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ABSTRACT

This report provides a practical guide for teachers, including a review of literature related to the integration of science and language arts, guidelines and methodologies to aid the practitioner in the integration of science and language arts, and an organizational matrix for teacher-designed integrated curricula. A review of literature reveals the rich history of the integration of language arts and science education. The current state of the two disciplines is discussed with a focus on reform movements in both disciplines. The nature of each individual discipline is then described. Research supporting the integration of language arts and science is also included. Guidelines and methodologies for integration are emphasized. Finally, an organizational matrix of graphics representing the main ideas and concepts covered in the document is presented. Contains 76 references. (Author/PVD)

Integrating Science and Language Arts:
A Guide for the Practitioner

by

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Report

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Integrating Science and Language Arts:

A Guide for the Practitioner

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Dedication

This report is dedicated to my family members, Joe, Rose, Carolyn, Josephine, Anne G., and Susan and to the teachers and colleagues that shaped my professional life, especially Mrs. Roberts, Mrs. Cadwallader, Ms. Behne, Mr. Espino, Dr. Stayton, Mrs. Collier, and Mrs. Ishman.

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Abstract

Integrating Science and Language Arts: A Guide for the Practitioner

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The University of Texas at Austin, 1996

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This report provides a practical guide for teachers, including the following: a review of literature related to the integration of science and language arts; guidelines and methodologies to aid the practitioner in the integration of science and language arts; and an organizational matrix for teacher-designed integrated curricula. A review of literature reveals the rich history of integration in language arts and science education. The current state of the two disciplines is discussed with a focus on reform movements in both disciplines. The nature of each individual discipline is then described. Also, research supporting the integration of language arts and science is included. Guidelines and methodologies for integration are emphasized. Finally, an organizational matrix of graphics, representing the main ideas and concepts covered in Chapters 1, 2, 3, and 4 is presented.

Table of Contents

Table of Contents, continued

List of Tables

List of Figures

Chapter 1: Rationale and Purpose

RATIONALE

Education in America is in a state of flux. Several reform movements have occurred in the past twenty years sufficient to upset the complacency of the status quo. Two recent examples have impacted the educational scene. First, in 1983, A Nation at Risk: The Imperative for Educational Reform prepared by the National Commission on Excellence in Education reported that U. S. students were falling behind their foreign counterparts. The Commission made five recommendations: increase high school graduation requirements in English, mathematics, science, social studies, and foreign language; raise standards and expectations for student conduct and academic achievement; spend more time on the basics; improve teacher preparation and garner respect for the teaching profession; and encourage leadership and fiscal support for the reform movement. Second, in 1991, President Bush's educational strategy America 2000 (cited in Carson, Huelskamp, & Woodall, 1993) formulated six educational goals by the year 2000:

> 1. All children will enter school ready to learn. 2. The high school graduation rate will increase to at least 90%. 3. All students will demonstrate competency in at least English, math, science, history, and geography. 4. American students will be first in the world in math and science achievement. 5. Every American adult will be literate and able to compete in the work force. 6. Every school in America will be free of drugs and violence. (Carson, Huelskamp, & Woodall, 1993, p. 305)

America 2000 is important because this strategy has delineated six goals for the education system to achieve by the year 2000. In a briefing by Carson et al.

(1993), there seems to be consensus that education reform must occur. However, many of the recommended changes are inconsistent with each other.[1]

In January 1996 (National Science Teachers Association, 1996), a report noted that at least one consensus has occurred in the education field- seven professional education organizations have agreed upon guidelines for integrating curricula. The National Council of Teachers of Mathematics, National Council of Teachers of English, the International Reading Association, the National Science Teachers Association (NSTA), the National Council for the Social Studies, the Speech Communication Association, and the Council for Elementary Science International formulated guidelines for integrating curriculum:

> Interdisciplinary preK-grade 4 curricula should: 1. Maintain the integrity of content drawn from the disciplines by using meaningful connections to sustain students' inquiry between and among those disciplines; 2. Foster a learning community in which students and teachers determine together the issues, questions, and strategies for investigation; 3. Develop democratic classrooms; 4. Provide a variety of opportunities for interaction among diverse learners-for example, discussion, investigation, product development, drama, and telecommunications; 5. Respect diversity of thought and culture; 6. Teach students to use a wide variety of sources, including primary sources, oral communication, direct observation, and experimentation; 7. Use multiple symbol systems as tools to learn and present knowledge; 8. Use wide-ranging assessments to evaluate both the processes and outcomes of student learning. (NSTA, 1996, pp. 6, 8)

The afore mentioned guidelines apply to the elementary level and could dramatically affect elementary science. How can elementary science be improved to reflect these guidelines while it accomplishes the outcome of integration? Improving elementary science involves many aspects such as the teaching conditions, the history of integration, and the aspects of an integrated curriculum.

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[1] See the organizational matrix in Chapter 4.

Elementary school teachers must offer a variety of subjects to a diversified student population. Research shows that elementary classroom teachers prefer teaching reading and writing (Stefanich, 1989). Why don't they prefer science? Several factors constrain elementary science teaching. Factors include poor academic preparation, inadequate time and materials, low subject priority, and lack of confidence (Abell, 1990). Teachers' attitudes directly affect student attitudes. As Yager reports (cited in Stefanich, 1989) as students continue to take science, their attitudes become more negative. They become less curious about science. This, in turn, affects student achievement. I propose interdisciplinary curriculum integration to break this unfortunate chain of events.

The integration of curriculum is not a new idea. Integration is rooted in John Dewey's philosophy of education that focused on the student and the curriculum. In Democracy and Education (cited in Gutek, 1988), Dewey organized curriculum into three levels: "(1) making and doing; (2) history and geography; and (3) organized sciences" (Gutek, 1988, p. 106). "Making and doing" was activity-oriented, while "history and geography" uncovered real-life issues and stressed participation in society. "Organized sciences construed knowledge to be interdisciplinary and instrumental" (Gutek, 1988, p. 107). In The Child and the Curriculum (Dewey, 1977), Dewey identified the importance of the student and teacher relationship. He discussed the role of the teacher in engaging the child in active learning:

> Hence, what concerns him, as teacher, is the ways in which that subject may become a part of experience; what there is in the child's present that is usable with reference to it; how such elements are to be used; how his own knowledge of the subject matter may assist in interpreting the child's needs

> and doings, and determine the medium in which the child should be placed in order that his growth may be properly directed. (Dewey, 1977, p. 175)

Today, there are many supporters for educating students in congruence with Dewey's philosophy.

The Association of Supervision and Curriculum Development (cited in Lipson, Valencia, Wixson & Peters, 1993) identifies four aspects of an integrated curriculum. Curriculum should be "authentic, generative, iterative, and integrative" (Lipson et al., 1993, p. 252). An authentic curriculum promotes authentic student achievement. The Carnegie Corporation of New York, Elmore and Associates, and Murphy (cited in Newmann & Wehlage, 1993) identify three principles of authentic achievement:

> First, students construct meaning and produce knowledge. Second, students use disciplined inquiry to construct meaning. Third, students aim their work toward production of discourse, products, and performances that have value and meaning beyond success in school. (Newmann & Wehlage, 1993, p.8)

A generative curriculum, indicative of the constructivist tradition, derives from the generative learning model and incorporates Piagetian psychology (Osborn & Wittrock, 1985). Students generate meaning that fits into their prior learning. If curriculum is iterative, it encourages the learner to study problems, to form concepts, to apply and evaluate them, and finally, to modify and adjust these concepts. Finally, curriculum that is integrative incorporates thinking skills and encourages concept transfer.

To integrate language arts, the rationale has been that reading and writing are interrelated and together help develop language knowledge. This type of instruction has actually improved student attitudes towards reading and writing. If science is embedded into the language experience, this integration of knowledge could result in more efficient information retrieval and concept transfer (Lipson et al., 1993). Thematic instruction encourages deeper and broader learning (Lipson et al., 1993). Developing a practical guide for interdisciplinary integration will demonstrate ways to choose skillfully, how to integrate elementary science and language arts. A thoughtfully integrated elementary science curriculum could produce benefits that have long-lasting effects.

PURPOSE

The purposes of this report are to review literature related to the integration of science and language arts, to present guidelines and methodologies to aid the practitioner in the integration of science and language arts, and to provide an organizational matrix for teacher-designed integrated curricula in science and language arts.

Chapter 2 includes a review of literature concerning the origins of integration, the state of science education in the 1990s, the state of language arts education in the 1990s, the nature of science, the nature of language arts, and research supporting the integration of science and language arts.

Chapter 3 discusses the theoretical underpinnings for integrating language arts and science and includes a theory of learning, links to literacy, and connections between science and language arts.

Chapter 4 includes integration models, methods to integrate science and language arts, a model for integrating language arts and science (MILAS), and an organizational matrix of graphics.

Chapter 5 provides a summary and conclusions and recommendations for the future.

Chapter 2: A Review of Literature

Science is not an entity unto itself. Although considered a distinct discipline in the early 1800s in Europe, to be used as a "concrete social system of scientific communication" (Stichweh, 1992, p. 3), it is now evident that science is embedded within our democratic system. "The coupling between science and politics in our time is based on a mutual dependence: resources and accessibility are exchanged for solutions to problems and legitimation" (Weingart, 1993, p. 555). Hurd (1991) concurs when he states that "modern science is driven more by societal needs than by theory" (Hurd, 1991, p. 33). And society is concerned about the state of science education in this informational and technological age. Evidenced by the reform movements of the 1990s, many teaching strategies and curricular ideas are being tried. One such curricular approach integrates subject matter and concepts. Although integrating subjects is a controversial subject, society and educators alike must address this issue if the schools are expected to educate students to become rational problem solvers and lifelong learners.

Integration has typically occurred at the elementary level because the internal structure of schools at this level allows for more flexibility in scheduling. There is less departmentalization than at the middle and high school levels. Language arts and social studies or science and mathematics have been the preferred choices of disciplines to integrate. This notion of integrating science into the elementary curriculum requires a careful look at several contextual factors such as the origins of integration, the state of science education in the 1990s, the state of language arts education in the 1990s, the nature of science and language arts, and research supporting integration of science and language arts.

ORIGINS OF SUBJECT INTEGRATION

When did integrated subject matter originate in education? To answer this, the social, economic, and political influences throughout the history of integration will be addressed. The themes that permeate throughout history can be organized into six parts: philosophical underpinnings; psychological influences; the general integration of the core curriculum; integration of language arts; the whole language movement and reading research; and integration of science.

Philosophical Underpinnings

To trace the history of integration, it is important to begin with an operational definition. "Integration is a strategy for intentionally combining subject matter so that students are aware of this integration during implementation. Additionally, subject matter can be combined to allow one subject matter to aid in the learning of another" (Roehler, 1983, p. 28). Integrated subject content has a rich history which dates back to the late nineteenth century.

Gutek (1988) discusses several individuals who were philosophically influential in helping formulate integrated studies. In the 1800s, Herbert Spencer and Colonel Francis Parker each contributed their philosophies of education. In the 1850s, education was only for the aristocracy. In 1859, Charles Darwin published Origin of the Species. When he introduced the concept of survival of the fittest, this theory had a revolutionary impact on society. Competition and the importance of the individual in the larger group were liberalist ideals as well. As a liberalist, Herbert Spencer was so influenced by Darwinism that he developed a process-centered curriculum emphasizing the democratic process. He wanted the curriculum to stress scientific knowledge and the scientific method as well as to maintain a sense of balance. The depression of the 1870s spurred society to examine the goals of public education. Exposed to every facet of public education in the United States from 1855 to 1902, Colonel Francis Parker criticized the traditional schools of the day for segmenting subjects and emphasizing rote learning (Parker, 1883). Parker's theory of concentration focused on unity of purpose, method, and subject matter. Based on systematic child-study in the 1880s, he chose the environment as a source for the central subjects. He started with science and history and introduced new conditions. Other subjects developed from these, such as reading and language. Subjects were unified and correlated to economize educational effort. In the late 1800s, a German, Johann Herbart, proposed the teaching of concepts and ideas instead of fragmented pieces of knowledge, in order for children to achieve a conceptual understanding (Harville, 1954). Charles DeGarmo, who translated Herbart's study from original German, took this notion even further when he proposed the coordination of individual courses instead of an interdisciplinary approach. To build a conceptual understanding, children needed ideas that were coherent rather than fragmented pieces of knowledge. The curriculum needed to be organized into themes which showed relationships between two or more areas of the curriculum.

The urbanization, immigration, and industrialization at the turn of the century coincided with the philosophical era, Pragmatism. As a social, political, and economic reform movement, Pragmatism spanned from the late 1890s to 1917, marking the U.S. entry into World War I. John Dewey was the father of Pragmatism. He supported the notion that the scientific method should be used in application to the problems of his day. His theory stressed the following concepts. Truth is derived through experience. Education provides the method to solve problems. Learning by doing is a central premise. In relation to the elementary curriculum, activities should be tailored to the child's interests and readiness. Children should be active. Their experiences are the basis for their learning. In his article entitled The Child and the Curriculum, Dewey describes the child and the curriculum (Dewey, 1902/1977):

> The child's life is an integral, a total one. He goes to school, and various studies divide and fractionize the world for him. In school, each of these subjects is classified. Facts are torn away from their original place in experience and rearranged with reference to some general principle. Classification is not a matter of child experience; things do not come to the individual pigeonholed. (Dewey, 1977, p. 175)

Dewey took his ideas and incorporated them into a child-centered curriculum which he used at the Laboratory School at the University of Chicago. In his later writings, he maintained that knowledge was interdisciplinary and instrumental. Dewey's philosophy continued to influence integration through the Progressive era of the 1930s.

Psychological Influences

Subject integration has also been shaped by the field of psychology. Hilgard, Aklinson, and Atkinson (1979) discuss two famous psychologists- Gestalt and Piaget. Originating at the end of the 1800s, Gestalt psychology stated "the whole was different from the sum of its parts" (Hilgard et al., 1979, p. 129).

Subject matter needed to be organized so that children could see relationships. Thematic and unit teaching helped convey this holistic approach. Inquiry and discovery learning were preferred teaching methods. In addition, Piagetian psychology has impacted subject integration. Although Piaget's theories were formulated in the 1920s, developmental psychology did not evolve in the U.S. until the 1950s and 1960s. Piaget is known as both a cognitive and developmental psychologist (Hilgard et al., 1979, p. 70). He believed that knowledge is stored in an organized fashion or schema. In order to learn new concepts, students must assimilate and accommodate this knowledge into existing schema. Once again, determining the interconnections of concepts is key towards subject matter integration.

General Integration of the Core Curriculum

The general integration of the core curriculum[1] is yet another building block that appears in the development of subject integration. Oliva (1988) states that the core curriculum was based on the following aspects:

> 1) part of the curriculum is required by all students; 2) unify or fuse subject matter; 3) content centers on problems that cut across disciplines; 4) organized into blocks of time; 5) encourage teachers to plan with students; 6) provide pupil guidance. (Oliva, 1988, p. 313)

Whereas Vars (1991) helps us to understand the overall historical development of the idea of integrated curriculum, he especially singles out Harville's study (1954) of the core curriculum. Evidently this core curriculum was a major contributing

[1] "The term core curriculum was first used to designate the group of required courses in a school" (Fraley, 1977, 5883-A). However, Oliva (1988) defines the term core curriculum differently. "The terms 'core' and 'core curriculum' describe a unique organizational structure in the secondary school" (Oliva, 1988, p. 311).

step to the enhancement of integrated curricula. In the 1830s, there was a demand for free and universal education in the United States. By the early 1870s, the high school was supported by taxes. By the 1900s, industrialization demanded a more educated work force. The responsibility for citizenship education fell to the secondary schools. Until this time, it had been the elementary school's job. Harville attributes this change as the motivating force behind the core curriculum. When the core curriculum was established in high schools, it was an unstructured curriculum designed to meet the social need of students. Subjects and disciplines were derived from the social needs.

In the educational field, the Committee of Ten pushed to improve the secondary school curriculum (Harville, 1954). In 1893, the Committee of Ten (created by the National Education Association) set standards for secondary schooling. The committee's recommendations impacted the education scene for decades to come. Around 1910, when junior high schools appeared, the curriculum was organized around broad subjects such as general science, social studies, and language arts. In 1918, the Commission on the Reorganization of Secondary Education "recognized that 'unification' and 'specialization' were supplementary roles of secondary school curriculum" (Harville, 1954, p. 162). In 1926, the National Society for the Study of Education called for broader units of study. Vars (1991) notes that the core curriculum was researched in the Eight-Year Study, conducted from 1933-1941, by the Progressive Education Association. The Eight-Year Study compared traditional programs with innovative programs. The study showed that a single pattern of courses was not essential for academic success. In 1935, the Society for Curriculum Study discussed the core curriculum plans for Virginia's secondary schools. In the 1940s and early 1950s, the National Education Association and the United States Office of Education provided further support for the core curriculum. However, by 1955, declining interest and lack of support saw an end to the core curriculum movement. Tanner and Tanner (cited in Oliva, 1988) analyze problems associated with acceptance of the core curriculum:

> The core idea never gained the widespread acceptance that was expected of it by progressive educators. Not only was it countered by the discipline-centered curriculum reforms of the 1950's and 1960's but it has met with other difficulties over the years....[sic] teachers are products of discipline-centered curricula in the colleges and univeristies, and so they tend to be oriented toward the subject curriculum. Textbooks and other curriculum materials are geared to the subject curriculum. (Oliva, 1988, pp. 316, 317)

The core curriculum movement (however unsuccessful) attempted to relax the stifling structure of the junior and senior high schools in the 1910s through the 1950s, encouraging integrated learning.

Integration of Language Arts

The history of language arts and integration is chronicled in this section. The field of language arts reflects the significance that English education has placed on an integrated language arts approach. An historical view of language arts helps elucidate its role in educational reform. Clifford (1987) traces the cyclical concern for an integrated approach to language instruction in an historical perspective. In 1894, the Committee of Ten stated that writing and reading were equally important, but recommended that twice as much time be spent on reading at the secondary level. In 1917, James F. Hosic stated, in the report entitled Reorganization of English in Secondary Schools, that connections needed to be made between elementary schools and high schools. "This was the first comprehensive curriculum statement in the history of English language instruction in the United States" (Clifford, 1987, p. 21). "In the 1930's, the term for enhancing the desired writing/reading relationships was 'integration'" (Clifford, 1987, p. 12). The National Council of Teachers of English (NCTE) encouraged integration of the language arts in the 1930s and 1950s. In 1935, the Hatfield Commission reported that the elementary school structure made it easier for teachers to integrate language arts than in secondary schools. In 1936, NCTE's A Correlated Curriculum called for an integrated curriculum that made connections between different subjects. In the 1950s, the NCTE Commission on the English Curriculum suggested that writing be taught in an integrated language arts approach. This recommendation seemed to have little effect on teaching practices. However, in the 1960s, the College Entrance Examination Board's Commission on English proposed that high school English be divided into three parts: language, literature, and composition. In the 1970s, NCTE called for integrated language arts again and coincided with the whole-language movement.

The Whole-Language Movement and Reading Research

Goodman (1989) provided a history of the whole-language movement and discussed many influences that philosophy, psychology, linguistics, and education have had on its development. Philosophically, she cites John Dewey as a major influence, noting that he was a proponent of the "integration of language with all other studies in the curriculum" (Goodman, 1989, p. 116). Through the field of psychology, Piaget and Vygotsky contributed to the knowledge base of pedagogy when they said that children construct their own meaning through active learning.

Vygotsky focused on the learner and social context by saying that students had to be supported by adults and peers because they do not learn in social isolation.

Perhaps somewhat unexpectedly, research from tangential fields such as linguistics and reading supported the integrated approach (Goodman, 1989). Halliday, from the field of linguistics, has also promoted the integration of language arts and other subjects. The field of reading has been a contributor the whole-language movement as well. In the 1940s, Lee and Lamoreaux described the 'language-experience' approach to reading. 'Language-experience' incorporated group activities focusing on science, social studies, or math and included a broad array of experiences. These activities incorporated literature, resulting in a variety of written reading materials that the children could use. In the 1960s, reading research by Kenneth Goodman and Frank Smith described reading as "an interaction between the reader, the text, and language" (Goodman, 1989, p. 117). Don Holdaway, a holistic educator from New Zealand, developed the shared-book experience and promoted literature-based reading programs. His work in the late 1970s was supported by Marie Clay's reading research in the early 1970s. Her research highly recommended the integration of reading and writing. In the 1980s, A Nation at Risk caused a "back to the basics" movement which was the antithesis of the whole-language movement. Yet, in the reform movements of the 1990s, whole language has carved out a niche and continues to flourish.

Integration of Science

Zeitler and Barufaldi (1988) chronicle the history of elementary school science. The integration of science can be traced back to the late 1800s. As stated earlier, Colonel Francis Parker and G. Stanley Hall substantially influenced the elementary science curriculum. In 1880, Parker became the principal of the Cook County Normal School in Chicago, with emphasis on integration. He used science as a unifying principle in the elementary curriculum. The children moved away from rote memorization and began to study the interrelationships among subjects and the unity of science. In 1893, Charles Eliot chaired the Committee of Ten; and its recommendations for high school science were reflected in elementary schools soon after. The Committee of Ten recommended that science teachers receive special training; that emphasis should be on labs, field, and reference work; that labs should be doubled; that students should be taught to think, not just memorize; and that schools should have labs and equipment.

The Committee of Ten's recommendations were put into practice by several Pragmatists. During the 1910s and 1920s, John Dewey, Charles Pierce, and William James supported the integration of science. They felt the need to link concepts and experience. The distinct methodology of science was as important as the knowledge of science. Dewey's Laboratory School did away with static instruction and discrete subjects. He believed that the scientific method could be used by students to inquire about the world. He also emphasized this method so students could use it to solve problems rationally in all areas of their lives.

In 1927, Gerald Craig completed his thesis at Columbia University. His work was probably the single most important event in its influence on elementary science, especially in respect to the philosophy of integration. People at this time believed in faculty psychology. This viewpoint alleged that elementary age students could do nothing more than observe and describe objects. Hence, science was not taught as an elementary subject. Craig, however, believed these students were able to observe, analyze, and compare. He recommended that science be taught at the elementary level because science was important in conveying concepts, principles, and generalizations. Additionally, science was useful in the areas of health, safety, and economics. In 1928, The American Association for the Advancement of Science's Committee Report on the Place of Science Education further urged that the scientific method be an important goal of science instruction. Both of these works advanced the cause of science integration.

In 1932, the 31st National Society on the Study of Education (NSSE) Yearbook was dedicated to science education. The Yearbook recommended a comprehensive program for first through twelfth grades, saying that science instruction should focus on the major generalizations or principles of science. The 31st Yearbook favored elementary science rather than the nature-study.[2] In 1938, the Progressive Education Association published a report. Hurd, in 1991, documented these recommendations:

> The democratic way of life constitutes the goals of education. The concept of science teaching exists within the context of general education rather than contributing to it. Courses should be organized around large units of human experiences, rather than the logic of the subject. The personal-social needs of students should be the point of departure in curriculum construction. Functional or operative science instruction is sought rather than the memorization of masses of facts. (Zeitler & Barufaldi, 1988, p. 16)

This study added momentum to the growing integration movement.

In 1947, the 46th Yearbook of the NSSE endorsed more general objectives for science instruction. In relation to integrated learning, the NSSE made the

[2] The nature-study integrated school subjects and helped develop the affective domain of students. The nature-study employed questioning strategies and encouraged students to directly observe their environment (Babineaux & Westerlund, 1990).

following recommendations for science instruction: incorporate science content into a social context; relate content to problem solving relevant to a social context; involve students in the instructional planning process; integrate the sciences; utilize inductive and deductive teaching methods; and employ the thematic approach to teaching (Henry, 1947). This time period culminated in the launching of Sputnik in 1957, spurring a great deal of "panic" reaction in the U.S.

In 1960, the NSSE devoted another yearbook to science education. The 59th Yearbook spoke of the increased dependency of society on science. The Yearbook stressed inquiry and process in science instruction, often called the process approach. Furthermore, it advocated an interdisciplinary, spiral sequencing of science. With few students entering science careers and the dawn of a technological revolution, the 1960s witnessed a curriculum reform movement which received, for the first time, federal monies to further the cause, especially because of this new "catch-up" mentality regarding the Russians. These new curricula emphasized scientific knowledge and the use of the scientific method, as Bybee (1993) notes. The whole purpose of this new emphasis was to generate as many U.S. science Ph.D.'s as fast as possible. However, by the mid-60s, the Sputnik scare was well over. Different, urgent problems loomed on the horizon. Because these were problems of a socio-political nature, the emphasis was adjusted to include a more humanistic approach to science teaching.

During the 1970s, the National Science Foundation (NSF) continued to fund science programs (Ravitch, 1983). The NSF programs were widely used at all pre-college grade levels. The science programs induced commercial textbook producers to revise their science content and science teaching approaches.

By 1980, another challenge presented itself to the U.S. education system. A Nation at Risk: The Imperative for Educational Reform, produced by the National Commission on Excellence in Education in 1983, reported that U. S. students were falling behind their foreign counterparts. The Commission recommended increases in high school graduation requirements in English, math, science, social studies, and foreign language. Emphasis was placed on a "back to basics" movement. Presumably, the movement detracted momentarily from the integration momentum.

Integrated subject matter has a rich history. The philosophical and psychological underpinnings throughout its history have served to reinforce this educational thought through many social, economic, and political pressures. Since the Committee of Ten's recommendations, the core curriculum tried to mend the structural road blocks to subject matter integration existing in the secondary schools. Periods of success throughout its history have shown it to be influential. Integration of the language arts has had a tumultuous history, finally evolving into the whole-language movement. Recent reading research in the 1960s and 1970s provided a research base that whole-language desperately needed. Finally, integration of the sciences has been a recurring theme since the 1880s.

What will be the fate of integration at the turn of the 21st century? To intelligently answer this question, one must examine the state of science and language arts education in the 1990s.

THE STATE OF SCIENCE EDUCATION IN THE 1990S

The reform movement of the 1990s had its impetus in the mid-1980s. In 1985, Project 2061 began developing goals for science, math, and technology. In 1989, Science for All Americans was published. It recommended that schools focus on a "common core of learning" which is needed for scientific literacy. For this goal to be met, the American Association for the Advancement of Science (1993) suggested that:

> The amount of curriculum materials must be reduced; focus on the interrelationships between science, mathematics, and technology; teaching methods should be based on sound research; lessons should capitalize on student creativity; inquiry approach is highly recommended; call for comprehensive reform based on needs of children; collaborative reform at all levels. (AAAS, 1993, p. 5)

Since 1988, AAAS has been working on Benchmarks for Scientific Literacy. Completed in 1993, the benchmarks target expectations of student progress by the end of grades K-12. They include "progression-of-understanding maps" and "connection-among-discipline maps" (AAAS, 1993, p. 305). Additional curriculum "models" and "blocks" are currently being developed. School districts can use these resources as curricular tools when developing their own K-12 curricula. Hopefully in the future, cross-grade and cross-curricular integration will occur, thereby adding impetus to the integration movement (AAAS, 1993).

The National Science Teachers Association urged the National Research Council (NRC) to start developing national standards in science. In 1992, the NRC approved a plan to produce a document to articulate national standards for science teaching and learning practice. In 1996, the NRC, in conjunction with a broad base of science educators, general educators, business leaders, parents, and policy communities, published the National Science Education Standards (National Research Council, 1996). The Standards focus on teaching, assessment, and content. Program and system standards are also included. Teaching standards involve the skills and knowledge teachers need to achieve set outcomes; the professional development that is needed; and the support systems and resources that are needed. Assessment standards involve the methods of assessing achievement and the aspects of valid, reliable assessment data. Content standards involve the nature of school science experiences; the information and modes of reasoning expected; and the applications of scientific principles (NRC, 1996).

Elementary Science Education

And what of elementary science? As stated earlier, elementary teachers must teach a variety of subjects to a diversified student population. Several factors cause elementary science teaching to be somewhat unsuccessful. These include poor academic preparation, inadequate time and materials, low subject priority, and lack of confidence (Abell, 1990). Teachers' attitudes directly affect student attitudes. As Yager reports (cited in Stefanich, 1989), as students continue to take science, their attitudes become more negative. They become less curious about science. This, in turn, affects student achievement.

Yager and Penick (1988) studied the various attitudes toward the goals for science instruction in schools. Their survey spanned from 1976 to 1986. The four goals included meeting personal needs; resolving societal issues; achieving career awareness; and preparing for further study. The results were organized by grade level divisions including K-3, 4-6, 7-9, and 10-12. For K-3, 4-6, and 7-9, preparation for further study and meeting personal needs ranked 1st and 2nd. For 10-12, preparation for further study and resolving societal issues ranked 1st and 2nd. Compared to 1976, career awareness and societal issues ranked much higher in 1986. Including these goals at the elementary level would provide opportunities for students to attempt to resolve societal issues using problem solving and thinking skills.

Stefanich (1992) outlines seven trends which are likely in the coming decade, three of which are dangerous and harmful to reform in science education. They include the increased use of departmentalization extending below grade five, increased textbook usage, and greater emphasis on desk work. He also notes that elementary science too often stresses reading, note taking, and worksheets. Stefanich cites a 1989 report by the Carnegie Council on Adolescent Development that departmentalization is the organization in many middle schools. However, he does not cite any evidence that this is occurring at the elementary level. Therefore, perhaps the elementary school level is the most hopeful site for science education reform. Comparing "hands-on" science in 1980 and 1987, Anderson and Norton's research (cited in Stefanich, 1992) showed that:

> teachers who spend less than 20% of their instructional time in active investigation has increased by 30% at all grade levels, while the percentage of teachers who devote over 80% of class time using hands-on science has decreased considerably. (Stefanich, 1992, p. 17)

Drawing a conclusion from Anderson and Norton's research, Stefanich notes a decrease in hands-on science and a trend towards increased deskwork and teacher demonstration.

New elementary programs do seem to be on the right track, as they address societal and current issues and shift their focus from a strictly cognitive orientation to one that includes the affective domain as well. The informational and technological advances in the coming years will also impact education. A true understanding of practical problem solving and information retrieval will gain importance. In addition, a shift from criterion-referenced tests to a form of standardized assessment may be encouraged for accountability. These aspects of new elementary programs could help students make greater gains in achievement.

Stefanich (1992) offers suggestions for educators in order to improve the quality of science learning. First, it is important to develop age-appropriate programs which incorporate "hands-on, minds-on" science. Second, instructional methods which utilize the discovery approach are essential. The textbook should be one of many resources used in teaching science. Third, a consistent time slot for science will discourage teachers from using science to fill in the gaps. Fourth, many science concepts require integration across disciplines. Finally, assessment techniques must be flexible in order to evaluate students' thinking strategies and process skills in science.

Hurd (1991) offers six suggestions to help reform the existing state of science education. These are "to integrate the disciplines; to modernize the content; to teach higher-order thinking; to use better texts, less jargon; to teach for change; and to invent integrated curriculum" (Hurd, 1991, pp. 33-35). An integrated curriculum focusing on social perspectives will help students attack life's daily problems. Science courses must address relevant, everyday questions so that students can apply the scientific knowledge in a social context. Scientists use a variety of methods to solve problems, whereas a single "scientific" method is often memorized in elementary schools. This is not enough training for students if they are to be able to compare and contrast, to process new information, and critically to analyze a situation in order to make a rational decision. Students must be taught a variety of strategies in higher-order thinking. Hurd points out that science texts contain pages and pages of facts and include reams of scientific vocabulary. It has been said that learning the terminology alone is like learning a foreign language. Even if students knew all this information, they would still not be scientifically literate. As a final goal for science education, Hurd (1991) encourages us to ''recognize and deal with change" (Hurd, 1991, p. 34) because we live in an informational and technological society. Elaborating further, Hurd (1991) says the following:

> Knowledge has replaced brawn, land, and other natural resources as the leading factor in determining our gross national product. Hence, our students will need to know more and work smarter than any past generation. Not surprisingly, support for an economic goal for science teaching comes primarily from business and industry. (Hurd, 1991, p. 34)

"Learning to learn" must be a new mandate for science education, so that students can become lifelong learners and can plan for their future. Hurd (1991) discusses the reform movement of the 1990s:

> The reform movement of the 1990s calls for an integration of school subjects: a conceptual convergence of the natural sciences, mathematics, and technology with the social and behavioral sciences and the humanities into a coherent whole. A unity of knowledge will make it possible for students to take learning from different fields of study and use it to view human problems in their fullness from several perspectives. (Hurd, 1991, p. 35)

THE STATE OF LANGUAGE ARTS EDUCATION IN THE 1990S

The language arts reform movement is embedded in the educational reform of the 1980s and parallels science education reform. Salinger (1996) attributes the interest in reform to several influential occurrences. First, A Nation at Risk (NCEE, 1983) recommended increases in high school graduation requirements in English. Second, in 1992, Elley (cited in Salinger, 1996) documented the international assessment results of reading levels. Third, in 1993, the National Academy of Education (cited in Salinger, 1996) documented the results of the National Assessment of Educational Progress. Fourth, in 1994, Elkind & Mitchell (cited in Salinger, 1996) noted the concerns, evident in the business sector, for qualified high school graduates. Finally, Public Law 103-227, Goals 2000: Educate America Act, contains several aspects that affect educational reform. This law proposed that national standards provide goals for students but state and local districts determine how to meet the goals. Also, in order to secure federal funding states must "establish and enforce the use of standards" (Salinger, 1996, p. 292).

In 1996, the International Reading Association (IRA) and the National Council of Teachers of English (NCTE) produced the national standards for the English language arts. As noted in Myers (1994), these standards are different from earlier ones because:

> First, the learner is recognized as active, not passive. Second, the meaning is socially and historically contingent, not universal for all times. Third, the purpose is the development of language for political power and the creation and appreciation of connections-intertextual, intratextual, interpersonal, and intergroup. These aims are commitments for all students. (Myers, 1994, p. 152)

Adopting a systems approach (Elkind, cited in Salinger, 1996), the IRA/NCTE developed broad standards[3] based on a model of literacy that includes "content, purpose, development, and context" (IRA/NCTE, 1996, p. 12). Salinger states that the standards are integrated across the language arts. In 1994, the IRA/NCTE published Standards for the Assessment of Reading and Writing. However, "New Standards is developing a new system of assessments (performance tasks, projects, and portfolios) in English language arts, mathematics, science, and applied learning" (IRA/NCTE, 1996, p. 112).

As the IRA Director of Research, Salinger (1996) discusses concerns about the standards as well as provides suggestions about how the standards could be helpful. Concerns include the following: efforts to centralize decision making at the national level; formulation of a national curriculum; "top-down effort" (Salinger, 1996, p. 293); and inconsistencies in national standards' (different disciplines) design. Salinger (1996) suggests several changes that need to occur so that the standards are useful. Learning must be seen as a continuum. Students must be alternatively assessed according to a set standard rather than being compared and ranked with their peers. The opportunity to learn must be in place for all students, even if this opportunity requires additional time and/or resources. Finally, teachers must be trained effectively, including training in pedagogical[4] knowledge in their respective disciplines.

Before reviewing research supporting integration of science and language arts, it is important to understand the nature of each individual discipline.

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[3] See organizational matrix in Chapter 4.

[4] Pedagogy is defined as "the art or science of teaching, esp. instruction in teaching methods" (Guralnik, 1971, p. 548).

THE NATURE OF SCIENCE

Science for All Americans: A Project 2061 report on literacy goals in science, mathematics, and technology (American Association for the Advancement of Science, 1989) addresses the nature of science. Science is a way of knowing about the world that emphasizes observing, thinking, experimenting, and validating. The nature of science is divided into three main parts: the scientific world view; scientific inquiry; and the scientific enterprise. The scientific world view is further divided into the following categories: the world is understandable; scientific ideas are subject to change; scientific knowledge is durable; and science cannot provide complete answers to all questions. Scientists believe that there are basic patterns and rules which define overriding principles existing in the universe. As our knowledge base grows about our world, old theories are modified with new bits of information, thus providing evidence that change is constant. In contrast to this, scientific knowledge is also relatively constant. Principles and generalizations are for the most part fairly stable. Finally, science cannot answer all questions-some things cannot be proved or disproved.

Scientific inquiry is sectioned into the following sub-categories: science demands evidence; science is a blend of logic and imagination; science explains and predicts; scientists try to identify and avoid bias; and science is not authoritarian. To inquire is to ask questions. Scientists use a variety of methods and techniques to determine answers for these questions. Scientific knowledge is supported by observations and data in natural or controlled settings. Science combines creativity and logical reasoning in order to interpret these data. This wealth of knowledge is used to further explain certain phenomena as well as to predict further occurrences in nature. Scientists must be attuned to how data are interpreted and must guard against bias. Furthermore, no one scientist possesses "the truth" about the world. Healthy dialogue and discussion about new findings is welcomed.

The scientific enterprise is divided into the following concepts: science is a complex social activity; science is organized into content disciplines and is conducted in various institutions; there are generally accepted ethical principles in the conduct of science; and scientists participate in public affairs both as specialists and as citizens. Science is influenced by the social and political structure of the time. These factors determine what arenas receive funding and are researched. Being a social activity, science goes on in a variety of settings; and the information produced by research must be shared with others. Specialization has dictated the division of science into various disciplines. Research in these disciplines is directed and funded by universities, industries, and government. Ethical and professional behavior is scrutinized in the scientific community. This is evidenced by the fact that any experiment should be able to be replicated if researchers report the data and results in a professional manner. Finally, scientists often take an advisory role when needed to separate fact from opinion in the scientific arena. However, more often than not, scientists participate as informed citizens with their own personal perspectives on public affairs.

NATURE OF LANGUAGE ARTS

Although there is a multitude of information on the "nature of science", I was unable to find (through a fairly in-depth search) any information on the "nature of language arts". So, I have developed my own description of the "nature of language arts". By its nature, language arts is integrated among reading, writing, listening, and speaking for a purpose. Anderson, Hiebert, Scott, and Wilkinson (1985) concur when noting "all of the uses of language- listening, speaking, reading, and writing- are interrelated and mutually supportive" (Anderson et al., 1985, p. 79). I define language arts as a way of learning about the world and communicating this knowledge. Anderson et al. (1985) describe reading, one way to learn about the world. "Reading is the process of constructing meaning from written texts. It is a complex skill requiring the coordination of a number of interrelated sources of information" (Anderson et al., 1985, p. 7). Their description exemplifies the nature of reading. Language learning is another aspect of the nature of language arts. The IRA/NCTE Standards note that language learning includes four factors: what students should know (content); why students use language arts (purpose); and how students develop competencies (development). The fourth factor, context, surrounds the previous three factors (IRA & NCTE, 1996). The Standards provide a comprehensive perspective of language learning. Finally, by its nature, language arts performs a function. Peterson (1982) notes the following:

> Language underlies learning in all disciplines. Using language promotes learning. Students and teachers must see talking, writing, listening, and speaking as essential elements in the development of knowledge in all fields. (Peterson, 1982, p. 179)

Peterson indicates the greater purpose of language arts- development of knowledge- a purpose that can only be accomplished when language arts is integrated with other disciplines.

In reviewing the nature of science and language arts, one sees the difference in perspective from each field. Does this perspective persist when considering integrating suject matter? The following section will address this issue.

RESEARCH SUPPORTING INTEGRATION OF SCIENCE AND LANGUAGE ARTS

Mischler (1982) analyzed the relationships between experiential science instruction, language arts, and cognitive development. In a section entitled, "The Relationship Between Experiential Science and Language Arts" (Mischler, 1992, pp. 16-20), Mischler examined the research from 1969-1980 in relation to reading, reading readiness, speaking and listening, and science. Ayers and Ayers, Ayers and Mason, Merricks and Crocker, and Wellman (cited in Mischler, 1982) found that science process curricula, such as Science- A Process Approach and others, enhance reading readiness, promote language development, and improve reading comprehension. Barufaldi and Swift, Carter and Simpson, and Lucas and Burlando (cited in Mischler, 1982) noted several skills that are common to reading readiness and science such as observing, describing, classifying, communicating, comparing, inferring, predicting, interpreting, and forming conclusions. Barufaldi and Swift, Huff and Languis, and Morgan and others (cited in Mischler, 1982) found that science activities and science process curriculum can have a positive effect on motivation and oral communication skills, can improve some speaking skills for disadvantaged children, and can benefit students with 'requisite' listening skills. Swift (1977) noted an increase in listening skills of elementary children when participating in selected activities from the Biological Sciences Curriculum Study- Elementary School Sciences Program. Fuller and others, and Hopper (cited in Mischler, 1982) found that significant correlations exist between reading achievement and science concept attainment as well as between primary reading and science performance on statewide tests.

In a section entitled, "The Process of Integrating Experiential Science and Language Arts Instruction" (Mischler, 1982, pp. 21, 22), Mischler examined related research and articles from 1975-1980. Based on research and practical experience, Carter, Donlan, Esler and Merritt, and Simon and Zimmerman (cited in Mischler, 1982) proposed integrating science with reading/writing and teaching reading through science experience stories. Based on research and practical experience, Bishop, and Rice and Sisk (cited in Mischler, 1982), made suggestions pairing science and brain theory. They noted ways of relating science to right hemisphere processes. In addition, they suggested ways to incorporate creative dramatics in science, thus helping the right hemisphere complement the left hemisphere's verbal function.

Further encouraging research came from Helgeson, Howe, and Blosser (1990), who conducted a two-year project that identified 36 exemplary science programs. Fifteen of the 36 programs are applicable at the elementary level. Each program is described in detail, and available materials are listed. Common characteristics of all the programs are included in the summary. Many of the programs and materials stressed an interdisciplinary approach to teaching. They also focused on changing students' attitudes to science rather than on the memorization of facts. The programs incorporated societal and technological issues. Cooperative learning and hands-on activities were emphasized. Additionally, videos and computers were used in many of the programs. Most of these characteristics are derived from the integrated approach.

Roth, Pressley, and Hazelwood (1992) conducted a three-year study called the Literacy in Science and Social Studies Project (LISSS). The research question that fueled the study was "how could writing and discourse support students in developing meaningful understandings about science, social studies, and writing?" (Roth et al., 1992, p. 1). The initial focus of the study was to help fifth grade students integrate within disciplines, not across disciplines. Student interviews shed light on some interesting and unexpected results. Instead of viewing "data from an integration perspective" (Roth et al., 1992, p. 2), the researchers looked "at integration (both within and across disciplines) from the students' perspectives" (Roth et al., 1992, p. 2). Because of this, the researchers ended up adjusting the focus of their study to include integrating subjects across disciplines. The results showed that several important common features among the different subject matter teams were evident. Based on Marshall's (cited in Roth et. al, 1992) metaphor of a learning community versus a work-oriented classroom setting, each team created a similar learning community in their classroom which stressed sense making and learning as a goal. Each team's view of "how we come to know" was based on the fact that knowledge is tentative and socially constructed. Collective cognition was paramount. Students viewed their science texts as resources to be questioned and became critical readers of multiple texts. Finally, the curriculum was planned around the students' thinking and experiences. Roth et al. (1992) attributed the students' integrated thinking to these three factors. Although the complete results were not included in this article, the researchers included two case studies which highlighted how the students began to think within and across disciplines.

Colvin and Ross and Strickland and Morrow (cited in Colasanti & Follo, 1992) provide literature which supports integration through a whole-language approach as well as through the integration of science and language arts. In addition, in association with the Mid-California Science Improvement Program, Greene (1991) conducted research at an elementary school. The program used an integrated, thematic approach. Teachers developed a theme for the year, accompanied by a monthly breakdown of related topics. "The program actually turns the table on the school day, making science the ingredient that unites all other subjects" (Greene, 1991, p. 43). The attitudes of students and teachers were measured as well as the program's influence on science achievement by students. At the end of the second year, students showed statistically significant gains (78% of students improved their NAEP scores)[5]; and teacher attitudes toward science rose considerably.

Lipson, Valencia, Wixson, and Peters (1993) encourage integration. Thematic instruction provides coherence and promotes transfer of learning among different contexts. Pappas, Kiefer, and Levstik (cited in Lipson et al., 1993) note that thematic organization encourages "deeper and broader learning" (Lipson et al., 1993, p. 254) and promotes "metacognitive awareness" (Lipson et al., 1993, p.

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[5] For more information concerning assessment of this program, Greene (1991) cites the following source: Okamoto, Y. (1989). "Evaluation of 1988-1989 Mid-California Science Improvement Program". Stanford, CA: Stanford University.

254). Integration of a knowledge base, such as science, could result in faster information retrieval and concept transfer.

Another strong body of evidence supporting integration of subjects is recent research in brain theory:

> This brain research challenges the belief that the cognitive, affective, and psychomotor domains can be treated separately in teaching. In their book, Making Connections: Teaching and the Human Brain, Caine and Caine (1991) emphasize interdisciplinary education and thematic teaching as ways to immerse students in knowledge. (Colasanti & Follo, 1992, p. 16)

Three premises of brain-based learning are discussed. First, the brain naturally searches for patterns and connections when it is processing information. Second, "every experience actually contains in it the seeds of many disciplines" (Colasanti & Follo, 1992, p. 17). Third, reiteration, meaning "presenting learners with several perspectives of a certain topic" (Colasanti & Follo, 1992, p. 18) is another key to learning. These premises have direct application if subject matter and concepts are integrated. Furthermore, brain theory adds to the research base supporting constructivism (discussed in Chapter 3) as a learning theory.

The factors that facilitate science integration include the origins of integration, the state of science education in the 1990s, the state of language arts in the 1990s, the nature of science and language arts, and research supporting integration of science language. How far have we come in our efforts to integrate science into the curriculum? Blum (1993) states the following:

> The new science teaching curricula, both the discipline-centered and the interdisciplinary types, have stressed the paramount importance of structure in science. Some stress the need to understand conceptual schemes, others emphasize the processes, the ways of collecting and using evidence. But all agree that science is not merely a collection of facts, which grows by accretion, but a building in which the bricks of knowledge would fall apart without the cement which holds them together. Furthermore, in the light of

> the 'knowledge explosion' and faced with the problem of what to teach in the limited time allotted to science education in school, a review of the situation has shown that structures change much more slowly than factual knowledge and therefore are more likely to be of use, when today's students become adults. (Blum, 1993, p. 33)

Blum's statement, made over 21 years ago, has relevance even now. Have our educational structures changed so slowly that we still face the same problems we faced in 1973? It is time to experiment with a different paradigm. In the 1990s, there has been a resurgence of integrated curricula and programs. Education must prepare students to be functionally literate in a variety of fields, as well as to be proficient problem solvers. Integrated curriculum helps prepare students in a more holistic fashion. Developing criteria for interdisciplinary integration will permit teachers to choose skillfully how they will integrate elementary science into the language arts curriculum. This may be the key for survival in the 21st century.

Chapter 3: Theoretical Underpinnings for Integrating Science and Language Arts

The theoretical underpinnings for integrating science and language arts include learning theory, literacy, and connections. First, the constructivist theory of learning and the application of integrating the disciplines are elucidated. Second, the importance of literacy and its relationship to language arts and science are discussed. Finally, connections between language arts and science are made explicitly, so teachers can provide a web of support for students and can thereby reinforce learning.

THEORY OF LEARNING

Constructivism[1] is a theory of learning shared by both science and language arts educators. A theory of learning by definition embodies accepted principles and methods about gaining understanding through experiences (Guralnik, 1971). Learning theories have their origins in different schools of psychology, such as behaviorism or psychoanalysis. Constructivism is considered a cognitive theory of learning because it focuses on the individual's "current perception and interpretation of events" (Hilgard et al., 1979, p. 11). Since a theory of learning underscores how disciplines will be taught, a sampling of research from language arts and science will be provided to elucidate the general theory and the application of constructivism.

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[1] The term's root words are 'construct' and 'constructive' meaning "something built or put together systematically" and "not directly expressed but deduced by interpretation" (Guralnik, 1971, p. 163) respectively.

Anderson, Carey, and Champagne & Hornig (cited in Bybee, 1988) articulate the constructivist theory. A learner brings a conceptual understanding to a learning environment. Experiences challenge the learner's current concept ("disequilibrium" [Bybee, 1988, p. 160]), thereby promoting other ways of thinking. The learner realizes her original conceptual understanding is incomplete. Teachers provide additional experiences and time for the learner to grapple with dissonances. The learner leaves the environment with a new, broadened conceptual understanding ("cognitive equilibrium" [Bybee, 1988, p. 160]).

Science educators have applied constructivist learning theory more explicitly to science education. Tobin (cited in Appleton, 1993, p. 274) defines constructivism as "a theory that assumes knowledge cannot exist outside the bodies of cognising beings....[sic]Knowledge is a construction or reality" (Appleton, 1993, p. 274). On the basis of research, Appleton (1993) explains a theoretical constructivist learning model that focuses on the learner and explores the four paths a learner might experience when coming to a new learning situation. The four paths end in "exits" that include "reinforcement of existing idea (right or wrong); previous ideas now changed; existing ideas unchanged- a new set of ideas for school situations; and existing ideas unchanged" (Appleton, 1993, pp. 269, 270).[2] Additionally, Appleton compares a traditional and constructivist teaching approach in a science lesson that addresses floating and sinking. He urges teachers to consider this approach when planning and to apply this approach in small increments. He acknowledges that a constructivist approach

[2] See organizational matrix in Chapter 4.

requires a shift in thinking for the teacher. Appleton's model is relevant because the model applies constructivism to a classroom situation. Furthermore, the model focuses on the four possible outcomes that could result from student learning and participation.

As one of the ten regional consortia established by the United States Department of Education, the Southwest Consortium for the Improvement of Mathematics and Science Teaching (SCIMAST) believes that all educators should be involved in educational reform. Prominent in promoting systemic reform in mathematics and science, SCIMAST (1995) is housed at the Southwest Educational Development Laboratory in Austin, Texas. SCIMAST publishes Classroom Compass, which is distributed to teachers in the Arkansas, Louisiana, New Mexico, Oklahoma, and Texas region. The winter 1995 issue discusses constructivism in two articles entitled "Constructing Knowledge in the Classroom" (Adams & Powell, 1995, pp. 1, 2) and "Building an Understanding of Constructivism" (Adams & Powell, 1995, p. 3). Students don't readily accept new concepts to replace old ones; rather they meld the two concepts into a compromised concept. Brooks and Brooks (cited in Adams & Powell, 1995) present the characteristics of a constructivist classroom.[3] These include the following:

> Student autonomy and initiative are accepted and encouraged. The teacher asks open-ended questions and allows wait time for responses. Higher-level thinking is encouraged. Students are engaged in dialogue with the teacher and with each other. Students are engaged in experiences that challenge hypotheses and encourage discussion. The class uses raw data, primary sources, manipulatives, and physical, interactive materials. (Adams & Powell, 1995, p. 2)

[3] See organizational matrix in Chapter 4.

Teachers can refer to these characteristics as they try to move from a traditional paradigm to a constructivist one. The articles point out that it is imperative that teachers focus on "science doing" and overtly instruct children that any resources, ideas, or concepts used in the classroom have been formed through observation, data gathering, and analysis . When students are overtly instructed about resources, students realize that information in secondary sources has to be generated from similar processes that they use to formulate research reports and writing projects in their own classroom.

As a reading researcher, Au has developed reading approaches that emphasize the students' prior knowledge base (Mason & Au, 1986). Philosophically aligned with constructivism, she discusses this theory of learning from a language arts and literacy viewpoint. Au (1993) cites Applebee, stating that "the roots of social constructivism and of constructivist models of instruction may be traced to frameworks in a range of fields, including philosophy, linguistics, and the history of science" (Au, 1993, p. 40). Au compares a transmission (traditional) model of instruction with a constructivist model of learning. A constructivist model of learning has four advantages. Au (1993) summarizes these as follows:

> Constructivist models encourage us to embed literacy instruction in meaningful social contexts. They remind us of the importance of allowing students to explore the functions of literacy. They prompt us to look first at students' needs and interests, and then to teach skill as they are needed. Finally, constructivist models call our attention to the place of different life experiences and cultural schemata in the meaning making process. (Au, 1993, p. 47)

A constructivist model, as compared to a traditional model, allows for instruction and learning in multicultural settings. Au's work is particularly weighty because she combines constructivism and multiculturalism. As a theory of learning that draws on prior knowledge and can be applied in the most diverse cultural melting pot- the United States, constructivism is a guide for all educators.

LINKS TO LITERACY

Constructivism, as a theory of learning, can be applied in a classroom situation; but there must be a goal for learning. What greater goal is there for the educational system than teaching children to be literate? Literacy by definition is the "ability to read and write" (Guralnik, 1971, p. 437). I define literacy as the ability to read and write for one's own purpose; the ability to synthesize information from reading and writing; the ability to see the broader context and to make connections among related areas from reading and writing; the ability to make informed decisions based on reading and writing; and the ability to communicate thoughts in a coherent, organized fashion.

If literacy is the goal of education, insight from the language arts field is presented to acknowledge and discuss the importance of literacy learning. Cambourne has researched literacy for twenty years. Not only does his research add to the knowledge base about literacy, but also he has taken his research one step further. He formed his research into a model of literacy and then transformed his model for classroom situations. Through researching literacy learning, Cambourne (1995) identifies eight conditions evident in acquiring oral language. These include "immersion, demonstration, engagement, expectations, responsibility, approximations, employment, and response" (Cambourne, 1995, pp. 185, 186). Cambourne incorporates these conditions[4] in a model of literacy learning.[5] Through collaboration with teachers, Cambourne uses this model and applies it to the classroom.[6] He lists and describes the characteristics of a relevant theory of literacy learning. These include "internal consistency; ecological validity; theory-into-practice congruence; pragmatic coherency; transferability; and high success rate" (Cambourne, 1995, p. 190).

In addition to Cambourne, Au is a prominent reading researcher who discusses literacy in her book entitled Literacy Instruction in Multicultural Settings. Not only does she iterate the aspects of literacy; she also outlines four principles of literacy instruction. On the basis of research, Au describes the nature of literacy learning. Literacy learning incorporates "knowledge of the functions and forms of literacy" (Au, 1993, p. 35). Literacy is embedded in a social context and is not used in isolation. The teacher's responsibility is twofold: to help children formulate their own goals for literacy; and to facilitate and supervise goal attainment. Au details six aspects of literacy. "Ownership, the writing process, reading comprehension, language and vocabulary knowledge, word reading strategies, and voluntary reading" (Au, 1993, pp. 63-66) can be used as a curriculum structure.[7] Also, Au outlines the four principles of literacy instruction:

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[4] Cambourne defines the term to include"particular states of being, as well as a set of indispensable circumstances that co-occur and are synergistic in the sense that they both affect and are affected by each other" (Cambourne, 1995, p. 184).
[5] Each condition is described in detail in Cambourne's literacy learning model seen in the organizational matrix in Chapter 4.
[6] See Cambourne's classroom model in the organizational matrix in Chapter 4.
[7] See Au's six aspects of literacy diagram in the organizational matrix in Chapter 4.

> First, literacy instruction centers on understanding and the communication of meaning. Second, literacy instruction takes place in the context of a rich and challenging curriculum. Third, literacy instruction takes place through a diversity of activities. Finally, literacy instruction incorporates students' experiences. (Au, 1993, p. 151)

Au's work is particularly important in this report. By detailing the aspects of literacy and describing the principles of literacy instruction, she clarifies the nature of literacy, which is essential for a complete understanding when one is teaching the language arts.

CONNECTIONS BETWEEN SCIENCE AND LANGUAGE ARTS

The fields of science and language arts have both contributed to the information concerning integration by explicitly identifying commonalities among their fields. Relationships do exist between the disciplines of science and language arts. To better understand these connections, it is helpful to identify the underlying concepts and skills common to both.

Carter and Simpson (1978), Simpson and Butts (1982), Casteel and Isom (1994), and Mechling and Kepler (1991) elucidate these connections. Carter and Simpson (1978) note that "close examination of reading skills reveals that many are actually inherent in logical thought, and thus represent some of the most fundamental 'tools of the trade' for scientists" (Carter & Simpson, 1978, p. 19). The preceding authors state that the relationship between reading and science is a reciprocal one. Reading promotes science process skill attainment, and science process skills promote reading. Included is a table that identifies skills common to both science and reading.[8] Since there are process skills common to reading and science, teachers can combine reading and science and develop activites to support the process skills of both.

Simpson and Butts (1982) discuss the connectedness of reading, mathematics, and science. The authors examine the reciprocal relationship among reading, mathematics, and science. Simpson and Butts present a grade-level summary of skills common to science, reading, and mathematics.[9] By providing this valuable information, these researchers have taken integrated learning one step further than the Carter and Simpson (1978) article by including mathematics.

Casteel and Isom (1994) identify reciprocal processes between science and literacy learning. The authors state that using literature-based instruction will broaden students' scientific knowledge because parallels exist among literature, literacy process skill, and science process skills. Casteel and Isom (1994) assert that:

> The literacy processes appear as the basic or root system for growth in scientific knowledge, which is itself composed of facts, concepts, laws, and theories. The literacy processes are the means by which science content is learned because content information is rooted in written and oral language. (Casteel & Isom, 1994, p. 540)

Casteel and Isom make an important link between science and the natural dependence on oral and written language to facilitate science learning.[10] Next, Casteel and Isom compare science process and literacy process skills. Although these skills are not exactly the same, the authors remark that overlaps are

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8 See organizational matrix in Chapter 4.
9 See organizational matrix in Chapter 4.
10 See organizational matrix in Chapter 4.

evident.[11] Casteel and Isom address the application of skills when stating that "the literacy skills of graphing, diagramming, recording, and reporting are also very important in organizing, analyzing, and publishing science data" (Casteel & Isom, 1994, p. 542). The researchers point out parallels between science and literacy and, in so doing, help teachers focus on these parallels when planning for lessons and activities.

In Mechling and Kepler's (1991) article, science is a beginning point for cross-curricular integration.[12] Presented at the end of the article is a chart displaying "science process skills across the curriculum" (Mechling & Kepler, 1991, p. 37).[13] Mechling and Kepler's article is significant because they weave the science process skills across all curricular areas, thereby presenting an even greater degree of integration.

This chapter presented the theoretical underpinnings for integrating science and language arts. Constructivism, literacy, and connections are crucial for the integration of language arts and science. Melded together with models, methodologies, and guidelines for integration (presented in Chapter 4), teachers can design integrated curricula that meets the needs of their students.

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[11] See organizational matrix in Chapter 4.

[12] Reasons for beginning instruction with science are presented in "Methods to Integrate Science and Language Arts" in Chapter 4.

[13] See organizational matrix in Chapter 4.

Chapter 4: Models, Methodologies, Guidelines, and an Organizational Matrix of Graphics

Previously, as a middle school science teacher and as an elementary Special Education teacher, I saw first-hand that students are often unable to take what they are learning and to make connections. This led me to explore and study the state of elementary science in terms of integrated teaching and learning. From direct experience with elementary teachers and through my readings, I have identified a need in the elementary science field. As stated earlier, elementary teachers prefer teaching reading and writing (Stefanich, 1989). Research has shown that elementary teachers do not feel prepared to teach science. To infuse science into the elementary curriculum, I have developed a practical guide that will help elementary teachers integrate language arts and science effectively. This guide includes models; methodologies[1]; a Model for Integrating Language Arts and Science (MILAS); guidelines[2]; and an organizational matrix of graphics.[3]

INTEGRATION MODELS

In the late 1980s and early 1990s, the revisitation of integration has spurred the development of many models. Integration models can be used as a guide for curriculum planning. I have previewed the existing interdisciplinary

[1] Methodologies are defined as "a systematic procedure; a plan or system of conduct or action" (Morehead & Morehead, 1972, p. 334).
[2] Guidelines are defined as "a recommendation or principle for determining a course of action" (Morehead & Morehead, 1972, p. 243).
[3] A matrix is defined as "that within which something originates, takes form" (Guralnik, 1971, p. 462). See organizational matrix in Chapter 4.

models to furnish a continuum from which teachers can choose. Each teacher or team of teachers could begin integrating at any point along this continuum.

Jacobs (1989), Fogarty (1991), Schumacher (1992), and Drake (1993) present general integration models. In so doing, these general models define integration; describe the models; and provide concrete examples. They provide a descriptive picture of what an integrated curriculum can look like if used in a classroom setting. I include specific models for language arts (Roehler, 1983) and mathematics/ science (Berlin & White, 1994) since language arts and science are the focus of this report.

General Integration Models

Jacobs (1989) discusses the need for interdisciplinary curriculum content and presents design options for an integrated curriculum. "A 1988 poll by the Association for the Supervision of Curriculum Developement (ASCD), says interest in curriculum integration is the number one issue among the members of the ASCD" (Jacobs, 1989, p. 9). Reasons for this interest are as follows: the growth of knowledge, especially in science; fragmentation of schedules; relevance of the curriculum; and society's response to fragmentation. The six design options for integrating curriculum include *discipline-based content; parallel discipline; complementary discipline* units or courses; *interdisciplinary* units or courses; *integrated-day;* and *complete program*.. The first requires no integration and is the most common in the U. S. today[4]. We're used to this design, but it

[4] This design option does not support integration. It would stand to reason that it should not be included as an integrated model. However, Fogarty (1991) and Schumacher (1992) include similar models in their integrated categories.

fragments the students' day and is not like real life outside the school. The second requires sequencing of two disciplines in order to cover similar concepts. This is commonly found in elementary schools when related subjects are taught concurrently. However, connections are not explicitly stated for students; and subjects are still isolated. The third design combines related disciplines to study a theme and adopts its own scope and sequence. The fourth option brings together all disciplines into a unit that has a specified length. A unit approach is a comprehensive way to motivate and stimulate teachers and students; but it requires effort, change, time for planning, careful timing, money, and parent support. The fifth design is based on students' needs, questions, and interests in a thematic or problem-oriented full day. Although highly motivating for the students, this design is usually at odds philosophically with teachers. Since there is no existing curriculum, it requires teacher time, effort, and support. The sixth option is a residential program which is totally integrated. The curriculum comes from the students' interests on a day-to-day basis. Encouraging self-discipline and self-direction, this option requires parent and administrative support.

Another perspective on curriculum integration is seen in Fogarty's (1991) book. Fogarty describes ten models for curriculum integration that a teacher or team of teachers can utilize in planning and instruction. The models are divided into four general categories: "within single disciplines; across several disciplines; within learners themselves; and across networks of learners" (Fogarty, 1991, p. 61). "'Within single disciplines' includes the *fragmented*, *connected*, and *nested* models" (Fogarty, 1991, p. 61). The *fragmented* model parallels the traditional, departmentalized curriculum evident even at the elementary level. For example, math is taught as a single discipline, not integrated with other subject areas. The *connected* model focuses on explicitly stating related ideas in one content area. In this way, teachers link and note for their students the interrelationships that exist in the subject matter. For example, in science, a teacher notes patterns that recur such as the life cycle and the water cycle. The *nested* model engages students in content learning along with a targeted thinking skill and social skill appropriate for the lesson. For example, when studying the human body, the teacher combines the unit with a thinking skill such as comparing and contrasting the body systems.

"'Across several disciplines' includes the *sequenced, shared, webbed, threaded*, and *integrated* models" (Fogarty, 1991, p. 61). The *sequenced* model views subjects separately, but sequences units from different subjects in order to provide a broader picture of related concepts. For example, a teacher sequences language arts and science to emphasize a related concept such as "change". The *shared* model identifies the common concepts in two different disciplines and involves team planning. For example, pairing language arts and science, a teacher plans a unit focused on the animal kingdom. The teacher can then use literature to target common concepts such as classifying, common attributes, and prediction. The *webbed* model combines many disciplines at once in an underlying thematic approach. Studying a theme such as mobility and incorporating all the subject areas would exemplify this model. The *threaded* model identifies the broader concepts that are evident across disciplines. "This model threads thinking skills, social skills, study skills, graphic organizers, technology, and a multiple intelligences approach to learning throughout all disciplines" (Fogarty, 1991, p.

63, 64). For example, the teacher would choose"an attribute cluster of thinking skills to infuse into each content: Science (classify), Social Studies (compare and contrast), Language Arts (attribute), Math (sequence)" (Fogarty, 1991, p. 64). The *integrated* model focuses on common concepts and skills across four major disciplines in an interdisciplinary approach. At the elementary level, a whole-language strategy integrating reading, writing, speaking, and listening would exemplify this model.

"The 'within learners themselves' and 'across networks of learners' include the *immersed* and the *networked* model" (Fogarty, 1991, p. 61) respectively. The *immersed* model adheres to an intrinsic type of integration dependent upon the learner. Learners, motivated by intense interest in a certain subject, will tackle every aspect related to the subject at hand and will integrate the data. The *networked* model is organized by the learners. Each learner brings her expertise to the learning environment. Then, the sharing of knowledge and ideas is networked "within and across areas of specialization" (Fogarty, 1991, p. 65).

Fogarty's work gives teachers many choices and is adaptable depending upon the teacher's philosophical views, whether these be student-centered or teacher-centered. When a curriculum specialist offers variety and flexibility, greater numbers of teachers are more likely to use such an approach.

Schumacher (1992) discusses five levels of curriculum integration that she and H. L. Irvin synthesized and developed based on several previous models, including Fogarty's model. The levels include "*departmentalized; parallel; complementary; webbed;* and *integrated* themes" (Schumacher, 1992, p. 7). *Departmentalized* is the traditional model in which disciplines are taught separately and no coordination between teachers exists. *Parallel* refers to a model in which disciplines are still taught separately, but they are sequenced so that similar concepts or ideas correspond with each other. *Complementary* coordinates two or more disciplines by identifying common concepts in order to study a theme. *Webbed* refers to a connected, thematic unit requiring team planning. Each team member instructs the unit from her discipline's perspective. *Integrated* themes is planned around student ideas. "The themes are based on students' personal and social concerns with the subject matter being woven into the investigation of the themes" (Schumacher, 1992, p. 7).

Schumacher's work provides more evidence that the curriculum specialists agree on the basic levels of curriculum integration. Although the specialists may use different terms for the levels of integration, the descriptions they provide are very similar. For example, the *discipline-based* content design (Jacobs, 1989), the *fragmented* model (Fogarty, 1991), and the *departmentalized* level of integration (Schumacher, 1992) all refer to a traditional, departmentalized curriculum.

An overarching curriculum integration which provides even more flexibility is seen in Drake's (1993) three models. Drake (1993) discusses three integrated models-*multidisciplinary, interdisciplinary,* and *transdisciplinary* -and defines three aspects for each model: conceptual framework; what is worth knowing?; and connection making. Multidisciplinary is defined as using other disciplines to increase the relevance of a discipline. In the *multidisciplinary* approach, teachers bring their expertise and insight to planning around a theme. They pose the question: "what is important to learn within different disciplines?"

(Drake, 1993, p. 36). In selecting themes, a teacher/team brainstorms through a semantic webbing or a "cluster and recluster" (developed by Sanders; cited in Drake, 1993, p. 42) technique. The *interdisciplinary-skills* approach focuses on connections across disciplines. A team poses the question: "how can we teach a student higher order competencies?" (Drake, 1993, p. 43). In selecting a theme, a team uses a tool called a "curriculum planning wheel" (Drake, 1993, p. 44). Jacobs and Palmer (cited in Drake, 1993) delineate this approach. This method helps in choosing skills present in all disciplines. Jacobs (cited in Drake, 1993) suggests using Bloom's taxonomy[5] as an organizational, thinking strategy for highlighting appropriate skills. The *transdisciplinary/real-world* approach focuses on a relevant issue or problem. A team poses the question: "how can we teach students to be productive citizens in the future?" (Drake, 1993, p. 46). A team uses a transdisciplinary web that includes "economics, law, media, environment, technology, politics, social issues, time (past, present, future)" (Drake, 1993, p. 46). Each approach is followed by learning outcomes and assessment.[6]

Drake's approach to categorizing integrated models is interesting because she views her models in an evolutionary fashion. As teachers become familiar with integrating, they can and will take more risks to move along the integrated evolutionary path. Each model provides strategies with which to determine the

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5 "The six major categories (or levels) in Bloom's taxonomy of cognitive objectives are knowledge, comprehension, application, analysis, synthesis, and evaluation" (Kellough, Carin, Seefeldt, Barbour, & Souviney, 1996, p. 84).

6 See organizational matrix in Chapter 4.

instructional focus. The suggested strategies are particularly helpful to and practical for teachers.

Specific Integration Models

Next, an integration model from the language arts perspective is presented since language arts is one of the foci in this report. Roehler (1983) discusses ten ways to integrate language and subject matter. She divides integration into two aspects: subject matter and levels of instruction. Subject matter is further divided into "(a) the knowledge base of our culture and (b) the language strategies that carry the information of our knowledge base" (Roehler, 1983, p. 28). Levels of instruction are divided into "the initial learning of new information and how previously learned information is used" (Roehler, 1983, p. 29). Roehler (1983) outlines each type:

> The *initial learning of language strategies* can be integrated: (1) with the initial learning of another language strategy; (2) with another language strategy previously learned and now being used during learning; (3) with the initial learning of concepts from the knowledge base; and (4) with previously learned concepts from the knowledge base. The use of *previously learned language strategies* can be integrated (5) with the use of previously learned strategies; (6) with the initial learning of concepts from the knowledge base; and (7) with the use of previously learned concepts from the knowledge base. *Initial learning of concepts from the knowledge base* can be integrated (8) with the initial learning of other concepts from the knowledge base; and (9) with the use of previously learned concepts from the knowledge base. Use of *previously learned concepts from the knowledge base* can be integrated with other concepts from the knowledge base to provide the tenth type of integration. (Roehler, 1983, p. 31)

Roehler's integration strategies are advantageous because they offer a specific structure for language arts teachers to integrate content from other subject areas.

Next, an integration model from the mathematics and science perspective is presented. Influential researchers in the integration of science and mathematics have developed the Berlin-White Integrated Science and Mathematics Model. This model is divided into six areas: "ways of learning; ways of knowing; process and thinking skills; content knowledge; attitudes and perceptions; and teaching strategies" (Berlin & White, 1994, p. 3, 4). Berlin and White (1995) elaborate on the six aspects. "Ways of learning" encompasses general principles that include the following:

> Knowledge is built on previous knowledge. Knowledge is organized around big ideas, concepts, or themes. Knowledge involves the interrelationship of concepts and processes. Knowledge is situation- or context-specific. Knowledge is advanced through social discourse. Knowledge is socially constructed over time. (Berlin & White, 1995, p. 23)

These principles are rooted in constructivism. Berlin and White's Ways of Knowing Model[7] focuses on induction[8] and deduction[9], which are often interconnected. Science offers the opportunity for inductive reasoning, while mathematics uses deductive reasoning, thereby encouraging "an integrated, holistic view of the generation of knowledge" (Berlin & White, 1995, p. 25). The next aspect of the model addresses process and thinking skills. Although science and mathematics process skills are common knowledge, Berlin and White include the less conspicuous thinking skills common to both. Champagne (cited in Berlin & White, 1995) lists "science and mathematics thinking skills that include

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[7] See organizational matrix in Chapter 4.
[8] Induction is defined as "reasoning from particular facts to a general conclusion" (Guralnik, 1971, p. 382).
[9] Deduction is defined as "reasoning from the general to the specific or from a premise to a logical conclusion" (Guralnik, 1971, p. 197).

reasoning, metacognitive information-manipulating, information-management, formal-reasoning, and symbolic-representation skills" (Berlin & White, 1995, p. 26). These researchers see integration as the "overlap of conceptual knowledge of science and mathematics" (Berlin & White, 1995, p. 26) and note the specific concepts that overlap. Also, the researchers discuss attitudes and perceptions shared by science and mathematics reformers. Loucks-Horsley et al. (cited in Berlin & White, 1995) lists the commonalities:

> Desiring knowledge; being skeptical; relying on data; accepting ambiquity; being willing to modify explanations; cooperating in answering questions and solving problems; respecting reason; and being honest. (Berlin & White, 1995, p. 27)

The last aspect is teaching. "Teaching includes four dimensions: the structure and organization of the learning environment, instructional strategies, assessment, and the changing role of the teacher" (Berlin & White, 1995, p. 28).

The major thrust of this model is the establishment of a connection between the six areas in relation to mathematics and science. Their model is notable because it takes a comprehensive approach to integration and is based on sound research. Additionally, the model highlights the importance of a reasoning process in order to integrate. The absence of a thinking process for integration is common in resource materials today (Lipson, Valencia, Wixson, & Peters, 1993). A model that includes a thinking process for integration demonstrates forward thinking.

METHODS TO INTEGRATE SCIENCE AND LANGUAGE ARTS

Although the integration of science and language arts is of primary importance, a survey of the field by Lipson, Valencia, Wixson, and Peters (1993) show that no explicit methods existed for teachers to follow in accomplishing this integration. I include several articles that discuss different methods because the articles address practical ways teachers can integrate science and language arts. Furthermore, during the early 1990s, there has not been a multitude of work that explicitly discusses integrating science and language arts. I include articles that address this issue as well. Finally, I include an instructional method which is used in science. If one believes that language arts and science instructional approaches are process-oriented, it is possible that this method could be used to integrate both disciplines.

Cohen and Staley (1982) discuss practical ways to integrate science into the elementary school day and state the benefits that would arise if this occurs.

> Integrating science in the general curriculum can help reflect the relationships between science and other disciplines, increase or sustain student interest in science, increase teachers' confidence in their abilities to understand and teach science, increase students' science achievement, and increase students' awareness of the role of science in everyday life and the role of scientists in society. (Cohen & Staley, 1982, p. 565)

These benefits are in line with the goals of science education reform. The researchers proceed to outline seven ways to foster integration. A unit approach uses topics, usually based on natural phenomena, which offer a broad enough scope so that every discipline can be incorporated into the topic. Thematic units are a subtype of the unit approach. Organizing themes around processes, concepts, and problems would also be an appropriate opportunity for including science.

Science process skills can also be integrated because they are similar to many process skills in mathematics, language arts, and social studies. Learning centers can be used in combination with the previous strategies to help display information and to manage the integrated curriculum. Project work is yet another alternative to facilitate integration of science. A group of students selects a topic and researches it for a specific period of time. Student choice helps motivate them. A language-experience approach combines active experiences with language, reading, and writing. This strategy parallels the process approach to science. Teachers can plan and encourage students to use different types of writing to integrate mathematics and social studies. Another strategy which utilizes a natural setting for integration is the outdoor environment. Outdoor experiences are a wonderful way to participate in an interdisciplinary activity. As always, a supportive and cooperative classroom environment promotes a positive, learning experience for all students. Cohen and Staley highlight existing elementary science programs that could be used with the previously mentioned integrative strategies, offering an invaluable resource to teachers.[10]

Mechling and Kepler (1991) suggest using science as the hub for cross-curricular learning. Six reasons supporting this choice are as follows: children love science; science provides opportunities for sensory experiences; real experiences lead to integration; the hub approach saves time; science process skills promote thinking; and research indicates that experience-based science

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[10] The scope of this report is such that these resources are not included.

improves language, reading, and thinking skills. Included is a chart which correlates science process skills with reading, math, and social science.[11]

Mechling and Kepler not only provide a rationale for using integration, but also group the common process skills which can be accessed by teachers. Process skills are considered higher-order skills. Teachers are encouraged by their districts and state and national agencies to focus on higher-order processing. Teachers can take advantage of Mechling and Kepler's information and chart to engage their students in higher-order instruction.

A language arts perspective on methods for integration is also pertinent since I am forming a practical guide for integrating language arts and science. Lipson, Valencia, Wixson, and Peters (1993) encourage using the thematic approach for integration. In analyzing this approach, the authors provide a rationale for use. Thematic instruction provides coherence and promotes transfer of learning among different contexts. Pappas, Kiefer, and Levstik (cited in Lipson et al., 1993) note that thematic organization encourages "deeper and broader learning" (Lipson et al., 1993, p. 254) and promotes "metacognitive awareness" (Lipson et al., 1993, p. 254). Integration of a knowledge base, such as science, could result in faster information retrieval and concept transfer. The two main types of themes are intradisciplinary and interdisciplinary. Lipson et al. (1993) identify a basic area of need that, if targeted, would help the integration process:

> Classroom teachers need information that will help them make decisions about the focus or topics of themes, instructional goals and strategies, appropriate activities, and other design and implementation issues. (Lipson et al., 1993, p. 255)

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[11] See organizational matrix in Chapter 4.

As stated earlier in Chapter 1, broad guidelines for integrating curriculum have just been suggested (NSTA, 1996) and can be used in further curriculum formation. Additionally, my model provides criteria for making decisions about the focus of themes, guidelines for choosing an integrated model, and guidelines for choosing appropriate activities.

Lipson et al. (1993) analyze the existing professional materials, basal reading programs, and supplementary materials addressing thematic instruction which teachers use as resources when integrating curriculum. When one consults the professional materials, "there seems to be no recommended list of topics nor does there seem to be a coherent recommendation for a process for thinking about selecting themes" (Lipson et al., 1993, p. 257). The basal reading programs use intradisciplinary integration and state rationales for integration. However, they "lack the focus and coherence necessary to enhance learning at a thematic level" (Lipson et al., 1993, p. 258). Lipson et al. (1993) identified a need which I targeted in this report. Developing an organized and coherent guide for integrating subject matter addresses this need.

The researchers also analyze "comprehensive cross-disciplinary, multigrade curriculum supplements" (Lipson et al., 1993, p. 259) and did not find a consistent, operational definition of the thematic approach. Even though the supplements are cross-disciplinary, the objectives focus on language arts outcomes. If instruction is cross-disciplinary, the objectives should include language arts outcomes, as well as outcomes from all the other disciplines involved. "The best way to characterize these units of instruction is as a collection of activities that are more likely to fragment than to integrate students' understanding of the general theme" (Lipson et al., 1993, p. 260). Lipson et al. (1993) offers suggestions to help teachers plan curriculum using the thematic approach: avoid themes of convenience; identify the purposes and goals; focus on themes versus activities; plan to provide instruction throughout the theme; and work toward an integrated knowledge base.

Lipson, Valencia, Wixson, and Peters' seminal work is important on many different levels. The authors preview actual research concerning integration in language arts, as well as research supporting integration of language arts and science. As stated before, there is little extant research to highlight this combination in comparison to massive research on the integration of science and mathematics. Next, the authors discuss approaches for integration and rationalize why educators should integrate subject matter. Also, Lipson et al. discuss the actual benefits for students. In addition, their analysis of integrated curricular materials is very important because their assessment identifies weaknesses in existing resources, thereby directing others to develop a process of thinking to accompany any resources that assist teachers. Finally, Lipson et al. make concrete suggestions for implementing a thematic approach.

A significant instructional model in science education is the Biological Sciences Curriculum Study (BSCS) Instructional Model (Bybee, 1988). The BSCS model is promoted in the Texas Elementary Science Inservice Program (TESIP); a program designed to improve teaching in elementary science (Barufaldi, Carnahan, & Rakow, 1991). The BSCS or 5-E instructional model includes five stages: "engagement, exploration, explanation, elaboration, and evaluation" (Bybee, 1988, p. 162). The initial stage, engagement, involves actively connecting the present learning activity to the students' prior knowledge (also known as "minds-on"). The second stage, exploration, focuses on active student exploration of the environment ("hands-on"). The third stage, explanation, provides the opportunity for students to discuss their current understanding about the activity. The fourth stage, elaboration, focuses on extending the students' conceptual understanding by providing more experiences. The fifth stage, evaluation, is a time when students demonstrate newly acquired process skills and conceptual knowledge.

As a possible method for teaching integrated language arts and science, the 5-E model follows an inquiry approach, incorporating learning theory that encourages hands-on, minds-on activities. Colasanti and Follo (1992) point out that the inquiry or discovery approach and the whole-language approach are both process approaches. The researchers note that the inquiry approach shifts from learning isolated facts toward learning how to predict and to experiment; i.e., processes that are used in the exploration stage. The whole-language approach shifts from learning isolated skills toward using past experiences and prior knowledge to predict in reading and writing. Once again, the 5-E model uses these components in the engagement phase of learning. The 5-E approach could be adapted to integrate the language arts.

MODEL FOR INTEGRATING LANGUAGE ARTS AND SCIENCE (MILAS)

Through my research and reading, I have developed a model within a model for implementing integrated curricula. I have addressed the current research and information related to integrating subject matter. I envision a fluid framework[12] that links literacy, learning theory, context, methodology, integrated activities, and assessment. Literacy is the basis of my framework and therefore the final goal of integration. Every other aspect of my model is firmly situated in literacy. Literacy must occur within a context. Language arts and science, actually any discipline, provide such an intellectual, learning context. A learning environment provides a situational and social context. Constructivism, a theory of learning, acts as a bridge between literacy and the disciplines. The methodology, guided by constructivism, includes choosing an appropriate model of integration based on specific guidelines and using criteria to determine the integrated focus. Developing integrated activities based on specific guidelines is the fifth aspect of my model. Finally, assessment offers feedback that will be used to improve the framework.

Three aspects of my framework that need to be explained are the guidelines for choosing an appropriate model, criteria for determining an integrated focus, and guidelines for choosing integrated activites. My guidelines, in a question format, for choosing an integration model are as follow:

•Does the conceptual framework of the model reflect your individual educational philosophy or your team's philosophy?

•Does the model provide an overarching structure?

•Does the model provide (a reasonable amount of) for flexibility?

•Does the model provide for variety (in organization and content choice)?

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[12] See organizational matrix in Chapter 4.

•Does the model provide methods for determining a focus for integration?

•Does the model provide criteria or suggestions for choosing activities?

•Does the model provide suggestions for assessment?

A clear, concise set of criteria for choosing themes is crucial in assisting teachers and in helping guide teachers' thinking process. I have chosen the criteria that Perkins (1989) lists for choosing integrated themes. He uses "a lens worth looking through" metaphor. "A lens applies broadly; a lens applies pervasively; a lens discloses fundamental patterns; a lens reveals similarities and contrasts; and a lens fascinates" (Perkins, 1989. pp. 70-71). Perkins describes each criterion further. First, a good theme looks at a broad array of areas, but is not limited to just those covered. Second, a theme applies to all areas of a discipline. Third, a theme identifies patterns that are pivotal in each discipline. Fourth, a theme compares and "contrasts within and across disciplines" (Perkins, 1989, p. 71). Fifth, a theme pulls in students and teachers because of their interests. The theme makes you want to delve deeper. Perkins offers a final suggestion. If you have to try to make a theme work, it is probably not appropriate.

My specific guidelines, in a question format, for planning and choosing integrated activities follow:

•Does the activity maintain the integrity of the content from each included discipline (NSTA, 1996)?

•Does the activity incorporate parallels between the concepts of each discipline?

•Does the activity incorporate parallels between the process skills of each discipline?

•Does the activity target a wide range of learning styles?

•Does the activity lend itself to assessment?

In summary, MILAS is a framework that incorporates literacy, learning theory, context, methodology, and assessment. I devised guidelines for choosing an appropriate integration model, presented criteria for determining an integrated focus (Perkins, 1989), and devised guidelines for choosing integrated activites. By combining these components, MILAS can be used by elementary teachers to integrate language arts and science.

AN ORGANIZATIONAL MATRIX

After providing a rationale for integration, reviewing the literature on integration, identifying the theoretical underpinnings of integrating science and language arts, and formulating a framework for integration, I have gathered and organized graphic displays. The graphics represent the main ideas and concepts presented in Chapters 1, 2, 3, and 4. As another aspect of this practical guide, an organizational matrix provides an efficient means for previewing these graphics. The matrix includes the following topics: educational reform; national standards; constructivism; literacy; connections; models; activities; and assessment.

Table 4.1: Organizational Matrix of Graphics

	TITLE	SOURCE	SIGNIFICANCE
1.	Future Education Requirements	Sandia National Laboratories. (cited in Carson, Huelskamp, & Woodall, 1993).	Summarizes the changes needed in the U. S. education system
2.	Content Standards K - 12	National Research Council. (1996).	National science standards to guide teacher instruction and assessment
3.	Standards for the English language arts	IRA/NCTE. (1996).	National language arts standards to guide teacher instruction
4.	Learning model for science education	Appleton, K. (1993).	Applies constructivism to science education and includes student outcomes
5.	In a constructivist classroom...	Adams, S. & Powell, M. J. (1995).	Details the characteristics of a constructivist classroom
6.	The conditions of learning: A model of learning as it applies to literacy	Cambourne, B. (1995).	Diagrams a research-based model of literacy
7.	A model of classroom literacy learning	Cambourne, B. (1995).	Applies a literacy model to a classroom setting
8.	Six aspects of literacy	Au, K. H. (1993).	Displays the six aspects of literacy and shows their interrelatedness
9.	Skills important both to science and reading	Carter, G. S. & Simpson, R. D. (1978).	Lists process skills common to science and reading
10.	Summary of potential skills shared by the reading, mathematics, and science curriculum	Simpson, R. D. & Butts, D. P. (1982).	Lists skills common to reading, science, and mathematics by grade level
11.	Illustration of the supportive nature of literacy processes to science understanding	Casteel, C. P. & Isom, B. A. (1994).	Diagrams the connectedness of literacy and science

Table 4.1, continued

	TITLE	SOURCE	SIGNIFICANCE
12.	A comaprison of science and literacy process skills	Casteel, C. P. & Isom. B. A. (1994)	Compares process skills in literacy and science
13.	Process skills across the curriculum	Mechling, K. R. & Kepler, L. E. (1991).	Identifies similar process skills in science, reading, math, and social science
14.	Three integrated curriculum models	Drake, S. M. (1993).	Presents three models that can be used by a teacher or team of teachers
15.	The five aspects of three integrated curriculum models	Drake, S. M. (1993).	Charts the five aspects of Drake's three models
16.	Ways of knowing: Induction-deduction	Berlin, D. F. & White, A. L. (1995).	Displays a model integrating science and mathematics through an inductive-deductive cycle
17.	Model for integrating language arts and science	Moore, M. (1996).	Displays a model that can be used to integrate language arts and science
18.	Sample student activities depicting parallels in science and literacy processes	Casteel, C. P. & Isom, B. A. (1994).	Presents an integrated science and language arts activity that incorporates common process skills
19.	Assessment standards	National Research Council. (1996).	Documents the assessment standards
20.	Components of the assessment process	National Research Council. (1996).	Documents the suggested assessment process components for educators
21.	Five standards for authentic instruction	Newmann, F. M. & Wehlage, G. G. (1993).	Provides a standardized method to evaluate authentic instruction

Table 4.2: Future Education Requirements: Summary of Education Commentary

* There is consensus that the U. S. system of education must change.	
* There is little agreement on what changes must occur.	
Some proposed changes appear to be in	conflict:
Parental Choice......................................	Support for Troubled Schools
Back to Basics......................................	Increased Flexibility
Lifetime Learning.................................	Early Identifcation & Pipelining
Improved National Test Scores.............	Increased Access
College Preparation...............................	Workforce Preparation
Emphasis on Local Needs.....................	National Curriculum & School Comparisons
Fewer Dropouts....................................	Tougher Standards
Legislated Improvements......................	Site-Based Management
Increased Special Ed.............................	Decreased Special Ed Pull-out Programs

Carson, C.C., Huelskamp, R.M., & Woodall, T.D. (1993). Perspectives on education in America: An annotated briefing. The Journal of Educational Research, 86(5), p. 306.

Table 4.3: Science as Inquiry Standards

LEVELS K-4	LEVELS 5-8	LEVELS 9-12
Abilities necessary to do scientific inquiry	Abilities necessary to do scientific inquiry	Abilities necessary to do scientific inquiry
Understanding about scientific inquiry	Understanding about scientific inquiry	Understanding about scientific inquiry

Table 4.4: Physical Science Standards

LEVELS K-4	LEVELS 5-8	LEVELS 9-12
Properties of objects and materials	Properties and changes of properties in matter	Structure of atoms
Position and motion of objects	Motions and forces	Structure and properties of matter
Light, heat, electricity, and magnetism	Transfer of energy	Chemical reactions
		Motions and forces
		Conservation of energy and increase in disorder Interactions of energy and matter

Table 4.5: Life Science Standards

LEVELS K-4	LEVELS 5-8	LEVELS 9-12
Characteristics of organisms	Structure and function in living systems	The cell
Life cycle of organisms	Reproduction and heredity	Molecular basis of heredity
Organisms and environments	Regulation and behavior	Biological evolution
	Populations and ecosystems	Interdependence of organisms
	Diversity and adaptations of organisms	Matter, energy, and organization in living systems
		Behavior of organisms

Table 4.6: Earth and Space Science Standards

LEVELS K-4	LEVELS 5-8	LEVELS 9-12
Properties of earth materials	Structure of the earth system	Energy in the earth system
Objects in the sky	Earth's history	Geochemical cycles
Changes in earth and sky	Earth in the solar system	Origin and evolution of the earth system
		Origin and evolution of the universe

Table 4.7: Science and Technology Standards

LEVELS K-4	LEVELS 5-8	LEVELS 9-12
Abilities to distinguish between natural objects and objects made by humans	Abilities of technological design	Abilities of technological design
Abilities of technological design	Understanding about science and technology	Understanding about science and technology
Understanding about science and technology		

Table 4.8: Science in Personal and Social Perspectives

LEVELS K-4	LEVELS 5-8	LEVELS 9-12
Personal health	Personal health	Personal and community health
Characteristics and changes in populations	Populations, resources, and environments	Population growth
Types of resources	Natural hazards	Natural resources
Changes in environments	Risks and benefits	Environmental quality
Science and technology in local challenges	Science and technology in society	Natural and human-induced hazards
		Science and technology in local, national, and global challenges

Table 4.9: History And Nature Of Science Standards

LEVELS K-4	LEVELS 5-8	LEVELS 9-12
Science as a human endeavor	Science as a human endeavor	Science as a human endeavor
	Nature of science	Nature of scientific knowledge
	History of science	Historical perspectives

National Research Council. (1996). National science education standards. Washington, D. C.: National Academy Press. p. 105-108.

Table 4.10: IRA / NCTE Standards for the English Language Arts

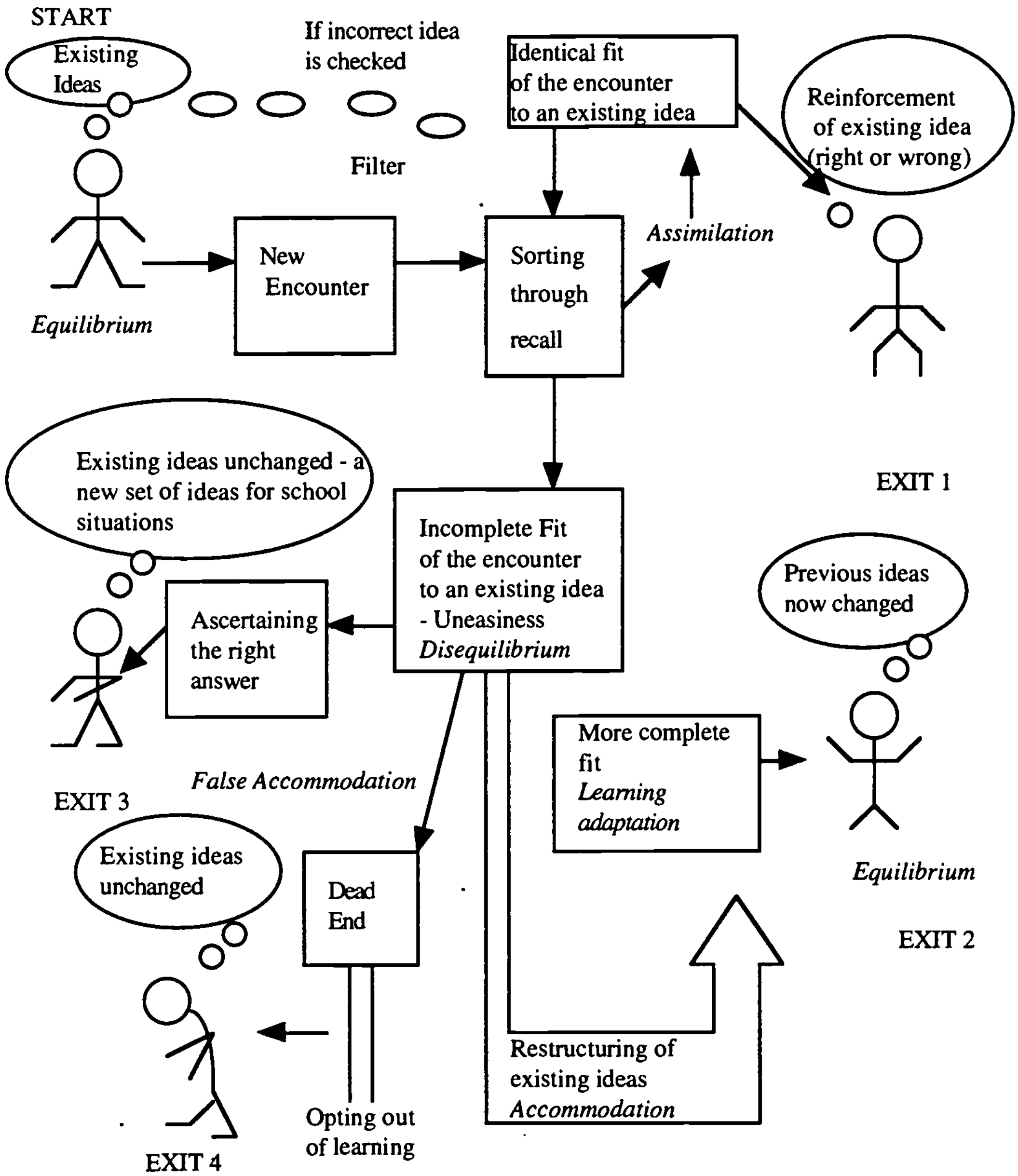
1.	Students read a wide range of print and nonprint texts to build an understanding of texts, of themselves, and of the cultures of the United States and the world; to acquire new information; to respond to the needs and demands of society and the workplace; and for personal fulfillment. Among these texts are fiction and nonfiction, classic and contemporary works.
2.	Students read a wide range of literature from many periods in many genres to build an understanding of the many dimensions (e.g., philosophical, ethical, aesthetic) of human experience.
3.	Students apply a wide range of strategies to comprehend, interpret, evaluate, and appreciate texts. They draw on their prior experience, their interactions with other readers and writers, their knowledge of word meaning and of other texts, their word identification strategies, and their understanding of textual features (e.g., sound-letter correspondence, sentence structure, context, graphics).
4.	Students adjust their use of spoken, written, and visual language (e.g., conventions, style, vocabulary) to communicate effectively with different audiences for a variety of purposes.
5.	Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences for a variety of purposes.
6.	Students apply knowledge of language structure, language conventions (e.g., spelling and punctuation), media techniques, figurative language, and genre to create, critique, and discuss print and nonprint texts.
7.	Students conduct research on issues and interests by generating ideas and questions, and by posing problems. They gather, evaluate, and synthesize data from a variety of sources (e.g., print and nonprint texts, artifacts, people) to communicate their discoveries in ways that suit their purpose and audience.
8.	Students use a variety of technological and informational resources (e.g., libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge.
9.	Students develop an understanding of and respect for diversity in language use, patterns, and dialects across cultures, ethnic groups, geographic regions, and social roles.
10.	Students whose first language is not English make use of their first language to develop competency in the English language arts and to develop understanding of content across the curriculum.
11.	Students participate as knowledgeable, reflective, creative, and critical members of a variety of literacy communities.

Table 4.10, continued

12.	Students use spoken, written, and visual language to accomplish their own purposes (e.g., for learning, enjoyment, persuasion, and the exchange of information).

International Reading Association, & National Council of Teachers of English (1996). Standards for the English language arts. Newark, DE: International Reading Association and National Council of Teachers of English. p. 25.

Figure 4.1: Learning Model for Science Education



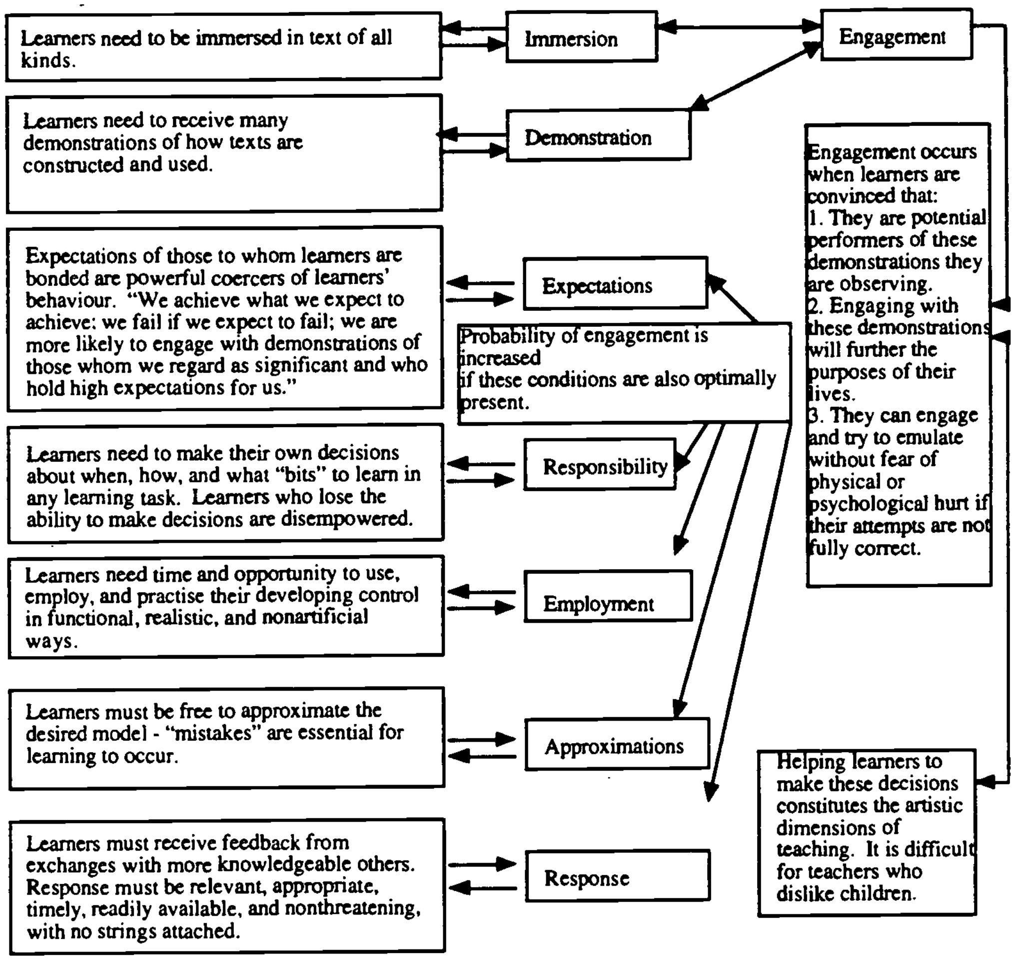
Appleton, K. (1993). Using theory to guide practice: Teaching science from a constructivist perspective. School Science and Mathematics, 93(5), p. 270.

Table 4.11: In a Constructivist Classroom...

Student autonomy and initiative are accepted and encouraged. By respecting student's ideas and encouraging independent thinking, teachers help students attain their own intellectual identity. Students who frame questions and issues and then go about analyzing and answering them take responsibility for their own learning and become problem solvers.
The teacher asks open-ended questions and allows wait time for responses. Reflective thought takes time and is often built on others' ideas and comments. The ways teachers ask questions and the ways students respond will structure the success of the student inquiry.
Higher-level thinking is encouraged. The constructivist teacher challenges students to reach beyond the simple factual response. He encourages students to connect and summarize concepts by analyzing, predicting, justifying, and defending their ideas.
Students are engaged in dialogue with the teacher and with each other. Social discourse helps students change or reinforce their ideas. If they have the chance to present what they think and hear others' ideas, students can build a personal knowledge base that they understand. Only when they feel comfortable enough to express their ideas will meaningful classroom dialogue occur.
Students are engaged in experiences that challenges hypotheses and encourage discussion. When allowed to make predictions, students often generate varying hypotheses about natural phenomena. The constructivist teacher provides ample opportunities for students to test their hypotheses, especially through group discussion of concrete experiences.
The class uses raw data, primary sources, manipulatives, and physical, interactive materials. The constructivist approach involves students in real-world possibilities, then helps them generate the abstractions that bind phenomena together.

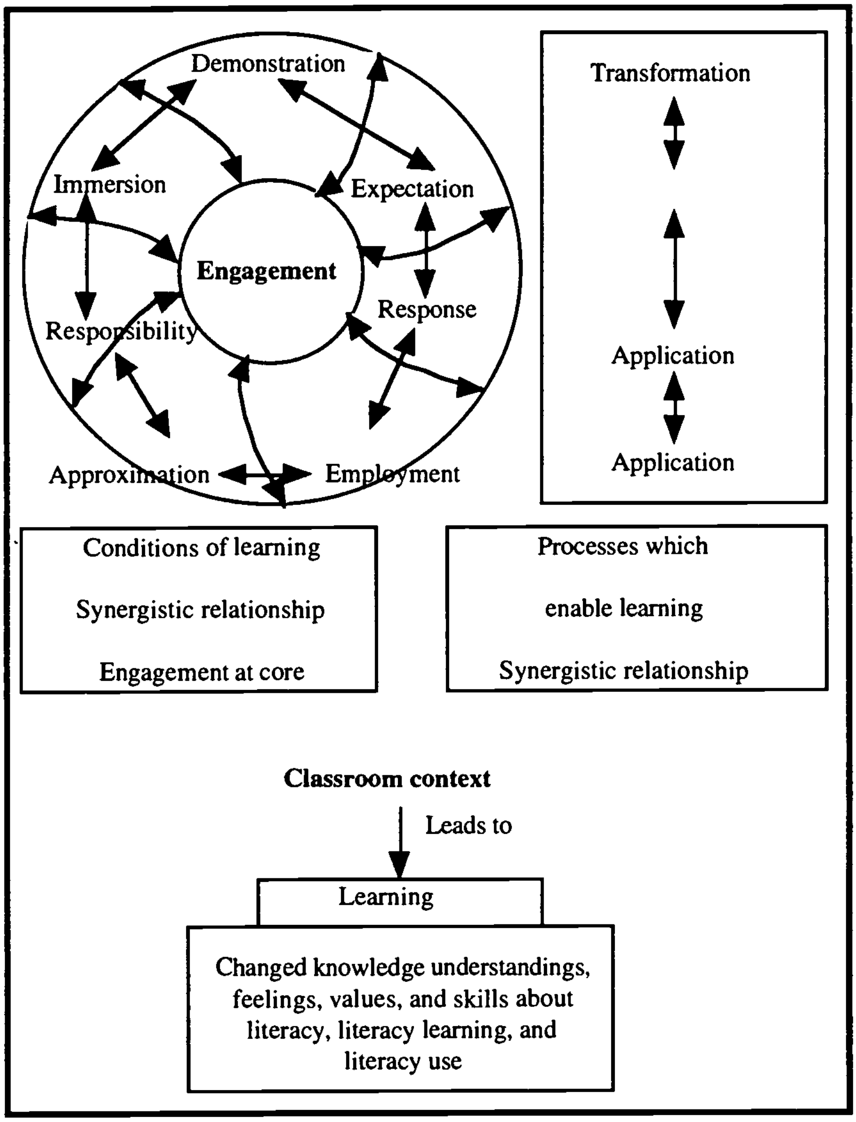
Adams, S., & Powell, M. J. (Eds.). (1995). Constructing knowledge in the classroom. Classroom Compass, 1(3), p. 2.

Figure 4.2: The Conditions of Learning: A Model of Learning as it Applies to Literacy



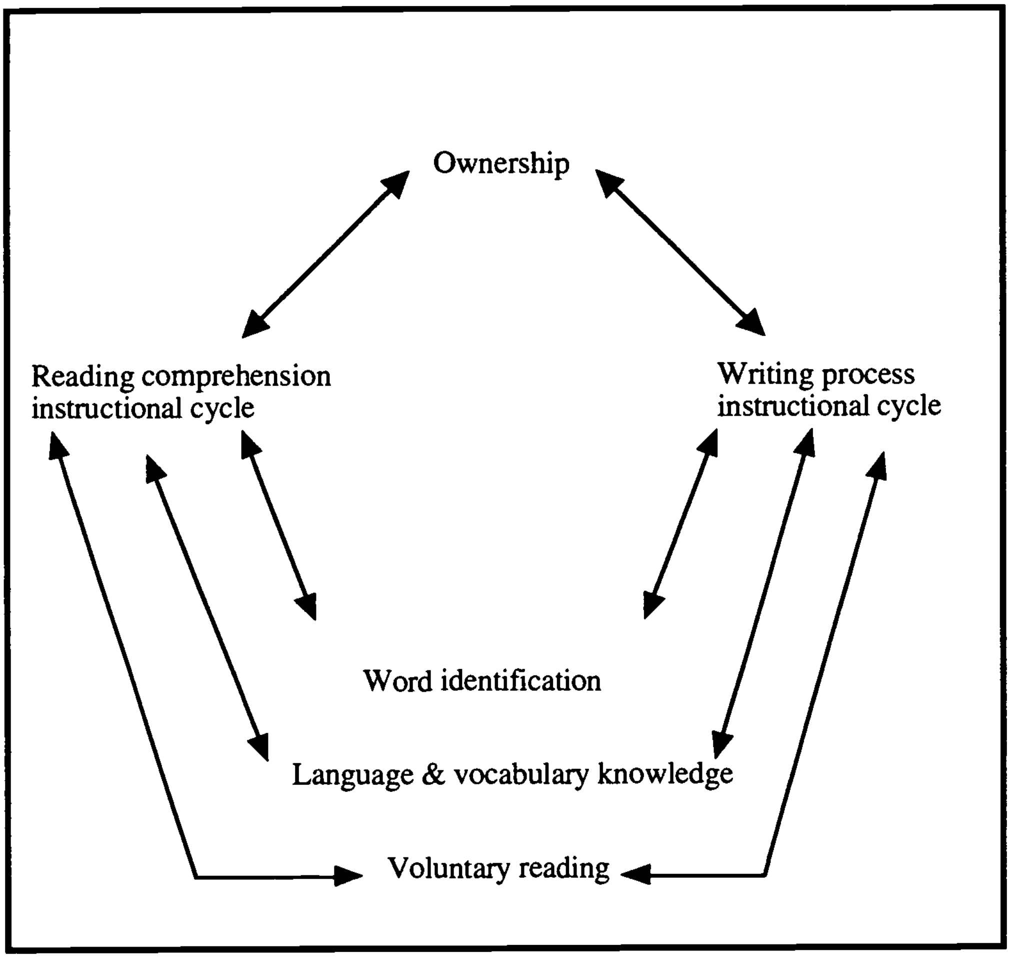
Cambourne, B. (1995). Toward an educationally relevant theory of literacy learning: Twenty years of inquiry. The Reading Teacher, 49(3), p. 187.

Figure 4.3: A Model of Classroom Literacy Learning



Cambourne, B. (1995). Toward an educationally relevant theory of literacy learning: Twenty years of inquiry. The Reading Teacher, 49(3), p. 189.

Figure 4.4: Six Aspects of Literacy



Au, K. H. (1993). Literacy instruction in multicultural settings. Fort Worth, TX: Harcourt Brace College Publishers, p. 62.

Table 4.12: Skills Important Both to Science and Reading

EXAMPLES OF PROBLEM-SOLVING SKILLS IN SCIENCE	CORRESPONDING READING SKILLS
Observing	Discriminating shapes; Discriminating sounds; Discriminating syllables and accents
Identifying	Recognizing letters; Recognizing words; Recognizing common prefixes; Recognizing common suffixes; Recognizing common base words; Naming objects, events, and people
Describing	Isolating important characteristics; Enumerating characteristics; Using appropriate terminology; Using synonyms
Classifying	Comparing characteristics; Contrasting characteristics; Ordering sequencing; Arranging ideas; Considering multiple factors
Designing investigations	Asking questions; Looking for potential relationships; Following organized procedures; Reviewing prior studies; Developing outlines
Collecting Data	Taking notes; Surveying reference materials; Using several parts of a book; Recording data in an orderly fashion; Developing precision and accuracy
Interpreting data	Recognizing cause-and-effect relationships; Organizing facts; Summarizing new information; Varying rate of reading; Inductive and deductive thinking
Communicating results	Using graphic aids; Logically arranging information; Sequencing ideas; Knowledge of technical vocabulary; Describing with clarity

Table 4.12, continued

Formulating Conclusions	Generalizing Analyzing critically Evaluating information Recognizing main ideas and concepts Establishing relationships Applying information to other situations

Carter, G. S., & Simpson, R. D. (1978). Science and reading: A basic duo. The Science Teacher, 45(3), p. 20.

Table 4.13: Summary of Potential Skills Shared by the Reading, Mathematics, and Science Curriculum

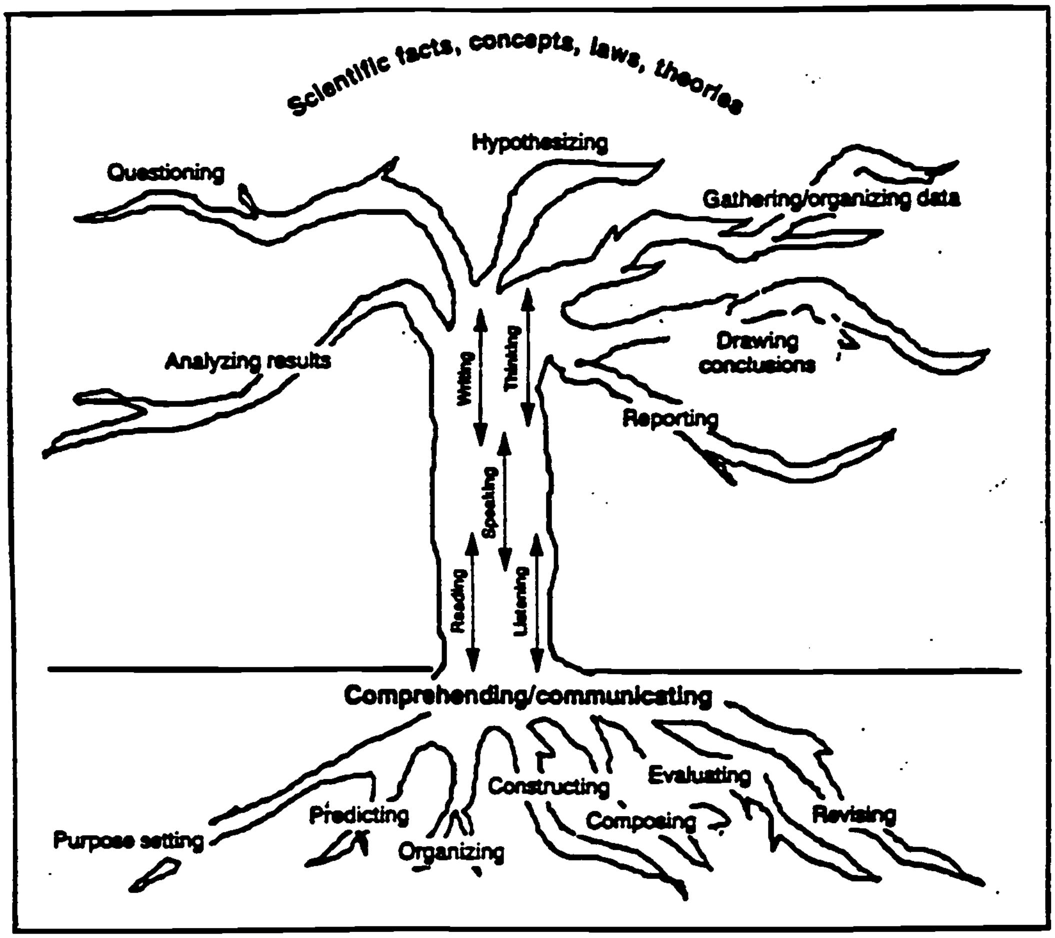
GRADE	SKILLS	
First	Recognizing shapes Recognizing letters Recognizing words Using whole numbers Understanding sets Understanding number theory Measuring Communicating Observing texture	Observing size Observing sounds Observing odors Observing organisms Observing time intervals Observing physical material Identifying similarities Identifying differences Describing time-space relationships
Second	Communicating events Sequencing Arranging major events Using set concept Applying numeration Graphing Observing change Describing change Communicating change	Comparing Contrasting Describing symmetry and angles Describing distance Describing direction Grouping items into categories
Third	Communicating results Understanding numeration Understanding number theory Using fractions Applying basic geometry Classifying observations	Making inferences Describing materials Describing events Making predictions Using graphs Illustrating relationships
Fourth	Dealing with multiple characteristics Describing sequences Comprehending what is read Encouraging creativity Number operations Problem solving Using decimal and fractions	Describing more complex variables Classifying more complex variables Measuring and quantifying variables Inferring variables Extending observations Understanding relationships

Table 4.13, continued

Fifth	Using synonyms Identifying more complex characteristics Describing relationships Using number combinations Apply number relationships Understanding relationships Formulating hypotheses Graphing data	Using scientific notation Understanding decimals and fractions Using scales Recognizing error Appreciating accuracy Recognizing precision Controlling variables Interpreting data Formulating models
Sixth	Formulating concepts Understanding principles Abstract reasoning Understanding quantitative readings Searching for common rules Searching for common relationships	Solving complex Pproblems Integrating problem-solving skill Understanding ratios Exposure to probability theory Introduction to statistical concepts Internalizing language

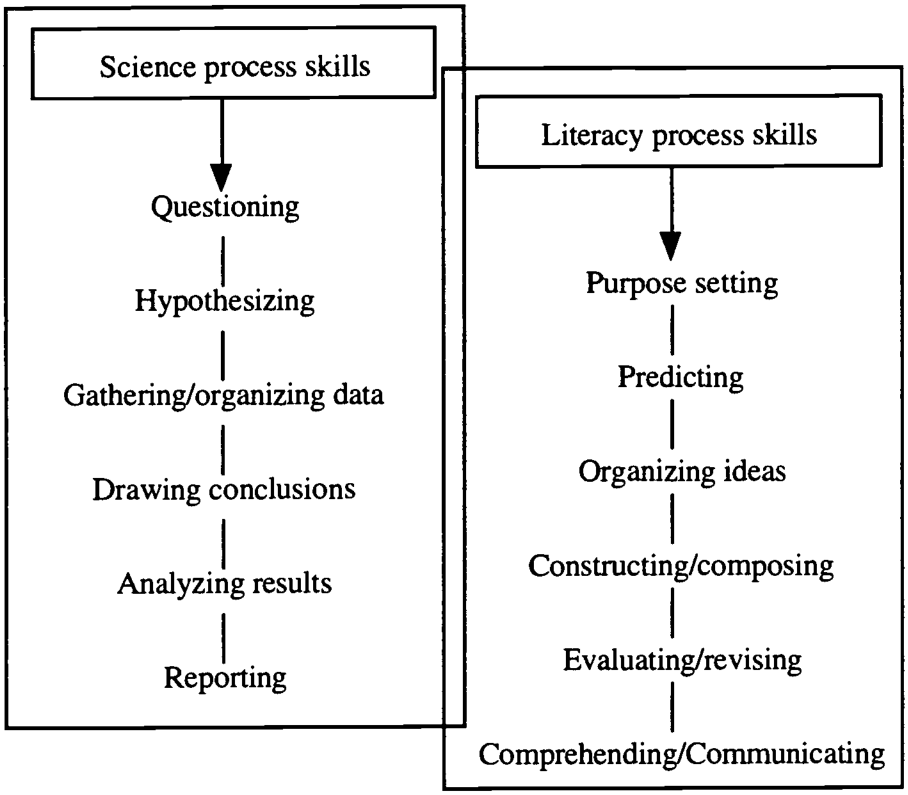
Simpson, R. D., & Butts, D. P. (1982). Valuing the infusion process. In B. W. Benson (Ed.). Teaching children science: Changing adversity into advocacy. 1983 AETS Yearbook (pp. 83-97). Columbus, OH: ERIC Information Reference Center. p. 92-93. (ERIC Document Reproduction Service No. ED 224 706)

Figure 4.5: Illustration of the Supportive Nature of Literacy Processes to Science Understanding



Casteel, C. P. & Isom, B. A. (1994). Reciprocal processes in science and literacy learning. The Reading Teacher, 47(7), p. 540.

Figure 4.6: A Comparison of Science and Literacy Process Skills



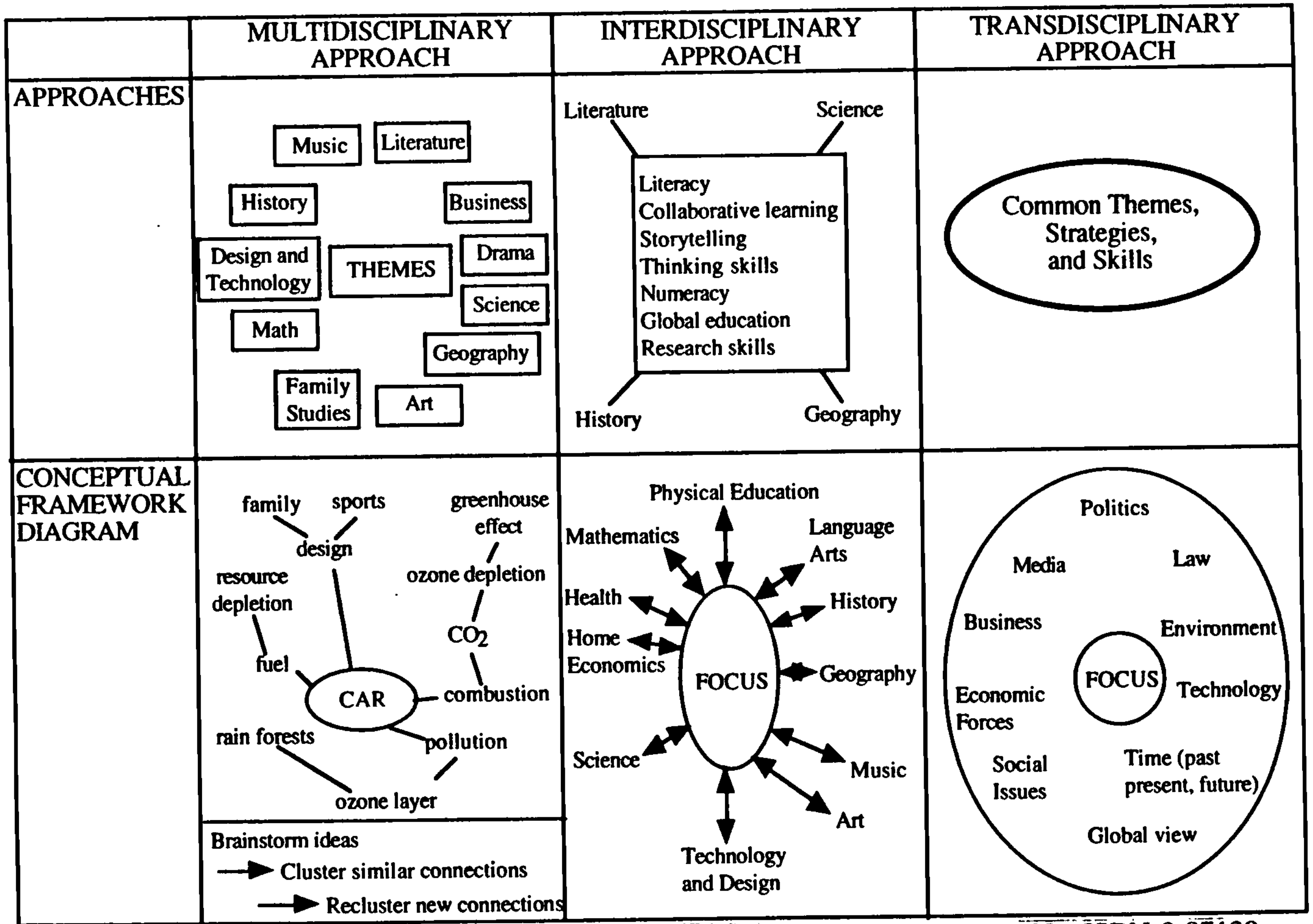
Casteel, C. P., & Isom, B. A. (1994). Reciprocal processes in science and literacy learning. The Reading Teacher, 47(7), p. 541.

Table 4.14: Process Skills Across the Curriculum

SCIENCE	READING	MATH	SOCIAL SCIENCE
Classifying	Comparing & contrasting characteristics	Sorting, sequencing	Comparing ideas
Collecting data	Taking notes	Collecting data	Collecting data
Interpreting data	Organizing facts, recognizing cause and effect	Analyzing	Interpreting data
Communicating results	Logically arranging information	Graphing, constructing tables	Making maps
Predicting	Predicting	Predicting	Predicting

Mechling, K. R., & Kepler, L. E. (1991). Start with science. Instructor, 100(7), p. 37.

Figure 4.7: Three Integrated Curriculum Models



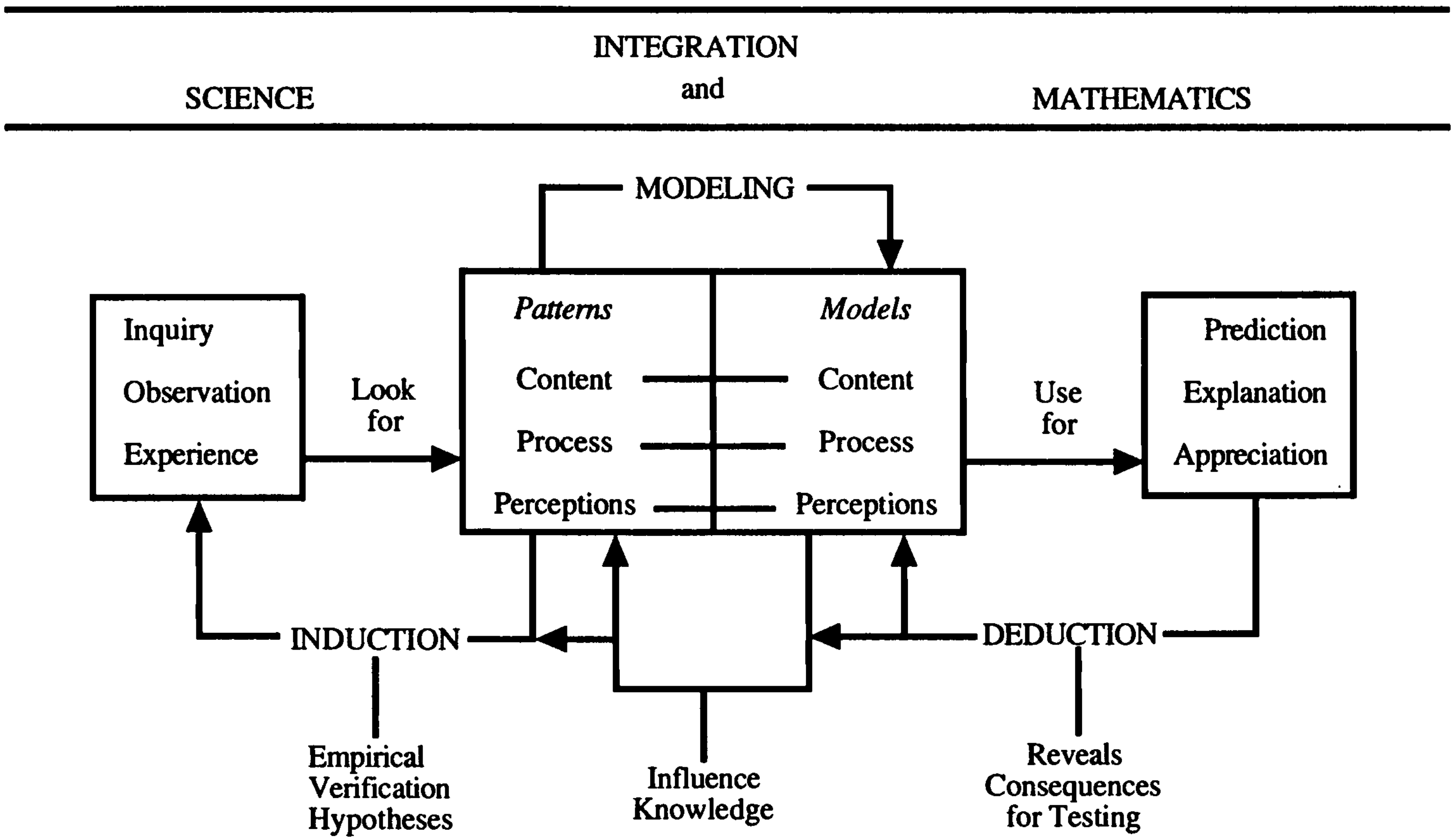
Drake, S. M. (1993). Planning integrated curriculum: The call to adventure (Report No. ISBN-0-87120-208-5). Alexandria, VA: Association for Supervision and Curriculum Development. p. 46. (ERIC Document Reproduction Service No. ED 355 660)

Table 4.15: Five Aspects of Three Integrated Curriculum Models

CONCEPTUAL FRAMEWORK	• Semantic Web • Cluster and Recluster	Curriculum Wheel	Transdisciplinary Web
WHAT IS WORTH KNOWING?	Procedures of discipline	Procedures of generic skills (e.g., critical thinking, interpersonal)	Skills for productive citizen of the future (e.g., change management, perseverance, confidence, problem solving)
CONNECTION MAKING	Obvious connections through lens of discipline(s)	Connections across disciplines through an inquiry lens	Connections embedded in real-life context emphasizing meaning and relevance
LEARNING OUTCOMES ➪	**discipline based** → • May be cognitive, skill, and affective	**across discipline** → • blended statements (cognitive, skill, and affective dimensions merge)	**essential learnings** • transcend disciplines
ASSESSMENT ➪	Mastery of procedures of → discipline	Mastery of generic skills →	Attainment of life-skills (higher-order, lite-role skills)

Drake, S. M. (1993). Planning integrated curriculum: The call to adventure (Report No. ISBN-0-87120-208-5). Alexandria, VA: Association for Supervision and Curriculum Development. p. 47. (ERIC Document Reproduction Service No. ED 355 660)

Figure 4.8: Ways of Knowing: Induction-Deduction (Barnes, Conway, Narisimhan, Shumway, & White, 1992)



Berlin, D.F., & White, A.L. (1996). Science and math: Links for tomorrow. In National Science Teachers Association Area Convention. San Antonio, TX. National Center for Science Teaching and Learning.

Figure 4.9: Model for Integrating Language Arts and Science (MILAS)

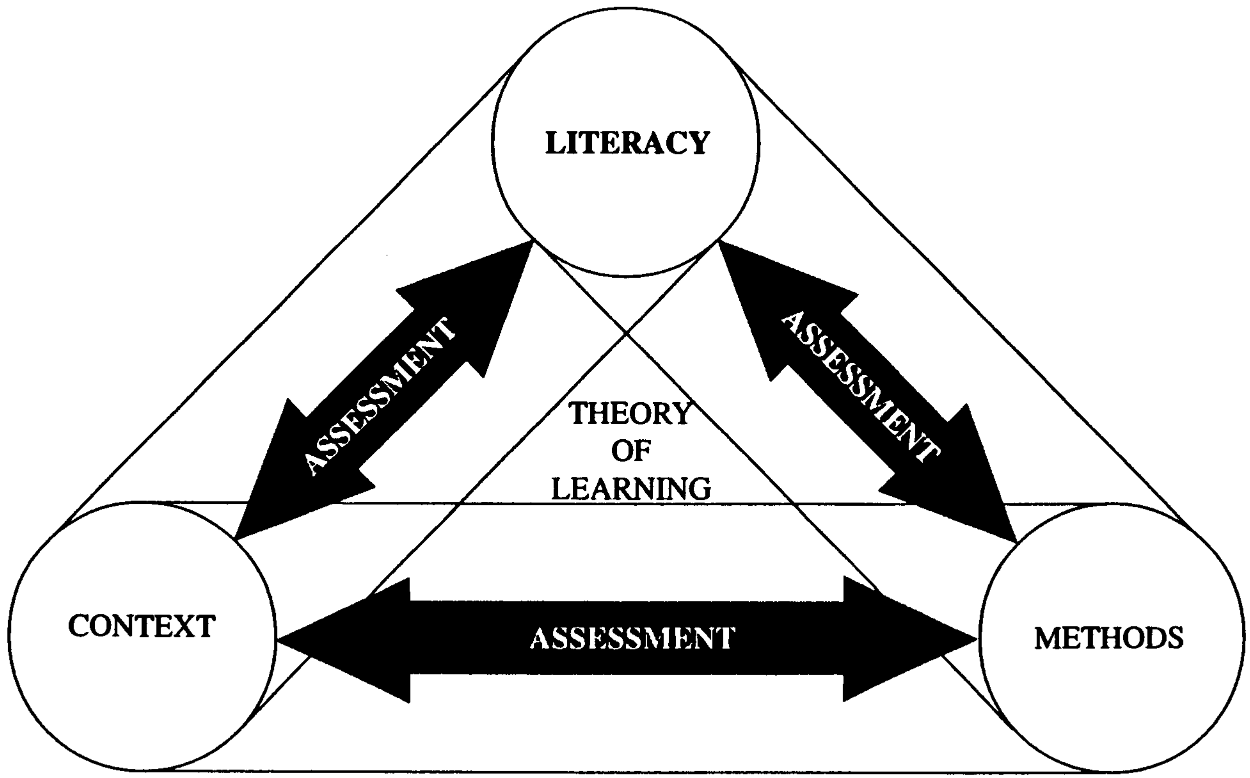


Table 4.16: Sample Student Activities Depicting Parallels in Science and Literacy Processes

Science Activities	Literacy-based Activities
Questioning	**Purpose setting**
Ask questions about conditions leading to different types of weather. Example: What is weather? What conditions contribute to changes in the weather?	Set purposes for reading a trade book about weather by having students write information they hope to find in response journals. Read to find out what conditions contribute to weather changes.
Hypothesizing	**Predicting**
Form hypotheses about what will happen when air temperatures and pressures change. Example: Conditions of the air contribute to changes in weather. Temperature contributes to rain, sleet, snow, and hail conditions.	Predict how weather conditions might influence plot and affect characters, setting, and mood in various stories.
Gathering/organizing data	**Organizing ideas**
Record and categorize daily pressure/temperature changes and weather conditions. Also, record results of experiments on air temperature such as making a hygrometer to measure moisture. Participate in computer simulations of weather experiments. Research methods for collecting weather data such as the use of weather balloons.	Create cognitive maps to organize information learned from reading trade books about weather. Also, complete word webs or semantic feature analyses relating to technical vocabulary words.
Analyzing results	**Constructing/composing**
Analyze all collected data and identify factors that affected results. Use charts, tables, and diagrams to illustrate analysis.	Discuss personal experiences relating to different types of weather conditions and participate in language-experience activities to write comparisons between weather conditions and effects on human behavior.
Drawing conclusions	**Evaluating/revising**
Meet in cooperative group-s to review data and draw conclusions relative to the hypotheses.	Make judgments about and edit written compositions about weather. Example: Evaluate accuracy of facts, clarity of ideas, and use of mechanics in writing.

Table 4.16, continued

Reporting	Comprehending/communicating
Prepare a written report summarizing information learned. Make oral presentations to another class.	Publish a classroom book about weather. Share individual entries through the use of the author's chair.

Casteel, C. P., & Isom, B. A. (1994). Reciprocal processes in science and literacy learning. The Reading Teacher, 47(7), p. 543.

Table 4.17: Assessment Standards

Assessment Standard A	Assessments must be consistent with the decisions they are designed to inform.
Assessment Standard B	Achievement and opportunity to learn science must be assessed.
Assessment Standard C	The technical quality of the data collected is well matched to the decisions and actions taken on the basis of their interpretation.
Assessment Standard D	Assessment practices must be fair.
Assessment Standard E	The inferences made from assessment data about student achievement and opportunity to learn must be sound.

National Research Council. (1996). National science education standards. Washington, DC: National Academy Press, pp. 78-86.

Figure 4.10: Components of the Assessment Process

DATA USE	DATA COLLECTION	METHODS TO COLLECT DATA	USERS OF DATA
Plan teaching	To describe and quantify:	Paper and pencil testing	Teachers
Guide learning	Student achievement and attitude	Performance testing	Students
Calculate grades	Teacher preparation and quality	Interviews	Educational administrators
Make comparisons	Program characteristics	Portfolios	Parents
Credential and license	Resource allocation	Performances	Public
Determine access to special or advanced education	Policy instruments	Observing programs, students, and teachers in classroom	Policymakers
Develop education theory		Transcript analysis	Institutions of higher education
Inform Policy formulation		Expert reviews of educational materials	Business and industry
Monitor effects of policies		Expert reviews of educational materials	Government
Allocate resources			
Evaluate quality of curricula, programs, and teaching practices			

↓

Decisions and Action Based on Data

National Research Council (1996). National science education standards. Washington, DC: National Academy Press, p. 77.

Figure 4.11: Five Standards of Authentic Instruction

1. Higher-Order Thinking

lower-order thinking only 1...2...3...4...5 higher-order thinking is central

2. Depth of Knowledge

knowledge is shallow 1...2...3...4...5 knowledge is deep

3. Connectedness to the World Beyond the Classroom

no connection 1...2...3...4...5 connected

4. Substantive Conversation

no substantive conversation 1...2...3...4...5 high-level substantive conversation

5. Social Support for Student Achievement

negative social support 1...2...3...4...5 positive social support

Newmann, F. M. & Wehlage, G. G. (1993). Five standards of authentic instruction. Educational Leadership, 5(7), p. 10.

Models, methodologies, guidelines, and an organizational matrix for integrating language arts and science have been presented. I presented an array of integration models in this report so that teachers have a variety from which to choose. I presented a Model for Integrating Language Arts and Science (MILAS) that links literacy, constructivism, context, methodology, activities, and assessment. MILAS can be used as a springboard for elementary teachers to infuse science into language arts. Additionally, I included methodologies for integrating science and language arts. I devised guidelines for choosing an integrated model, presented criteria for choosing themes (Perkins, 1989), and devised guidelines for planning and choosing integrated activities. An organizational matrix of graphics included current research and information that supports the integration of science and language arts. By providing models, methodologies, guidelines, and an organizational matrix, I have given teachers a practical tool for integrating science and language arts.

Chapter 5: Summary, Conclusions, and Recommendations

SUMMARY

This report is designed to provide a practical guide for teachers, including the following: a review of literature related to the integration of science and language arts; guidelines and methodologies to aid the practitioner in the integration of science and language arts; and an organizational matrix for teacher-designed integrated curricula.

A review of literature revealed the rich history of integration in the language arts and science education fields. From a historical perspective on integration, I then presented a current picture of the two disciplines. Language arts and science education are in a reform period, dating from the beginning of 1980. The reform movements in both disciplines focus on literacy as their goal. After reviewing the current state of both disciplines, I presented the nature of each individual discipline. Science is a way of knowing about the world that emphasizes observing, thinking, experimenting, and validating. Language arts is a way of learning about the world and communicating this knowledge. Taught together, science and language arts work to communicate the experience of living on this planet. Finally, I presented research supporting the integration of language arts and science. Research from both fields identifies the positive outcomes of integration.

Guidelines and methodologies for integration aid the practitioner. Along with guidelines for integration from seven professional educational organizations

(NSTA, 1996), I devised guidelines for choosing an integration model, presented criteria for choosing themes (Perkins, 1989), and devised guidelines for planning and choosing integrated activities.

Finally, I formulated an organizational matrix of graphics. Representing the main ideas and concepts covered in Chapters 1, 2, 3, and 4, the matrix included graphic displays on educational reform, the national standards, constructivism, literacy, connections between language arts and science, models, activities, and assessment.

CONCLUSIONS AND RECOMMENDATIONS

In many respects, the education system has remained unchanged since the early 1900s. However, the client population is no longer exclusively white male. With a society demanding a highly educated workforce and a changing population of educable students, the education system as we move into the twenty-first century must make adaptations. Although reform movements in the early 1980s were meant to provide such changes, a 1987 study by the Carnegie Foundation for the Advancement of Teaching (cited in Bybee, 1988) showed teachers were unconvinced that changes had occurred. What can be done to improve our education system? By integrating subject matter, teachers can improve student learning and provide the grass-roots systemic change that is needed.

At what level will and should integration start? According to NSTA (1996), the original guidelines for integration are designed for early elementary. Further support for this notion is seen in Clifford's (1987) work. He notes that integrating subjects is easier at the elementary level because of the way elementary education is structured. Furthermore, citing Cuban, Clifford (1987) asserts that elementary teachers tend to be risk-takers. The elementary structure and the risk-taking nature of elementary teachers are a vital combination towards promoting integration.

What conclusions can be drawn about the subject matter to be integrated? Although science and mathematics are often paired, there is research (sometimes overlooked) supporting science and language arts integration. Language arts, by its nature, is already integrated, whereas currently science has been segmented into its many content areas. Sufficient parallel and overlapping concepts and process-oriented skills exist between science and language arts to make integration a valuable and worthwhile enterprise. I recommend combining language arts and science to draw on the strengths of both disciplines. Furthermore, a common goal is defined in the recent language arts and science standards- literacy. Language arts and science can and should be integrated to accomplish this shared goal.

How should integrating language arts and science be accomplished? My model for integration establishes a framework that educators can use to design integrated curricula. Within the general framework, I have included guidelines and methodologies that provide flexibility. A flexible framework is crucial if the change process among teachers is to be successful.

How will integration be assessed? Although integration has had a long history, research is still needed to assess this methodology. The reasons for insufficient research are two-fold. First, a paradigm shift in thinking about assessment must occur. Movement away from norm-referenced assessment to criterion-referenced assessment needs to be reconceptualized to fit with the holistic integration of thought facilitated with integrated teaching. Also, teachers must take into account student growth on an individual basis. Second, assessment instruments are not yet available to assess integrated learning. I recommend that alternative assessment instruments be devised. This remains a project to be undertaken in the future.

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