Researched and Approved

RESEARCH REPORT

Early Science

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Executive Summary

Introduction

For children to succeed in the adult roles they will eventually take on, they will need to become scientifically literate. Science literacy is the ability to understand and apply the language, methods, and basic facts of science and technology. This skill has become essential for careers in almost every business and industry, as well as for a healthy citizenry to evaluate so many of the issues of our time.

As is true of most educational goals, science literacy begins in the primary classroom. Young children are especially open to learning more about the world around them, which is the basis of all science inquiry. Moreover, these children will be assessed on science objectives as early as grades 3, 4, or 5, as required by No Child Left Behind legislation.

How can primary teachers best incorporate science lessons into the curriculum? Research has identified several instructional strategies that both meet the needs of teachers and enable students to succeed. The authors and editors at Newbridge incorporated these research-based strategies and best practices as they developed the *Early Science* program.

Foundational Research Basis

This report will address four key topics related to science and the primary classroom:

- *Science Instruction in the Primary Grades*
- *The Benefits of Differentiated Instruction*
- *How Young Children Learn Science*
- *Comprehension Strategies for Young Readers*

For each topic, the report includes a section on Research Findings, which presents facts, conclusions, and recommendations from recent studies and scholarly articles, as well as a section on Research Implications, which presents specific features of the Newbridge *Early Science* program that address the research.

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Foundational Research Basis for Early Science

Science Instruction in the Primary Grades

More so than at any time in their history, average Americans are asked to apply science facts and science skills to their daily lives. Consider the array of choices people face when they are involved in such mundane tasks as buying groceries *(Should I choose organic milk? Should I choose whole milk, skim milk, or 2 percent?)*, landscaping the back yard *(Which trees will grow best in my soil and climate? Will pest species harm them?)*, or buying a major appliance *(Is the energy-efficient model worth the extra cost?)*. Questions like these have only become more complicated in the past few years. Many simply did not exist a generation or two ago (Mandan 2005).

Of course, science and technology are hardly confined to personal and domestic life. For proof, one need only to glance at daily newspapers or popular news magazines. Science researcher Robert Hazen compiled the following list of newspaper headlines for November 21, 2002:

- Boxing the Genome Code
- Scientist to Attempt Creation of Living Cell
- 2 Black Holes May Collide, Say Astronomers
- Ottawa Unveils Updated Kyoto Plan [on global warming]
- 'Death Gene' Discovery

Such news stories and events have become the rule, not the exception. As voter and consumer, as homeowner and parent, as reader and writer, everyone is asked to be scientifically literate—that is, to understand the basic principles, facts, and vocabulary of science and technology, and to practice those principles as needed. This literacy is essential to participate fully and effectively in modern society (Hazen 2002).

But science literacy must be learned and practiced. While science literacy is connected and linked to literacy in other disciplines, science encompasses a language and set of principles that are unique (Bodzen and Beerer 2003). For children to attain science literacy, they must acquire a knowledge of basic science facts and learn to practice science skills. Moreover, for America to maintain its leadership in science and technology, many of those children will need to undergo years of study and rigorous training to become experts in a wide variety of fields.

How well is America's educational system meeting these two objectives: creating a scientifically-literate citizenry and training the next generation of professional scientists? Unfortunately, the answer appears to be that the system is falling short. As agreed upon almost in unison by academic researchers, professional scientists, and government officials, the nation's public schools need to improve the ways they teach science, beginning in the primary and intermediate grades. To date, America's public schools as a whole have been slow to increase the classroom hours they devote to science curriculum. The problem is especially acute in the primary classrooms, where science traditionally has been one of the least taught subjects (Hurd 2000; Marx and Harris 2006).

Challenges of Teaching Science

Why is science not a priority in primary education? No one argues that children of ages six through eight are developmentally unready for science instruction. To the contrary, children at these ages are forming new interests in the world around them and are especially open to new learning constructions and experiences. Consequently, they are ideal candidates for science education (Reinhardt 1998).

One important factor that influences the entire K–12 classroom experience now is national education policy. Until 2007, the No Child Left Behind act required elementary school students to be tested only in reading and math. As a result, many schools squeezed other subjects, including science and social studies, into small time slots in the daily curriculum, or out of the curriculum entirely (Symonds 2004; Starnes 2006).

Other factors that have contributed to the sidelining of science in the elementary curriculum center around the special demands, unique to the discipline, that science lessons place on both children and teachers. Several researchers cite much anecdotal evidence of teachers—including veterans at teaching science in the elementary classroom—describing how leading a class in a hands-on science activity is typically more challenging than conducting other types of lessons. Their reasons include the preparation and expense of materials, keeping children on task during the activity, helping children achieve the expected outcome of an activity, and safety issues. Teachers also note the difficulty of meeting the needs of a diverse class of children, especially special needs students (Sumrall 1997; Krapfl 1997; Appleton 1999).

To expand on findings such as these, researchers Ana Houseal and Cherin Lee interviewed elementary school teachers and observed how they taught science in their classrooms. The study was conducted in several school districts, encompassing rural, suburban, and urban communities. Across all these settings, the researchers found science education to be limited and constrained due to a host of factors, nearly all of them beyond the teachers' control. Among these factors were the demands of the school's daily schedule, the introduction of new standards and curricula, and the materials and space required for certain investigations and activities. Such factors affected all teachers, including those who enjoyed teaching science and those who would prefer to teach it more comprehensively.

Houseal and Lee found the teaching of science especially challenging for the reluctant science teacher—that is, the teacher who would prefer, for whatever reasons, not to teach the subject. These teachers were more likely than their counterparts to shy away from hands-on activities. They instead focused on instructional strategies drawn from reading and language arts pedagogy, such as reading and class discussion of text, journal writing, and memorizing vocabulary words. Frustrating these teachers, however, were the curriculum models employed by textbook- or kit-based science programs. Typically, such programs prescribed more content-heavy and time-consuming lessons than were feasible (Houseal and Lee 2003).

Effective Science Education in the Primary Grades

As argued in an essay by Mary Carson Reinhardt of Lesley University, many science curricula and instructional materials intended for the primary and intermediate classrooms have been designed without the realities of those classrooms in mind. Supporting evidence comes from case studies complementary to the work of Houseal and Lee, in which researchers and teachers alike concluded that basal science textbooks present a more expansive curriculum than teachers have time and resources to implement, plus they require significant teacher training and professional development (Reinhardt 1998; Kelly and Staver 2004).

For explanation, Reinhardt cited British scientist C. P. Snow, who claimed that science professionals had become too institutionally separated and isolated from the studies of literature, arts, and the humanities—that is, the basis for the bulk of the curriculum of the primary grades. The result often is a presentation of science as a discrete, isolated subject, one that is unrelated to other curriculum areas and that demands unique skills and materials to teach and learn properly.

So how can science be effectively taught in the primary classroom? Reinhardt and other experts cite evidence for a simple solution: the integration into the science curriculum of methodologies from other disciplines, especially reading and language arts. In practice, this means more classroom time devoted to grade-appropriate, nonfiction books that cover science themes. The approach takes advantage of the primary teacher's expertise in reading and language arts pedagogy, and shows teachers and students the relevance of science to many aspects of human knowledge and experience (Reinhardt 1998).

Linda Baker and Wendy Saul, both at the University of Maryland, sponsored a two-year project in which elementary teachers well-versed in language arts instruction collaborated with those expert in science. The team's goal was to integrate the two disciplines in a way that proved beneficial to both teacher and children. By the end of the project, the teachers had recognized the cognitive overlap among their different instructional methodologies—meaning, in essence, that traditionally taught reading and language arts skills are as applicable to science texts as to other types of literature, as well as equally useful for children's understanding of science concepts (Baker and Saul 1994).

Valarie Dickinson and Terrell Young, both at Washington State University, helped to develop a similar curriculum. Teachers successfully enacted integrated, interdisciplinary science and language arts lessons that met national standards for both disciplines (Dickinson and Young 1998).

Putting teaching strategies such as these to the test was the objective for researchers Nancy Romance and Michael Vitale. In a controlled, five-year experiment covering many primary and intermediate grades, they studied the effect of replacing a two-hour block of traditional lessons in reading and language arts with a block of science instruction. Children read science texts and received relevant lessons on reading comprehension and language arts skills, and also conducted hands-on activities and wrote in personal journals.

The results of the experiment included an expected finding: Children in the science group scored higher than their counterparts on science comprehension exams. Yet those same children also scored significantly higher on standardized reading tests, including the reading components of both the Iowa Test of Basic Skills and the Stanford Achievement Tests (Romance and Vitale 2001).

Research Implications

Leaders in education, government, and academia agree on the need to increase and improve science education across the K–12 curriculum. In the primary classroom, this goal can be effectively accomplished by integrating reading comprehension lessons on science themes into the curriculum, thus tapping the strength of many teachers in reading and language arts instruction.

With the *Early Science* program, every primary teacher can help children meet state and national standards for science education and prepare them for success on standardized exams. The 56 titles of the program encompass a wide variety of science concepts in familiar formats that have proven to be successful in the primary classroom, including a Big Book for shared reading and leveled books for independent reading and differentiated instruction.

Children and their teachers should find all titles in *Early Science* to be engaging, motivating, and instructional. The pages feature large, attractive photographs, always matched to explanatory text and captions. Frequently the text invites children to pose or answer questions as they read. In addition, several photographs from each title have been adapted into concept development cards, which feature a teacher script of background information and questions to ask the class.

By following the lesson plans in the Teacher's Guide, teachers can teach skills in science and reading concurrently. For every two-page section of the children's reader, the Teacher's Guide presents the "Big Idea" of the section, appropriate reading- and vocabulary-comprehension strategies, and explanations of the science concepts as warranted.

The Teacher's Guide for each title also presents investigations and hands-on activities from which teachers may select. These investigations and activities offer a variety of educational experiences that complement and expand on the reading instruction, and they may be incorporated into any stage of the lesson plan.

The Benefits of Differentiated Instruction

What is differentiated instruction? Education professor Carol Ann Tomlinson, author of several essays and books on differentiated instruction and its merits, offers this definition:

> *[Differentiated instruction] emphasizes vigorous attempts on the part of classroom teachers to meet students where they are in the learning process and move them along as quickly and as far as possible in the context of a mixed-ability classroom.*

Tomlinson also distinguishes between the common instructional goal for all children in the classroom, which is to affect improvement in important subject areas, and the teacher's means toward this goal, which vary according to children's abilities (Tomlinson 1999).

Educators and education researchers cite numerous explanations for why differentiated instruction should be practiced in the modern classroom, especially in the primary grades. Chief among these reasons is the increasing diversity of children within a classroom, a phenomenon reported in rural, suburban, and urban school districts. Within a single class, the primary teacher is more likely than ever before to face children of diverse backgrounds, including children new to the school district, English-language learners and, in many cases, mainstreamed special needs children (Noguera 1999; Rosenkoetter et al. 2001).

Experts also cite the national emphasis on achievement in standardized tests as a reason for providing differentiated instruction. As argued by Rosemary Murray and her collaborators, today's textbooks and other educational materials typically are constructed with the principle goal of meeting state standards and aiming instruction toward assessment. Such materials encompass a "one-size-fits-all" approach that both neglects children's individual needs and fails to encourage an interest in learning (Murray, Shea, and Shea 2004).

Educator James VanSciver argues that the basis of the No Child Left Behind (NCLB) legislation poses a fundamental challenge to teachers, a challenge that differentiated instruction can help meet. In the NCLB metric for measuring yearly progress, children's test scores are disaggregated into various groups based on demographic factors. Yet children are not segregated into these demographic groups within the school, but rather are distributed nearly evenly among all classrooms. Only by differentiating their instruction to meet each group's needs can teachers hope to achieve adequate yearly progress for all, as NCLB demands (VanSciver 2005).

Methods of Differentiated Instruction

Experts are clear that classroom instruction cannot and should not be differentiated in all its aspects. For many reasons inherent to the public school setting, teachers cannot manage separate, potentially diverging instructional tracks for every child in the class. While children should be encouraged to pursue their own questions and interests, the teacher needs to establish classroom-wide, overarching objectives for children's education (Tomlinson 1999).

Within these limits, Tomlinson identifies three areas for which differentiation is appropriate and useful. In her research, teachers that have successfully incorporated differentiated instruction employ strategies in one, two, or all three of these areas:

Content refers to the subject matter under study. All students should be given access to the same core content, but at adjusted degrees of complexity. Struggling learners should be taught the same "big ideas" of a lesson as taught to other students, while advanced learners may explore any number of related ideas and supporting facts and details.

Process refers to the instructional approaches that children employ to learn content. These approaches include reading texts, conducting hands-on activities, listening to teacher lectures, and participating in class or small-group discussions. As with content, teachers can modify process to best meet the learners' needs and set of learning skills.

Products include children's projects or reports that show what they have learned, as well as extend the content beyond the classroom setting. Children can create a wide variety of projects based on their readiness levels, interests, and learning preferences (Willis and Mann 2000; Tomlinson 1999).

By necessity, all methods of successful differentiated instruction begin with the grouping of children according to their level of accomplishment. Such groups should be flexible, meaning that children in an advanced group for science lessons may be grouped in an on-level or low-level group for lessons in other subject areas. Moreover, teachers can and should reassess and regroup children throughout the school year (Tieso 2003).

Once grouped, children may be charted onto parallel curricular tracks that typically lead to a common goal, although some groups may achieve additional or more complex goals than other groups. For example, teachers may have children in all groups read the same science text but differentiate the hands-on activity they conduct, which is an example of differentiating by process. Or she may assign texts that cover the same content at different reading levels, an example of differentiating by content (Tomlinson 2001).

To manage and instruct the different groups, successful teachers employ a variety of specific strategies and methods. The following are some of the most commonly cited:

Individualized pacing allows children to proceed through a curriculum at the rate that suits them best. Lists of words to spell or arithmetic facts to memorize are common choices for this approach.

Scaffolded questioning during class discussions is an instructional method in which teachers ask a range of questions, typically beginning with simple recall or identification and then progressing in complexity to questions that demand critical thinking skills. With this approach, all levels of learners can take part in and benefit from the discussion.

Curriculum compacting for the advanced learner is a strategy in which essential learning is completed first, and then children delve into concepts in greater depth or breadth.

Independent learning centers provide remediation for the below-level learner or enrichment for the advanced learner. Supplemental curriculum, trade books, and multimedia products are useful components for these centers.

Tiered activities offer an approach in which the teacher provides a sequence of activities that increase in complexity, although all are related to the same core curriculum concept. Children complete the activities in this sequence that are appropriate to their abilities (Tomlinson 1999; Kapusnick and Hauslein 2001; Forsten, Grant, and Hollas 2002; Tieso 2003).

For successful implementation of any of these strategies, curriculum experts and veteran teachers cite the need for appropriate assessment. This may take the form of traditional exams or worksheets. However, especially for the primary grades, the assessment may be a product that the child completes, such as a drawing, an oral presentation, or an arts-and-crafts project (Tomlinson 1999).

Meeting the Needs of Gifted and Talented Children

As researched by education professor Sally Reis, robust programs for gifted and talented children were not widespread before the implementation of NCLB legislation, and programs of any sort for these children have only declined since. In a recent study involving 92 days of classroom observations in all subject areas, Reis and her colleagues found that gifted and talented children received only minimal appropriate instruction. In one example, these children were sent to the library for independent study. The children used the time to view Web sites on popular culture, chat among themselves, and read commercial fiction titles that were well below their reading levels.

To explain such events, both Reis and the teachers she interviewed cite the demands of underachieving children on the teacher's time. Said one teacher: "So many of my other students read below grade level that it is hard to justify not working with them. Many of these lower readers will be retained in this grade if they do not improve" (Reis 2007).

Reis and other experts argue that differentiated instruction is an effective and essential tool for meeting the needs of gifted and talented children. In one study, researchers concluded that teachers need only a few hours of training to eliminate about half of the previously mastered curriculum for their high-ability and gifted students, replacing it with more appropriate and challenging curriculum. Other studies showed similar results (Moon et al. 1999; Megay-Nespoli 2001; Reis and McCoach 2002; Reis 2007).

Research Implications

More so today than ever before, teachers are asked to meet the needs of a diverse classroom, to which children bring a wide range of skills, knowledge, and abilities. With the *Early Science* program, teachers in the primary grades can differentiate science and reading instruction easily and effectively.

Every title in the *Early Science* program is published in three versions: below-, on-, and above-level. All versions teach the same core content, but differentiate in reading level and vocabulary, depth of supporting details, and levels of complexity. By grouping children and assigning the leveled readers accordingly, teachers allow all children to access science content in a manner appropriate to their educational development.

Each *Early Science* Teacher's Guide presents teaching strategies specific for the three levels of readers. It also presents a variety of investigations and science activities that teach or expand on the concepts taught in the readers. The investigations and activities vary in complexity and scope, and are ideal for a tiered activity approach to differentiated instruction.

Teachers may monitor and assess children's progress with pretests and posttests, as well as performance assessment worksheets.

How Young Children Learn Science

To explain how children learn, education experts cite leading ideas and theories from the field of educational psychology.

Lev Vygotsky, one of the first significant educational psychologists, proposed that children's intellectual development was dependent on and nurtured by their social interactions. He believed in what today is called cooperative learning, in which children work together toward a common end. Much current research supports this idea. Educators Shaw and Blake, for example, documented the benefits of young children talking congenially among themselves during classtime. Such discussions helped children both to construct concepts and develop social skills (Gallenstein 2005; Shaw and Blake 1998).

In the 1960s, Jerome Bruner proposed that learning takes place in three stages: enactive, iconic, and symbolic. For example, at the enactive stage children would observe or handle real eggs and chickens, at the iconic stage they study an illustration that shows the development of a chicken from egg to adult, and then at the symbolic stage they read an essay about the life cycle of a chicken, or analyze a line graph that shows a chicken's changing size over time. If children have not experienced the first stage—in this example, if they have never seen chickens or eggs before—then education that relied on the symbolic or iconic stages would hold far less meaning and be ineffective (Bruner 1966; Sperry Smith 2001).

In recent years, arguably the most commonly cited theory of learning has been the theory of multiple intelligences developed by Howard Gardner. Gardner classifies eight intelligences that both children and adults use to acquire new knowledge. They are logical-mathematical, verbal-linguistic, visual-spatial, bodily-kinesthetic, musical, naturalist, intrapersonal, and interpersonal. While everyone has strengths and weaknesses among these intelligences, they may use many or all of them every day, typically in a variety of combinations. Thus, a goal for the teacher is to educate children through a variety of intelligence modalities and learning styles. This serves both to increase content knowledge and skills and to establish a complete, well-balanced method of learning (Gardner 1999; Armstrong 2000; Rubado 2002).

Common to all modern theories of learning is the principle that the use of a single, isolated vehicle or method of instruction does not yield optimal results. This means, in practice, that teachers should mix a variety of teaching methods and instructional materials into their lessons (Rubado 2002; Vaidya 1993).

Learning Styles and the Nature of Science

Scientists describe their discipline as a process: a way of thinking about, investigating, and making sense of the natural world. They agree that the goals of an elementary science curriculum should be to instruct children not merely about specific facts and theories but also about the process and methods of science inquiry on which those facts and theories are based. National and state standards for science education support this idea, as they include objectives for both science content and process at all grade levels (Gallenstein 2005; Jeanpierre 2006).

Science experts typically define science inquiry as a series of steps involving observations, experiments, and analysis. One popular textbook for elementary school describes five steps: make observations, ask a question, form a hypothesis, do an experiment, and draw conclusions. The textbook also identifies several skills of scientific inquiry, including comparing, classifying, predicting, communicating, and using variables (Badders, Carnine et al. 2007).

While young children do not have the vocabulary or developmental skills for understanding concepts such as a hypothesis and a variable, they nevertheless exhibit many of the traits of scientific inquiry and reasoning. They are curious about the world around them, they recognize patterns and order, and they invent rationales to explain personal decisions or phenomena they observe. Kellough and collaborators cite common children's complaints, such as "My big brother got three cookies and I only got two!" and "Dad can reach higher than me!" as evidence of their nascent abilities in science (Kellough et al. 1996).

How can teachers in the primary grades take advantage of children's natural curiosity and preconceptions about science (whether or not those conceptions are correct) and channel them into effective instruction? Nancy Gallenstein cites teachers that successfully use different instructional methods, among them individual reading, shared reading, class discussion, journal writing, directed inquiry activities, and guided inquiry activities. Yet consistent with Gardner's theory of multiple intelligences and related theories, these teachers never use only a single strategy, or even only two or three. In science, the varied approach is especially important because the objectives are so diverse, including both the mastery of basic facts and the development of critical scientific thinking (Gallenstein 2005).

In her research, Mary Carson Reinhardt cited a teacher who creates theme-based lessons that integrate science with other curriculum areas. As a result, children learn science as they read, write, do mathematics, and draw, as well as conduct hands-on activities. The result is a rich educational experience that meets children's multiple learning styles and shows the significance of science to the world at large (Reinhardt 1998).

Learning Styles and English-Language Learners

At the primary grades especially, English-language learners (ELL) face the significant challenge of catching up to their peers. Whereas English speakers generally have mastered basic English sentence structure and have a speaking vocabulary of between 2,000 and 8,000 words by the time they enter kindergarten, English learners enter school at all grades with limited or no knowledge of English vocabulary and sentence structure (California Commission on Teacher Credentialing 2001).

As argued by education professor Beatrice Gibbons, traditional instructional techniques favor the English-speaking child from a European or American culture. These techniques focus on individual learning, such as children reading texts by themselves, or passive learning, such as listening to a lecture. Gibbons cites research that shows English learners especially benefit from working in small-group instruction, as well as from activities and demonstrations that help children construct the meaning of the content (Gibbons 2003).

Research Implications

Effective science instruction employs a variety of instructional modalities that reach children's different styles of learning. The *Early Science* program includes an array of components, as well as strategies for teachers to use them, thus allowing teachers to meet the needs of all learners.

The 56 units of *Early Science* access subject matter already familiar to young children, including such topics as foods, animals, trees, weather, and objects in the sky. By following the strategies in the Teacher's Guide, teachers access children's prior knowledge to help them construct science concepts from the images and text presented to them.

Components of *Early Science* include Big Books for shared reading and class discussion, leveled readers for individual reading, and audio recordings of the leveled readers to help struggling readers and to access an auditory learning modality. Teachers may also use photo cards with teacher script for combining visual and auditory learning styles in whole-class or small-group instruction. In addition, teachers may choose from a variety of investigations and hands-on activities.

Specific strategies for teaching English-Language Learners appear on page 8 of each Teacher's Guide. These strategies encompass a variety of learning styles and are offered through several components of the program, including the readers, Smart Word vocabulary cards, and photo cards. The photo cards present teacher scripts in both English and Spanish.

Comprehension Strategies for Young Readers

How do readers comprehend what they read, and how can teachers effectively instruct young children to develop reading comprehension skills? Researchers have conducted a large number of studies to answer these questions. Indeed, their work has firmly established that explicit instruction of reading comprehension strategies will effectively improve reading and prevent reading difficulties (National Reading Panel 2000; Geary 2006).

Reading comprehension is now understood to be an active, purposeful goal of the reader, in which he or she relates to text in ways that help build understanding. While simple or superficial reading may allow a limited amount of information processing, skilled readers use a variety of strategies that help them make sense of a text and draw meaning in the context of both their own lives and the world around them. According to the Committee on the Prevention of Reading Difficulties in Young Children, a child's failure to acquire and use comprehension skills and strategies is one of the three primary obstacles to becoming a skilled reader (Snow, Burns, and Griffin 1999).

The following sections present a brief overview of the research in support of five reading comprehension strategies.

Make Connections

According to the generative model of learning (Wittrock 1974), understanding is constructed by making connections between the text and one's existing knowledge and experience. The reader then builds relationships among the ideas in a text to garner its meaning.

Specific strategies to help children make connections to the text include asking them to reflect on their existing knowledge, engaging them in a discussion of this knowledge, and asking them directed questions that depend on this knowledge. Research suggests that these strategies can be used successfully at any stage of the reading process, including before, during, or after reading (Carr and Thompson 1996; King 1994).

Read and Talk About It

In this strategy, the teacher reads text together with children, pausing at times to comment on the text and to pose questions for the class to ponder and respond to. This strategy encompasses a specific technique often called "thinking aloud." Education authors Harris and Hedges describe thinking aloud as "a metacognitive technique … in which a teacher verbalizes thoughts aloud while reading a selection orally, thus modeling the process of comprehension" (Harris and Hedges 1995).

A mixture of reading and talking teaches children to stop periodically to reflect on the thinking they do to understand a text. By encouraging children to verbalize their thoughts during reading, teachers bring this process into the open so that children can replicate it effectively when they read independently (Block and Israel 2004; Oster 2001).

Identifying the Main Idea

The National Reading Panel (2000) identified summarizing as one of eight procedures proven effective in adult reading comprehension. Yet research shows that summarizing is a late-developing skill, not mastered until high school (Brown, Day, and Jones 1983).

For younger children, the more appropriate version of this skill is identifying main ideas. The value of the skill lies in organizing the content. The main idea (often called the "big idea") encompasses the purpose of a passage, and is most likely to relate to previous passages and be extended into the following ones (Dougherty Stall 2004).

As discussed in a report of the National Reading Panel, identifying the main idea is a more complex skill than it may first appear to be. The skill combines accessing prior knowledge, making inferences, and generalizing (National Reading Panel 2000).

Incorporating Photographs and Illustrations

Researchers Hunter, Crismore, and Pearson identified five possible relationships that, in their words, a "visual display has in relation to the text it accompanies." These relationships are to reinforce (repeat all information presented in the text), to elaborate (partly repeat and partly add to information), to embellish (provide completely new information), to summarize (provide a broad overview, much like a graphic organizer), and to compare (provide information intended to be compared with another graphic) (Hunter, Crismore, and Pearson 1987; Iding 2000).

Today, every science text intended for the primary grades presents visual images on nearly every page. Not surprisingly, research shows that novices in a field are helped more than experts by such images (Mayer 1989). Yet not all types of visuals are equally applicable at these grade levels.

As young children develop reading skills, they learn to use and incorporate the different types of visuals into their comprehension. The simplest type to incorporate are the visuals that reinforce the text, particularly those that encapsulate the text entirely. For example, the sentence "An alligator has many sharp teeth" could be completely encapsulated by a photograph of an alligator with its mouth open and teeth exposed. Only as children mature as readers do they become open to interpreting other visual types. Or, as psychologist Jerome Bruner stated this idea, they progress in learning stages from the enactive to the iconic to the symbolic (Pantaleo 2004; Sipe 2000; Bruner 1966).

Developing Reading Fluency

When children leave the primary classroom, their new teachers will expect them to read independently. Research shows that children with inadequate fluency in their reading can easily become trapped in a downward spiral of poor performance in schoolwork, negative self-image, and less time spent reading (Allington 1977; Anderson, Wilson, and Fielding 1988).

Reading specialists Karen Broaddus and Jo Worthy argue that effective fluency instruction involves more than just asking children to read aloud. Rather, teachers need to model fluent reading and to provide appropriate instruction and feedback. Many effective strategies include repeated reading, in which the teacher reads the text aloud first, and then children read independently or together. Children may repeat a sentence after the teacher reads it (called echo reading) or read the text with the teacher at the same time (called choral reading) (Broaddus and Worthy 2001).

Research Implications

Primary teachers are challenged to help young children develop the reading comprehension skills they need to succeed throughout their education and as adults. The *Early Science* program provides both the instructional materials and the support that teachers need for effective comprehension instruction.

Every page of an *Early Science* Big Book or leveled reader presents developmentally appropriate concepts in text and matching visuals. Only the books of higher reading level present advanced visual representations, such as charts and graphic illustrations of concepts.

For each unit, the Teacher's Guide presents page-by-page reading comprehension strategies for both the Big Book and leveled readers. The "big idea" is presented for each block of narrative text, followed by specific instructional strategies that include reading and talking about the text, using the photographs, developing reading fluency, and developing vocabulary skills.

To help children make connections to the text, teachers may use the photo cards included in the program. The teacher script for each photo includes a narrative and questions that help children access their prior knowledge and relate the photo to their own experiences.

Summary of Foundational Research Basis

- ✔ Educators and government leaders agree that a healthy citizenry depends on all citizens being science literate. The development of this literacy begins in the primary grades.
- ✔ Young children are ready and eager to learn science concepts and skills. Yet the many demands placed on primary education often squeeze science out of the curriculum.
- ✔ One effective way to increase science instruction is to integrate science texts into reading and language arts lessons, and to apply reading skills in their instruction.
- ✔ By differentiating instruction according to children's abilities, teachers can meet the educational needs of all children, keep them engaged and motivated, and facilitate yearly progress.
- ✔ Children learn science optimally through multiple instructional techniques and learning modalities.
- ✔ Reading comprehension is an active, purposeful goal of the successful reader. Learning a variety of comprehension skills helps young children develop as readers and prepares them to read independently.

Research Implications

The *Early Science* program will help primary teachers and children meet their objectives for both science and reading instruction. The program's suite of components allows teachers to differentiate instruction, access children's multiple learning styles, and teach reading comprehension skills. Early Science is an ideal supplement to any basal reading or science program for the primary classroom.

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