kirst, 1994).

The third factor that contributed to the failure of the Curriculum Reform Movement was that the scientists and professors who designed the new curricula "had little understanding of the reality of schools" (White, 2010, p. 8). This led them to the decision to base the new curricula on a subject-specific emphasis, without taking into account the social needs of the time (Frandsen, 2006; Prather, 1993). Instead, "their interest was in extending exposure of the structures of their academic disciplines into the earlier grades" (White, 2010, p. 6). However, it was precisely at this time that the U.S. found itself in the midst of a variety of pressing social issues. These included the demographic and economic changes associated with increasing population and insufficient accommodations that were taking place in urban areas all across the U.S., with their attendant problems of poverty and pollution (Bybee, 1993; Frandsen, 2006; Tyack, 1974). These issues, juxtaposed against the new curriculum model of turning public school children into junior scientists, highlighted the disparity between the lived reality of the majority of people in U.S. society and the curricula that academics were trying to introduce into the classroom (Tyack, 1974). This oversight underscored the deficiencies of the first reform movement, as leaders were forced to acknowledge the need to focus curricula on preparing citizens to solve personal and societal problems (Bybee, 1993).

As reform efforts began to slow in the late 1970s and early 1980s, those who were aware of its deficiencies began to initiate discussions centered on the need to establish a society that would be scientifically literate, as well as mechanisms whereby this goal could be achieved (Bybee, 1985; Frandsen, 2006; Graubard, 1983; Hickman & Kahle, 1982; Hurd, 1986). Within a number of years, the U.S. science education community had shifted its aims to include the goal of a U.S. population whose citizens would all possess a basic level of competence in science and technology concepts.

The second reform movement: **Science for All Americans.** As with the launching of Sputnik I in 1957, the publication of the document titled *A Nation at Risk* (National Commission on Excellence in Education [NCEE], 1983) captured the attention of the nation and led to the conclusion that, once again, the U.S. faced a crisis in science education, as well as in multiple other areas of education (Frandsen, 2006). This time, however, the threat was not limited solely to the risk of falling behind the Soviet Union in a race for global military dominance due to a shortage of U.S. scientists. Instead, the narrative of this second crisis was expanded to include the fact that science and technology had become woven into the very fabric of our economy, our "society," our "culture, our lives, and the course of our democracy" (Hurd, 1997, p. 411). The NCEE revealed that test scores of American students, especially in math and science, had fallen behind those of students in other industrialized nations. As a result, it was claimed, the U.S. faced a crisis that threatened the individual American, who was deemed to be insufficiently science literate to live a successful life in a new, modern world and contribute in a significant way to a society that had been restructured along scientific and technological lines. What was at risk was

> the promise first made on this continent: All, regardless of race or class or economic status, are entitled to a fair chance and to the tools for developing their individual powers of mind and spirit to the utmost . . . to attain the mature and informed judgment needed to secure gainful employment, and to manage their own lives, thereby serving not only their own interests but also the progress of society itself. (NCEE, 1983, p. 8)

Because the crisis threatened the individual, it threatened the very future of American democracy itself. "A high level of shared education is essential to a free, democratic society and to the fostering of a common culture, especially in a country that prides itself on pluralism and individual freedom" (Seaborg, 1991, p. 7). According to critics, public education had failed to provide the average citizen with this high level of shared education (Seaborg, 1991). What was wanting in science education was not an abundance of professional scientists, but, rather, a society in which all citizens could think scientifically. Such a society, it was argued, would preserve U.S. economic and military dominance in a global economy that was becoming increasingly reliant on science and technology (NCEE, 1983). As with the launching of Sputnik

1 and the first reform movement, although the publication of *A Nation at Risk* (NCEE, 1983) elicited a response from the public and spurred efforts by reform leaders, the seeds of the second reform movement were planted long before the publication of *A Nation at Risk* (NCEE, 1983).

The term *science literacy* was actually first articulated in the 1950s (Cohen & Watson, 1952; Frandsen, 2006; Hurd, 1958; McCurdy, 1958; Rockefeller Brothers Fund, 1958), although a clear definition of what the term science literacy might mean was not forthcoming at the time. However, the science education community was captivated by the very idea of science literacy and began discussing what the term might mean (Frandsen, 2006). These discussions eventually resulted in the National Science Teachers Association's (NSTA) adoption of science literacy as its primary objective: "The major goal of science education is to develop scientifically literate and personally concerned individuals with a high competence for rational thought and action" (DeBoer, 2006, p. 30).

Consequently, when the National Commission on Excellence in Education published *A Nation at Risk* (1983), the science education community had already been tinkering with its most fundamental tenets for new reform for years. What the publication did accomplish, much like the launch of Sputnik 1 during the first reform movement, was to galvanize public indignation, which set the stage for increased efforts by reform leaders by placing public pressure upon the perceived inadequacies of science education.

The science education community responded to this "strident message" (Klopfer & Champagne, 1990, p. 133) by creating three documents that have come to define the current reform movement in science education: *Science for All Americans: Project 2061* (American Association for the Advancement of Science [AAAS], 1990), *Benchmarks for Science Literacy* (AAAS, 1993, 2009), and the *National Science Education Standards* (National Research Council

[NRC], 1996). These documents, which will be explained in detail later, acted as key frameworks and curriculum guides for science instruction and placed the achievement of science literacy for all students at the forefront of science education. They became fundamental to reform efforts and the tenets included in them are still considered essential to achieving science literacy for all students (NRC, 2012).

Although the efforts to define and describe a foundational knowledge base within the sciences as a requirement for all Americans continues today with the development of the *Next Generation Science Standards* (NAS, 2013), the term science literacy represented the mantra for a new reform movement in science education. How to go about actually achieving high levels of science literacy, however, especially for historically marginalized populations like ELLs, was a different matter. As the science education community set out to accomplish their lofty goal, it soon became apparent that there were significant challenges to its realization.

The current state of science education reform in the United States. In the two decades since the publication of *Science for All Americans: Project 2061* (AAAS, 1990) gave shape to the current reform movement in science education, a significant effort has been made by educators to achieve the goal of providing equal access to science literacy for all Americans. This effort has included a more detailed articulation of the specific aims of the reform movement in the subsequent publication of *Benchmarks for Science Literacy* (AAAS, 1993) and the *National Science Education Standards* (NRC, 1996). These, in turn, have been foundational in the development of a new conceptual framework for science education in the U.S. (NRC, 2012) that has given rise to the *Next Generation Science Standards* (NAS, 2013).

The emphasis on national standards has also been strengthened by the *No Child Left Behind Act* (NCLB) of 2001, which has made content standards and annual achievement tests a required part of federal and state accountability systems (Hovey, Hazelwood, & Svedkauskaite, 2005). All 50 states have complied by drafting state science education standards based on the national standards and administering annual competency-based, standardized assessments, if they had not previously done so. Hopes have been high within the reform community that this would cause student achievement to rise over the ensuing years (Erpenbach, Forte-Fast, & Potts, 2003; Hill & DePascale, 2003; Hovey, Hazelwood, & Svedkauskaite, 2005). However, the expected improvement in student performance has not occurred (Hovey, Hazelwood, & Svedkauskaite, 2005), as documented by the results of national and international science assessments. An examination of assessment data reveals that "trend results in science from the National Assessment of Educational Progress (NAEP) show essentially no change in student performance over the past 30 years" (Schmidt & Kher, 2010, p. 66). Additionally, assessments such as the TIMSS indicate that, when compared to students in many other countries, the "grasp of science" of U.S. students in some grades "is actually slipping" (Gross et al., 2005, p. 8). These test results also reveal that ELL science and mathematics scores consistently fall near the bottom of all U.S. students assessed (Hampden-Thompson, Mulligan, Kinukawa, & Halle, 2008; U.S. Department of Education, 2010, 2012).

Many explanations of why reform efforts have not led to expected improvements in student performance identify standards as being somehow connected to the problem. For example, some have suggested that the NCLB emphasis on testing has caused states to develop standards which tend to include an "extensive listing of topics to be covered in the year" (Schmidt & Kher, 2010, p. 66) which are more detailed and specific than the standards recommendations found in the reform documents (DeBoer, 2002, p. 413). This lack of connection between state standards and the reform documents (Marx & Harris, 2006) may have prohibited "a robust, clear, intensive treatment of foundational ideas" (Southerland, Smith, Sowell, & Kittleson, 2007, p. 63), preventing students from gaining the big picture of the discipline they are taught (Wandersee & Fisher, 2000). Other standards-related explanations suggest that teaching practices are often not aligned with state standards (Hovey, Hazelwood, & Svedkauskaite, 2005) and that the standards advocated by the reform documents are simply not compatible with the mandates of NCLB (Southerland et al., 2007).

A different explanation for the lack of improvement in the science literacy of American students is that the accountability measures imposed by NCLB initially focused exclusively on mathematics and reading. Because student performance in mathematics and reading was the main criterion for achieving adequate-yearly-progress (AYP; Draper, Hall, & Smith, 2005; McShane, 2002; Saul & Dieckman, 2005), the focus on science instruction in schools was dramatically reduced (Saka, 2007). Mathematics and reading were given "significantly more school time and money compared with science" (Hovey, Hazelwood, & Svedkauskaite, 2005, p. 503) and science education fell into a "quiet crisis" (Friedman, 2005, p. 276). So it was that within a few years of the development of the reform documents the impetus toward raising the quality of science education in the U.S. and increasing the science literacy of all students threatened to stall, even as the science education community continued to push for reform.

As researchers have continued to investigate the various obstacles that have threatened reform efforts since their inception, a number of other challenges to the achievement of science literacy have emerged (Hovey, Hazelwood, & Svedkauskaite, 2005; Marx & Harris, 2006). These challenges, which derive from the nature of students themselves, will be discussed in the following section.

Scientific Literacy for Adolescent Learners

This section of the chapter is devoted to a discussion of three factors that specifically impact the ability of adolescents to develop science literacy: culture, identity, and the nature of science literacy. An overview of each factor and an explanation of why it is important to adolescent student development of science literacy will be included, as well as why each factor could pose a challenge to developing science literacy. Additionally, the reasons why each of these factors poses an even greater challenge for ELL adolescents than for mainstream adolescents in the development of science literacy will be discussed.

Culture. The first factor that impacts adolescent development of science literacy is culture. The teaching and learning of science at the secondary level is a highly complex undertaking, in part because it requires students to navigate a host of cultures and subcultures with which they may not be familiar (Aikenhead, 1980, 2000; Hurd, 1975, 2000; Millar & Osborne, 1998; Pajares, 1996). For the purposes of this study, the culture that is most relevant, because it has the greatest impact on student acquisition of science literacy, is the culture of school science (Aikenhead, 2002).

Reformers advocate that secondary science instruction "treat students as future citizens whose scientific literacy should be sufficiently informed to deal with personal or social issues related to science" (Aikenhead, 2002, para. 2) by creating "a classroom environment . . . that might raise pupils' interests in studying school science" (Osborne, Simon, & Collins, 2003, p. 1049). However, many secondary schools, including some that have proclaimed their commitment to implementing reform goals, have not succeeded in changing the culture of school science to reflect this ideal (Reeves, 2009). Various explanations have been put forth as to why this has been the case. One such explanation invokes an expression that was coined even before the science education reform documents were published. Stewart and O'Brien (1989) warned, over two decades ago, of the effects that the "immutable structure" of schools tend to have on change efforts (p. 396). More contemporary researchers have echoed that observation, noting that "the traditional 'authoritarian-transmission' model" that has long been the hallmark of teaching in the U.S. continues to dominate instruction in all content areas, but especially those of math and science (Miller, 2009, p. 909).

Other researchers have suggested other causes, including the phenomenon sometimes referred to as the apprenticeship of observation, first coined in 1975 by Lortie and expanded upon by other researchers during the past four decades, but which remains just as relevant today as it was then (Borg, 2004). This term describes the tendency of new teachers to teach the same way they were taught as students, without considering the many "backstage" requirements of practice they were not privy to as students, but which are nonetheless "a crucial part of a teacher's job" (Lortie, 1975, p. 62). These include such actions as "private intentions, personal reflections . . . selecting goals, making preparations, or post-mortem analyses" (Borg, 2004, p. 274). Without the ability to place their teachers' actions, such as "monitoring, correcting, and lecturing . . . in a pedagogically oriented framework," students end up with the impression that such "frontstage" actions constitute the essence of teaching (Lortie, 1975, p. 62). These students, upon entering the teaching profession, often revert to these "intuitive and imitative" (Lortie, 1975, p. 62) "ready-made recipes for action and interpretation that do not require testing or analysis, while promising familiar, safe results" (Buchmann, 1987, p. 161). These default options then come to constitute a new teacher's practice and are perpetuated onto the next generation of students (Tomlinson, 1999; Borg, 2004). Consequently, efforts at reforming the pedagogical framework that informs the practice of new teachers through teacher education often have little effect on the actual practice of new teachers once they enter the classroom (Borg, 2004). Even new teachers who attempt to distance themselves from the teacher-centered beliefs about teaching they developed during their apprenticeship of observation by implementing a teaching approach based on reform-oriented beliefs about teaching and learning, frequently report feeling powerless to change (Borg, 2004; Johnson, 1994).

One aspect of science teacher preparation programs that seems to influence new teacher practice may actually exacerbate the problems described above. Over time, those responsible for preparing new teachers have placed greater and greater emphasis on the acquisition of content knowledge as the principal prerequisite for entry into the profession (The Mathematical Association of America, 2010). This has not always been the case in the U.S. education system. Historically, the emphasis in science teacher education has been on learning the art of teaching at the expense of content knowledge (Gess-Newsome & Lederman, 1999; Shulman, 1987; The Mathematical Association of America, 2010). Over time, however, and especially recently, the demand for ever-more content knowledge has led to the requirement of all teachers being "highly qualified" (NCLB, 2002). The definition of a highly qualified teacher varies from state to state, but is often indicated by the completion of a college major in the content area taught, with the added requirement of passing a content-related exam, among other things (U.S. Department of Education, 2004).

This emphasis on content has increased due to a variety of factors, including pressure from political figures and special-interest groups, legislation (e.g., NCLB), stakeholders such as parents, and the professional organizations that guide the discourse about teaching in the difference content areas (Gess-Newsome & Lederman, 1999; Shulman, 1987; The Mathematical Association of America, 2010). Regardless of the reason, many teacher preparation programs for secondary teachers, especially in the sciences and mathematics, are heavily weighted toward college courses taught by professors who are not necessarily concerned with pedagogy in secondary level classrooms (Ingersoll, 2007; The Mathematical Association of America, 2010). Preservice teachers exposed to such courses may duplicate both the transmission model of teaching demonstrated by university professors as well as the emphasis on acquiring content in their own practice, thus exacerbating and reinforcing the phenomenon of the apprenticeship of observation (Borg, 2004).

The net effect of these factors can be a powerful impression created in the minds of the preservice teachers who are the participants, consciously or subconsciously, in the above phenomena. This impression leads to the direct implication that the content being taught in secondary science classrooms is important for students only as preparation for future studies in upper-level secondary science classes and in post-secondary studies (Ravetz, 2002; Lyons, 2006; Wright, 2012).

Implications for all adolescent learners. Perhaps the main challenge that this school culture of secondary science instruction poses for adolescent learners is that it obscures the relevance of science content to adolescents' lives (Aikenhead, 1980; Fensham, 2004; Hinchman, 2006; Layton et al., 1993; Lyons, 2003; Millar & Osborne, 1998; Osborne & Collins, 2001). It is safe to assume that most secondary adolescent students are not planning to pursue a science-related profession (Osborne, Simon, & Collins, 2003). In fact, up to a third of these students will not pursue post-secondary studies at all, at least initially, upon completing high school (Bureau of Labor Statistics, 2012). When the school culture of secondary science instruction sends students the message that science is only important for students who are planning to enroll in upper-level secondary science classes and in post-secondary studies (Ravetz, 2002; Lyons, 2006;

Wright, 2012), it is very likely that many of these students will not perceive science as relevant to their lives (Dugger, 2010; Johnson, Rochkind, & Ott, 2010; Kadlec & Friedman, 2007). As was the case with the Curriculum Reform Movement of the 1950s through the 1970s, when students such as those described above are exposed to the contemporary school culture of secondary science classrooms, they may conclude that science is not for all Americans, and is instead only for future scientists. Osborne (2007) suggests that this may explain why, large numbers of students are disengaging from science, in many cases before they even reach high school, after which reengagement with science is rare.

Students who have disengaged with science often struggle with what appears to them to be a lack of congruence between their various "worlds" (Costa, 1995, p. 313) of school and science achievement, and their "worlds" (p. 313) of personal, home, and work experiences. While they may believe that science is important, it is "not for [them]" (Jenkins & Nelson, 2005, p. 41). It has also been suggested that if the culture of secondary school science consists of the behaviors that are typical of or identify one specific group, and which distinguish its members from those of other groups (Reeves, 2009; The Center for Advanced Research on Language Acquisition, 2012), many adolescents may not see themselves as exhibiting the behaviors that are associated with the group of students that participates in science (Costa, 1995).

Implications for adolescent ELLs. In addition to the barrier imposed on adolescent learners by the culture of contemporary school science, ELL students must also overcome several other major cultural hurdles if they are to successfully develop science literacy. These hurdles often stem from a socio-cultural, and sometimes economic, difference between ELLs and mainstream students, which originates from the fact that many ELLs are either first- or second-generation immigrants to the U.S. (Mount-Cors, 2008). This difference is often reflected by

> …different sets of cultural values and beliefs. . . . Students from cultures where cooperation is valued over competition, for example, may be at a disadvantage . . . in the United States where the goal is for each individual student to perform at his or her best on his or her own. (Pitoniak et al., 2009, p. 8)

This cultural difference is sometimes also reflected by a lack of overt parental involvement in the academic lives of their ELL children. Parental support has been identified as one of the most important factors in adolescents' academic success (Rivera & Waxman, 2011). Yet, the parents of ELLs are less likely than mainstream parents to participate in their children's schooling in the ways that school personnel expect. This includes a tendency to not attend school functions or fulfill expected responsibilities, such as parent teacher conferences, volunteering in their child's classroom, or helping their children with homework assignments (U.S. Department of Education, 2005). These behaviors often lead school personnel to mistakenly conclude that the parents of ELLs do not care about education. The errors inherent in this myth have been reported by various researchers, such as Valencia and Black (2002).

Instead of apathy towards education, these parental behaviors tend to stem from realities of life over which the families of ELL students may have no direct control. Such factors may include: parents holding multiple jobs, irregular work schedules, lack of transportation, lack of child care, parents' own lack of knowledge of schooling and academic content, parents' lack of English language proficiency, and low levels of income (Bollin, 2003). These problems can be further compounded by a belief that schooling is the domain of school personnel, and is not to be tampered with by outsiders, such as parents (Gorski, 2008). While this belief is sometimes embedded in ELL parents' culture of origin, it is also often communicated to them by school personnel, either intentionally or unintentionally (Bollin, 2003).

Other socio-cultural challenges to successful academic experiences for ELLs may include role expectations. For example, gender expectations, such as the expectation that girls have children early and boys begin working at a young age to contribute to family finances (Bollin, 2003), may serve as barriers to academic success. Additionally, many ELL students serve as cultural brokers in their homes, and may convey an inaccurate representation of the realities of their school situation to their parents (Beykont, 2002).

To the above challenges for ELLs are added additional problems associated with transitioning to a school in the U.S. from another country. Many ELLs have little understanding of the nature of schooling in the U.S., at least at first. Thus, the fact that "children of immigrants are at a disadvantage when it comes to understanding how U.S. schools function" (Rueda, Monzo, & Arzubiaga, 2003, para. 5) often leads to struggles in transitioning to the mainstream classroom. This makes it difficult for ELLs to "compete on an equal footing with native speakers of the school language" (Harklau, 1994, p. 241). ELLs are also simultaneously confronted with the prospect of having to acquire academic English proficiency, which typically takes between four and seven years (Hakuta, Butler, & Witt, 2000).

Identity. The second factor that influences adolescents' ability to develop science literacy is identity. According to contemporary researchers, a person's identity is constructed within discourses, which are the various constructs about the "self" (e.g., self-concept and self-efficacy) that arise from the connections that a person makes with various "ways of being in the world" (Gee, 1990, p. 142) throughout his or her life (Hall & du Gay, 1996). These constructs then formulate peoples' identity, including their perceptions of both who they believe themselves to be and what they believe they can do (Alvermann, 2001; Hall & du Guy, 1996; Heath, 1981). This is important because "adolescents' perceptions of how competent they are . . . will affect how motivated they are to learn in . . . the sciences" (Alvermann, 2001, p. 6) because "it is the strength of one's belief in the ability of the self to tackle a particular task that affects whether or not (and how well) the task will be performed" (p. 8). For this reason, it is important that science instruction address issues of self-efficacy and engagement.

Implications for all adolescent learners. As mentioned previously, one of the greatest cultural challenges that adolescent learners face is their lack of engagement with secondary school science content because of the way science is taught in U.S. schools. This lack of engagement, which is a cultural challenge, leads to an identity challenge, where students are unable to identify with science—to see themselves as scientific thinkers (Aikenhead, 2001; Lynch, 2000; Parker, Rennie, & Fraser, 1996). As a result, students may not understand that science is important in their lives even if they are not planning to study science in college or pursue a science-related profession. They may not understand that if "they learn how scientists go about constructing explanations of natural phenomena" they will "come to recognize that these methods are appropriate for questions posed in their own lives" (Southerland et al., 2007, xvi).

Researchers have identified a number of reasons why it is difficult for teachers to facilitate their adolescent students' identification with science. It was Gardner (1975) who first proposed that developing an identity of oneself as a scientific thinker involves the activation of completely different personal attributes than does the act of doing science. Doing science, or the development of "scientific attitudes" (Osborne, Simon, & Collins, 2003, p. 1053), is inherently cognitive in nature; whereas identifying with science, or the development of "attitudes *towards* science," is inherently affective in nature (p. 1053). However, science teachers in the U.S. have often focused their instruction on doing science without simultaneously attending to the need to affectively develop students' attitudes towards science, and, thus, support their developing identification with science (McCarthy, 2005).

Osborne (2007) further reports that even if secondary teachers successfully change their instruction to help their students develop positive attitudes towards science, it is likely that students will still not identify with science unless they had "sustained positive experience of science from the beginning of elementary school" (p. 105). Such experiences "are the major determinant of any decision to pursue the study of science" (p. 105). Without such experiences "prior to [age] 14" (p. 105), students frequently lose interest in science, after which "the likelihood of re-engaging with science is low" (p. 105). By the time students have developed into adolescents and entered a high school science course, the difficulties associated with student engagement can be much greater than they were in the lower grades (Lindahl, 2007).

According to some researchers (Tai, Liu, Maltese, & Fan, 2006), if students could overcome this identity crisis and perceive themselves as scientific thinkers, this would also serve as a source of motivation that would help them engage with the content, solving the cultural challenge described in the previous section. That students consistently do not succeed at assuming this identity remains one of the challenges to adolescents becoming science literate.

Implications for adolescent ELLs. Adolescent ELLs struggle with the same identity crisis described for mainstream students. Additionally, these students face an identity challenge that derives specifically from the fact that much of the science instruction in classrooms in the U.S. takes place through textbook readings, or other text-related activities (Alvermann, 2001; Gersten, 1999; Ravitch, 2004), which ELLs are not adequately prepared to navigate without support (Bifuh-Ambe, 2011; Cummins, 1984; National Council of Teachers of English, 2006; Peregoy & Boyle, 2000; Vacca & Vacca, 2005).

Research suggests that the experiences readers have encountered throughout their lifetime affect the meanings they draw from text (National Council of Teachers of English, 2006; Stern & Huber, 1997). Yore, Bisanz, and Hand (2003) explain that readers construct understanding in short-term memory by reading the text and analyzing information from past experience, which is then evaluated using background knowledge from long-term memory to make global meaning or meta-cognition. Knowledge gained previously through experience is, by this means, connected to new language, vocabulary, and concepts.

This method that learners use to construct meaning from new textual language helps explain the challenges that ELL students experience when confronted with a new suite of languages in U.S. classrooms, each of which is difficult for the ELL student to navigate without support. These languages are, in order of increasing difficulty: everyday language, school language, and content language (National Council of Teachers of English, 2006; U.S. Department of Education, 1997). Igoa (1995) writes of the “extreme loneliness, frustration, and fear” produced in ELL students in a world that is governed by a “new” (p. 85) and “unfamiliar” (p. 85) everyday language, often leading to a “period of relative silence” (Watts-Taffe & Truscott, 2000, p. 260) on the part of the student.

The difficulties increase when ELL students encounter school language, which frequently leads to what psychologists have termed “specific anxiety reactions” (Horwitz, 1986, p. 125) due to “the defensive position imposed on the learner” (p. 125) in the classroom. Defined as “the subjective feeling of tension, apprehension, nervousness, and worry associated with an arousal of the autonomic nervous system” (p. 125), such anxiety often “prevents” (p. 125) such students “from performing successfully in science and mathematics” (p. 125).

Still, it is the content language encountered in the classroom that presents the greatest challenge to the ELL student because attempting to navigate it is “a profoundly unsettling psychological proposition,” which may “directly threaten an individual’s self-concept and worldview," or identity (Horwitz et al., 1986, p. 125), the very aspects of a student's psyche that determine their willingness to attempt a given task (Alvermann, 2001; Hall & du Guy, 1996; Heath, 1981). In other words, for the ELL student who is forced to interact with a science text that is unnavigable, and, therefore, activates no prior knowledge, the very act of attempting to construct meaning out of newly-encountered content language threatens the knowledge and experiences that confer upon the ELL student his or her identity (Yore, Bisanz, & Hand, 2003). In such situations, rather than constructing meaning from the new content language of the science text, many ELL learners simply end up “feeling mentally and emotionally exhausted” and give up (Watts-Taffe & Truscott, 2000, p. 260). It can be argued that, while both mainstream and ELL adolescents struggle with identity issues, it is the ELL student who most likely has the greater challenge. Such threats to an ELL's self-concept and self-efficacy present a significant barrier to his or her ability or willingness to attempt to engage with the science content.

The term science literacy. The third factor that affects adolescents’ ability to develop science literacy is the confusion associated with what is meant by the term science literacy, which has historically been an elusive concept to define. Indeed, even today, when most science education researchers are in agreement on the nature of science literacy, some dynamic tension is still inherent in the meaning of the concept. This tension occasionally results in difficulties for teachers, as well as students, in the quest to increase science literacy levels (DeBoer, 2000).

This dynamic tension is the result of the fact that researchers understand science literacy to be composed of two different, yet interrelated, senses, both of which are required in order to become science literate. The first sense of science literacy, called the *derived sense*, has been traditionally held by science educators and views science literacy as "being knowledgeable, learned, and educated in science" (Norris & Phillips, 2003, p. 224), or knowing science content (AAAS, 1990; DeBoer, 2000; NRC, 1996). The second sense of science literacy, called the *fundamental sense* (Norris & Phillips, 2003), views science literacy in terms of language literacy, or the ability to successfully negotiate science text, to read and write in science (Yager, 2005). The challenges that result from these historically divided perceptions of the nature of science literacy are described in the following sections.

Implications for all adolescent learners. Attempts to capture the essence of what it means to be science literate are important for adolescent learners because such definitions are likely to influence the way science teachers instruct their students (Brickhouse & Bodner, 1992; Frandsen, 2006). If science literacy were understood to include features that would fall under both the derived and fundamental senses of what it means to be science literate, science teachers would likely emphasize both understanding content and the negotiation of science-related text in their instruction (Norris & Phillips, 2003). However, if science teachers perceive science literacy as limited to the derived sense of science literacy, they would likely emphasize only the acquisition of content knowledge. They would routinely deny their students the opportunity to become fully science literate, ignoring the need for content area literacy instruction (Alverman & Phelps, 1994; McCarthy, 2005; Stewart & O'Brien, 1989).

The belief that science literacy is limited to the derived sense seems to be shared not only by many science teachers, but also by some members of the science education community (Saul & Dieckman, 2005). These individuals have expressed concern that "the new focus on [fundamental] literacy will take away from the kinds of experience-based learning and firsthand investigations they see as necessary to an understanding of content" (p. 503). Objections such as "science is not written but can be written about" (Yager, 2004, p. 95), and, we need to "read the world before reading the word" (Dyasi & Dyasi, 2004, p. 420), occasionally appear.

Even science teachers who believe that the fundamental sense is an important part of science literacy often fail to incorporate it into their instruction for two main reasons (Stewart & O'Brien, 1989). First, teachers may feel that content-area literacy instruction is important, but that it does not "fall within their domain" (Stewart & O'Brien, 1989, p. 397). Instead, such teachers often believe that it is the responsibility of elementary school teachers or high school English teachers to teach the fundamental sense of science literacy (Barton, Heidema, & Jordan, 2002; Burnett, 1966; DiGisi, Lyman & Willett, 1995; Hourigan, 1994; Yore, 1991). Many secondary science teachers "assume that students...need no additional strengthening in the use of language and that students have acquired adequate literacy skills to communicate science ideas effectively" (Thier & Daviss, 2002, p. 11).

Such beliefs are contradicted by research, which indicates that "elementary teachers often have little background in science; many are uncomfortable teaching science or even intimidated by their limited knowledge of the subject" (Thier & Daviss, 2002, p. 10). As a result, elementary teachers have a tendency to teach science as an independent subject, focusing upon content instruction as separate and distinct from literacy instruction (Alvermann & Moore, 1991; Stewart & O'Brien, 1989), which emphasizes primarily the negotiation of narrative texts rather than the expository texts that are specific to the language of science (Saul & Dieckman, 2005).

Similarly, English teachers tend to define themselves first and foremost as literature teachers (Heller, 2012), and tend to feel "unsure" and "not prepared" to teach literacy within a science context (Stoddart, Bravo, Solis, Stevens, & Vega de Jesus, 2009, p. 5). The reality is that by the time they arrive in the secondary science classroom, adolescent students have experienced very little instruction about how to negotiate or create science texts, and have done very little science content reading. As a result, these students often possess little stamina or persistence with science texts (AAAS, 2000; Schoenbach et al., 1999), and "have problems . . . with comprehension" (Thier & Daviss, 2002, p. 12), they "can read the words but cannot as easily extract and link their meanings" (p. 12).

The education community has attempted to respond to this challenge by developing the Common Core standards (Common Core State Standards Initiative, 2012a), which contain a new English/Language Arts (Common Core State Standards Initiative, 2012b) component that specifically addresses the issue of teaching and learning from and about informational texts in the elementary and English classrooms (Zygouris-Coe, 2012). However, this is a very recent development, and there has not been sufficient time for the education community to determine what effect this development has had, or will yet have, on the science literacy of students.

The second reason science teachers frequently fail to incorporate the fundamental sense of science literacy into their instruction is that while many secondary science teachers may feel confident in their science content knowledge, they frequently feel insecure about their grasp of "the natural relationship between science and language" (Thier & Daviss, 2002, p. 11). Even though they may feel that content-area literacy instruction is important, and even that it falls within their domain of responsibility, they may possess "feelings of inadequacy or lack of confidence" (Stewart & O'Brien, 1989, p. 397) regarding their ability to incorporate this instruction into their practice (Digisi & Willett, 2006). Some researchers report that even when science teachers "reject the text-driven model of reading" to learn science content, they still "do not have well-formulated alternative models to guide their teaching practices," and do not know what to do (Yore, 1991, p. 55). In the absence of a viable alternative, many science teachers continue to use the course textbook as the primary vehicle to both organize and deliver their instruction, which remains focused on the acquisition of science content, whatever their beliefs to the contrary might be (McCarthy, 2005). Literacy researchers and an increasing number of science teacher educators and researchers argue that science educators should be the ones to teach both science content and the literacy skills associated with that content (Hand, Alvermann, Gee, Guzzetti, Norris, Phillips, Prain, & Yore, 2003; Pappas, Varelas, Barry, & Rife, 2004; Saul, Reardon, Pearce, & Dieckman, 2002). For the reasons cited above, many secondary science teachers have still not brought their instruction into alignment with this viewpoint (Alverman & Phelps, 1994; Davis, 2003; Loucks-Horsley, Stiles, Mundry, Love, & Hewson, 2010).

Implications for adolescent ELLs. While lack of appropriate attention to both senses of science literacy in school classrooms makes becoming science literate difficult for adolescent learners in general, it makes it even more difficult for ELLs. Whereas adolescent students in science classrooms frequently struggle with comprehension of science texts, ELLs often face the additional challenge of decoding (Thier & Daviss, 2002). The barrier to developing science literacy for ELLs goes beyond struggling to make meaning out of the words on the page; they often are "unable to decode the words on the page" (Thier & Daviss, 2002, p. 11). This is particularly challenging given that textbook readings are often the dominant method of content delivery in secondary science classrooms in the U.S. (Alvermann, 2001). ELLs find themselves in a difficult, and fundamentally self-contradictory, situation. Their teachers provide them with little or no instruction in the fundamental sense of science literacy (Digisi & Willett, 2006), and, yet, expect that they learn science concepts and facts mainly through the use of a textbook that they cannot read (Li & Zhang, 2004).

Scientific Literacy for ELLs

Numerous efforts have been made to improve the quality of education available to ELLs in U.S. classrooms. Such efforts include a variety of actions taken by a wide range of societal players, including policy makers, government agencies, industry leaders, researchers, educators, and a variety of professional organizations. The contributions of these groups have resulted in a number of important educational outcomes which have significant implications for ELLs and the issue of science for all Americans. These outcomes can be broadly organized into three categories: legislation, science education reform documents, and ELL standards.

Legislation. Policy makers have taken action in all branches of government to ensure that diverse student populations, including ELLs, receive the support they need to overcome the many challenges they face in U.S. schools, thus achieving the goal of equal access to high quality learning for all (Echevarria, Vogt, & Short, 2004; U.S. Department of Education, 2002, 2004a, 2004b; Wolf et al., 2008). The first action taken by the U.S. government that can be seen as an effort to protect diverse populations can be found in the *U.S. Constitution* itself. The *Equal Protection Clause* of the *Fourteenth Amendment* to the *Constitution* asserts: "No State shall . . . deny to any person within its jurisdiction the equal protection of the laws" (The Charters of Freedom). Vague language notwithstanding, this amendment established a framework that would serve as a reference point for much of the legislation created in the twentieth century to protect and support ELLs.

Much later, the mid-twentieth century saw the first specific reference to education as a "right which must be made available to all on equal terms" with the U.S. Supreme Court's *Brown v. Board of Education* decision in 1954 (Intercultural Development Research Association, 2012, para. 5). By striking down the separate but equal doctrine, declaring segregation unconstitutional, and ordering the desegregation of schools, the court provided the next piece of the legislative framework which would lead to radical change in U.S. policy regarding the education of diverse student populations.

In 1964 that change came when Congress passed the Civil Rights Act, which, in part, "prohibits discrimination based on race, color, or national origin in programs or activities which receive federal financial assistance" (U.S. Department of Education, 2005, para. 2). Additionally, Title VI of the Act identifies any situation "where inability to speak and understand the English language excludes national origin-minority group children from effective participation in [an] educational program" as a violation of the act, and, thus, a violation of the civil rights of such children (Department of Health, Education, and Welfare, 1970, para. 7). Thus, the U.S. Civil Rights Act of 1964 provided the first specific legal mandate for providing instructional assistance for ELLs.

The next legal action taken to ensure equal access to academic content for ELLs was the Elementary and Secondary Education Act (ESEA) of 1965. This act was originally passed to ensure that "all children have a fair, equal, and significant opportunity to obtain a high-quality education and reach, at a minimum, proficiency on challenging state academic achievement standards and state academic assessments" (U.S. Department of Education, 2004, para. 6). One of the ways, specifically articulated in Title I of the act, through which this purpose can be accomplished is by "meeting the educational needs of . . . limited English proficient children" (para. 8).

Since 1965, the federal government has continued to push for greater access to academic content for ELLs through periodic reauthorizations of the ESEA, including the Bilingual Education Act of 1968, the Improving America's Schools Act of 1994, and the No Child Left

Behind Act of 2001 (Cordasco, 1969; U.S. Department of Education, 1994, 2002, 2012). The creation, in 1979, of the U.S. Department of Education was, among other things, an important step toward ensuring that ELLs would receive an education of equal quality to that received by mainstream students (S. Res. 210, 1979). Considered together, all of these government actions can be described as advancing a policy of broad, loosely-definable statements of support for the educational rights for ELLs (Multicultural Education and Advocacy, 1991).

The implementation of this legislative framework was followed by a series of challenges to the federal mandates imposed by these laws on states, school districts, and schools. In response to these challenges, courts in various states upheld the educational rights of ELLs by handing down a series of landmark decisions (e.g., *Aspira of New York, Inc v. New York Board of Education, 1972; Keyes v. Denver School District No. 1, 1973; Lau v. Nichols, 1974; Serna v. Portales, 1974; Rios v. Reed, 1978;* and *Castañeda v. Pickard, 1981*) (Cerda & Hernandez, 2006; Sugarman, 1974).

Science education reform documents. It is one thing to mandate the achievement of a specific goal in a law or court decision. It is another thing, however, to identify and execute the necessary steps required to accomplish that goal. In view of this reality, various organizations, including the American Association for the Advancement of Science (AAAS), the National Research Council (NRC), The National Science Teachers Association (NSTA), and The National Academy of Science (NAS), created research-based documents designed to assist educators in the task of bringing their instruction into compliance with the mandates of the laws, governing bodies, and judicial decisions by making academic content equally available to all students. A few of these documents have been adopted by the science education community as the definitive articulation of what must be done to achieve the aims of the legislation described above. Taken together, these documents are often referred to as the science education reform documents.

The first of these documents became the foundational document of the current reform movement in science education. In 1989, AAAS hosted a series of symposia to articulate the aims of the science education community and to identify what would have to be done in order to achieve those aims (Bybee, 1993; Frandsen, 2006). The culmination of these symposia was the publication *Science for All Americans: Project 2061* (AAAS, 1990). This document, "one of the most comprehensive and innovative statements of scientific literacy in the history of science education" (Bybee, 2003, p. 64), is a framework designed to guide the actions of the science education community toward its goal of scientifically literate citizens by the year 2061 (Frandsen, 2006). Its recommendations are specifically pertinent to "those who in the past have largely been bypassed in science and mathematics education: ethnic and language minorities" (AAAS, 1990, p. xviii).

Following the publication of *Science for All Americans*, reformers who were committed to achieving the aim of science literacy for all Americans needed practical definitions of science literacy, which were subsequently developed and published as *Benchmarks for Science Literacy* (AAAS, 1993), hereafter referred to as benchmarks (Frandsen, 2006). The benchmarks further define what content knowledge and habits of mind students should acquire by the end of their K-12 educational experience. Thus, "while the purpose of project 2061 is to present a compelling vision of achievable learning goals, that of benchmarks is to chart the territory that will have to be traveled to reach those goals" (AAAS, 2003, p. x).

The final piece missing from the reform framework was the ability to judge when the specific learning goals established by *Science for All Americans* have been achieved. This missing piece was provided with the creation of the *National Science Education Standards* (NRC, 1996), hereafter referred to as the standards, through the collaboration of the National Science Teachers Association, the National Academy of Science, and the National Research Council (Frandsen, 2006). The standards function as a framework that educators can use to develop curricula, as well as to assess how well curricula are meeting the science literacy needs of learners. Unlike the two reform documents that preceded them, The standards are uniquely designed to "provide criteria that people at the local, state, and national levels can use to judge whether particular actions will serve the vision of a scientifically literate society" (NRC, 1996, p. 3).

Science for All Americans: Project 2061 (AAAS, 1990), benchmarks (AAAS, 1993), and the standards (NRC, 1996) were foundational in developing the recently published document, *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (NRC, 2012), which guided the creation of the *Next Generation Science Standards* (NAS, 2013). Each of these documents has helped further the aim of achieving science literacy for all Americans (Frandsen, 2006).

ELL standards. The legislation described above provided the legal mandate that academic content be made equally available to all American students, including ELLs. The reform documents provided the framework for science curriculum content and assessment that is necessary for the science education community to comply with that mandate, at least as it pertains to science literacy. However, the legislation and reform documents do not attend to all of the specific aspects of what science teachers must consider and do in their day-to-day instruction in order to achieve these goals. Further, some student populations possess built-in barriers that make it difficult for both teachers and students to achieve the kinds of educational outcomes in science envisioned by the science education reform documents and implied by the legislation. Within a few years of the publication of the first science education reform documents, work began on new sets of documents that would provide specific assistance to the teachers of at risk students, so they could begin to support their students' academic growth.

Of the various new documents that have been created for this purpose, four have been selected for use in this study, because, taken together, they address all of the relevant instructional aspects of developing the science literacy of at-risk students, including ELLs: linguistics and language, pedagogy, cognition, and content. These documents are referred to in this study as the ELL standards and include: the *Benchmarks for Science Literacy* (AAAS, 1993), the CREDE standards (University of California Berkeley Graduate School of Education, 2002), the WIDA standards (Board of Regents of the University of Wisconsin System, 2007), and the TIMSS standards (National Center for Education Statistics, 2011). The following sections are devoted to a brief discussion of the background and purpose of each of these standards.

The WIDA standards: Linguistics and language. The development of the WIDA standards by the WIDA Consortium at the University of Wisconsin-Madison, in 2007, was intended to facilitate a link between language learning and state academic content standards, as well as to address educators' needs in the areas of pedagogy, assessment, and educational policy (Anstrom et al., 2010; Board of Regents of the University of Wisconsin System, 2007; Cook & Zhao, 2011; Gee, 2008). Their goal was that through contextually-based language linkages, the WIDA standards would make the task of developing language proficiency become relevant to students' lives (Bailey, Butler, Stevens, & Lord, 2007; Board of Regents of the University of Wisconsin System, 2007, 2012; Commins, 2012). The WIDA standards are not specific to science. They encompass all content areas, with a separate set of standards for each content area. This means that within the WIDA standards is a set of standards that are specifically designed to connect student development of language-use with the ability to communicate about and within the field of science.

The CREDE standards: Pedagogy. The Standards for Effective Pedagogy and Learning, published in 2002 by the *Center for Research on Education, Diversity and Excellence*, are often referred to as the CREDE Standards. These standards are the result of a collaborative effort to develop teaching methodologies that will be effective for all students, since it is not feasible to do so for every at-risk group separately. This includes those students at risk of educational failure due to cultural, racial, geographic, economic, or language factors, regardless of age level or subject matter (Doherty, Hilberg, Pinal, & Tharp, 2003; Hilberg, Tharp, & DeGeest, 2000). The five recommendations that resulted from this collaboration establish a pedagogical foundation for teaching practices that are effective for all students (Doherty, Hilberg, Pinal, & Tharp, 2002; Saunders & Goldenberg, 1999). Thus, even for mainstream students, the standards describe the ideal conditions for instruction; but for students at risk of educational failure, for whom the navigation of science texts often presents a significant barrier, effective classroom implementation of the standards is vital (Hilberg, Tharp, & DeGeest, 2000; Saunders & Goldenberg, 1999).

The TIMSS standards: Cognition. The *Trends in International Mathematics and Science Study* (TIMMS) standards were developed in 2011 to help students make informed decisions about the changing world in which they live, which now requires a sound, fundamental understanding of science and technology (Atweh & Goos, 2011; Delen & Bulut, 2011; National Center for Education Statistics, 2011; Sjøberg, 2001; Wang & O'Dwyer, 2011). This kind of "meaningful and significant participation in modern democracies" also requires the further development of cognitive ability that will allow students to "judge evidence and arguments in the many socio-scientific issues that are on the political agenda" (Sjøberg, 2001, p. 2).

In order to address these societal needs, the science assessment framework for the TIMSS standards was designed to include two dimensions. The first dimension is a content dimension specifying the subject matter domains to be assessed within science. The second dimension is a cognitive dimension, adapted from Bloom's Taxonomy (Bloom et al., 1956), specifying the cognitive domains expected of students as they engage with science content (Kaur, 2011; Llewellyn, 2005; National Center for Education Statistics, 2011).

The benchmarks: Content. *Benchmarks for Science Literacy,* which was described briefly, is the Project 2061 statement, published in 1993, of what all students should know and be able to do in science, mathematics, and technology by the end of grades 2, 5, 8, and 12 (AAAS, 2009). The recommendations at each grade level can help educators decide what concepts to include or exclude from a core curriculum, when to teach them, and why (AAAS, 2009). However, benchmarks is not a curriculum, a curriculum framework, or a plan for a curriculum. Rather, it provides science teachers with sequences of specific learning goals that they can use to design a core curriculum, one that makes sense to them and will help students achieve the basic science literacy goals outlined in *Science for All Americans,* rather than simply using the textbook as a curriculum (AAAS, 1993, 2000, 2009; Haury, 2000; Kulm & Roseman, 1999; Singer, Marx, Krajcik, & Clay, 2000). These science teachers and their course textbooks will be examined in the next section.

Issues Regarding Resources for Teaching Science Literacy

In the quest for science literacy for all Americans, legislation has provided the legal mandate, the reform documents have provided the content curriculum and assessment frameworks, and the national ELL standards have provided the research-based instructional recommendations. Ultimately, it is up to the individual secondary science teacher to utilize the various resources that are available to engage in effective teaching practices that will lead to the development of science literacy for all students in their classrooms. However, research has shown that, regardless of available resources, many teachers tend to rely heavily on two main resources in their instruction: textbooks and their own expertise (Darling-Hammond, 1999; Moulton, 1994; Svinicki & McKeachie, 2011; Tobin et al., 1990). Thus, it is reasonable to conclude that, regardless what the legislation might mandate or the reform documents might recommend, it is upon the effectiveness of these two resources that student development of science literacy typically depends. A discussion of these resources, including how effective they have been at developing science literacy among ELL students in the U.S., follows.

Textbooks: The primary resource for teachers. The primary resource that secondary teachers have available to help them develop the science literacy of their students is the course textbook (Moulton, 1994; Tarr, Chavez, & Reys, 2006; Tobin et al., 1990). The reason for this is simply that, in most cases, a school, school district, board of education, or state office of education, has approved and provided a specific textbook for each course. Typically, this is because these stakeholders have determined that a given textbook is the one that comes closest to meeting the criteria for science instruction in their state, district, or school. The individual components of such criteria are varied, but often center on how closely a textbook is aligned with state science standards. Other factors include whether the stakeholders approve of the way textbooks "make content available, organize it and set out learning tasks in a form designed to be appealing to students" (Schmidt, McKnight, & Raizen, 1997, p. 8). Textbooks, then, become the main source of student learning for a given science course (Ravitch, 2004), because they "drastically affect what U.S. teachers are likely to do under the pressure of daily instruction" (Schmidt, McKnight, & Raizen, 1997, p. 8). Once a textbook selection is made, change is unlikely for relatively long periods of time, due to expense, the burdensome nature of the review process, and the political battle that such change can occasionally generate (Bailey, 1988; Marshall, 1986; Moulton, 1994). Consequently, even if teachers come and go, the textbook tends to stay the same.

Even in situations where a specific textbook has not been mandated by a teacher's superiors, textbooks are so widely used in classrooms in the U.S. that their use is described by some researchers as ubiquitous (Woodward & Elliott, 1990). Researchers have estimated that textbooks are used regularly in secondary classrooms by up to 80% of teachers (Tarr, Chavez, & Reys, 2006; Weiss, 1987). Whatever the actual percentage is, it is clear that "the majority of schools are still relying on textbooks as the primary source of the classroom curriculum" (Stern & Roseman, 2004, p. 556). And, even in situations where students are not working directly out of the textbook, textbooks still "strongly influence student learning through their influence on teachers" (p. 556).

The reasons for such heavy reliance on textbooks in science classrooms across the U.S. are varied, and may include

- the belief that textbooks hold content expertise and authority;
- beliefs about what school should be like;
- beliefs about the need for uniformity and continuity;

- the belief that because the textbook was provided and is present in the classroom it must therefore be used
- the apparent high quality design of textbooks;
- the seeming congruence of textbooks with local curricula;
- textbooks' organization and ease of use
- pressure from other teachers;
- pressure from parents;
- education courses taken in college;
- assignment to teach many, sometimes up to seven or eight, content areas;
- little planning time
- local culture;
- a lack of other resource materials;
- widely varied student abilities; and
- lack of content knowledge (McCutcheon, 1982; Moulton, 1994; Stern & Roseman, 2004; Woodward and Elliott, 1990).

Regardless of the reason, such exclusive reliance on this resource for instruction can be problematic, as described below.

More than just textbooks. The textbook market has narrowed in recent years to include just a few massive, multinational publishing houses. These publishers have recently issued new editions of their science textbooks, each aimed at meeting the needs of an ever-growing number of students, while simultaneously claiming to align with both the *National Science Education Standards* and the ELL standards (AAAS, 1993; Biggs et al., 2009; Miller & Levine, 2010; NRC, 1996; Pearson, 2012; Postelthwait & Hopson, 2006). Upon examination, these contemporary science textbooks appear to be the embodiment of predictions by researchers such as McInerney (1986), who called attention to "the growing tendency toward producing encyclopedic, vocabulary-laden textbooks, a trend that will likely accelerate as a result of new information and newly developed state science requirements" (p. 25). McInerney (1986) also voiced the concern that such textbooks' "concentration on minutia demonstrates that the developers did not sufficiently comprehend the major precepts of the discipline, or consciously subordinated major principles in favor of information for its own sake," leading to large numbers of students subjected to learning "useless information" (p. 25). McInerney was joined by Schmidt, McKnight, and Raizen (1997) in warning of the accelerated production of

> unfocused . . . textbooks that fail to define clearly what is intended to be taught. They influence teachers to implement diffuse learning goals in their classrooms. They emphasize familiarity with many topics rather than concentrate attention to a few. And they likely lower the academic performance of students who spend years in such a learning environment. Our . . . textbooks are all 'a mile wide and an inch deep'. (p. 1-2)

The most recent iterations of science textbooks do, in fact, seem to be encyclopedic, vocabulary-laden publications that "in an attempt to meet wide-ranging science standards, cover a daunting array of topics and offer students an extremely incoherent and, at times, almost incomprehensible array of facts" (Resnick & Zurawski, 2007, p. 2). However, today's textbooks do not stop there. They are, in the words of one publisher, "more than just . . . [textbooks]" (Biggs et al., 2009). Secondary science textbooks published today devote a section at the front of the text to what publishers variously refer to as a "Program Framework" (Biggs et al., 2009, p. 2T), "Program Highlights" (Miller & Levine, 2010, p. T6), "Program Overview" (Postelthwait & Hopson, 2006, p. T2), or other similar terms. These sections contain "Classroom Solutions"

(Biggs et al., 2009, p. 10T), "Teaching Support" (Miller & Levine, 2010, p. T12), and "How to Use Your Textbook" (Postelthwait & Hopson, 2006, p. xxii) sections that are advertized as resources to help teachers design their curriculum and select appropriate instructional and assessment strategies (Biggs et al., 2009; Miller & Levine, 2010; Postelthwait & Hopson, 2006). However, such program overviews and highlights appear to go beyond providing resources, and, instead, comprise what appears to be an entire self-contained curriculum package in itself. An example of this phenomenon is the text published by Glencoe Biology (2009) that was selected for use in this study, which contains a resources for teachers section titled *Program Framework*, and includes, among other things:

- a text outline;
- connections between the text and the national standards;
- an explanation of how to use the various features of the text;
- the location of various instructional strategies within the text;
- an explanation of how to use the different instructional strategies;
- explanations of where and when to teach each concept;
- leveled activities for differentiated instruction;
- descriptions of how to provide review and reinforcement;
- formal assessments and interventions;
- differentiated instruction suggestions in each section of the text for students working above grade level, on grade level, below grade level, and for ELLs;
- answers and additional support for each section of the text;
- an explanation of how each unit fits within the themes of the text;

- a pre-teaching activity to help teachers introduce students to the content covered in each unit of the text;
- a clarifying misconceptions section in each unit;
- service-learning activities for each unit;
- planning the chapter sections;
- teaching the chapter sections;
- assessment sections, including formative assessments, section assessments, and answers to all assessment questions;
- chapter assessments, including vocabulary review and end-of-chapter assessments;
- laboratories, including a list of labs that are prescribed for each section of the text, along with a list of the necessary materials required to conduct each lab and instructions on how to set up and run a lab; and
- a pacing guide, including recommended time-frames for completion of the various units, chapters, and sections of the text (Biggs et al., 2009).

This list constitutes a very brief overview of the Program Framework that provides resources for teachers in a single secondary biology textbook that is in wide use today.

Textbooks as de facto course curricula. By following such a Program Framework, it is unclear at what point a science teacher would do any of his or her own curriculum design, instruction, or assessment. In fact, the publisher of one of the textbooks selected for use in this study asserts on its website that their textbook is "one program that ensures success for all . . ." (Pearson, 2012, para. 1). This elevation of the course textbook from the status of resource to that of a program raises the question of how relevant the classroom instructor is to the teaching process, at least within the framework provided by these textbook publishers. That being the case, it is understandable that many teachers allow the textbook to become "the exclusive reading matter for a course for a whole school year. Indeed, in many cases the textbook is also the teacher's lesson plan" (English, 1980, p. 275). In one study on textbook use, the researchers concluded that the role of the teachers they studied was that of a technician whose job was to administer "a preplanned lesson" found in the course textbook (Moulton, 1994, p. 17). In these cases, the pedagogical and content expertise and authority in the classroom seems to have shifted from the teacher to the textbook publishers (Gersten, 1999; Ravitch, 2004; Stern & Roseman, 2004; Woodward & Elliott, 1990). The result of this phenomenon appears to be the substitution of the textbook for the course curriculum (Ashton, 1996; Ravitch, 2004; Stern & Roseman, 2004).

In some ways, this phenomenon resembles the Curriculum Reform Movement's emphasis on heavily scripted, teacher-proof curricula (Prather, 1993), that teachers "could not mess . . . up" (Yager, 1992, p. 905). The contemporary secondary science textbooks, then, might lead one to conclude that science education in the U.S. has, to some degree, returned to where it began in the crusade to reform science education in the United States, insofar as textbook publishers are concerned. Yet, the publishers of some secondary science textbooks that have been published within the past decade, and are currently in use in many secondary classrooms in the U.S., claim that their textbooks are aligned with the *National Science Education Standards* (1996), the very standards that argue that, within the framework of the reform documents, teachers should develop their own curricula (Biggs et al., 2009; Craig, 2006; Miller & Levine, 2010; NRC, 1996; Postelthwait & Hopson, 2006).

This causes one to wonder whether the textbook curricula are keeping pace with the recommendations of the current reform movement, as described in the science education reform documents (Aikenhead, 2002; Schmidt, McKnight, & Raizen, 1997), since science curricula must adapt to reflect the prevailing perceptions of the purpose of science education (Boyer, 1983; Goodlad, 1984; McInerney, 1986; Sizer, 1984). With the advent of the second reform movement in science education, the prevailing perceptions about the purpose of science education have clearly changed. What is less clear is whether textbook publishers have kept pace with that change in their published curricula. Some researchers have suggested that textbook publishers have not supported curriculum innovation. Instead, they claim, publishers have responded to calls for curricular reform by adding new content to already existing, fragmented, unfocused material, instead of devoting time to restructuring the materials (Schmidt, McKnight, & Raizen, 1997). This led to a growing chorus within the science education community calling for the development of "new teaching materials" (Aikenhead, 2002, para. 5), and even for new processes for developing classroom materials altogether (Aikenhead, 2002; Schmidt, McKnight, & Raizen, 1997).

The extensive influence exerted by textbook publishers on the curriculum and instruction in U.S. classrooms is sometimes defended as merely an attempt to help teachers, especially new teachers who "lack the knowledge and experience needed to develop their own curriculum" (Ball & Feiman-Nemser, 1988, p. 401). The use of textbooks by teachers will be described in the following section.

Teacher use of textbooks. Many teachers use the textbook as the curricular framework of their science courses because they tend to perceive their role in the instructional process as the agent by which that curriculum is transmitted to the minds of their students (Tobin et al, 1990), as "deliverers of pre-packaged and homogenized information" (Kincheloe, 2003, p. 3). However, even within the constraints imposed by such an instructional paradigm, some teachers are better deliverers than others, because they have greater expertise (Svinicki & McKeachie, 2011). In fact, the entire premise of the current educational climate of assessment and accountability is based on the belief in the importance of the skill of the classroom teacher in determining student educational outcomes (Barnett & Hirsch, 2005). Thus, if the course textbook is the primary resource available for teachers to use in the development of their ELL students' science literacy, teacher expertise is the other most important resource (Darling-Hammond, 1999; Svinicki & McKeachie, 2011). This can become problematic for ELL students' development of science literacy because schools with high populations of ELLs are often faced with a variety of challenges associated with teacher knowledge and skill (National Commission on Teaching and America's Future, 2004). These challenges are described in the following section.

Teacher challenges in ELL schools. Teacher-related challenges in schools with high populations of ELLs are well documented. It has long been suggested by researchers, such as Bartels (1979), for example, that some of the most important constraints to promoting effective instruction within schools that have large ELL populations are teacher attitudes and behaviors. One teacher behavior that frequently creates challenges in schools with high ELL populations is teacher transiency (Kozol, 2005). Many teachers are reluctant to teach in schools that have large ELL populations (Costigan, 2005; Rhoton & Shane, 2006), and when teachers do accept faculty positions in such schools, they are twice as likely as teachers in more traditional schools to leave, often after just one year (Ingersoll, 2004; Kozol, 2005). When this occurs, finding qualified replacements can be very difficult (Ingersoll, 2004; Kozol, 2005; Rosa & Hill, 2004). In a report by the Center On Education Policy (2012), administrators describe the year-to-year task of staffing schools with large ELL populations as "mind-boggling" (p. 4), as they may re-staff over half of the faculty between the end of one school year and the beginning of the next because teachers tend to see such schools as places of employment only as a last resort. Thus, while attempting to recruit teachers to schools with large ELL populations, administrators are frequently frustrated by the fact that "anybody that's trying to get a job or trying to get a good position has already been placed" (p. 4).

There are teachers, however, who are willing, even eager, to teach in ELL-dominated schools. Overwhelmingly, though, such teachers tend to be new to the profession and inexperienced (Ingersoll, 2004), entering the classroom as a teacher for the first time (Lankford, Loeb, & Wyckoff, 2002). These teachers are almost always the least prepared to effectively use the curricular framework found in the course textbook to assist ELL students overcome the many challenges that exist to their development of science literacy (Gersten, 1999; U.S. Department of Education, 1996). As problematic as this is, however, being new to the profession is not the only challenge presented by this group of willing teachers. Many of them are also underprepared for their job, from either a content or a pedagogical perspective (Harrell & Jackson, 2004). Consequently, lack of sufficient teacher preparation poses another significant barrier to ELLs developing science literacy (Darling-Hammond, 2007; Ingersoll, 2012; Ravitch, 2004), since these students, unlike many of their mainstream peers, often face "a revolving door of untried novices who do not have the skills to help [their students] reach high academic standards" (Barnett & Hirsch, 2005, p. 2). Such underprepared teachers also include those who enter the classroom with the intention to pursue an alternate route to licensure, such as interns and participants in programs such as *Teach for America* (2012), as well as those who are hired as long-term substitutes and frequently occupy a teaching post for an entire school year because no other candidate for the position could be located (Harrell & Jackson, 2004).

This group of novices, which constitutes a significant portion of the teaching force (Darling-Hammond, 2006), especially in ELL-dominated schools, is not uniform across content areas. Those who are recruited to teach science and math classes tend to have higher levels of content preparation than those who are recruited to teach in other content areas, although many still lack adequate content preparation (Ingersoll, 2012). What does tend to be relatively uniform about this group of teachers is that many of them, including those who teach science and math, have very little pedagogical training (Ingersoll, 2012). This tends to compound the problem of turnover, since teachers with low levels of pedagogical training are more likely to leave teaching after a year or two than their counterparts are (Ingersoll, 2012).

The phenomenon of underprepared teachers being hired to teach in U.S. schools is a controversial subject, with some members of the education community insisting that the problem is exaggerated by the media and political figures (Ingersoll, 2004, 2007). This has led to some sparring in the academic community over the exact nature of the situation, including disagreements over such things as the precise definitions of certain terms, such as "teacher shortage" (Ingersoll, 2003, p. 30). Semantics aside, there exists a large body of literature that confirms that the practice of assigning teachers to teach classes they are underprepared to teach, whatever the specific reason for it, continues to not only be prevalent in U.S. schools, but occurs at higher levels in ELL dominated schools than it does elsewhere (see, for example, Barnett & Hirsch, 2005; Cleary, 2004; Darling-Hammond, 2006; Harrell & Jackson, 2004; Kozol, 2005; Wallace & Kang, 2004).

This problem is compounded because science is one of the content areas that has been identified as requiring "specific skills unique to [that] content area" (Torgeson et al., 2007, p. 18) in order to successfully teach the fundamental reading and writing skills necessary for the development of science literacy (Norris & Phillips, 1994). Indeed, the No Child Left Behind (NCLB) Act specifically mandates that "all teachers" (U.S. Department of Education, 2004, para. 1) are required to be "highly qualified" (para. 1) in order to teach science, including possession of the necessary certification in their content area, before securing a faculty position. Some researchers continue to point to this requirement as evidence that passage of NCLB has resulted in higher proportions of teachers who are more qualified than they used to be, or at least are more qualified than political figures and media outlets tell the public they are (Ingersoll, 2007).

Some research suggests that since the passage of NCLB more teachers seem to possess one of the criteria identified as an indicator of qualification for teaching: a college degree (Ingersoll, 2007). However, although teacher possession of a college degree is more desirable than the lack of a degree, there is no indication the degrees earned by teachers are in the content area they have been hired to teach. And, even if they are, teachers may still not possess the other requirements necessary to be considered "highly qualified" (Ingersoll, 2007, p. 5) under NCLB (i.e., a teaching license or certificate and demonstrated competence in each academic subject that they teach, such as a passing score on a content-area exam) to teach the content area they have been assigned (Ingersoll, 2007). In fact, in contrast to the claims that teachers are more highly qualified, some researchers report evidence that the number of underprepared teachers who hold faculty posts in schools in the U.S., especially in ELL-dominated schools, may have actually grown since the passage of NCLB (Eppley, 2009; Harrell & Jackson, 2004). In any case, in many schools, especially those with large ELL populations, it is still common to find teachers that did not major or even minor in the content area they teach. Moreover, many of these teachers never completed a university teacher education program nor passed a content-related pre-service exam, such as the PRAXIS (Harrell & Jackson, 2004). Additionally, some teachers in schools with large ELL populations never completed a college degree of any kind (Ravitch, 2004).

The argument of critics who continue to insist that there is no evidence of a teacher preparation problem in ELL-dominated schools in the U.S. is further weakened by research which has shown that even when adequately prepared teachers are successfully recruited and retained at ELL-dominated schools, many of these teachers have been assigned to teach courses outside of their area of preparation (Ingersoll, 2002, 2004, 2007). This practice is one of the ways schools evade scrutiny by the Federal government for not complying with the highly qualified mandate of NCLB. According to Harrell and Jackson (2004), these schools hire teachers who possess the required qualifications under NCLB for the post for which they were technically hired, but then reassign them to teach other courses, often science and math classes, for which they are not qualified, and for which the school administration has difficulty finding qualified, willing teachers. Another way of avoiding sanctions from the government for not complying with the highly qualified mandate of NCLB, but one that has the same negative consequences for the instruction of ELLs, is that of simply procuring a waiver from the highly qualified mandate of NCLB (Harrell & Jackson, 2004).

Even when a school with a large ELL population is staffed with high numbers of experienced teachers who meet the highly qualified criteria for the content areas they teach, ELL students still often experience inadequate content-area instruction, due to three other teacher-related problems. The first of these problems is that even though the highly qualified mandate in NCLB is sometimes perceived as onerous by school personnel, the criteria of the mandate are written in neutral language that result in flexibility in how a state can grant highly qualified status to a teacher (U.S. Department of Education, 2004). Therefore, some schools are successful at procuring teachers who meet the minimum criteria for being highly qualified in the content area that they are assigned to teach, and yet, may be neither "excellent" nor "qualified" as a teacher (Nieto, 2003, para. 5). Conversely, some teachers who are considered highly competent by their administrators, and who consistently achieve impressive results with their students, are deemed unqualified because their preparation does not match the specific language found in their state's adaptation of NCLB (Eppley, 2009). Thus, on the one hand, the media frequently remind the public of the importance of having quality teachers in the classroom, which is a point against which few would argue (Carey, 2004; Darling-Hammond, 1999); while on the other hand, some researchers claim that the highly qualified mandate, which was intended to guarantee quality teachers for every child, is having "minimal or no impact on student achievement or . . . efforts to improve teacher quality" (Eppley, 2009, p. 2). Consequently, schools and districts in many communities report that they have lost "their opportunity to define teacher quality in ways that meet local needs" (p. 3).

The second reason having access to teachers who meet the highly qualified criteria under NCLB may not necessarily result in high levels of learning for ELLs is that even in school districts that have large numbers of highly qualified teachers, the ELL students tend to be taught by the most inexperienced, under-prepared teachers. This occurs because (a) school districts tend to assign the least experienced and least prepared teachers within the district to the schools with the largest ELL populations (Kozol, 2005) and (b) within individual schools, school personnel frequently assign ELLs to the least experienced teachers in the school (Berman et al., 1992; Gersten, 1996; Saunders, 1999).

The final reason having a large number of qualified teachers in a school may not necessarily result in high levels of learning for ELLs is that NCLB does not identify English language learning as a "specialized academic discipline in which teachers should be highly qualified" (Harper, de Jong, & Platt, 2008, p. 267). As a result, NCLB "devalues" the kinds of "teacher expertise," "professional knowledge and skills," and "instructional roles" that are required for content-area teachers to be effective at teaching ELLs in the mainstream classroom (p. 267). The result is that even teachers who are highly qualified to teach the content areas they teach, including science, may not actually be highly qualified to teach the ELLs in their classroom in ways that support high levels of learning (Harper, de Jong, & Platt, 2008, p. 267). Indeed, it has been noted that the majority of teachers with assignments in ELL-dominated schools report receiving no preparation in how to teach ELLs (Darling-Hammond, 2006; U.S. Department of Education, 1996).

Whether the problem be lack of preparation for teaching, lack of qualifications to teach the content area assigned, or lack of training in how to teach ELL students, with these kinds of gaps in the preparation of many of the teachers who teach science classes in schools with large ELL populations, it makes sense that the course textbook has been relied upon so heavily as the source of instructional decisions in the science classroom (Carlsen, 1991; Stern & Roseman, 2004). When designing effective curriculum, preparing and delivering instruction, and developing assessments in ways that make learning accessible to students, teachers who lack expertise may feel that they have no choice but to turn to the course textbook's "disembodied voice of authority whose facts and interpretations are beyond quibble" (Ravitch, 2004, p. 63), as a crutch (Ball & Feiman-Nemser, 1988; U.S. Department of Education, 1996). This may be why, for many students in public schools the textbook "constitutes both course and curriculum," because it is the only content and pedagogical authority, or source of expertise, in the classroom

(Ravitch, 2004, p. 13). As a result, a substantial number of secondary students spend a significant amount of time reading from or working in their textbook daily or weekly (Ravitch, 2004).

Teacher reliance on textbooks. The reliance of many teachers of ELL students on readings, assignments, and assessments in textbooks to teach and assess science content is problematic for ELL students' development of science literacy (Gersten, 1999). The assumption in this instructional model is that students will successfully navigate the textbook and understand its content on their own (Barton, Heidema, & Jordan, 2002; DiGisi, Lyman & Willett, 1995; Yore, 1991). Typically, however, little to no instruction on how to successfully use the textbook to understand the content is provided (Digisi & Willett, 2006). As a result, many ELL students cannot access the science content because they cannot navigate the science text and their teacher is unsure how to teach them how to do so (Digisi & Willett, 2006). Such students seem to be set up for failure, since "essentially all students - even the best and the brightest - have predictable difficulties grasping many ideas that are covered in the textbooks" (Roseman, Kulm, & Shuttleworth, 2001, para. 9).

Textual tools for teaching ELL students. The ELL population has consistently been identified as the least science literate student demographic in the U.S. (Durán, 2008; Hart & Lee, 2003; Lee, Maerten-Rivera, Penfield, LeRoy, & Secada, 2008; Tate, 2001). However, in recent years, textbook publishers have proposed a solution to this problem. They have created a resource they claim does what no other resource has been able to do: make science content explicit to ELLs according to the guidelines established by national ELL standards (Biggs et al., 2009; Miller & Levine, 2010; Postlethwait & Hopson, 2006). This resource consists of a textual tool for teaching ELLs that makes instructional recommendations to teachers of ELLs. These recommendations span a wide range of activities and strategies. They also contain instructions for what teachers should ask their ELL students to do, along with the expected outcomes so teachers will know if students have achieved the desired learning goal.

According to textbook publishers, these instructional recommendations, which are found in virtually all contemporary editions of secondary biology textbooks, are informed by both the *National Science Education Standards* and the ELL standards (Biggs et al., 2009; Miller & Levine, 2010; Postlethwait & Hopson, 2006). Teachers are reassured that by closely adhering to these recommendations, they will overcome the barriers to learning that are experienced by many ELLs. Because so many teachers of ELLs do not possess all of the necessary expertise to teach ELLs, these textual tools may be the only authority in an ELL's science classroom purported to have the necessary content and pedagogical expertise to meet ELL science literacy needs (Biggs et al., 2009; Miller & Levine, 2010; Postlethwait & Hopson, 2006).

Analyses of science textbooks have been conducted for a variety of purposes (AAAS, 2000). Some of these analyses have evaluated the effectiveness of proposed activities found in the student edition of science textbooks designed for student use and completion (AAAS, 2000). Most of these evaluations concluded that such activities for student learning in contemporary science texts are inadequate, including the charge that "students are given little guidance in interpreting the results in terms of the scientific concepts to be learned" (AAAS, 2000, para. 9). A search of the literature revealed, however, that these analyses have never attended to textbooks' textual tools for teaching ELLs, possibly because they are of relatively recent origin. Thus, it is apparent that a study of the kind proposed here is necessary to improve understanding of how today's secondary science textbooks align with the standards for how to teach ELLs.

Chapter 3

Methods and Procedures

The purpose of this examination was to determine how the textual tools for teaching ELL students found in three secondary biology textbooks align with the tenets of four national standards: (a) the *Benchmarks for Science Literacy* (American Association for the Advancement of Science [AAAS], 1993); (b) the *Center for Research on Education, Diversity and Excellence: Five Standards for Effective Pedagogy and Learning* (University of California Berkeley Graduate School of Education, 2002); (c) the *World-Class Instructional Design and Assessment: English Language Proficiency Standards* (Board of Regents of the University of Wisconsin System, 2007); and (d) the *Trends in International Mathematics and Science Study Standards* (National Center for Education Statistics, 2011). These standards were chosen because they represent different ways of meeting the linguistic, pedagogical, cognition, and content needs of ELL students in terms of developing science literacy. This chapter is devoted to a description of the methods and procedures that were used in conducting this study. Information related to the design of the study, data sources, data analysis, researcher stance, and the limitations of the study are outlined and explained.

Research Design

This qualitative study employed descriptive content analysis (Sandelowski, 2000) to determine how the textual tools found in the teacher editions of three secondary biology textbooks published in the United States align with the national standards. A description of this methodology and the rationale for its use in this study is included in this section.

Content analyses. Because content analysis constitutes a broad approach to research, it can have many, varied applications, depending on the kind of data involved and the nature of the questions being asked (Zhang & Wildemuth, 2009). The specific variation of content analysis that was used in this study is influenced by two definitions of content analysis. The first definition, provided by Zhang and Wildemuth (2009), indicates that "content analysis goes beyond merely counting words . . . it allows researchers to understand social reality in a subjective but scientific manner" (p. 1). For this study, the social reality that the data were used to understand is how the textual tools align with national ELL standards and, therefore, whether the textual tools for ELL students in the teacher editions of secondary science textbooks meet the needs of ELL students. The "subjective but scientific manner" (Zhang & Wildemuth, 2009, p. 1) that was used in this content analysis is described further in the second definition of content analysis that influenced this study, which is provided by Hsieh and Shannon (2005). They suggest that content analysis is "a research method for the subjective interpretation of the content of text data through the systematic classification process of coding and identifying themes or patterns" (p. 1278).

In this study, the text data to which the "process of coding and identifying themes or patterns" (Hsieh & Shannon, 2005, p. 1278) were applied were the textual tools for teaching ELL students that are included in the teacher editions of three secondary biology textbooks, as well as the four standards documents described in Chapter 2. As indicated previously, these four documents represent different ways of meeting the needs of students in terms of their science literacy. The benchmarks address science content; the CREDE standards inform the pedagogical aspect of curricula; the WIDA standards address the linguistics and language aspects of curricula; and the TIMMS standards represent cognitive complexity. The "process of coding and identifying themes or patterns" (p. 1278) within the textual tools for ELL students using these standards was used to reveal how secondary science textbooks align with these different standards.

Although content analyses can involve both quantitative and qualitative strategies, they have traditionally been performed using quantitative designs in which the researcher selects categories a priori, which are then broken down into individual coding units (Fraenkel & Wallen, 1993; Holsti, 1969; Krippendorff, 1980). These coding units generally consist of a word, word sense, or phrase, whose verbatim frequency within a text comprises the basis for the statistical analysis of that text (Busch et al., 2005). More recently, qualitative content analysis strategies have also been used to examine the meanings or messages found in texts (Hsieh & Shannon, 2005; Mayring, 2000; Patton, 2002).

Qualitative content analysis is similar to quantitative content analysis in the sense that developing categories and coding units comprises the fundamental methodology of the analytic process. However, qualitative content analysis differs from quantitative content analysis in the way that the analytic process is used to garner results. Rather than focusing on the "statistical significance of particular texts or concepts," qualitative content analysis "pays attention to unique themes that illustrate the range of the meanings of the phenomenon" (Zhang & Wildemuth, 2009, p. 2). With this emphasis on "concepts rather than simply words" and "semantic relationships rather than just presence," qualitative content analysis may be used to reveal, among other things, "a person's or group's…ideas" (Fraenkel & Wallen, 1993, p. 389). It is for this reason, the ability to reveal the presence of the ideas that underlie the words, that qualitative content analysis is appropriate for this study.

Qualitative content analyses. Qualitative content analysis can be broken down into several types. Among these is descriptive content analysis, which, according to Sandelowski

(2000), entails the categorical "presentation of …facts…in everyday language" (p. 336), without the requirement of deep interpretation or "a conceptual or otherwise highly abstract rendering of data" (p. 335). To be sure, interpretation is a necessary part of descriptive content analysis, as is the case with all inquiry, indeed, "there are no 'facts' outside the particular context that gives those facts meaning. Descriptions always depend on the perceptions, inclinations, sensitivities and sensibilities of the describer" (Sandelowski, 2000, p. 335). Although "no description is free of interpretation," descriptive content analysis utilizes a sort of "low-inference" interpretation that tends to "result in easier consensus among researchers" (p. 335). This is in contrast to other forms of qualitative content analysis, such as ethnographic, narrative, theoretical, phenomenological, and grounded theory studies, which "re-present events in other terms," requiring investigators to "put much more of their own interpretive spin on what they see and hear" (p. 336).

Grounded theory, for example, requires that researchers frame data within a "conditional/consequential matrix" (Strauss & Corbin, 1998, p. 181). Likewise, the use of phenomenology often impels researchers to frame data from the perspective of "lifeworld existentials" (Van Manen, 1990, p. 101), including those of "corporeality" and "temporality" (Sandelowski, 2000, p. 336). In other words, such approaches to qualitative content analysis "require researchers to move farther into or beyond their data as they demand not just reading words and scenes, but rather reading into, between, and over them" (Sandelowski, 2000, p. 336). A classic example of just such a transformation from a participant's original description of an event to a researcher's expanded and modified phenomenological description of the same event is provided by Wertz's (1983) "moments" of a phenomenological study. Wertz describes the successive process of reflection on, dwelling with, and magnification of "each detail of the experience" by the researcher. This required Wertz to: reflect on the data's "relevance," attempt to "grasp implicit meanings," distinguish "different moments or constituents of meaning," consider "the relationship of each meaning unit to each other and to the whole" and identify "recurrent meanings," culminating in the final interpretive act of "imaginatively var[ying] the case so as to discern what was essential to its meaning and put the findings of these reflections into language" (p. 256). These "findings," produced by a researcher who was filled with an "attitude . . . of empathy" for the participant, comprised a document that was "several times longer than the participant's original description" (p. 256).

In contrast to a grounded theory or phenomenological approach to content analysis, qualitative descriptive content analyses use language as "a vehicle of communication, not itself an interpretive structure that must be read" (Sandelowski, 2000, p. 336). The goal of descriptive content analysis, then, is simply to get "the facts, and the meanings participants give to those facts," and then convey them "in a coherent and useful manner" (Sandelowski, 2000, p. 336). This is particularly appropriate for this study because it was ideas that were counted, instead of just specific words or phrases within the texts, as with a quantitative approach. Furthermore, instead of re-presenting these ideas in terms of a "conceptual philosophy or other highly abstract framework or system" (Sandelowski, 2000, p. 336), as with other types of qualitative approaches, these ideas were "compress[ed]" into "content categories based on explicit rules of coding" (Chambers, 2010, p. 3; Krippendorff, 1980). Thus, through this process, "knowledge and understanding of the phenomenon under study" (Downe-Wamboldt, 1992, p. 314) were provided through the discovery and revelation of the "facts about that phenomenon" (Sandelowski, 2000, p. 335). In this case, the phenomenon under study was how the instructional practices and procedures recommended by the textual tools for ELL learners found in the three secondary biology textbooks selected for this study align with the standards and benchmarks for teaching science to high-school English learners.

Data Sources

The data source for this study was the textual tools for teaching ELLs found in the three secondary biology textbooks. The textual tools in each of the three textbooks constituted the population for this study. The researcher did not identify the textual tools used as the data source for this study; rather, the publisher of each textbook spatially separated the textual tools from the rest of the text in the book by placing them in the margins of the teacher edition of the textbook and assigning them a name. Pearson (Miller & Levine, 2010) identified some of these textual tools by the name *Differentiated Instruction: English Language Learners*, and the rest of the tools by the name *Differentiated Instruction: Focus on ELL*. Glencoe (Biggs et al., 2009) identified these tools by the name *EL*. Holt, Rinehart, and Winston (Postlethwait & Hopson, 2006) identified these tools by the name *English Language Learners*. The extent of the interaction between the researcher and the textual tools, then, was limited to counting them and comparing them to the ELL standards documents.

When deciding how many textbooks with textual tools for teaching ELLs to use for this study, the number three was resolved upon in order to increase the trustworthiness of the study by using multiple data sources (Erlandson, Harris, Skipper, & Allen, 1993). The three textbooks selected for this study were (a) Pearson Biology (Miller & Levine, 2010), best-seller rank #73,283; (b) Glencoe Biology (Biggs et al., 2009), best-seller rank #193,640; and (c) Modern Biology (Postlethwait & Hopson, 2006), best-seller rank #214,676. These textbooks were not randomly chosen, but were purposively selected because they are the three most-used biology textbooks in secondary biology classrooms throughout the United States. This determination was made by a search of bestseller rankings on Amazon.com, the largest bookseller in the United States (Brynjolfsson, Hu, & Smith, 2003). A bestseller ranking indicates the relative location of a given text on a list of all the books sold by that bookseller, arranged in order of most copies sold to fewest copies sold. The bestseller ranking search used for this study was conducted on December fifth, 2011. The secondary biology textbooks that occupied the top three places relative to other secondary biology textbooks in Amazon.com's bestseller rankings were then selected.

In order to ensure that no textbooks were overlooked during the search, a series of category and keyword searches was conducted using the search engine found on the Amazon.com website. The category search included, in order of increasing specificity, the following categories: Textbooks, Science and Mathematics, Biology and Life Sciences, Biology. The keyword searches, used within the most general, and, therefore, most inclusive category on the website, *Books*, included the following terms: High School Biology Textbook, High School Biology Textbook Student Edition, High School Biology Textbook Teacher Edition, Secondary Biology Textbook, Biology Textbook, Biology, Science.

It was important that this study include the textbooks used in the majority of high school biology classrooms nationally for three reasons. The first reason stems from the fact that textbooks are frequently substituted for a curriculum (Radcliffe, Caverly, Peterson, & Emmons, 2004). That being the case, it could be argued that these three textbooks constitute the course curriculum in a large number of secondary biology classrooms in the U.S.

The second reason stems from the fact that the role that textbooks play in the classroom often goes beyond that of curriculum. Textbooks are also relied on heavily by teachers as a vehicle for instruction (McCarthy, 2005). Textbooks can act as vehicles for instruction either directly, through readings and completion of assignments found in the text; or indirectly, through the heavy influence that instructional recommendations made by publishers have on a teacher's day to day decisions about how to deliver instruction (McCarthy, 2005; Ravitch, 2004; Schmidt, McKnight, & Raizen, 1997). Because these textbooks are most likely to be used by the greatest number of teachers and students in the U.S., they are representative of the strategies used for biology instruction nationally.

Third, the textbooks' publishers make the claim that these strategies are "standards based" (Biggs et al, 2009, p. 39; Miller & Levine, 2010, pp. 18-24; Postlethwait & Hopson, 2006, pp. 28-35). These three textbooks would be expected, at least hypothetically, to address the needs of all populations of students in the U.S.

Data Analysis

After the initial content analysis, a cross-text analysis was conducted. The cross-text analysis provided information about how the textbooks compare regarding their attention to the four different standards. The content analysis, and the cross-text analysis that followed, was conducted in four distinct phases, which are described in the following sections.

Phase I: Preparing for analysis. Each of the textual tools for teaching ELLs found in each of the biology textbooks was read with the intent of identifying ideas. These ideas were then compared with a priori coding categories derived from the national ELL standards to determine if the textual tools from the biology textbooks align with the standards. In other words, the standards were used as a framework for analysis.

During the first phase in the analysis process, two preparatory tasks occurred. First, the standards were organized into coding categories; second, a type of coding unit was selected. These tasks are described below.

Organizing the standards into coding categories. The first phase of data analysis began with a breakdown of the national standards into individual a priori coding categories (see Appendixes C, D, E, and F). "A category is a group of words with similar meaning or connotations" (Weber, 1990, p. 37), which "must be mutually exclusive and exhaustive" (U.S. General Accounting Office, 1996, p. 20). Accordingly, the four standards documents were organized into the a priori coding categories that were created by the authors of the standards documents. The recommendations made by the authors of the four standards documents are divided into individual components, which the researcher has labeled *indicators*. Each indicator encapsulates a specific concept or idea. These ideas, created and identified by the authors of the standards documents, with no modifications by the researcher, were selected as the coding categories that were compared with the textual tools in the biology textbooks. This was done to ensure that there would be the least possible amount of "interpretive spin" (Sandelowski, 2000, p. 336) from the researcher injected into any alignment that was identified between the textual tools and the coding categories in the standards.

The next task was the creation of text analysis coding forms for each set of standards (see Appendix G). These forms were used to record the inclusion or absence of the ideas contained within each standard's coding categories in the textual tools for teaching ELL students found in each of the three secondary biology textbooks selected for this study.

Selecting the type of coding units. The next step in this first phase of data analysis was to select the appropriate type of coding unit to use in this study. There are three basic kinds of coding units used in qualitative content analyses: sampling units, context units, and recording units (Stemler, 2001). Recording units were chosen as the coding unit for this study. This is because sampling units are too rigid, requiring the repeated use of a specific, narrowly defined unit such as a sentence or a paragraph. Conversely, context units are too vague, due to their arbitrary selection and their propensity for overlapping each other (Stemler, 2001). Recording units, by contrast, are ideal for this study because they are not "defined in terms of physical boundaries" (Stemler, 2001, p. 4) like sampling units, and are not arbitrary like context units (Krippendorff; 1980; Stemler, 2001). Instead, recording units identify ideas within a text and assign each idea to a specific category. These ideas, or recording units, vary in size. An individual recording unit might consist of a single word, a phrase, a sentence, or even an entire paragraph. In each case, the emphasis during analysis was not on the given word, phrase, sentence, or paragraph that was selected, but, rather, on the idea identified within and conveyed by that particular word, phrase, sentence, or paragraph.

Phase II: Comparing and coding. During this phase, a comparison was made of the textual tools from the three textbooks with all of the coding categories from each of the four ELL standards. This examination resulted in recording units being identified and coded, resulting in the designation of *instances of alignment* between the textual tools and the ELL standards. This process proceeded as described below.

Textual tools aligned with the standards. The comparative process began with the opening of one of the three biology textbooks selected for this study to the first textual tool for teaching ELL students that appears in the textbook. This textual tool was then examined by comparing it with all of the coding categories from each of the national standards, one at a time. When the idea contained within and expressed by a word, phrase, sentence, or paragraph in this textual tool matched one of the indicators in a coding category from the ELL standards, that word, phrase, sentence, or paragraph was deemed a recording unit. That match between the recording unit from the textual tool and the coding category from the standards was then designated an instance of alignment. Each instance of alignment was then given an identifying code to indicate the standard to which it was aligned, as well as to identify the indicator and coding category within the standard that it was matched with, and recorded on the appropriate text analysis coding form. Instances of alignment were only reported on the text analysis coding forms when the match between a textual tool and a coding category in one of the standards was with an indicator that was both at the appropriate grade level for the textbooks selected for this study (grades 9-12), as well as within the content area that is covered by the course for which the textbooks were written (biology).

When the first textual tool in the textbook had been compared with all of the coding categories in each of the standards, the second textual tool in the same textbook was then examined through the same process. Once such comparisons were made for all the textual tools in the first textbook, the same process was repeated for the remaining two textbooks.

This process of identifying instances of alignment between the biology textbooks and the ELL standards required that the breaking up of the textual tools for ELL students into coding units take place during the analytic process itself, rather than beforehand, as is frequently the case with other content analyses. This meant that there were often multiple recording units identified within a single textual tool that matched coding categories, either from the same standard or from different standards. It also meant that a single recording unit from one of the textual tools often matched multiple coding categories from the standards, with the syntax of that recording unit frequently changing each time such a match occurred, depending on the standard to which it was being compared. For example, a recording unit that was an entire sentence when matched with one standard might have been reduced to a phrase, or even a single word, within that sentence when matched with another standard. This was because what was important was not the words, phrases, sentences, and paragraphs within the textual tools, but, rather, the idea identified within and conveyed by a particular word, phrase, sentence, or paragraph. Finally, a recording unit within a textual tool occasionally matched more than one indicator for the same coding category within a standard. Each of the three scenarios described above, when it occurred, was coded as a separate instance of alignment between a textual tool and the standard.

An example of an instance of alignment between the textual tools for teaching ELL students and the national ELL standards is found in the Pearson textbook. The three coding categories from the WIDA English Language Development standards take the form of instructional supports. One of these supports, or coding categories, is *Interactive Support*, which has a variety of indicators with which a recording unit could potentially be aligned. One of these indicators is the phrase "In Triads or Small Groups" (see Appendix D). In the Pearson textbook, the textual tool reads,

> BEGINNING AND INTERMEDIATE SPEAKERS: Have students write the term *science* in a Vocabulary Word Map. Then, have them write words or phrases that describe attributes of science or topics related to science in the lower boxes. Encourage beginning speakers to use one of the boxes to make an illustration to represent the process of science. After students have completed their vocabulary word maps, have them form small groups to discuss how their maps are similar and how they are different. (Miller & Levine, 2010, p. 5; see Appendix A)

This textual tool recommends that teachers have their students "form small groups" for a portion of the recommended activity. Because the phrase "small groups" in the textual tool is a word-for-word match with the phrase "Small Groups" in the coding category, the same idea is expressed by both the textual tool and the coding category, that of having students work in small groups during a learning activity. The idea expressed in the textual tools for teaching ELL students, which meets the criteria for a recording unit, matches the coding category from the WIDA standards. This was deemed an instance of alignment between the Pearson textbook and the ELL standards.

Textual tools not aligned with the standards. Textual tools that were identified as having no instances of alignment with a given standard were so coded because none of the ideas found in the standard was present anywhere in the textual tool, either explicitly or implicitly. Such textual tools tended to fall into one or more of a number of categories, which will be described below.

Non-alignment with the benchmarks. There were six reasons why a given textual tool was not determined to be a match with the benchmarks, the standard designed to help make grade-appropriate science content accessible to students. First, a textual tool was not coded as an instance of alignment with the benchmarks if it contained no science content or if it did not refer students to any science content. Instead, these textual tools typically recommended the use of a particular activity, anticipatory set, or teaching strategy. While such activities and strategies might be considered effective teaching methodologies, they were not coded as matches to the benchmarks because they lacked content. An example of this type of textual tool was found in the Glencoe textbook: "Have students discuss books they might have read or movies they might have seen that describe earlier times in the history of Earth" (2009, p. 392). Because this recommendation consists of a pedagogical strategy, in this case an anticipatory set, rather than biology content of any kind, it was not coded as a match with the benchmarks.

Second, if a given textual tool contained or referred students to science content, but did not specifically identify the content to be learned or did not modify the content to make it more accessible to the learner in some way, it was not coded as an instance of alignment. An example of such a textual tool was found in the Holt, Rinehart, and Winston textbook: "Have students pair up to read this section" (2006, p. 142). Although directing students to read the section does refer them to content, the reference to the content does not identify any specific aspect of the content to be learned; nor does it modify the content in any way to make it more accessible to the learner.

A third reason a textual tool was not determined to be aligned with the benchmarks was when a given textual tool contained science content that can be found in the standard, but lies in an area that is outside the content area of the course for which the standard and textbook are intended: high school biology. For example, a textual tool found in the Glencoe textbook recommended, "Have students draw depictions of covalent and ionic bonds" (2009, p. 153). The concept of covalent and ionic bonds is found in the benchmarks, but not in the content area of the benchmarks that is associated with teaching biology. It is, instead, found in the *Physical Setting* category of the benchmarks, which is intended for use when teaching a chemistry or physics course. This recommendation was not coded as an instance of alignment with the benchmarks.

Fourth, when a given textual tool contained biology content that is beyond the scope of the benchmarks, or above grade level, it was not coded as an instance of alignment. The following example is found in the Glencoe textbook: "Have students construct a concept map that outlines the applications and steps involved in microarray analysis" (2009, p. 377). Microarray analysis is part of the field of genetics, which, at a basic level, is found in the benchmarks. However, directing students to learn about microarray analysis takes the study of genetics to the level of a college biology course, not a high school general biology course. This recommendation was not coded as an instance of alignment with the benchmarks.

Fifth, if a given textual tool contained science content that aligned with the content described in the benchmarks within a lower grade band (e.g., grades 3-5) than that of the course for which the textbooks are intended to be used (e.g., grades 9-12), the textual tool was not coded as an instance of alignment. An example was found in the Holt, Rinehart, and Winston textbook: "Point out that we often organize things - such as products in a store and subjects in a school curriculum - into classes or groups. Have the class develop a list of other things that are organized into classes or groups" (2006, p. 346). This concept matches the benchmarks' coding category for grades 3-5, which is science content at a lower level than that described within the grades 9-12 coding category, which is appropriate for a high school biology course. This recommendation was not coded as an instance of alignment with the benchmarks.

Finally, the sixth reason why a given textual tool was not coded as an instance of alignment with the benchmarks was when it introduced or defined science terms that are not found in the coding categories of the benchmarks and are not necessary to understand any of the concepts described in the coding categories of the benchmarks. In other words, such textual tools advocate the learning of extraneous information that is not relevant to an understanding of the content outlined in the standards. An example of such a textual tool is found in the Pearson textbook.

> Point out to English language learners that the term *smog* may remind them of another English word, *fog*. Explain that the two words are related. The origins of *smog* come from a description of this form of pollution in the early twentieth century, when gray-brown haze was described as a 'smoky fog.' Parts of the two words were put together to make the word *smog*." (2010, p. 163)

The need to learn the definition of the term smog is not found in the coding categories for the benchmarks and is not necessary for an understanding of the concepts found in any of its coding categories. Thus, this recommendation was not coded as an instance of alignment with the benchmarks.

Non-alignment with the CREDE standards. There were two reasons why a given textual tool was not deemed to be an instance of alignment with the CREDE standards, which is the standard designed to help teachers improve their pedagogy. First, a textual tool was not deemed a match with the CREDE standards because its recommendations contained no instructional strategy (i.e., pedagogy) at all. An example, found in the Pearson textbook, recommended, "After students have read each passage, have them stop and answer the question orally. Make sure students can answer all of the questions before they continue reading" (2010, p. 427). While this recommendation could be considered important or useful, it does not constitute an instructional strategy. There is no direction in this recommendation for how the teacher in this scenario will "make sure students can answer all of the questions before they continue reading." In the absence of such direction from the textual tool, it is impossible to know what the teacher should or will do to accomplish the recommendation. As an instance of an instructional recommendation that lacks an instructional strategy, this recommendation and others similar to it, were not coded as instances of alignment with the CREDE standards.

Second, when a given textual tool contained an instructional strategy, but not one found in the CREDE standards, it was not counted as an instance of alignment. For example, a textual tool found in the Glencoe textbook makes the following recommendation: "Prior to reading Section 31.2, have students read the section assessment questions" (2009, p. 916). While this recommendation could be considered an instructional strategy, it does not match any of the coding categories in the CREDE standards for providing instructional support. It was not coded as an instance of alignment with the CREDE standards.

Non-alignment with the WIDA standards. There were two reasons why a given textual tool was not deemed to be an instance of alignment with the WIDA standards, which is the standard designed to support students' developing academic linguistic and language abilities. First, a textual tool was not deemed a match with the WIDA standards because its recommendations would not necessarily result in the instructor actually providing any kind of instructional support for his or her students. An example, found in the Pearson textbook, recommended: "If your students have trouble with Question 1b, have them review the Build Vocabulary feature on the word *inter-dependence*" (2010, p. 68). This recommendation, which directs the teacher to have students go back and reread a portion of the text, does not match any of the coding categories for providing support to ELLs found in the WIDA standards. This recommendation was not coded as an instance of alignment with the WIDA standards.

Second, when a given textual tool recommended providing instructional support for students, but not in a way that is found in the WIDA standards for science, it was not counted as an instance of alignment. For example, a textual tool found in the Holt, Rinehart, and Winston textbook recommended: "Assign Chapter 1 of the Modern Biology Guided Reading Audio CD Program to help students achieve greater success in reading the chapter" (2006, p. 5). This recommendation matches the WIDA standards, but for a coding category that was created for a different content area than science (language arts). For the purpose of this study, it could not be coded as an instance of alignment with the WIDA standards.

Non-alignment with the TIMSS standards. There were two reasons why a given textual tool was not deemed to be an instance of alignment with the TIMSS standards, which is the standard designed to increase the cognitive rigor of instructional activities. First, a textual tool was not deemed a match with the TIMSS standards because the activities it recommends did not require that students engage in thinking of any kind. An example, found in the Holt, Rinehart, and Winston textbook, recommended: "Write some of the frog sounds from various languages on the board. Then invite students to pronounce them . . ." (2006, p. 810). This recommendation might be an interesting and engaging activity. However, it does not require thinking of any kind according to the coding categories for the TIMSS standards. This recommendation and others similar to it, were not coded as instances of alignment with the TIMSS standards.

Second, when a given textual tool recommended an activity that created the potential for thinking to take place, but lacked specific recommendations regarding what kind of thinking that might be, it was not counted as an instance of alignment. For example, a textual tool found in the Glencoe textbook makes the following recommendation: "In groups of 3-4, have students volunteer to read the text under the heading Inflammatory Diseases. SAY TO STUDENTS: Write questions about topics you would like to know more about" (2009, p. 1094). This recommendation creates the opportunity for thinking to take place, depending on the kinds of questions that students might formulate and write down. However, given the nature of the recommendation, it is impossible to know what kinds of questions students will formulate. Therefore, it is impossible to know whether any thinking will take place in the minds of such students, let alone what kind of thinking that might be. As a result, this recommendation was not coded as an instance of alignment with the TIMSS standards.

Level of intensity: The strength of alignment. As each instance of alignment was identified, it was also assigned a level of *intensity*, defined here as variation of an attribute that "can provide meaningful insights that deepen one's understanding of the content under investigation" (Downe-Wamboldt, 1992, p. 5). More specifically, in this study intensity describes the strength of the alignment between the textbooks' textual tools for ELL students and the coding categories of the standards. This was accomplished by placing each instance of alignment into one of two categories: *explicit* or *implicit.* Instances of alignment that were placed in the explicit category of intensity were those whose match with the coding category was word-for-word. Explicit instances of alignment could be considered an example of a case where the strength of the alignment between the textual tool and the standards was high. Instances of alignment that were placed in the implicit category of intensity were those whose match with the coding category was not word-for-word, but was, rather, inferred from the nature of the language used, including context clues (Holsti, 1969). Implicit instances of alignment could be considered an example of a case where alignment between the textual tool and the standard existed, but the strength of the alignment was low.

Explicit instances of alignment with the benchmarks. An example of an explicit instance of alignment between a textual tool from one of the three biology textbooks and the benchmarks is a textual tool from the Pearson textbook (2010, p. 1025). This textual tool contains a word-for-word match with the words "immune system . . . attack . . . the body's own cells" from the *Human Organism* coding category in the benchmarks.

Implicit instances of alignment with the benchmarks. An example of an implicit instance of alignment between a textual tool from one of the three biology textbooks and the benchmarks is a textual tool from the Pearson textbook. Even though the match is not word-for-word, the recommendation in the textual tool to use a certain instructional strategy to help students learn about "carbohydrates, lipids, nucleic acids, and proteins" conveys the same idea as the following indicator phrase from *The Living Environment* coding category

> A living cell is composed of a small number of chemical elements mainly carbon, hydrogen, nitrogen, oxygen, phosphorous, and sulfur. Carbon, because of its small size and four available bonding electrons, can join to other carbon atoms in chains and rings to form large and complex molecules. (Pearson, 2010, p. 48)

Explicit instances of alignment with the CREDE standards. An example of an explicit instance of alignment is a textual tool from the Glencoe textbook (2009, p. 937). This textual tool contains a word for word match with the following indicator from the *Language Development* coding category in the CREDE standards: "first . . . languages" (University of California Berkeley Graduate School of Education, 2002)

Implicit instances of alignment with the CREDE standards. There were no implicit instances of alignment between the textual tools from the three biology textbooks and the CREDE standards. This was because the key words that were identified as indicators of an instance of alignment between the textbooks and the coding categories in the CREDE standards were either present in the textual tools or they were not.

Explicit instances of alignment with the WIDA standards. An example of an explicit instance of alignment between a textual tool from one of the 3 biology textbooks and the WIDA standards is a textual tool from the Holt, Rinehart, and Winston textbook (2006, p. 36). This textual tool contains a word for word match with the indicator term "drawing" from the *Sensory Support* coding category in the WIDA standards (Board of Regents of the University of Wisconsin System, 2007).

Implicit instances of alignment with the WIDA standards. An example of an implicit instance of alignment between a textual tool from one of the three biology textbooks and the WIDA standards is a textual tool from the Glencoe textbook (2009, p. 12). This textual tool contains the recommendation: "Share your own visualization or connection as you read to model the process of reading. Modeling helps students understand how good readers construct meaning from text" (2009, p. 12). This recommendation is not a word for word match with any of the indicators in any of the coding categories from the WIDA standards. However, the WIDA standards indicate that the use of modeling, as an instructional strategy, does constitute a match, albiet not a word for word one, with the *With mentors* indicator that is found in the *Interactive Support* coding category in the WIDA standards (Board of Regents of the University of Wisconsin System, 2007). This recommendation constitutes an implicit instance of alignment between the Glencoe textbook and the WIDA standards.

Explicit instances of alignment with the TIMSS standards. An example of an explicit instance of alignment between a textual tool from one of the three biology textbooks and the TIMSS standards is a textual tool from the Holt, Rinehart, and Winston textbook (2006, p. 77). This textual tool contains a word for word match with the indicator term "identify" from the *Knowing* coding category in the TIMSS standards (National Center for Education Statistics, 2011).

Implicit instances of alignment with the TIMSS standards. An example of an implicit instance of alignment between a textual tool from one of the three biology textbooks and the TIMSS standards is a textual tool from the Holt, Rinehart, and Winston textbook. This textual tool contains the recommendation "Students should write the meanings of the vocabulary words . . ." (2006, p. 177). This recommendation is not a word for word match with any of the indicators in any of the coding categories from the TIMSS standards. However, the phrase "write the meanings of" is a very clear indication that students are expected to "provide or identify definitions of scientific terms," which is one of the indicators for the *Knowing* coding category for the TIMSS standards (National Center for Education Statistics, 2011). Although the match is not word for word, this recommendation constitutes an implicit instance of alignment between the Holt, Rinehart, and Winston textbook and the TIMSS standards.

Reliability of interpretation. The researcher was the primary or central instrument in analyzing the data because the methodology used for this study was interpretive in nature (see Researcher Perspective below). To help minimize bias, it was necessary to ensure reliability (Stemler, 2001).

Defining and coding. Reliability was attended to by first using a priori coding categories that were created by the authors of the standards documents, rather than the researcher. The second step taken to minimize bias was that of carefully identifying the recording units of the study, within the textual tools, during the coding of the data. Great care was also employed in developing a coding form and specific procedures for coding, which will be described later in this section.

Coding, comparing, and clarifying. The above process alone, however, was not enough to ensure reliability, since "the ambiguity of word meanings, category definitions, or other coding rules" tend to create "reliability problems" (Weber, 1990, p. 15), no matter how careful a researcher might be. A second method of ensuring reliability of the data coding was employed through a form of inter-rater reliability that is sometimes called *reproducibility* (Stemler, 2001). As Stemler (2001) indicates, reproducibility seeks to establish that a given coding scheme leads to "the same text being coded in the same category by different people" (para. 20). Reproducibility was employed in this study by inviting a science teacher educator considered to be experienced in the field to verify the categories, examine the coding form, and independently code one of the textual tools for teaching ELL students in each of the three biology textbooks selected for this study. The science teacher educator and the researcher then compared their coding of the same text to establish the trustworthiness of the researcher's coding.

As the process of reproducibility proceeded, minor differences in the coding of the science teacher educator and the researcher appeared, due to different interpretations of the national standards. As Weber (1990) points out: "To make valid inferences from the text, it is important that the classification procedure be reliable in the sense of being consistent: Different people should code the same text in the same way" (p. 12). Thus, these coding differences needed to be resolved. One way in which those differences were resolved was by comparing the results of the coding process and seeking out clarifying information regarding how the coding categories from the ELL standards were interpreted and matched with the text in the textual tools for teaching ELL students in the three biology textbooks. This, alone, was not sufficient to ensure that "different people code the same text in the same way" (Weber, 1990, p. 15), while simultaneously avoiding "reliability problems" (Weber, 1990, p. 12). The reason for this is that when a group of people work closely on a study, and, specifically, develop a coding scheme together, they tend to establish "shared and hidden meanings of the coding" (Stemler, 2001, para. 18). This frequently causes the reliability reported to be artificially inflated (Krippendorff, 1980). In order to avoid this, the science teacher educator and the researcher used the process of independent coding, followed by comparison and clarification, described above, to "develop a set of explicit recording instructions" (Stemler, 2001, para. 18), which constituted a sort of "training" (para. 18). Having been trained, the expert and the researcher proceeded with the process of coding, comparison, and clarification, using the set of recording instructions that were developed, until the inter-rater agreement reached the 95% requirement level, as established by

Krippendorff (1980). At this point, with the aid of the explicit recording instructions (see Appendix B), the researcher completed the coding process independently.

Coding forms. As the ideas, or recording units, within each textual tool were coded, they were recorded on a Textual Tools for ELL Students Analysis Coding Form. Twelve such forms were created (See Appendix G): four coding forms for each of the three textbooks selected for analysis in this study. Each of the four forms contains both the chapter number and title, the section number and title of each of the textual tools in that textbook, and all of the coding categories from one of the national standards (three from benchmarks, five from CREDE, three from WIDA, three from TIMSS). During this phase of analysis, all instances of alignment between the recording units identified in the textual tools for ELL students and the coding categories from each standards document were recorded. Each form includes the following: a unique code that identifies each coding category from the national standards; space for the researcher to indicate whether alignment exists between any of the textual tools for ELL students from the three biology textbooks and any of the coding categories from the national standards, including both the chapter number and title and the section number and title in which that textual tool is found; as well as space for the researcher to indicate the level of intensity of each instance of alignment identified.

Phase III: Calculating frequencies. During Phase III of the data analysis, the data from the coded textual tools for teaching ELL students were calculated and reported as frequency counts of instances of alignment with the standards, in varying levels of detail. These frequency counts were reported first as whole numbers, then as percentages in order to standardize the data. One example of how this took place follows. The Glencoe textbook contains 309 textual tools for teaching ELLs. Of those 309 textual tools, 59 were aligned with the benchmarks, meaning that they contained at least one recording unit that was aligned with the coding categories in the benchmarks. This alignment was recorded by the following frequency count: 59 out of 309, or 19.1%, of the textual tools from the Glencoe textbook were identified as being aligned with the benchmarks.

After the frequency counts described above were reported, the frequency of total instances of alignment for the aligned textual tools was reported. In the case of the Glencoe text, the 59 textual tools that were aligned with the benchmarks contained a total of 63 recording units that were aligned with the coding categories in the benchmarks. Therefore, the researcher reported a frequency of 63 total instances of alignment between the textual tools in the Glencoe text and the benchmarks.

Finally, the frequency of instances of alignment described above were broken down and reported according to the strength of each instance of alignment: explicit or implicit. Thus, through this analysis, not only was the alignment of the textual tools from the three secondary biology textbooks with the ELL standards identified, but the strength of that alignment was also revealed. Using the above example of the Glencoe textbook, the 59 textual tools that were aligned with the benchmarks contained a total of 63 instances of alignment with the benchmarks. Of these 63 instances of alignment, four (6.3%) were explicit, and 59 (93.7%) were implicit.

Phase IV: Comparing across textbooks. As mentioned previously, the coding and calculation of frequencies took place first with each textbook separately, followed by a comparison across textbooks, identifying similarities and differences in how the three textbooks align with the standards. This process included comparisons of (a) the frequency of instances of alignment between the textbooks and the standards; (b) whether a textbook was consistently aligned with one standard, or one indicator within a standard, to the exclusion of other standards or other indicators; (c) the level of intensity of the frequencies of instances of alignment; and (d) the actual number of instances of alignment between a textbook and the standards, regardless what the frequency of the instances of alignment might be.

Researcher Perspective

The attributes of the researcher are important because experience and knowledge play an active role in sensitizing the researcher during data analysis (Strauss & Corbin, 1998). This is especially the case whenever a study is qualitative in nature because the researcher becomes a tool or lens for analysis (Creswell, 2008). It is important that the reader gain some understanding of the lens through which the researcher interpreted the data. This includes gaining an understanding of the researcher's educational background, professional background, and perspectives on teaching and learning. It is through these three lenses that the researcher will examine the textual tools for ELL students found in the selected secondary biology textbooks to determine how they make science content accessible to ELLs, as judged by how these textbooks align with the national standards.

The researcher has recently completed the coursework for a Teacher Education masters degree program, which included a course in content-area literacy instruction. This course introduced the researcher to current research concerning different definitions of text, reading, writing, and communication within different content areas or disciplines. The course also helped the researcher become more aware of differences in the way individuals and groups interact with texts. In particular, the researcher is now more aware of the differing ways in which learners from different linguistic backgrounds and cultural traditions use texts, as well as differences in how such learners might need to be scaffolded in their use of texts.

The researcher has a strong background in biology, having earned a bachelor's degree in biology and spent two years working in both the laboratory and the field in the capacity of biologist in private industry and for state government. The researcher is also experienced at teaching biology; having a level two teaching license in biology and six years of teaching experience in two secondary public schools. The researcher's first school was a large, affluent, suburban school whose students were mostly Caucasian and fluent English speakers. The researcher's second, and current, school is small, poor, rural, and mostly Hispanic, with a large ELL population. Thus, the researcher's teaching experience has spanned the educational spectrum in terms of school size and location, as well as student ethnicity, English-language proficiency, and socioeconomic status.

Limitations

In addition to the interpretive nature of qualitative content analysis, which may reflect the biases of the researcher, one limitation of this study is that the three textbooks analyzed constitute only a portion of the extant body of secondary biology textbooks used in secondary classrooms today. Consequently, the results of this study are not necessarily generalizable. The possibility exists that other secondary biology textbooks contain instructional resources for ELL students that are more or less aligned with the national standards than are the textbooks selected for this study. This means it is possible the results of this study might be misleading in terms of the degree to which textbook publishers in the U.S. are attuned to the textual and curricular needs of ELL students. However, since the selected textbooks represent the three top-selling secondary biology textbooks in the nation, it can be argued that they are representative of the collective thinking of the textbook publishing community. Additionally, because of their ranking, they are the textbooks that are most likely to be encountered in classrooms by ELL students.

Chapter 4

Findings

This content analysis was conducted to examine how the instructional recommendations of the textual tools for teaching ELLs found in three secondary biology textbooks align with the standards for teaching English learners. The findings of this study are discussed in the following sections: Textual Tools: Alignment of the Textbooks with the Standards, Recording Units Aligned with the Standards: Frequency and Strength of Alignment, and Patterns and Themes: A Comparison Across textbooks.

Textual Tools: Alignment of the Textbooks with the Standards

The process of coding and comparing the textbooks with the standards revealed that some of the textual tools in each of the three textbooks were aligned with the standards, meaning that they contained at least one recording unit that was aligned with the standards, which constituted an instance of alignment. The coding and comparing process also revealed that some of the textual tools in each of the three textbooks were not aligned with the standards. Textual tools aligned with the standards are identified in this section according to the textbook analyzed, the standard to which it was compared, the total number of textual tools in the textbook, the number of textual tools in the textbook that were aligned with each standard, and the frequency of alignment of the textual tools (the number of textual tools aligned with each standard divided by the total number of textual tools in the textbook) with each standard (see Table 1).

Several similarities and differences in the frequency of alignment between the standards and the textual tools in the textbooks emerge from an examination of Table 1. When the four standards were ranked in order of frequency of alignment with the textual tools in the textbooks, the order was the same for all three textbooks.

Table 1

Number of Textual Tools in the Textbooks Aligned with the Standards (n=total number of textual tools in each textbook)

	Pearson (n=211)	Glencoe (n=309)	Holt (n=102)
Standard	#/% Aligned	#/% Aligned	#/% Aligned
Benchmarks	48/22.7	59/19.1	14/13.7
CREDE	147/69.7	129/41.8	26/25.5
WIDA	156/73.9	244/79.0	30/29.4
TIMSS	160/75.8	274/88.7	40/39.2
Total Alignments With Textual Tools	60.5%	57.2%	26.9%

The frequency of alignment between standards and textual tools in the textbooks was highest, for all three textbooks, with the TIMSS standards (75.8% for Pearson, 88.7% for Glencoe, 39.2% for Holt). The second highest frequency, for all three textbooks, was with the WIDA standards (73.9% for Pearson, 79.0% for Glencoe, 29.4% for Holt). The next highest frequency, for all three textbooks, was with the CREDE standards (69.7% for Pearson, 41.8% for Glencoe, 25.5% for Holt). The lowest frequency, for all three textbooks, was with the benchmarks (22.7% for Pearson, 19.1% for Glencoe, 13.7% for Holt).

When the frequencies of alignment of the textual tools in each textbook with all four ELL standards were averaged, a percentage representing total alignment between each textbook and all four ELL standards was obtained. The Pearson textbook had the greatest overall percentage of total alignment between its textual tools and all four standards combined (60.5%), followed closely by the Glencoe textbook (57.2%). The Holt textbook had the lowest overall percentage of total alignment between its textual tools and all four standards combined (26.9%).

Recording Units Aligned with the Standards: Frequency and Strength of Alignment

In this section, the discussion of the findings moves beyond an articulation of how many textual tools in a textbook were aligned with a given standard, to describing the recording units, identified within the textual tools, that were aligned with the standards (i.e., instances of alignment). The focus here is on two aspects of these recording units: their frequency and their strength. The frequency of recording units is reported, first, as a total frequency, or total number of recording units per textbook per standard (see Table 2). That frequency is then broken down further by the strength of the recording units, which is reported here as explicit frequency and implicit frequency (see Table 3). The number of explicit recording units in each textbook for a given standard was divided by the total number of recording units in that textbook for that standard to produce a percent. The same was done for implicit recording units.

Each of the three textbooks analyzed for this study had more recording units than it had textual tools that were aligned with the standards. For example, the Pearson textbook had 48 textual tools that were aligned with the benchmarks. However, as Table 2 shows, the total number of recording units contained within those 48 textual tools was 56. This was because some textual tools had (a) more than one recording unit, (b) a recording unit that matched more than one coding category in the benchmarks, or (c) a recording unit that matched more than one indicator within the same coding category in the benchmarks. Table 2 displays the frequency of recording units in the textual tools of the textbooks. Table 3 displays the strength (explicit or implicit) of those recording units.

Table 2

Instances of Alignment between Textual Tools and Recording Units by Standards (n=total number of textual tools in each textbook)

	Pearson (n=211)		Glencoe (n=309)		Holt (n=102)	
	Textual Tools Aligned	Recording Units Aligned	Textual Tools Aligned	Recording Units Aligned	Textual Tools Aligned	Recording Units Aligned
Standard	#/%	#/#	#/%	#/#	#/%	#/#
Benchmarks	48/22.7	56/48	59/19.1	63/59	14/13.7	17/14
CREDE	147/69.7	264/147	129/41.8	215/129	26/25.5	33/26
WIDA	156/73.9	256/156	244/79.0	423/244	30/24.9	37/30
TIMSS	160/75.8	296/160	274/88.7	413/274	40/39.2	69/40

Note. #/# = No percentage is possible for the Recording Units Aligned columns, since the number of recording units is always larger than the number of textual tools aligned with the standards. Thus, any percentage derived from this relationship will always be greater than 1.0

Table 3

Explicit and Implicit Instances of Alignment between Recording Units and Standards

	Pearson Textual Tools = 48			Glencoe Textual Tools = 59			Holt Textual Tools = 14		
	Recording Units Aligned	Explicit	Implicit	Recording Units Aligned	Explicit	Implicit	Recording Units Aligned	Explicit	Implicit
Standard	#	#/%	#/%	#	#/%	#/%	#	#/%	#/%
Benchmarks	56	3/5.4	53/94.6	63	4/6.3	59/93.7	17	0/0.0	17/100.0
CREDE	264	264/100.0	0/0.0	215	215/100.0	0/0.0	33	33/100.0	0/0.0
WIDA	256	232/90.6	24/9.4	423	367/86.8	56/13.2	37	36/97.3	1/2.7
TIMSS	296	95/32.1	201/67.9	413	73/17.3	340/82.3	69	19/27.5	50/72.5

The benchmarks. The frequency of recording units aligned with the benchmarks for all three textbooks was low. The 48 textual tools in the Pearson textbook that aligned with the benchmarks contained 56 recording units. Similarly, the 59 textual tools in the Glencoe textbook that aligned with the benchmarks contained 63 recording units. This trend continued with the Holt textbook, which had 14 textual tools aligned with the benchmarks, containing a mere 17 recording units.

When the frequency of recording units aligned with the benchmarks for all three textbooks is broken down by strength of alignment, another pattern emerges. Of the recording units that were identified, almost all of them were implicit in strength (94.6% for Pearson, 93.7% for Glencoe, 100% for Holt). The Holt textbook's high frequency of implicit instances of alignment with the benchmarks (100%) only represents 17 recording units, while the lower implicit frequencies of the Pearson (94.6%) and Glencoe (93.7%) textbooks represent a much greater number of recording units (56 and 63 respectively). Only a few recording units had a high (i.e., explicit) strength of alignment with the benchmarks for all three textbooks (5.4% for Pearson, 6.3% for Glencoe, 0% for Holt).

The CREDE standards. The Glencoe textbook contained the most recording units aligned with the CREDE standards (264 recording units in 147 textual tools aligned with the CREDE standards). The Holt textbook had the fewest (33 recording units in 26 textual tools aligned with the CREDE standards). For all three of the textbooks, these recording units were all explicit.

The WIDA standards. The Glencoe textbook included the most recording units aligned with the WIDA standards (423 out of 244 textual tools aligned with the standards). The Holt textbook included the fewest (37 out of 30 textual tools aligned with the WIDA standards).

Additionally, a majority of the recording units were explicit for all three textbooks, and the frequencies were fairly similar, with the Holt textbook having the highest frequency of explicit recording units (90.6% for Pearson, 86.8% for Glencoe, 97.3% for Holt). The high explicit frequency of the Holt text only represents 36 recording units, while the lower frequencies of the Pearson and Glencoe textbooks represent many more recording units (232 and 367 respectively)

The TIMSS standards. The Glencoe textbook had more recording units aligned with the TIMSS standards (413 recording units out of 274 textual tools aligned with the TIMSS standards) than the other two textbooks. The Holt textbook, again, had the fewest (69 recording units out of 40 textual tools aligned with the TIMSS standards). In all three textbooks, a majority of these recording units were implicit, and the frequencies were fairly similar, with the Glencoe textbook having the highest percent of all (67.9% for Pearson, 82.3% for Glencoe, 72.5% for Holt). Although these frequencies are comparable, the frequency for the Holt textbook represents only 50 recording units, while the frequencies for the Pearson and Glencoe textbooks represent much higher numbers of recording units (201 and 340 respectively).

Patterns and Themes: A Comparison Across Textbooks by Standard

In this section, the frequencies of instances of alignment are further broken down by coding category per standard and by strength of alignment (explicit and implicit). Displaying the data in such detail makes clearer the picture of how the three textbooks align with the standards. It also allows for comparison across all three textbooks, which leads to the identification of a number of patterns and themes, which are discussed in the following section.

The benchmarks. The majority of the recording units that were aligned with the benchmarks from all three textbooks were aligned with *The Living Environment* coding category (69.7% Pearson, 66.7% Glencoe, 88.2% Holt), and the strength of almost all of those alignments was implicit (see Table 4; see Appendix C). The coding category that was aligned with the fewest recording units from all three textbooks was the *Nature of Science* category (10.7% Pearson, 7.9% Glencoe, 0% Holt), and the strength of all of those alignments was implicit.

The similarities between the Pearson and Glencoe textbooks in the overall explicit alignment of their recording units with the benchmarks (5.4% Pearson, 6.3% Glencoe) becomes nearly identical when the data are broken down by the specific coding category to which their recording units were aligned and the strength of that alignment (see Table 4). Of the recording units in the Pearson textbook that were aligned with the benchmarks, 3.6% were explicitly aligned with *The Living Environment* category, and 1.8% were explicitly aligned with *The Human Organism* category. In nearly identical fashion, of the recording units in the Glencoe textbook that were aligned with the benchmarks, 4.8% were explicitly aligned with *The Living Environment* category, and 1.6% were explicitly aligned with *The Human Organism* category.

An examination of the recording units from these two textbooks that were implicitly aligned with the benchmarks reveals that the similarities continue. Of the Pearson textbook's recording units that were implicitly aligned with the benchmarks, 10.7% were with the *Nature of Science* category, while for the Glencoe textbook, 7.9% were with that same category. Further, 66.1% of the Pearson textbook's recording units that were implicitly aligned with the benchmarks were with *The Living Environment* category, while the frequency for the Glencoe textbook with that same category was 61.9%.

In contrast, the Holt textbook was quite different from the other two textbooks. It contained no recording units aligned with the *Nature of Science* category. Conversely, it had the highest frequency of recording units aligned with *The Living Environment* category of all three textbooks (88.2%). It is important to note, however, that that high frequency only represents 15

Table 4

Recording Units Aligned by Coding Category Across the Three Textbooks for the Benchmarks

	Nature of Science			*The Living Environment*			*The Human Organism*		
	Explicit	Implicit	Total	Explicit	Implicit	Total	Explicit	Implicit	Total
Text	#/%	#/%	#/%	#/%	#/%	#/%	#/%	#/%	#/%
Pearson	0/0.0	6/10.7	6/10.7	2/3.6	37/66.1	39/69.7	1/1.8	10/17.9	11/19.6
Glencoe	0/0.0	5/7.9	5/7.9	3/4.8	39/61.9	42/66.7	1/1.6	15/23.8	16/25.4
Holt	0/0.0	0/0.0	0/0.0	0/0.0	15/88.2	15/88.2	0/0.0	2/11.8	2/11.8

recording units. On the other hand, while the Pearson and Glencoe textbooks had lower frequencies of recording units aligned with this category (69.7% and 66.7% respectively), they both had over twice as many actual recording units aligned with this category (39 and 42 respectively) than the Holt textbook did.

The CREDE standards. The great majority of recording units from all three textbooks that were aligned with this standard were aligned with the *Language Development* coding category (see Table 5; see Appendix D). The frequencies of recording units aligned with this category were similar for all three textbooks (69.7% for Pearson, 59.5% for Glencoe, 66.7% for Holt). Nearly all those alignments were with a single indicator within that category: "The teacher provides frequent opportunity for students to interact with each other and the teacher during instructional activities" (University of California Berkeley Graduate School of Education, 2002). The second highest number of recording units aligned with this standard from all three textbooks were aligned with the *Joint Productive Activity* coding category, for which all three textbooks, most particularly Pearson and Glencoe, again had similar frequencies (29.2% for Pearson, 33% for Glencoe, 18.2% for Holt). Again, almost all those alignments were with a single indicator within that category: "The teacher designs instructional activities requiring student collaboration to accomplish a joint product" (University of California Berkeley Graduate School of Education, 2002).

The remaining coding categories from this standard were minimally aligned with the textbooks. The *Contextualization* coding category was implicitly aligned with no recording units in any of the textbooks, and had very low explicit frequencies of recording units aligned with the Pearson textbook (1.1%) and the Glencoe textbook (6.5%). Conversely, this category had a much higher frequency of recording units explicitly aligned with the Holt textbook (15.2%). This high

Table 5

Recording Units Aligned by Coding Category Across the Three Textbooks for the CREDE Standards

	Joint Productive Activity		*Language Development*		*Contextualization*		*Challenging Activity*		*Instructional Conversation*	
	Explicit	Implicit	Explicit	Implicit	Explicit	Implicit	Explicit	Implicit	Explicit	Implicit
Text	#/%	#/%	#/%	#/%	#/%	#/%	#/%	#/%	#/%	#/%
Pearson	77/29.2	0/0.0	184/69.7	0/0.0	3/1.1	0/0.0	0/0.0	0/0.0	0/0.0	0/0.0
Glencoe	71/33.0	0/0.0	128/59.5	0/0.0	14/6.5	0/0.0	0/0.0	0/0.0	2/0.9	0/0.0
Holt	6/18.2	0/0.0	22/66.7	0/0.0	5/15.2	0/0.0	0/0.0	0/0.0	0/0.0	0/0.0

Note. Implicit = All instances of alignment were explicit. Thus, the Explicit Frequency column also represents the Total Frequency.

frequency, however, represents only five recording units, while the lower frequency of the Glencoe textbook, described above, represents a greater number of recording units (14).

Only one of the textbooks, the Glencoe textbook, had any alignment with the *Instructional Conversation* category, with an explicit frequency of 0.9%. The *Challenging Activity* category had no explicit or implicit alignment with any of the textbooks.

The WIDA standards. Frequencies of recording units aligned with this standard were evenly split between two coding categories (see Table 6). The first, the *Sensory Support* category (34.4% Pearson, 50.4% Glencoe, 40.5% Holt), experienced most of its alignment with the textbooks through the indicator: "Illustrations, Diagrams, & Drawings" (Board of Regents of the University of Wisconsin System, 2007; see Appendix E). The second, the *Interactive Support* category (47.7% Pearson, 39.2% Glencoe, 48.7% Holt), experienced almost all of its alignment with the textbooks through the indicators: "In Pairs or Partners" and "In Triads or Small Groups" (Board of Regents of the University of Wisconsin System, 2007). Frequencies of recording units aligned with the *Graphic Support* category was lower for all three textbooks than with the other two categories (17.9% Pearson, 10.4% Glencoe, 10.8% Holt). The only category implicitly aligned with any recording units from the three textbooks was the *Interactive Support* category.

The Pearson and Glencoe textbooks, while roughly similar in their alignment with this standard, were not as overtly different from the Holt textbook as they were in the case of other standards. There was one instance where the Pearson and Glencoe textbooks had similar, and higher, frequencies of recording units aligned with this standard than the Holt textbook did: implicit instances of alignment with the *Interactive Support* category (9.4% Pearson, 13.2% Glencoe, 2.7% Holt). Otherwise, the Holt textbook had much higher frequencies of recording units aligned with this standard, as compared to the other two textbooks, than it did for the other

Table 6

Recording Units Aligned by Coding Category Across the Three Textbooks for the WIDA Standards

	Sensory Support			*Graphic Support*			*Interactive Support*		
	Explicit	Implicit	Total	Explicit	Implicit	Total	Explicit	Implicit	Total
Text	#/%	#/%	#/%	#/%	#/%	#/%	#/%	#/%	#/%
Pearson	88/34.4	0/ 0.0	88/ 34.4	46/17.9	0/ 0.0	46/17.9	98/38.3	24/9.4	122/47.7
Glencoe	213/50.4	0/ 0.0	213/50.4	44/10.4	0/ 0.0	44/10.4	110/26.0	56/132.0	166/39.2
Holt	15/40.5	0/ 0.0	15/40.5	4/10.8	0/ 0.0	4/10.8	17/46.0	1/2.7	18/48.7

standards. For example, the Holt and Glencoe textbooks were very similar to each other in the frequency of their recording units aligned with the *Graphic Support* category (10.4% Glencoe, 10.8% Holt). Similarly, the Holt textbook's frequency of recording units that were explicitly aligned with the *Sensory Support* category was in between those of the Pearson and Glencoe textbooks (34.4% Pearson, 50.4% Glencoe, 40.5% Holt). Finally, the Holt textbook's frequency of recording units explicitly aligned with the *Interactive Support* category was higher than that of the other two textbooks (38.3% Pearson, 26% Glencoe, 46% Holt). In all of the above cases, however, the actual number of the Holt textbook's recording units aligned with the coding categories was very low (never more than 20), while the Pearson and Glencoe textbooks always had much greater numbers of recording units aligned with the coding categories (usually more than 100). Thus, while the Holt textbook had higher frequencies of recording units aligned with the various categories of this standard than it did for the other standards, when compared to the actual number of recording units from the other two textbooks, the number of recording units from the Holt textbook appears to be negligible.

The TIMSS standards. For all three textbooks, the great majority of recording units aligned with this standard were aligned with a single coding category: the *Knowing*, or lowest level of thinking, category (see Table 7; see Appendix F). The frequencies of recording units aligned with this category from the textual tools of all three textbooks were fairly similar (85.1% Pearson, 74.6% Glencoe, 75.4% Holt). The frequencies of recording units from the textbooks that were aligned with the *Applying* category were relatively low (11.1% Pearson, 22.5% Glencoe, 18.8% Holt). The frequencies of recording units from the textbooks that were aligned with the *Reasoning*, or highest level of thinking, category were very low (3.7% Pearson, 2.9% Glencoe, 5.8% Holt).

Table 7

Recording Units Aligned by Coding Category Across the Three Textbooks for the TIMSS Standards

	Knowing			*Applying*			*Reasoning*		
	Explicit	Implicit	Total	Explicit	Implicit	Total	Explicit	Implicit	Total
Text	#/%	#/%	#/%	#/%	#/%	#/%	#/%	#/%	#/%
Pearson	82/27.7	170/57.4	252/85.1	11/3.7	22/7.4	33/11.1	2/0.7	9/3.0	11/3.7
Glencoe	25/6.1	283/68.5	308/74.6	47/11.4	46/11.1	93/22.5	1/0.2	11/2.7	12/2.9
Holt	14/20.3	38/55.1	52/75.4	3/4.3	10/14.5	13/18.8	2/2.9	2/2.9	4/5.8

The Holt textbook had a higher frequency of recording units aligned with some of the coding categories within this standard than one, or sometimes both, of the other textbooks. For example, 20.3% of the Holt textbook's recording units were explicitly aligned with the *Knowing* category of this standard. This frequency is much higher than the frequency of recording units in the Glencoe textbook that were explicitly aligned with this category (6.1%). The Holt textbook also had a higher frequency of recording units explicitly aligned with the *Applying* category than the Pearson textbook did (4.3% Holt, 3.7% Pearson), as well as a higher frequency of recording units implicitly aligned with the *Applying* category than either the Pearson or Glencoe textbooks (14.5% Holt, 11.1% Glencoe, 7.4% Pearson). Finally, the Holt textbook had the highest frequency of recording units aligned with the *Reasoning* category out of all three textbooks (5.8% Holt, 3.7% Pearson, 2.9% for Glencoe). It is important to note that in every one of the cases cited above, the Holt textbook, although it may have had a higher frequency of recording units aligned with a given coding category, always had a lower number of actual recording units aligned with that category than the Pearson and Glencoe textbooks did. In fact, in most of those cases, the number of recording units from the Holt textbook was much lower than the number of recording units from the other two textbooks.

Chapter 5

Discussion

With the advent of the second reform movement in science education several decades ago, the focus of science education in the United States has shifted to embrace an approach of developing science literacy for all Americans, instead of just for those who plan to become scientists (NRC, 2012). According to the new *Conceptual Framework for K-12 Science Education* (2012), "a compelling case can . . . be made that understanding science and engineering, now more than ever, is essential for every American citizen" (p. 7). The specific science literacy goals toward which the science education community is working, as well as the framework for how this is to be accomplished, has been provided through the publication of the science education reform documents: *Science for All Americans: Project 2061* (AAAS, 1990), *Benchmarks for Science Literacy* (AAAS, 1993), and the *National Science Education Standards* (NRC, 1996). However, some student populations, such as ELLs, often have built-in barriers that cause them to require extra instructional support in order for them to successfully develop the kind of science literacy articulated in these documents (Mount-Cors, 2008).

Unfortunately, the teachers who tend to teach these groups of students are often underprepared and, thus, unable to provide this support (Barnett & Hirsch, 2005). Such teachers do have recourse to a number of resources: documents which have been labeled the ELL standards. These include the *Benchmarks for Science Literacy* (AAAS, 1993), the CREDE standards (University of California Berkeley Graduate School of Education, 2002), the WIDA standards (Board of Regents of the University of Wisconsin System, 2007), and the TIMSS standards (National Center for Education Statistics, 2011). These documents were designed to help teachers provide all their students with access to the content knowledge, pedagogy, language skills, and cognitive ability that they need in order to be successful in school and in life. By informing their teaching with the recommendations found in the ELL standards, science teachers would be more likely to achieve the outcomes envisioned in the science education reform documents: higher levels of science literacy for all Americans.

In spite of the availability of these resources, many teachers of ELL students often rely heavily instead on the course textbook to inform their instructional decisions (Stern & Roseman, 2004). Science textbooks constitute a sort of de facto curriculum in classrooms in the U.S. (Radcliffe, Caverly, Peterson, & Emmons, 2004). The publishers of these textbooks, being aware of both the science education reform documents and the ELL standards, have updated their textbooks to include textual tools for teaching ELLs. Publishers claim that these textual tools are aligned with both the science education reform documents and many aspects of the ELL standards, and that, by using them in their classrooms with their ELL students, teachers will be supporting their students' learning in such a way that ensures success for all (Biggs et al., 2009; Miller & Levine, 2010; Pearson, 2012; Postlethwait & Hopson, 2006).

Given the foregoing, it can be argued that the opportunity for ELL students in the U.S. to become science literate may rest on how well the textual tools for teaching ELLs, found in science textbooks, align with the ELL standards. Therefore, the purpose of this study was to determine how the textual tools for teaching ELLs, found in the three most-used secondary biology textbooks in the U.S., align with the ELL standards.

Summary of Alignment of Textbooks with the ELL Standards

In this study, it was revealed that all three of the textbooks that were analyzed for the study had some level of alignment with all four of the ELL standards. In other words, at least some textual tools in all three textbooks matched some portion of the benchmarks, the CREDE standards, the WIDA standards, and the TIMSS standards. This is encouraging, in the sense that textbook publishers do in fact seem to be attending to the need to provide support for ELLs in their development of science literacy. And, given that a large number of secondary science teachers in the U.S. rely heavily on textbooks as the curriculum for their classes, as well as the fact that the textbooks analyzed for this study are the most used secondary biology textbooks in the U.S., it is likely that many ELLs have the opportunity to be taught by teachers using some of these aligned textual tools.

However, the frequency of the alignment between the textbooks and the standards, the specific coding categories in the standards with which the textual tools in the textbooks were aligned and not aligned, as well as the strength of these alignments, are all causes for concern. This is because the alignment between the textual tools in the textbooks and the standards is not particularly high. Further, this alignment leaves out some important categories in all four of the standards. Finally, the alignments between the textual tools and the standards tend to be weak in their strength.

In this section, each of these three concerns will be discussed in turn, including an examination of how each standard's alignment with the three textbooks relates to that concern. The body of this chapter is organized according to the following sections: frequency of alignment of textbooks with the ELL standards, coding categories that the textual tools were most aligned with, and strength of alignment.

Frequency of Alignment of Textbooks with the ELL Standards. As mentioned above, all three of the textbooks had some alignment with all four ELL standards. However, each textbook had a different frequency of alignment, and, from an overall perspective (i.e., alignment of all textual tools with all the standards), none of them had particularly high levels of frequency (see Table 1). The Pearson textbook had the highest overall frequency of alignment (60.5%) followed closely by the Glencoe textbook (57.2%). Neither of these levels of frequency is particularly high, although they are much higher than the overall frequency of the Holt, Rinehart, and Winston textbook (hereafter referred to as the Holt textbook), which had an overall frequency of alignment of 26.9%. This frequency of alignment with all the standards taken together, especially the very low frequency of the Holt textbook, is concerning, given that the publishers of these textbooks claim that by using these textual tools with their ELL students, teachers will be supporting their students' learning in accordance with the recommendations found in the ELL standards. Such claims are clearly not the case, at least 39.5% of the time in the case of the Pearson textbook, 42.8% of the time in the case of the Glencoe textbook, and 73.1% of the time in the case of the Holt textbook.

Benchmarks. Of all the standards, the three textbooks analyzed in this study had, by far, the lowest frequencies of instances of alignment with this standard. This is disturbing because it indicates that, whatever other support is offered to ELLs through the textual tools in these three textbooks, content support is the least often provided. The biology content contained in these textbooks is not made accessible to ELLs through these textual tools to a very high degree, as revealed by the frequency of instances of alignment of the three textbooks with this standard (22.7% Pearson, 19.1% Glencoe, 13.7% Holt).

CREDE standards. The frequency of instances of alignment between the textbooks and this standard was higher than for the benchmarks, but still not particularly high (69.7% Pearson, 41.8% Glencoe, 25.5% Holt). This seems to be encouraging, especially since this standard is the one designed to help teachers modify their pedagogy in ways that will facilitate higher levels of learning among at risk students, including ELLs. However, as with the benchmarks above, these frequencies still do not reflect a high level of alignment between the textual tools in the textbooks and the CREDE standards. Further, future sections of this chapter will reveal that, when examined closely, these instances of alignment might not provide the opportunities for facilitating higher levels of learning that these frequencies might at first suggest.

WIDA standards. This standard had the second highest frequency of instances of alignment with the textbooks (73.9% Pearson, 79.0% Glencoe, 29.4% Holt). With the exception of the frequency for the Holt textbook, which is still very low, these high frequencies seem to be a positive finding, especially since this is the standard that provides linguistic and language support, something that all ELLs need. However, as with the CREDE standards above, future sections of this chapter will reveal that, when examined closely, these instances of alignment might not provide the level of linguistic and language support that these frequencies might at first suggest.

TIMSS standards. This standard had the highest frequency of instances of alignment with the textual tools in the textbooks of all the standards (75.8% Pearson, 88.7% Glencoe, 39.2% Holt). With the exception of the frequency for the Holt textbook, which is still very low, these frequencies seem to be reflect high levels of alignment between the textbooks and the TIMSS standards. If accurate, this finding would be heartening, as this is the standard that is designed to promote cognition with the content area (i.e., higher levels of thinking about and within science), an ability that is becoming ever more necessary in order for individuals to successfully function in contemporary society (Atweh & Goos, 2011; Delen & Bulut, 2011; National Center for Education Statistics, 2011). However, as with the CREDE standards and WIDA standards, future sections of this chapter will reveal that, when examined closely, these instances of alignment might not provide the level of cognitive development that these frequencies might at first suggest.

Coding Categories Most Frequently Aligned with Textual Tools. The sheer frequency of recording units from the textbooks that are aligned with the standards, while useful, does not tell the whole story of the alignment of these three textbooks with the ELL standards. There are two reasons for this, the first of which will be discussed in this section.

As indicated earlier, the fact that some textbooks had high frequencies of recording units aligned with a number of the ELL standards is not necessarily an indication that such textbooks are well aligned with the standards. Most of the recording units from these textbooks were aligned with just one or perhaps two of the coding categories in a given standard. In these cases, other categories, including some categories that are very important to developing science literacy, were left with just a few, and, in some cases, no instances of alignment at all. This is concerning for two reasons. First, it could result in the inaccurate perception that just because a textbook has a high frequency of instances of alignment with a standard, that it is well aligned with that whole standard. Second, teachers using only these tools to accomodate ELLs might not provide adequate support for learning some of the most important content. They might not attend to aspects of the standards that are most useful for helping ELLs, resulting in limited opportunities for ELLs to fully develop their science literacy.

Benchmarks. Of the few instances of alignment between the textual tools in the textbooks and this standard, the vast majority of them were with one coding category: *The Living Environment* (69.7% Pearson, 66.7% Glencoe, 88.2% Holt). This meant that the *Nature of Science* category had very few instances of alignment, and, in the case of the Holt textbook, it had none (10.7% Pearson, 7.9% Glencoe, 0% Holt). This is concerning because if ELLs are to develop their fundamental sense of science literacy (e.g., reading, writing, communicating in science; Norris & Phillips, 2003), the *Nature of Science* category would be an extremely important category for them to understand. Unfortunately, this is the category that has the least alignment with the three textbooks, and may be the least accessible to ELLs.

CREDE standards. Of the instances of alignment between the textual tools in the textbooks and this standard, the vast majority of them were with one coding category: *Language Development* (69.7% Pearson, 59.5% Glencoe, 66.7% Holt). This becomes even more interesting when one considers that almost all of the instances of alignment with this category were with one indicator within the category: "The teacher provides frequent opportunity for students to interact with each other and the teacher during instructional activities" (University of California Berkeley Graduate School of Education, 2002, p. 2). In other words, by simply recommending that teachers have students work in pairs or groups, or that the teacher interact with students in any way at all, a given textual tool can be said to be aligned with this standard, without attending to the vocabulary and literacy skills that students need. As it turns out, it was very common in all three of the textbooks for a textual tool to make no recommendations that match this standard at all, other than to direct the teacher to have students work in pairs or groups. By not attending to the vast majority of the recommendations found in the CREDE standards, textbooks such as the Pearson textbook (with a frequency of 69.7%) can still claim to have a moderate level of alignment with the CREDE standards simply by instructing teachers to nearly always put their students in groups, regardless of what they happen to be doing. While the strategy of having students work in pairs and partners certainly holds an important place in the suite of pedagogical strategies, if it is not done in a way that builds literacy skill, it can hardly be said that a textbook is closely aligned with all or most of the pedagogical recommendations in the CREDE standards.

That would be a misleading and inaccurate interpretation of the frequency of instances of alignment between one of these three textbooks and this standard.

Similarly, the instances of alignment with the *Joint Productive Activity* coding category (29.2% Pearson, 33% Glencoe, 18.2% Holt) almost all came from a single indicator within that category: "The teacher designs instructional activities requiring student collaboration to accomplish a joint product" (University of California Berkeley Graduate School of Education, 2002, p. 1). So, as with the *Language Development* category above, as long as a textual tool instructs teachers to ensure that students are in groups and working on something together, that textual tool is aligned with the CREDE standards. Once again, this is a fine strategy. However, when almost all the recording units aligned with this category are with this single indicator, the concern about potential misrepresentation and misinterpretation of the degree of alignment between a textbook and the entire CREDE standards is applicable.

Two other points are worth mentioning. The *Contextualization* category had very few instances of alignment, because its indicators were, for the most part, not present in any textual tools, either explicitly or implicitly (1.1% Pearson, 6.5% Glencoe, 15.2% Holt). However, the *Instructional Conversation* category had very few instances of alignment (0% Pearson, 0.9% Glencoe, 0% Holt), and the *Challenging Activity* category had no instances of alignment at all with any textbook, for different reasons. First, the *Instructional Conversation* category is designed to function as informal ongoing assessment, which is not the purpose of most of the recommendations in the textual tools. Furthermore, the language of most of the indicators in these two categories is such that it would be impossible to determine, through an examination of a textual tool alone, whether an instance of alignment existed between that textual tool and these categories. One would have to know exactly how a teacher was going to implement the recommendations in a given textual tool, including the things said to the students and the responses received, in order to know if a match existed or not. Since such a determination is beyond the design of this study, such indicators could not possibly be coded as instances of alignment with the textbooks.

Finally, the researcher was generous in his coding of the CREDE standards, by coding a match with a single indicator in the CREDE standards as an instance of alignment. This is because the standards were intended to be used in such a way that all the indicators in all the coding categories of the CREDE standards would be incorporated into instruction. According to the University of California Berkeley Graduate School of Education (2002), who designed the standards, a teacher's pedagogical paradigm must be altered to meet every indicator of all five standards in order to be supporting his or her at-risk learners in a way that is consistent with the standards. Had the researcher applied this interpretation to the textual tools in this study, there would have been no instances of alignment with the CREDE standards at all.

WIDA standards. Most of the instances of alignment between the textual tools in the textbooks and this standard were evenly split between the *Sensory Support* coding category and the *Interactive Support* coding category. The fact that most of these instances of alignment were aligned, for the most part, with just one indicator in each of these categories, raises the same concerns articulated in the section on the CREDE standards. The indicator: "Illustrations, Diagrams, & Drawings" (Board of Regents of the University of Wisconsin System, 2007, p. RG-21) dominated the instances of alignment with the *Sensory Support* category, and the indicators: "In Pairs or Partners" (Board of Regents of the University of Wisconsin System, 2007, RG-21) and "In Triads or Small Groups" (Board of Regents of the University of Wisconsin System, 2007, RG-21) dominated the instances of alignment with the *Interactive Support* category.

Again, a textbook can have a high frequency of alignment with a standard when most of those alignments are with only two indicators in two coding categories, out of a total of 37 indicators in five coding categories in the entire standard. By containing large numbers of textual tools that recommend that teachers have students get in pairs or groups to make a drawing, these textbooks appear to have a high level of alignment with the WIDA standards. However, the textbooks are not well aligned with the many other indicators in these categories and, further, have little alignment with the third category in this standard: *Graphic Support* (17.9% Pearson, 10.4% Glencoe, 10.8% Holt). This could lead to the inaccurate perception that textbooks such as Pearson (73.9% textual tools aligned with WIDA) and Glencoe (79.0% textual tools aligned with WIDA) have high levels of alignment with all of the WIDA standards, when in fact the argument could be made that they do not.

There is one further problem caused by this phenomenon. Teachers who use these textbooks as a curriculum may be limiting the opportunities that their students have to create, interpret, or use *Graphic Supports*, including charts, tables, graphs, and graphic organizers. This may result in their students missing out on one of the most important aspects of developing science literacy, especially the fundamental sense: the ability to communicate within and about science using the modes of representation commonly used in the language of science (Norris & Phillips, 2003).

TIMSS standards. Of the instances of alignment between the textual tools in the textbooks and this standard, the vast majority were with one coding category: *Knowing* (85.1% Pearson, 74.6% Glencoe, 75.4% Holt). As this is the standard that is designed to develop cognitive ability within science, this is deeply concerning, given that the *Knowing* category is that of the lowest levels of thought. This concern is compounded by the fact that this very high frequency of instances of alignment with the *Knowing* category necessitates low frequencies of instances of alignment with the *Applying* category, which represents middle levels of thought (11.1% Pearson, 22.5% Glencoe, 18.8% Holt). It further necessitates very low frequencies of instances of alignment with the *Reasoning* coding category, which represents the highest levels of thought (3.7% Pearson, 2.9% Glencoe, 5.8% Holt). This situation, again, leads to the concern that a misleading perception may arise regarding the alignment that exists between an ELL standard and textbooks, such as Pearson (75.8% textual tools aligned with TIMSS) and Glencoe (88.7% textual tools aligned with TIMSS), when those high levels of alignment are concentrated on one category, to the near exclusion of the other two categories. Even more concerning, however, is the implication that this domination of the textbooks by the *Knowing* category has for students who are being taught with these texts. Such low levels of frequency of alignment with the *Reasoning* category suggest that, by following the recommendations in the textual tools in these textbooks, teachers are routinely denying their students the opportunity to think at high levels. This has grave potential consequences for the vision of achieving high levels of science literacy for all Americans.

The low frequency of recording units aligned with the *Applying* and *Reasoning* categories was not surprising. This is because the TIMSS standards dovetail with the CREDE standards. The *Challenging Activity* category of the CREDE standards is actually intended to be cognitively challenging, at the *Applying* and *Reasoning* levels of thought. When the researcher did not identify any recording units aligned with the *Challenging Activity* category of the CREDE standards, it was very unlikely that there would be very many instances of alignment between the textual tools and the *Applying* and *Reasoning* categories of the TIMSS standards.

Strength of Alignment. As discussed above, the sheer frequency of recording units from the textbooks that are aligned with the coding categories in the standards does not tell the whole story about the alignment of the textbooks with the standards. This section is devoted to the second reason why this is the case.

Most of the instances of alignment were implicit, rather than explicit in strength. The lack of explicit, word for word matches between textual tools and standards results in a weak instance of alignment. This is concerning because it likely makes it more difficult for the teachers using these textual tools to connect their ELL students with the content, language, and cognition that the textual tool was ostensibly designed to help develop in their minds.

This concern takes on even greater significance for the many teachers of ELLs who rely heavily on the course textbook as the curriculum for the science classes they teach. If such teachers rely exclusively on the textual tools for teaching ELLs as the sole modification that they make to their classroom instruction for their ELL students, then the argument could be made that such students are not being adequately supported in their development of science literacy.

Benchmarks. Of the few instances of alignment that did exist between the benchmarks and the textual tools in the textbooks, almost all of them (94.6% Pearson, 93.7% Glencoe, 100% Holt) were implicit. This is of great concern because it indicates that most of the alignments between the textbooks and this standard are weak alignments. This is of especial concern for ELLs whose teachers are dependent on following the textbook as a curriculum, because if most of the alignments between the textual tools and the benchmarks are weak, it will be more difficult to connect students' developing content knowledge with the content recommendations in the standards. And since the standards articulate precisely what students should know before they graduate, any barrier to developing that science content knowledge makes it less likely that ELLs will achieve high levels of science literacy.

This further suggests that reports of the overall frequency of instances of alignment that exist between the textbooks and the benchmarks (22.7% Pearson, 19.1% Glencoe, 13.7% Holt), low as they might be, may still be misleading in terms of how much of the content in the text is actually made accessible to ELLs according to the recommendations found in the standards. In other words, as low as the frequencies reported here might seem to be, the actual strength of the alignment between the textbooks and the benchmarks is likely even lower than that.

CREDE standards. Interestingly, all instances of alignment with this standard were explicit. This appears to be a positive finding. However, it may not actually be that significant. This is because, due to the nature of these standards, and the language that was used to write them, the key words that served as indicators of an instance of alignment were simply either present in the textual tool or they were not. If they were not present, then, unlike the benchmarks, there was no possibility of inferring an implicit instance of alignment.

An example of this can be found in the instances of alignment with the following indicator of the *Joint Productive Activity* category: "The teacher organizes students in a variety of groupings, such as by friendship, mixed academic ability, language, project, or interests, to promote interaction" (University of California Berkeley Graduate School of Education, 2002, p. 1). A given textual tool always used a derivative of the word "group," which is found in this indicator, to indicate intentional groupings of students, as opposed to groupings based on some other factor. There were never any words used in any of the textual tools, besides the word "group" and its derivates, to denote the intentional grouping of students. For this particular set of standards, having 100% of the instances of alignment between the textbooks and the standards be explicit, as opposed to implicit, does not appear to be particularly meaningful or suggest that any added benefit is gained by either teacher or students from this phenomenon.

WIDA standards. With the exception of some of the instances of alignment with the *Interactive Support* category (9.4% implicit in Pearson, 13.2% implicit in Glencoe, 2.7% implicit in Holt), all the instances of alignment with this standard were explicit. As with the CREDE standards, above, this does not seem to be particularly meaningful for the purposes of this study. Indicators from the coding categories in the standard were either present in the textual tools or they were not.

An example of this is the fact that indicators found in the *Graphic Support* coding category, such as "charts," "tables," and "graphs," were always identified, in the textual tools of the textbooks, by these same terms (Board of Regents of the University of Wisconsin System, 2007). A recommendation in a textual tool to have students make a chart always included the use of the term "chart." In the case of the WIDA standards, there was never an opportunity to infer the existence of an idea, in a recording unit of a textual tool, that was not already coded as an explicit instance of alignment. A second example includes the fact that many of the instances of alignment with this standard matched one of the following two indicators: "In Pairs or Partners" (Board of Regents of the University of Wisconsin System, 2007) and "In Triads or Small Groups" (Board of Regents of the University of Wisconsin System, 2007). A given textual tool either used the words "pair[s]," "partner[s]," or "group[s]." There were never any words used in any of the textual tools, besides these words, to denote students working together in pairs or small groups.

The exception to this rule, in the case of the WIDA standards, was the *Interactive Support* category. The WIDA standards specifically identify the instructional activities of modeling, questioning, and feedback as instances of alignment with the "With Mentors" indicator of the *Interactive Support* category (Board of Regents of the University of Wisconsin System, 2007). However, these instances of alignment often had to be inferred from the language of a given textual tool. This was because the words "modeling," "questioning," and "feedback" were not necessarily present in the textual tool, even though the recommendations of the textual tool were such that one of those three strategies was a necessary part of the recommended activity.

Due to the above considerations, for this particular set of standards, having nearly 100% of the instances of alignment between the textbooks and the standards be explicit, as opposed to implicit, does not appear to be particularly meaningful. Thus, as was the case with the CREDE standards above, it is not apparent that any added benefit is gained by either teacher or students from this phenomenon.

TIMSS standards. Of the many instances of alignment that exist between the textbooks and the TIMSS standards, the majority were implicit, as opposed to explicit (67.9% Pearson, 82.3% Glencoe, 72.5% Holt). This is a cause for concern, especially for ELL students whose teachers are not familiar with the standards, and, thus, rely on the course textbook for curricular and instructional decisions. This is because the kinds of thinking that, according to the TIMSS standards, students need to engage in, in order to function effectively in a world in which science and technology has permeated every aspect of our lives (NRC, 2012), are not, for the most part, labeled in the textual tools of the three textbooks analyzed in this study. Most of the opportunities found in the recording units of the textual tools to classify, hypothesize, synthesize, relate, infer, model, evaluate, and a host of other cognitive tasks, are not actually found, by name, in the textual tools. It is likely that an underprepared teacher, which is the kind of teacher that many ELLs have, will not necessarily recognize the level and type of cognition that is being recommended by a given textual tool, even though it is present implicitly in the tool. The levels of cognition required by the recommendations in the textual tools are encrypted, as it were. The concern is that that encryption might fool the teacher as well as the student, leading to students not being pushed to engage in the kind of thinking that is being asked of them by a given textual tool, because the teacher was unable to identify its presence, and would not necessarily insist that students incorporate it into their learning activities.

Implications for Various Constituents

The implications of this study are relevant for a broad range of stake-holders within the science education community. Foremost among these are textbook publishers, teachers of ELLs, those who design and administer teacher preparation programs, and students.

Textbook publishers. The publishers of the textbooks analyzed in this study have created a vast number of textual tools intended to enhance the learning experience of ELLs, with the claim that they align, at least in part, with the ELL standards, and that they align entirely with the *National Science Education Standards* (NRC, 1996). Some of the textual tools do align with the ELL standards. However, many of them are not aligned with the standards at all. Others are aligned with just one or two coding categories, or even with just one or two indicators in one or two coding categories, excluding much of the standards from students' learning activities. In many cases, the categories that the textual tools do align with constitute the easiest, most convenient ways to align with the standards, leading to high levels of alignment with the lowest levels of thinking, the easiest pedagogical strategies such as doing nothing but constantly placing students in groups, and the easiest methods of support, such as constantly having students draw pictures. Furthermore, such instances of alignment are also often only weakly, or implicitly aligned with the standards, minimizing the likelihood that students' learning will be connected with what the standards intend for them to learn. As the science education community presses forward in its goal of achieving science literacy for all, textbook publishers are in a position to participate in this effort more fully by correcting these deficiencies in the textual tools of the textbooks. In this manner, by bringing their textbooks more in line with the standards whose endorsement they already claim, they will become more active participants in the effort to achieve higher levels of science literacy for all.

Teachers of ELLs. Adherence to the recommendations in the textual tools for teaching ELLs in secondary science textbooks by secondary teachers of ELLs may seem, on the surface, to make the content, cognition, and language that students need to acquire in order to become more science literate more accessible to ELLs. However, the results of this study suggest that such a course of action is less likely to accomplish that aim than it might seem. The implications of this study, for teachers, include the caution that they use these textual tools judiciously, perhaps as a source of ideas, but not in a slavish fashion. In spite of the fact that many of these textbooks claim to be one curriculum package that "ensures success for all students" (Pearson, 2012, para. 1), the use of supplemental materials, including the ELL standards themselves, to inform instructional decisions, would likely improve the results of teachers' efforts to make the desired outcomes of instruction more accessible to ELLs.

Teacher Preparation Programs. Given the high proportion of underprepared teachers who are reliant on textbooks for curriculum and instruction (Barnett & Hirsch, 2005; Stern & Roseman, 2004), it would behoove those involved with teacher preparation programs to prepare their preservice teachers to more effectively engage in standards-based teaching. This will require, first, greater exposure to the standards, but also the ability to be more critical consumers of textual and other teaching materials. Preservice teachers will need to be better prepared to independently design and implement standards-based curriculum and instruction on their own.

Students. The most important implication of this study relates to the many ELL students who are taught by teachers who are using the textbooks analyzed in this study, and, specifically, using the textual tools that were the focus of this study. Given that these textual tools are so problematic, including low levels of alignment, alignment with just a few categories in the standards to the exclusion of others, and instances of alignment that are weak, significant concern exists as to the effectiveness of the learning experiences that these students may be having in their science classrooms. Students whose teachers rely heavily on such textbooks, including the textual tools found therein, are, perhaps, unlikely to develop the high levels of science literacy that is the goal of the second reform movement in science education, as articulated by the science education reform documents. The future content knowledge, cognitive abilities, and linguistics and language skills of such students, then, may be in jeopardy. This calls into question these students' future ability to engage in full participation in a world that is ever more permeated with science and technology (NRC, 2012; Schleicher & Stewart, 2008). Further, it calls into the question the ability of the science education community to achieve the goal of the second reform movement: high levels of science literacy for all Americans.

Recommendations

While this study provided useful data on how three textbooks are aligned with the ELL standards, it was limited in its scope. It is recommended that further research be conducted that picks up where this study left off. The limitations of the research question and design of this study were such that some critical aspects of the textual tools in these textbooks were not analyzed. One of these aspects is how much secondary science teachers actually use the textual tools in their instruction. The researcher made the assumption that some teachers must use them, for a number of reasons which are described in chapter 2. However, there are no extant data to indicate how much the textual tools are actually used by secondary science teachers, possibly because they are of relatively recent origin.

Another aspect of the textual tools that is important, but is not addressed in this study, is how effective the recommendations in the textual tools actually are at promoting the outcomes identified in the standards, via the instructional recommendations found in the textual tools. Although it was useful for this study to identify how the textual tools were aligned with the standards, it would also be useful to know how effective those same instructional tools are when implemented in the classroom. For example, when coding a given textual tool for one of the standards (e.g., the benchmarks), the researcher occasionally encountered what appeared to be a very pedagogically sound recommendation that could not be coded as an instance of alignment with the benchmarks because it lacked content. Conversely, the researcher coded textual tools as instances of alignment with the benchmarks, because they contained the necessary content, that seemed very pedagogically weak. So, while providing useful insight into how aligned the textbooks are with the standards, this study's utility is limited. It is recommended that further studies in which textual tools, especially those that align with the standards, are analyzed to determine their actual effectiveness in the classroom. Knowing how aligned the textual tools are with the standards is helpful. Gaining the further knowledge that could be provided by attending to the gains in content, cognition, and linguistics and language that are actually made by students taught from the recommendations found in the tools that are aligned with the standards would be even more useful. When that is known, then the utility of the textual tools for teaching ELL students in secondary biology textbooks will be understood to a greater extent.

Future study should also include an examination of how different teachers use the textual tools. Do they use them in a similar manner? If not, what might their background (e.g., experience, level of certification, highly qualified status, etc.) have to do with any differences in their use of the tools? Also of interest would be to identify which teachers seem to achieve better results from using the tools, and what factors might impact such differences.

It would be of further interest to look at science textbooks in other content areas (e.g., chemistry, physics, earth science) to determine how they might compare with the results of this study. It would be useful to know if textbooks in other science content areas tend to have many more or many fewer textual tools for teaching ELLs than biology textbooks do. Other questions of interest include whether the textual tools in other content areas are formatted differently from those in biology textbooks. Finally, whether such textbooks are more or less aligned with the ELL standards than the biology textbooks would, perhaps, be the most useful outcome of such a study.

The next recommendation is that textbook publishers fully align their textual tools with the ELL standards. Given the fact that so many teachers of ELLs rely exclusively on textbooks to make their curricular and instructional decisions, these textual tools need to be fully aligned with the standards if the science education community is to move closer toward the goal of science literacy for all.

Another recommendation addresses the issue, introduced earlier, that the ways in which these textbooks align with the CREDE and TIMSS standards suggest that the recommendations in the textual tools are just instructional strategies. They do not seem to push a teacher into changing his or her pedagogy in such as way as to meet the needs of at-risk learners, including ELLs, which is the purpose of the CREDE standards, and, by extension, the TIMSS standards.

This causes one to wonder what exactly is driving the creation of these textual tools, and their placement in secondary biology textbooks. The answer to this question is intriguing, and would be important to explore.

Another issue that arises out of this analysis is the question of the difference between instruction that is effective for all learners versus instruction that is specifically effective for a particular group of learners. There is an ongoing debate within the education community on this issue (Meltzer & Hamann, 2005). This tension is reflected in the textual tools analyzed in this study. The textual tools in both the Glencoe textbook and the Holt textbook were labeled in such a way that teachers were directed to use them, not just for instructing ELLs, but also for instructing other groups of students as well. These other groups of students, with whom teachers were instructed to use the textual tools for teaching ELLs, included students who were labeled *basic* by the Holt text (Postlethwait & Hopson, 2006), and students who were labeled *below level*, *on level*, and *above level* by the Glencoe text (Biggs et al., 2009). The textual tools in the Glencoe text were also labeled for use in *cooperative learning* situations (Biggs et al., 2009).

On the other hand, the textual tools for teaching ELLs found in the Pearson text were labeled specifically for use only with ELLs. Other groups of students, such as those needing *remediation*, have their own set of instructional recommendations provided by the publishers of this text. This brings up an interesting question. Should the recommendations in the textual tools for teaching ELLs be used for all groups of students, at least in some situations, as the publishers of the Glencoe text seem to suggest? Or is good teaching just good teaching, which should be applied to all learners? At what point do the cultural, identity, and literacy differences that exist between ELLs and mainstream students require separate instruction for ELLs that is just for them and no other group of students?

Conclusions

In the decades since the publication of the science education reform documents, there has been a push for reforming how science is taught in public schools. This push has emphasized science for all, including for groups, such as ELLs, that have historically been marginalized in the classroom because the content has not always been made available to them in ways that they can access. ELL standards have been published, which articulate the various ways that such groups, including ELLs, should be instructed in order to support their learning. Knowing that teachers rely heavily on textbooks for their curricular and instructional decision making, and in an effort to provide support for ELL students, publishers have provided textual tools for teaching ELLs in the recent editions of their science textbooks. Publishers claim that these tools are aligned with the standards for teaching ELLs. Due to the reliance of many teachers of ELLs on textbooks, it can be argued that many ELLs are taught using the recommendations found in these textual tools. How these tools align with the ELL standards becomes very important.

While it is heartening such resources exist, and accomodations of some kind are being made to support ELLs' learning, many such textual tools do not align with the standards, and do not provide adequate support for ELLs' development of science literacy. Even for those tools that do align with the standards, such alignment is often superficial. It does not follow that, because a textual tool aligns with a standard, it can be claimed that that tool provides the needed support for the instruction of ELLs as they develop science literacy. Many tools align with the standards while still remaining fundamentally flawed in such ways as always putting students in groups every time they are assigned to complete a task, or by having them make large numbers of drawings. Other textual tools are simply weak (i.e., implicit) in their alignment with the standards, resulting in tenuous connections between the instructional recommendations found in the textual tools and the desired outcomes found in the standards. The textual tools do not constitute a robust treatment of academic content, as proposed by the benchmarks. They do not support high level of development of the fundamental sense of science literacy, through the use of academic and content language, as advocated by the WIDA standards. And they do not scaffold cognitive develop or build language fluency, which is the purpose of the CREDE and TIMSS standards. Even if the instructional recommendations in the textual tools were strengthened in treatment of content and literacy, they still lack the necessary pedagogical shift required to effectively implement the CREDE standards.

A two-pronged effort is suggested. On the one hand, publishers need to include higher-quality, more aligned textual tools in their texts. On the other hand, teachers need to be proficient in their pedagogy and content areas, as well as more familiar with the ELL standards, in order to be capable of using their textbooks, including the textual tools in their textbooks, as a resource instead of as a curriculum.

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Appendix A

Sample Textual Tool For Teaching Diverse Learners

ELL

Focus on ELL:
Extend Language

BEGINNING AND INTERMEDIATE SPEAKERS Have students write the term science in a **Vocabulary Word Map**. Then, have them write words or phrases that describe attributes of science or topics related to science in the lower boxes. Encourage beginning speakers to use one of the boxes to make an illustration to represent the process of science. After students have completed their vocabulary word maps, have them form small groups to discuss how their maps are similar and how they are different. Circulate among the groups, and have students share some of their responses with you.

Study Wkbks A/B, Appendix S32, Vocabulary Word Map. **Transparencies,** GO17.

Appendix B

Explicit Recording Instructions

The following constitutes a set of explicit recording instructions, thus serving as a training of sorts for the purpose of eliminating bias in coding. Having used these instructions to complete a test of inter-rater reliability on the textual tools for teaching ELLs found in the three textbooks used in this study, they were then used by the researcher to code the rest of the texts (Stemler, 2001).

Overall Instructions for All Standards:

1. A match with more than one coding category within a standard was counted as more than one instance of alignment. Likewise, a match between a textual tool and more than one indicator of the same coding category within a standard was counted as a separate instance of alignment.
2. Whether or not a textual tool matched a given standard was not a commentary on the quality of the recommendation in the textual tool (i.e., it was not an indicator of how good, pedagogically, the recommendation was). It was just an indicator of whether or not the publisher of the textbook was attending to the ELL standards.
3. The researcher made the decision to count all tools, including multiple tools per chapter or section of a given textbook, as separate textual tools, instead of combining all the textual tools in a section or chapter of the text and counting them all as a single textual tool. The decision was made that clumping multiple textual tools (which occurred in two out of the three textbooks) and counting them all as a single textual tool would make a comparison across all the textbooks an unfair comparison. In this way, the researcher accounted for the sheer number of tools, or the number of efforts the publisher made to support ELLs.

4. The researcher only counted instances of alignment that fell within the biology content area. This meant that for instances of alignment between textual tools and the standards that matched the standards outside the biology content area (e.g., physics or chemistry in the benchmarks or language arts in the WIDA standards), the researcher had to make a decision about what to do when a match with the standards outside the biology content area was encountered. This was a difficult decision because the argument could be made that all science disciplines are interrelated, and, therefore, are technically biology (e.g., biochemistry, or the chemistry of life, is chemistry that is also biology). However, the researcher decided that anything that was not specifically identified as a learning objective in the biology standards would not be coded as a match, regardless of whether it could be argued that it was technically still biology. Thus, there were a number of instances of alignment with the benchmarks and the WIDA standards that were not recorded as instances of alignment. However, these instances still needed to be reported somehow. Instead of adding a new column to the text analysis coding forms or creating a separate coding form for these events, the researcher decided to simply report the number of these occurrences in chapter 5 along with a brief description. The researcher attempted to identify patterns associated with these occurrences. Those events that were associated with the benchmarks all occurred relatively close to the front of the textbooks, during the so called review chapters. However, those events associated with the WIDA standards occurred in every chapter of the Holt textbook, and there were no occurrences associated with the WIDA standards in the Pearson or Glencoe textbooks.

5. The researcher's coding of the textbooks did not be attend to the body of the text, just the textual tools themselves.

6. This rule is an outgrowth of rule five above, and was, occasionally, an exception to it. It addressed the issue of what to do when the textual tool referred students right back to the text in the section. Should the researcher code that? Or, again, should he just code the actual words that are in the textual tool and absolutely nothing else? The researcher determined to code the text in the section, but only by specifically using the section headings, subheadings, and bolded terms. He chose to do this because it wouldn't be fair to claim that the publisher makes no provision for ELLs having access to the content if they are trying to point them to that content (caveat: as long as that content was on grade level and was in the biology content standards, as opposed to the standards for some other content area. If it was below grade level or not in the biology content standards, then the researcher was forced to conclude that there was no alignment with the ELL standards; see rules four and twelve).

7. The coding only considered the actual recommendation (i.e., the specific task or tasks) contained within the tool, rather than imagining or predicting what the teacher could do with the recommendation in his or her instruction.

8. When a textual tool aligned with part of the coding category of a standard, but not the whole thing (i.e., one or some of the indicators, but not all of them), the researcher decided to count it as an instance of alignment.

9. The implicit matches are interpretative in nature, so the researcher had to look very carefully at the words in both the textual tools and the coding categories when making this distinction.

10. The researcher did not create a separate level of coding for the derived vs. fundamental senses of science literacy, because those ideas are philosophies, and are not found in the standards. However, when coding for some of the standards, such as the WIDA standards, textual tools that dealt with writing, reading, etc (i.e., the tools that address the fundamental

sense of science literacy), were coded as a match, whereas in the benchmarks they were not because there's no content there. The researcher struggled with what to do about the fact that just because an activity has writing or reading in it (or even that it has reading and writing about science), that does not necessarily mean that the reading and writing is scientific in nature. The researcher finally decided not to make that subjective interpretation.

Benchmarks:

11. In order to claim an instance of alignment, there had to be a direct tie of some kind between the textual tool and the body of the text (because the publisher is claiming that the textual tool presents the content in the body of the text in a different way, a way that makes it more accessible to ELLs). In other words, in order for there to be an instance of alignment there had to actually be content (or a tie to content) in the textual tool itself or it must refer the user back to the content in the section (see rule six above).

12. Some (actually many) of the tools, like the example of the textual tool on page 8 in the Pearson textbook, matched the standards, but at a lower grade level than that for which the textbook and the benchmarks were written (grades 9-12). The reason this rule applies specifically to the benchmarks and not the other standards is because the benchmarks are the only standards that make recommendations that are specific to particular grade levels. The researcher did not code these occurrences as instances of alignment, but did mention them in chapter 5. The researcher only counted a match as being an instance of alignment if it matched the standard at grade level. The researcher initially thought that it might be interesting to also look at patterns here and see if most of the lower grade level matches are in the early chapters that are doing review (compare with rule four). However, this was not the case. Matches with coding categories at lower grade levels occurred all throughout all three texts, including many during the final

chapters. As with matches outside the content area, the researcher kept track of such events and reported them in chapter 5, but not on the coding forms (see rule four).

13. This rule describes how the researcher coded the explicit instances of alignment for the benchmarks. This was challenging because, unlike with the other standards, a word for word match with a single word in the benchmarks does not necessarily mean that the recommendation in the textual tools actually leads to learning activities that align with the ideas in the benchmarks. Explicit instances of alignment between the textual tools and the CREDE, WIDA, and TIMSS standards could usually be identified by a simple word for word match with a single word in both the textual tools and the standards. For example, the word "table" in a textual tool always aligned with the word "table" in the WIDA standards (i.e., to create, interpret, or interact in some other way with a table). However, this approach did not work with the benchmarks. For example, the word "membrane" in a textual tool was often part of a recommendation to draw a cell membrane. Drawing a picture of a cell membrane does not accomplish the purpose contained in the ideas of any of the indicators in the benchmarks that contained the word "membrane." So the researcher had to come up with a different rule for how to explicitly code the benchmarks. The rule that the researcher decided upon was as follows: if at least two consecutive words in a textual tool were a word for word match with the same two consecutive words in the benchmarks, that would constitute an implicit instance of alignment between a textual tool and the benchmarks. Even with this rather liberal rule, there were very few explicit instances of alignment identified in any of the textual tools of the three textbooks used for this study (3 from Pearson, 4 for Glencoe, 0 for Holt). An example of an explicit instance of alignment between a textual tool from the Glencoe text and the benchmarks is a word for word

match with the following words from the *Human Organism* coding category in the benchmarks: "immune system . . . attack . . . the body's own cells" (AAAS, 1993).

CREDE standards:

14. For this standard, the ideas were very clearly broken down in the coding categories by the kind of activity that is recommended by the textual tool.

15. The CREDE standards are talking about what the teacher, not student, will do. The researcher had to keep that in mind during the coding process.

16. For the CREDE standards, if there was one item that was aligned repeatedly, the researcher kept a mental note of it for mention in chapter 5, because that was an interesting occurrence.

WIDA standards:

17. The researcher looked for the three kinds of support specifically articulated in the standards document: sensory, graphic, interactive (these were always coded as explicit). Anything else was always implicit (e.g. modeling, feedback, questioning, which are specifically identified in the WIDA standards as instances of the *With mentors* indicator from the Interactive Support coding category, although not word for word; see p. RG-20).

18. When the researcher conducted the cross case comparison, WIDA was a sort of outlier because it focuses on methods, as opposed to content, as the other three standards did.

19. The WIDA standards recommend using posters as sensory supports and charts, tables, and graphs as graphic supports, etc. Some of the textual tools recommend showing the students a poster, chart, table, or graph, which would obviously be an instance of alignment. But some of the textual tools recommend having the students MAKE a poster, table, chart, or graph without ever showing them one. The researcher had to decide if having students make a poster, chart,

table, or graph counted as a match just as much as showing them one did. He decided that, given that the premise of these standards is support, he would count them in the same way.

TIMSS standards:

20. This standard required that the researcher use the Bloom's sentence stems provided in these standards to figure out if the textual tool is asking students to think at the knowing, applying, or reasoning level of cognition.

21. If the same tool asked students to engage in more than one level of cognition during the same recommendation (e.g., both knowing and reasoning), the researcher coded it twice (see rule one).

22. Most of the instances of alignment with this standard were explicit, because the verb stem in the textual tool usually indicated right away which TIMSS category it matched. In fact, in some cases the textual tool actually used the name of a coding category as its verb stem, such as "apply," for example.

Appendix C

Coding Categories - Benchmarks

The following categories were derived from the first of the ELL standards chosen for this study: the *Benchmarks for Science Literacy* (AAAS, 1993). When the benchmarks standards document was created, the American Association for the Advancement of Science (1993) presented their results in the form of what they called *Recommendations* (AAAS, 1993). Each of these Recommendations was given a name, and was then further broken down into a series of individual descriptors of what that recommendation might look like in practice. For the purposes of this study, each of these recommendations was designated as an a priori coding category, because they describe the "levels of understanding and ability that *all* students are expected to reach on the way to becoming science-literate" (AAAS, 1993, p. XIII). Thus, the coding categories for this standard are pre-existing, meaning that they were created by the authors of the standard document itself, instead of by the researcher. There are three of these recommendations, or coding categories: *The Nature of Science, The Living Environment,* and *The Human Organism*. The descriptors of each Recommendation, or coding category, were each designated as a *Description of Category,* and listed next to their respective Recommendation, or coding category.

Table C1

Coding Categories for the Benchmarks for Science Literacy: Recommendations (AAAS, 1993)

Category	Description of Category
Nature of Science	Science is based on the assumption that the universe is a vast single system in which the basic rules are everywhere the same and that the things and events in the universe occur in consistent patterns that are comprehensible through careful, systematic study
	From time to time, major shifts occur in the scientific view of how things work. More often, however, the changes that take place in the body of scientific knowledge are small modifications of prior knowledge. Continuity and change are persistent features of science.
	No matter how well one theory fits observations, a new theory might fit them just as well or better, or might fit a wider range of observations
	In science, the testing, revising, and occasional discarding of theories, new and old, never ends. This ongoing process leads to a better understanding of how things work in the world but not to absolute truth.
	In matters that can be investigated in a scientific way, evidence for the value of a scientific approach is given by the improving ability of scientists to offer reliable explanations and make accurate predictions
	Investigations are conducted for different reasons, including to explore new phenomena, to check on previous results, to test how well a theory predicts, and to compare theories
	Hypotheses are widely used in science for choosing what data to pay attention to and what additional data to seek, and for guiding the interpretation of the data (both new and previously available).
	Sometimes, scientists can control conditions in order to obtain evidence. When that is not possible, practical, or ethical, they try to observe as wide a range of natural occurrences as possible to discern patterns
	There are different traditions in science about what is investigated and how, but they all share a commitment to the use of logical arguments based on empirical evidence
	Scientists in any one research group tend to see things alike, so even groups of scientists may have trouble being entirely objective about their methods and findings. For that reason, scientific teams are expected to seek out the possible sources of bias in the design of their investigations and in their data analysis. Checking each other's results and explanations helps, but that is no guarantee against bias.
	In the short run, new ideas that do not mesh well with mainstream ideas in science often encounter vigorous criticism
	In the long run, theories are judged by the range of observations they

	explain, how well they explain observations, and how useful they are in making accurate predictions
	New ideas in science are limited by the context in which they are conceived; are often rejected by the scientific establishment; sometimes spring from unexpected findings; and usually grow slowly, through contributions from many investigators
	Scientists' nationality, sex, ethnic origin, age, political convictions, and so on may incline them to look for or emphasize one or another kind of evidence or interpretation
	To be useful, a hypothesis should suggest what evidence would support it and what evidence would refute it. A hypothesis that cannot, in principle, be put to the test of evidence may be interesting, but it may not be scientifically useful.
	Bias attributable to the investigator, the sample, the method, or the instrument may not be completely avoidable in every instance, but scientists want to know the possible sources of bias and how bias is likely to influence evidence
	To avoid biased observations, scientific studies sometimes use observers who don't know what the results are "supposed" to be
	The early Egyptian, Greek, Chinese, Hindu, and Arabic cultures are responsible for many scientific and mathematical ideas and technological inventions. Modern science is based on traditions of thought that came together in Europe about 500 years ago. People from all cultures now contribute to that tradition.
	Progress in science and invention depends heavily on what else is happening in society
	History often involves scientific and technological developments.
	Science disciplines differ from one another in what is studied, techniques used, and outcomes sought, but they share a common purpose and philosophy, and all are part of the same scientific enterprise. Although each discipline provides a conceptual structure for organizing and pursuing knowledge, many problems are studied by scientists using information and skills from many disciplines. Disciplines do not have fixed boundaries, and it happens that new scientific disciplines are being formed where existing ones meet and that some sub-disciplines spin off to become new disciplines in their own right.
	Current ethics in science hold that research involving human subjects may be conducted only with the informed consent of the subjects, even if this constraint limits some kinds of potentially important research or influences the results
	When applications of research could pose risks to society, scientists' decisions to participate in that research are based on personal as well as professional ethics

	Scientists can bring information, insights, and analytical skills to bear on matters of public concern. Acting in their areas of expertise, scientists can help people understand the likely causes of events and estimate their possible effects.
	Outside their areas of expertise, scientists should enjoy no special credibility
	Where a scientist's own personal, institutional, or community interests are at stake, he or she may be as biased as others are
	The strongly held traditions of science, including its commitment to peer review and publication, serve to keep the vast majority of scientists well within the bounds of ethical professional behavior. Deliberate deceit is rare and likely to be exposed sooner or later by the scientific enterprise itself. When violations of these scientific ethical traditions are discovered, they are strongly condemned by the scientific community, and the violators then have difficulty regaining the respect of other scientists.
	Funding influences the direction of science by virtue of the decisions that are made on which research to support. Research funding comes from various federal government agencies, industry, and private foundations.
	Scientists often cannot bring definitive answers to matters of public debate. There may be little reliable data available, or there may not yet be adequate theories to understand the phenomena involved, or the answer may involve the comparison of values that lie outside of science.
	Because science is a human activity, what is valued in society influences what is valued in science
	The direction of scientific research is affected by informal influences within the culture of science itself, such as prevailing opinion on which questions are most interesting or which methods of investigation are most likely to be fruitful. Elaborate processes involving scientists themselves have been developed to decide which research proposals receive funding, and committees of scientists regularly review progress in various disciplines to recommend general priorities for funding.
	The dissemination of scientific information is crucial to its progress. Some scientists present their findings and theories in papers that are delivered at meetings or published in scientific journals. Those papers enable scientists to inform others about their work, to expose their ideas to criticism by other scientists, and, of course, to stay abreast of scientific developments around the world.
The Living Environment	The variation of organisms within a species increases the likelihood that at least some members of the species will survive under changed environmental conditions.
	A great diversity of species increases the chance that at least some living things will survive in the face of large changes in the

	environment.
	The degree of relatedness between organisms or species can be estimated from the similarity of their DNA sequences, which often closely match their classification based on anatomical similarities.
	Similar patterns of development and internal anatomy suggest relatedness among organisms.
	Most complex molecules of living organisms are built up from smaller molecules. The various kinds of small molecules are much the same in all life forms, but the specific sequences of components that make up the very complex molecules are characteristic of a given species.
	A classification system is a framework created by scientists for describing the vast diversity of organisms, indicating the degree of relatedness between organisms, and framing research questions.
	Some new gene combinations make little difference, some can produce organisms with new and perhaps enhanced capabilities, and some can be deleterious.
	The sorting and recombination of genes in sexual reproduction results in a great variety of possible gene combinations in the offspring of any two parents.
	The information passed from parents to offspring is coded in DNA molecules, long chains linking just four kinds of smaller molecules, whose precise sequence encodes genetic information.
	Genes are segments of DNA molecules. Inserting, deleting, or substituting segments of DNA molecules can alter genes. An altered gene may be passed on to every cell that develops from it. The resulting features may help, harm, or have little or no effect on the offspring's success in its environment.
	Gene mutations can be caused by such things as radiation and chemicals. When they occur in sex cells, they can be passed on to offspring; if they occur in other cells, they can be passed on to descendant cells only. The experiences an organism has during its lifetime can affect its offspring only if the genes in its own sex cells are changed by the experience.
	The many body cells in an individual can be very different from one another, even though they are all descended from a single cell and thus have essentially identical genetic instructions.
	Different parts of the genetic instructions are used in different types of cells, influenced by the cell's environment and past history.
	Heritable characteristics can include details of biochemistry and anatomical features that are ultimately produced in the development of the organism. By biochemical or anatomical means, heritable characteristics may also influence behavior.
	Every cell is covered by a membrane that controls what can enter and

	leave the cell.
	In all but quite primitive cells, a complex network of proteins provides organization and shape and, for animal cells, movement.
	Within the cells are specialized parts for the transport of materials, energy capture and release, protein building, waste disposal, passing information, and even movement.
	In addition to the basic cellular functions common to all cells, most cells in multicellular organisms perform some special functions that others do not.
	The work of the cell is carried out by the many different types of molecules it assembles, mostly proteins. Protein molecules are long, usually folded chains made from 20 different kinds of amino acid molecules. The function of each protein molecule depends on its specific sequence of amino acids and its shape. The shape of the chain is a consequence of attractions between its parts.
	The genetic information encoded in DNA molecules provides instructions for assembling protein molecules.
	The genetic information encoded in DNA molecules is virtually the same for all life forms.
	Before a cell divides, the instructions are duplicated so that each of the two new cells gets all the necessary information for carrying on.
	Complex interactions among the different kinds of molecules in the cell cause distinct cycles of activities, such as growth and division. Cell behavior can also be affected by molecules from other parts of the organism or even other organisms.
	Gene mutation in a cell can result in uncontrolled division called cancer. Exposure of cells to certain chemicals and radiation increases mutations and thus the chance of cancer.
	Most cells function best within a narrow range of temperature and acidity. At very low temperatures, reaction rates are too slow. High temperatures and/or extremes of acidity can irreversibly change the structure of most protein molecules. Even small changes in acidity can alter the molecules and how they interact.
	A living cell is composed of a small number of chemical elements mainly carbon, hydrogen, nitrogen, oxygen, phosphorous, and sulfur. Carbon, because of its small size and four available bonding electrons, can join to other carbon atoms in chains and rings to form large and complex molecules.
	Some protein molecules assist in replicating genetic information, repairing cell structures, helping other molecules get in or out of the cell, and generally catalyzing and regulating molecular interactions.
	Ecosystems can be reasonably stable over hundreds or thousands of years. As any population grows, its size is limited by one or more environmental factors: availability of food, availability of nesting sites,

	or number of predators.
	If a disturbance such as flood, fire, or the addition or loss of species occurs, the affected ecosystem may return to a system similar to the original one, or it may take a new direction, leading to a very different type of ecosystem. Changes in climate can produce very large changes in ecosystems.
	Human beings are part of the earth's ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems.
	At times, environmental conditions are such that land and marine organisms reproduce and grow faster than they die and decompose to simple carbon containing molecules that are returned to the environment. Over time, layers of energy-rich organic material inside the earth have been chemically changed into great coal beds and oil pools.
	The chemical elements that make up the molecules of living things pass through food webs and are combined and recombined in different ways. At each link in a food web, some energy is stored in newly made structures but much is dissipated into the environment. Continual input of energy from sunlight keeps the process going.
	The basic idea of biological evolution is that the earth's present-day species are descended from earlier, distinctly different species.
	Molecular evidence substantiates the anatomical evidence for evolution and provides additional detail about the sequence in which various lines of descent branched off from one another.
	Natural selection provides the following mechanism for evolution: Some variation in heritable characteristics exists within every species; some of these characteristics give individuals an advantage over others in surviving and reproducing; and the advantaged offspring, in turn, are more likely than others to survive and reproduce. As a result, the proportion of individuals that have advantageous characteristics will increase.
	Heritable characteristics can be observed at molecular and whole-organism levels—in structure, chemistry, or behavior.
	Heritable characteristics influence how likely an organism is to survive and reproduce.
	New heritable characteristics can result from new combinations of existing genes or from mutations of genes in reproductive cells. Changes in other cells of an organism cannot be passed on to the next generation.
	Natural selection leads to organisms that are well-suited for survival in particular environments.
	Chance alone can result in the persistence of some heritable characteristics having no survival or reproductive advantage or disadvantage for the organism.

	When an environment, including other organisms that inhabit it changes, the survival value of inherited characteristics may change.
	Modern ideas about evolution and heredity provide a scientific explanation for the history of life on Earth as depicted in the fossil record and in the similarities evident within the diversity of existing organisms.
	Life on earth is thought to have begun as simple, one-celled organisms about four billion years ago. Once cells with nuclei developed about a billion years ago, increasingly complex multi-cellular organisms evolved.
	Evolution builds on what already exists, so the more variety there is, the more there can be in the future. But evolution does not necessitate long-term progress in some set direction. Evolutionary change appears to be like the growth of a bush: Some branches survive from the beginning with little or no change; many die out altogether; and others branch repeatedly, sometimes giving rise to more complex organisms.
	The continuing operation of natural selection on new characteristics and in diverse and changing environments, over and over again for millions of years, has produced a succession of diverse new species.
The Human Organism	The similarity of humans in their cell chemistry and DNA sequences reinforces the idea that all humans are part of a single species.
	Fossil and molecular evidence supports the idea that human beings evolved from earlier species.
	As successive generations of an embryo's cells form by division, small differences in their immediate environments cause them to develop slightly differently, by activating or inactivating different parts of the DNA information.
	The availability of artificial means to prevent or facilitate pregnancy raises social, moral, ethical, and legal issues.
	The complexity of the human brain allows humans to create technological, literary, and artistic works on a vast scale, and to develop a scientific understanding of the world.
	The development and use of technologies to sustain, prolong, or terminate life raise social, moral, ethical, and legal issues.
	Both genes and environmental factors influence the rate and extent of development.
	Following fertilization, cell division produces a small cluster of cells that embeds itself in the wall of the uterus. As the embryo develops, it receives nourishment and eliminates wastes by the transfer of substances between its blood and the blood of its mother.
	Patterns of human development are similar to those of other vertebrates.
	The immune system functions to protect against microscopic

	organisms and foreign substances that enter from outside the body and against some cancer cells that arise within.
	Communication between cells is required to coordinate their diverse activities. Cells may secrete molecules that spread locally to nearby cells or that are carried in the bloodstream to cells throughout the body. Nerve cells transmit electrochemical signals that carry information much more rapidly than is possible by diffusion or blood flow.
	Some drugs mimic or block the molecules involved in communication between cells and therefore affect operations of the brain and body.
	The human body is a complex system of cells, most of which are grouped into organ systems that have specialized functions. These systems can best be understood in terms of the essential functions they serve for the organism: deriving energy from food, protection against injury, internal coordination, and reproduction.
	Even instinctive behavior may not develop well if the individual is exposed to abnormal conditions.
	The expectations, moods, and prior experiences of human beings can affect how they interpret new perceptions or ideas. People tend to ignore evidence that challenges their beliefs and to accept evidence that supports them.
	The context in which something is learned may limit the contexts in which the learning can be used.
	Human thinking involves the interaction of ideas, and ideas about ideas. People can produce many associations internally without receiving information from their senses.
	Some allergic reactions are caused by the body's immune responses to usually harmless environmental substances. Sometimes the immune system may attack some of the body's own cells.
	Faulty genes can cause body parts or systems to work poorly. Some genetic diseases appear only when an individual has inherited a certain faulty gene from both parents.
	New medical techniques, efficient health care delivery systems, improved diet and sanitation, and a fuller understanding of the nature of health and disease give today's human beings a better chance of staying healthy than their ancestors had.
	Conditions now are very different from the conditions in which the species evolved. But some of the differences may not be good for human health.
	Some viral diseases, such as AIDS, destroy critical cells of the immune system, leaving the body unable to deal with multiple infection agents and cancerous cells.
	Stresses are especially difficult for children to deal with and may have

	long-lasting effects.
	Biological abnormalities, such as brain injuries or chemical imbalances, can cause or increase susceptability to psychological disturbances.
	Reactions of other people to an individual's emotional disturbance may increase its effects.
	Human beings differ greatly in how they cope with emotions and may therefore puzzle one another.
	Ideas about what constitutes good mental health and proper treatment for abnormal mental states vary from one culture to another and from one time period to another.
	Psychological distress may also affect an individual's vulnerability to biological disease.
	According to some theories of mental disturbance, anger, fear, or depression may result from exceptionally upsetting thoughts or memories that are blocked from becoming conscious.

Appendix D

Coding Categories - CREDE

The following categories were derived from the second of the ELL standards chosen for this study: the *Center for Research on Education, Diversity, and Excellence* (CREDE) standards (University of California Berkeley Graduate School of Education, 2002). When the CREDE standards document was created, the Center for Research on Education, Diversity, and Excellence presented their results in the form of what they called the *standards for effective pedagogy and learning/standards performance continuum* (University of California Berkeley Graduate School of Education, 2002). Each of these standards was given a name, and was then further broken down into a series of individual descriptors of what that standard might look like, thus making each standard recognizable in practice. For the purposes of this study, each of these standards was designated as an a priori coding category, because they "express the principles of effective pedagogy for all students" (University of California Berkeley Graduate School of Education, 2002, para. 1). Thus, the coding categories for this standard are pre-existing, meaning that they were created by the authors of the standard document itself, instead of by me. There are five of these standards, or coding categories: Joint Productive Activity, Language Development, Contextualization, Challenging Activities, and Instructional Conversation. The descriptors of each standard, or coding category, were each further designated as a *Description of Category,* and listed next to their respective standard, or coding category.

Table D1

Coding Categories for the Center for Research on Education, Diversity, and Excellence (CREDE): Standards Performance Continuum (University of California Berkeley Graduate School of Education, 2002)

Category	Description of Category
Joint Productive Activity	The teacher designs instructional activities requiring student collaboration to accomplish a joint product
	The teacher matches the demands of the joint productive activity to the time available for accomplishing them
	The teacher arranges classroom seating to accommodate students' individual and group needs to communicate and work jointly
	The teacher participates with students in joint productive activity
	The teacher organizes students in a variety of groupings, such as by friendship, mixed academic ability, language, project, or interests, to promote interaction
	The teacher plans with students how to work in groups and move from one activity to another, such as from large group introduction to small group activity, for clean-up, dismissal, and the like
	The teacher manages student and teacher access to materials and technology to facilitate joint productive activity
	The teacher monitors and supports student collaboration in positive ways
Language Development	The teacher listens to student talk about familiar topics such as home and community
	The teacher responds to students' talk and questions, making 'in-flight' changes during conversation that directly relate to students' comments
	The teacher assists written and oral language development through modeling, eliciting, probing, restating, clarifying, questioning, praising, etc., in purposeful conversation and writing
	The teacher interacts with students in ways that respect students' preferences for speaking that may be different from the teacher's, such as wait-time, eye contact, turn-taking, or spotlighting

	The teacher connects student language with literacy and content area knowledge through speaking, listening, reading, and writing activities
	The teacher encourages students to use content vocabulary to express their understanding
	The teacher provides frequent opportunity for students to interact with each other and the teacher during instructional activities
	The teacher encourages students' use of first and second languages in instructional activities
Contextualization	The teacher begins activities with what students already know from home, community, and school
	The teacher designs instructional activities that are meaningful to students in terms of local community norms and knowledge
	The teacher acquires knowledge of local norms and knowledge by talking to students, parents or family members, community members, and by reading pertinent documents
	The teacher assists students to connect and apply their learning to home and community
	The teacher plans jointly with students to design community-based learning activities
	The teacher provides opportunities for parents or families to participate in classroom instructional activities
	The teacher varies activities to include students' preferences, from collective and cooperative to individual and competitive
	The teacher varies styles of conversation and participation to include students' cultural preferences, such as co-narration, call-and-response, and choral, among others
Challenging Activities	The teacher assures that students - for each instructional topic - see the whole picture as a basis for understanding the parts
	The teacher presents challenging standards for student performance
	The teacher designs instructional tasks that advance student understanding to more complex levels
	The teacher assists students to accomplish more complex understanding by building from their previous success
	The teacher gives clear, direct feedback about how student performance compares with the challenging standards.
Instructional Conversation	The teacher arranges the classroom to accommodate

	conversation between the teacher and a small group of students on a regular and frequent basis
	The teacher has a clear academic goal that guides conversation with students
	The teacher ensures that student talk occurs at higher rates than teacher talk
	The teacher guides conversation to include students' views, judgments, and rationales using text evidence and other substantive support
	The teacher ensures that all students are included in the conversation according to their preferences
	The teacher listens carefully to assess levels of students' understanding
	The teacher assists students' learning throughout the conversation by questioning, restating, praising, encouraging, etc
	The teacher guides the students to prepare a product that indicates the Instructional Conversation's goal was achieved

Appendix E

Coding Categories - WIDA

The following categories were derived from the third of the ELL standards chosen for this study: the *World-Class Instructional Design and Assessment* (WIDA) standards (Board of Regents of the University of Wisconsin System, 2007). When the WIDA standards document was created, the WIDA Consortium (2007) presented their results in the form of what they called *English language proficiency standards* (Board of Regents of the University of Wisconsin System, 2007). Each of these standards was given a name, and was then further broken down into a descriptor of what that standard might look like in practice. For the purposes of this study, each of these standards was designated as an a priori coding category, because they comprise the "language needed and used by ELLs to succeed in school" (Board of Regents of the University of Wisconsin System, 2007, p. RG-9). Thus, the coding categories for this standard are pre-existing, meaning that they were created by the authors of the standard document itself, instead of by the researcher.

The coding categories selected from the WIDA standards for use in this study were taken from the MPIs (Model Performance Indicators) of the WIDA standards, which are organized into four language frameworks (Board of Regents of the University of Wisconsin System, 2007). These frameworks are: oral language development; literacy across content areas; attention to genre, text type, register, language forms, and conventions; and the use of instructional supports (p. 14). Of these four frameworks, the researcher used the instructional support framework, which is composed of sensory support, graphic support, and interactive support, as the coding categories for this standard (p. RG-20; RG-21-RG-24). The reason for this is because the instructional support framework constitutes the instructional aspect of the MPI, while the language and content stem components are not instructional in nature, they are evaluative. "Support is an instructional strategy or tool used to assist students in accessing content . . ." (p. RG-20). "They illustrate the importance of scaffolding the language development of ELLs (p. 11)." Then go to the supports paragraph (3.3 RG-20) and use some of that language in the rest of your explanation of why you're using the WIDA standards that way. The descriptors of each standard, or coding category, were each further designated as a *Description of Category,* and listed next to its respective standard, or coding category.

Table E1

Coding Categories for the World-Class Instructional Design and Assessment (WIDA) English Language Proficiency Standards (Board of Regents of the University of Wisconsin System, 2007)

Category	Description of Category
Sensory Support	Real-life objects (realia)
	Manipulatives
	Pictures & Photographs
	Illustrations, diagrams, & drawings
	Magazines & newspapers
	Physical activities
	Videos & Films
	Broadcasts
	Models & figures
Graphic Support	Charts
	Graphic Organizers
	Tables
	Graphs
	Timelines
	Number lines
Interactive Support	In pairs of partners
	In triads or small groups
	In a whole group
	Using cooperative groups structures
	With the Internet (Web sites) or software programs
	In the native language (L1)
	With mentors

Appendix F

Coding Categories - TIMSS

The following categories were derived from the fourth of the ELL standards chosen for this study: the *Trends in International Mathematics and Science Study* (TIMSS) standards (National Center for Education Statistics, 2011). When the TIMSS standards document was created, the National Center for Education Statistics presented their results in the form of what they called *cognitive domains* (National Center for Education Statistics, 2011). Each of these domains was given a name, and was then further broken down into a series of individual descriptors of what that domain might look like, thus making each domain recognizable in practice. For the purposes of this study, each of these domains was designated as an a priori coding category, because they comprise "the skills and abilities" required for students to be successful on international science assessments (National Center for Education Statistics, 2011, p. 80). Thus, the coding categories for this standard are pre-existing, meaning that they were created by the authors of the standard document itself, instead of by the researcher. There are three of these domains, or coding categories: Knowing, Applying, and Reasoning. The descriptors of each domain, or coding category, were each further designated as a *Description of Category,* and listed next to their respective domain, or coding category.

Table F1

Coding Categories for the Trends in International Mathematics and Science Study (TIMSS) Standards: Cognitive Domains (National Center for Education Statistics, 2011)

Category	Description of Category
Knowing	Make or identify accurate statements about science facts, relationships, processes, and concepts
	Identify the characteristics or properties of specific organisms, materials, and processes
	Provide or identify definitions of scientific terms
	Recognize and use scientific vocabulary, symbols, abbreviations, units, and scales in relevant contexts
	Describe organisms, physical materials, and science processes that demonstrate knowledge of properties, structure, function, and relationships
	Support or clarify statements of facts or concepts with appropriate examples
	Identify or provide specific examples to illustrate knowledge of general concepts
	Demonstrate knowledge of how to use science apparatus, equipment, tools, measurement devices, and scales
Applying	Identify or describe similarities and differences between groups of organisms, materials, or processes
	Distinguish, classify, or order individual objects, materials, organisms, and processes based on given characteristics and properties
	Use a diagram or model to demonstrate understanding of a science concept, structure, relationship, process, or biological or physical system or cycle (e.g., food web, electrical circuit, water cycle, solar system, atomic structure)
	Relate knowledge of an underlying biological or physical concept to an observed or inferred property, behavior, or use of objects, organisms, or materials
	Interpret relevant textual, tabular, or graphical information in light of a science concept or principle
	Identify or use a science relationship, equation, or formula to find a qualitative or quantitative solution involving the direct application/demonstration of a concept
	Provide or identify an explanation for an observation or natural phenomenon, demonstrating understanding of the underlying science concept, principle, law, or theory
Reasoning	Analyze problems to determine the relevant relationships, concepts, and problem-solving steps
	Develop and explain problem-solving strategies
	Provide solutions to problems that require consideration of a number of different factors or related concepts

	Make associations or connections between concepts in different areas of science
	Demonstrate understanding of unified concepts and themes across the domains of science
	Integrate mathematical concepts or procedures in the solutions to science problems
	Combine knowledge of science concepts with information from experience or observation to formulate questions that can be answered by investigation
	Formulate hypotheses as testable assumptions using knowledge from observation and/or analysis of scientific information and conceptual understanding
	Make predictions about the effects of changes in biological or physical conditions in light of evidence and scientific understanding
	Design or plan investigations appropriate for answering scientific questions or testing hypotheses
	Describe or recognize the characteristics of well-designed investigations in terms of variables to be measured and controlled and cause-and-effect relationships
	Make decisions about measurements or procedures to use in conducting investigations
	Detect patterns in data, describe or summarize data trends, and interpolate or extrapolate from data or given information
	Make valid inferences on the basis of evidence and/or understanding of science concepts
	Draw appropriate conclusions that address questions or hypotheses, and demonstrate understanding of cause and effect
	Make general conclusions that go beyond the experimental or given conditions, and apply conclusions to new situations
	Determine general formulas for expressing physical relationships
	Weigh advantages and disadvantages to make decisions about alternative processes, materials, and sources
	Consider scientific and social factors to evaluate the impact of science and technology on biological and physical systems
	Evaluate alternative explanations and problem-solving strategies and solutions
	Evaluate results of investigations with respect to sufficiency of data to support conclusions
	Use evidence and scientific understanding to justify explanations and problem solutions
	Construct arguments to support the reasonableness of solutions to problems,

	conclusions from investigations, or scientific explanations

Appendix G

Text Analysis Coding Forms

The following text analysis coding forms are samples of four of the twelve text analysis coding forms (four coding forms for each of the three textbooks) that were created for this study. Each form includes the coding categories of each of the four standards documents. Each form also includes all of the indicators for the coding categories, as well as the title and number of each chapter, and each section within each chapter, of the textbook that these specific sample forms refer to: the Glencoe textbook. These forms were used to record the presence or absence of an instance of alignment between the recording units in the textual tools for teaching ELL students found in the Glencoe textbook and the four ELL standards. Space was also included in each form to indicate the strength of each instance of alignment, explicit or implicit. Similar forms were used to code the Pearson and Holt textbooks. Only the first page of each coding form is shown here, due to the excessive length of the forms.

Table G1

Sample Text Analysis Coding Form for the Glencoe (2009) Textbook and the Benchmarks (AAAS, 1993)

Science Text: *Glencoe Biology* (Biggs et al., 2009)																			
Benchmarks Standards (American Association for the Advancement of Science, 1993)	**Code**	**Chapter 1: The Study of Life**						**Chapter 2: Principles of Ecology**						**Chapter 3: Communities, Biomes, and Ecosystems**					
		1.1: Introduction to Biology		**1.2: The Nature of Science**		**1.3: Methods of Science**		**2.1: Organisms and Their Relationships**		**2.2: Flow of Energy in an Ecosystem**		**2.3: Cycling of Matter**		**3.1: Community Ecology**		**3.2: Terrestrial Biomes**		**3.3: Aquatic Ecosystems**	
		Explicit	**Implicit**	**Explicit**	**Implicit**	**Explicit**	**Implicit**	**Explicit**	**Implicit**	**Explicit**	**Implicit**	**Explicit**	**Implicit**	**Explicit**	**Implicit**	**Explicit**	**Implicit**	**Explicit**	**Implicit**
Coding Category: Nature of Science																			
The Scientific Worldview																			
Science is based on the assumption that the universe is a vast single system in which the basic rules are everywhere the same and that the things and events in the universe occur in consistent patterns that are comprehensible through careful, systematic study	SW1																		
From time to time, major shifts occur in the scientific view of how things work. More often, however, the changes that take place in the body of scientific knowledge are small modifications of prior knowledge. Continuity and change are persistent features of science.	SW2																		

Table G2

Sample Text Analysis Coding Form for the Glencoe (2009) Textbook and the CREDE standards (University of California Berkeley Graduate School of Education, 2002)

Science Text: *Glencoe Biology* (Biggs et al., 2009)

CREDE Standards (University of California Berkeley Graduate School of Education, 2002)	**Code**	**Chapter 1: The Study of Life**						**Chapter 2: Principles of Ecology**						**Chapter 3: Communities, Biomes, and Ecosystems**					
		1.1: Introduction to Biology		**1.2: The Nature of Science**		**1.3: Methods of Science**		**2.1: Organisms and Their Relationships**		**2.2: Flow of Energy in an Ecosystem**		**2.3: Cycling of Matter**		**3.1: Community Ecology**		**3.2: Terrestrial Biomes**		**3.3: Aquatic Ecosystems**	
		Explicit	**Implicit**	**Explicit**	**Implicit**	**Explicit**	**Implicit**	**Explicit**	**Implicit**	**Explicit**	**Implicit**	**Explicit**	**Implicit**	**Explicit**	**Implicit**	**Explicit**	**Implicit**	**Explicit**	**Implicit**
Coding Category: Joint Productive Activity																			
The teacher designs instructional activities requiring student collaboration to accomplish a joint product	JPA1																		
The teacher matches the demands of the joint productive activity to the time available for accomplishing them	JPA2																		
The teacher arranges classroom seating to accommodate students' individual and group needs to communicate and work jointly	JPA3																		
The teacher participates with students in joint productive activity	JPA4																		
The teacher organizes students in a variety of groupings, such as by friendship, mixed academic ability, language, project, or interests, to promote interaction	JPA5																		
The teacher plans with students how to work in groups and move from one activity to another, such as from large group introduction to small group activity, for clean-up, dismissal, and the like	JPA6																		

Table G3

Sample Text Analysis Coding Form for the Glencoe (2009) Textbook and the WIDA standards (Board of Regents of the University of Wisconsin System, 2007)

Science Text: *Glencoe Biology* (Biggs et al., 2009)																			
WIDA Standards (Board of Regents of the University of Wisconsin System, 2007)	**Code**	**Chapter 1: The Study of Life**						**Chapter 2: Principles of Ecology**						**Chapter 3: Communities, Biomes, and Ecosystems**					
		1.1: Introduction to Biology		**1.2: The Nature of Science**		**1.3: Methods of Science**		**2.1: Organisms and Their Relationships**		**2.2: Flow of Energy in an Ecosystem**		**2.3: Cycling of Matter**		**3.1: Community Ecology**		**3.2: Terrestrial Biomes**		**3.3: Aquatic Ecosystems**	
		Explicit	**Implicit**	**Explicit**	**Implicit**	**Explicit**	**Implicit**	**Explicit**	**Implicit**	**Explicit**	**Implicit**	**Explicit**	**Implicit**	**Explicit**	**Implicit**	**Explicit**	**Implicit**	**Explicit**	**Implicit**
Coding Category: Sensory Supports																			
Real-life objects (realia)	SS1																		
Manipulatives	SS2																		
Pictures & photographs	SS3																		
Illustrations, diagrams, & drawings	SS4																		
Magazines & newspapers	SS5																		
Physical activities	SS6																		
Videos & films	SS7																		
Broadcasts	SS8																		
Models & figures	SS9																		
Graphic Supports																			
Charts	GS1																		
Graphic organizers	GS2																		
Tables	GS3																		
Graphs	GS4																		
Timelines	GS5																		
Numbers lines	GS6																		
Interactive Supports																			
In pairs or partners	IS1																		
In triads or small groups	IS2																		
In a whole group	IS3																		
Using cooperative group structures	IS4																		

Table G4

Sample Text Analysis Coding Form for the Glencoe (2009) Textbook and the TIMSS standards (National Center for Education Statistics, 2011)

Science Text: *Glencoe Biology* (Biggs et al., 2009)																			
TIMSS Standards (National Center for Education Statistics, 2011)	**Code**	**Chapter 1: The Study of Life**						**Chapter 2: Principles of Ecology**						**Chapter 3: Communities, Biomes, and Ecosystems**					
		1.1: Introduction to Biology		**1.2: The Nature of Science**		**1.3: Methods of Science**		**2.1: Organisms and Their Relationships**		**2.2: Flow of Energy in an Ecosystem**		**2.3: Cycling of Matter**		**3.1: Community Ecology**		**3.2: Terrestrial Biomes**		**3.3: Aquatic Ecosystems**	
		Explicit	Implicit	Explicit	Implicit	Explicit	Implicit	Explicit	Implicit	Explicit	Implicit	Explicit	Implicit	Explicit	Implicit	Explicit	Implicit	Explicit	Implicit
Coding Category: Knowing																			
Make or identify accurate statements about science facts, relationships, processes, and concepts	K1																		
Identify the characteristics or properties of specific organisms, materials, and processes	K2																		
Provide or identify definitions of scientific terms	K3																		
Recognize and use scientific vocabulary, symbols, abbreviations, units, and scales in relevant contexts	K4																		
Describe organisms, physical materials, and science processes that demonstrate knowledge of properties, structure, function, and relationships	K5																		
Support or clarify statements of facts or concepts with appropriate examples	K6																		
Identify or provide specific examples to illustrate knowledge of general concepts	K7																		
Demonstrate knowledge of how to use science apparatus, equipment, tools, measurement devices, and scales	K8																		