

1. **Title of Submission:** Teaching Science Across the Curriculum: A Discussion of "Why-to's," "How-to's," and "What-to-Expect's"
2. **Name of Author:** Kelly Gooden
3. **Affiliation of Author:** Towson University, College of Education, Elementary Education Department
4. **Address of Author:** 8000 York Road, Towson, Maryland 21252-0001
5. **E-mail Address of the Author:** kgooden@towson.edu
6. **Abstract of Paper:** Given the impact of the Information Age on society and the subsequent increased accountability to science literacy, the fact that science education and instruction are more important than ever seems obvious. But with the curricular shift to literacy and mathematics blocks in the elementary school schedule, little time is allotted to science. Teachers are not sufficiently trained in the pedagogy of teaching science and, more often than not, are inadequately prepared for the content themselves. Pressure from on high is to increase test scores. The message is clear -- science is not as important as other subjects. But wait a minute. How can we increase science literacy and improve instruction while, at the same time, decrease time and resources? The answer is simple, and as old as time. Teach science across the curriculum. The national standards in science as well as in the core content areas support the use of integration to increase proficiency, improve comprehension, and build lasting understanding. For more pragmatic reasons, integration also speaks to our issues of time, resources, and accountability. There are many levels of integration and many strategies to achieve integration. This paper will address these strategies and justify them using the national standards and the research. Additionally, the paper will share examples of effective integration tools and cases demonstrating the use of said tools in real classrooms in the Baltimore and Washington, D.C. metropolitan areas.

## **Teaching Science Across the Curriculum: A Discussion of “Why-To’s,” “How-To’s,” and “What-To-Expect’s”**

*“Education has no higher purpose than preparing people to lead personally fulfilling and responsible lives. For its part, science education should help students to develop the understandings and habits of mind they need to become compassionate human beings able to think for themselves and to face life head on. It should equip them also to participate thoughtfully with fellow citizens in building and protecting a society that is open, decent, and vital. America’s future depends more than ever on the character and quality of the education that the nation provides for all of its children.” (AAAS, 1990)*

So begins *Science for All Americans*—a set of recommendations on what is essential for scientific literacy written by the American Association for the Advancement of Science. The intentions seem lofty yet accurate. The goal of teachers and schools (and education itself) should be to prepare students to be at least productive and functioning and at best prosperous and thriving adults. This is true of science education today as it has not necessarily been true in the past for science, mathematics, and technology literacy are increasingly more essential in the productive and prosperous lives of adult citizens more so now than in any time prior to this Information Age.

The challenge is clear and daunting. And while science education researchers and public policy makers work to initiate reform on a national level, the bulk of the responsibility and accountability will fall at the feet of those at the battlefield. Science educators must rise to the challenge and facilitate the effective instruction of science to produce this literate citizenry to which we all strive.

Too often though, top-down reform efforts find little success in the classroom for a variety of reasons. But what if the changes came from the classroom, from the teachers themselves in the form of a familiar (albeit often misused) methodology? By integrating the instruction of science across all areas of the curriculum, teachers can meet standards

both in science and in other content areas economically; increase student proficiency in multiple subject areas; model the interdisciplinary approach by which adults often approach both local and global problems; and do their part to prepare their students to lead personally fulfilling and responsible lives.

[Author's Note: This report will focus on the integration of science across the curriculum. However, it should be understood that most of the points made in defense of science cross-curricular integration are true of cross-curricular integration in any of the so-called content areas. Social Studies, specifically, shares many of the same challenges and potential instructional solutions as Science in the elementary classroom.]

### **The National Standards**

#### **In Defense of Integration**

In 1985, AAAS began Project 2061, a long-range effort designed to help the nation achieve scientific literacy. In 1989, Project 2061 created *Science for All Americans*. This text outlined a vision of a scientific population by describing what students should know and be able to do by the end of twelfth grade. Despite the operational definition of scientific literacy it provided, the document was problematic in that it was difficult to translate to actual instructional planning. In response to the call for a more explicit set of guidelines that could be more easily used in practice, Project 2061 produced *Benchmarks for Science Literacy* in 1993. *Benchmarks* broke it down to what students needed to know and be able to do by the end of not only twelfth grade, but second, fifth, and eighth grades as well. Among these benchmarks are a number that speak directly to the idea of integration as an effective reform methodology. Under the benchmark titled The Nature of Science, it states that “clear communication is an

essential part of doing science. It enables scientists to inform others about their work, expose their ideas to criticism by other scientists, and stay informed about scientific discoveries around the world.” (Benchmark 1c, The Scientific Enterprise) This speaks to integrating science and Language Arts (especially writing and reading for a variety of purposes). The same benchmark states that “no matter who does science and mathematics or invents things, or when or where they do it, the knowledge and technology that result can eventually become available to everyone in the world.” (Benchmark 1c, The Scientific Enterprise) Integration between science, mathematics, and technology to social studies is implied here -- as it is in similar passages from the same section, which read as follows. “Progress in science and invention depends heavily on what else is happening in society, and history often depends on scientific and technological developments;” and “Scientists can bring information, insights, and analytical skills to bear on matters of public concern.” Other passages throughout the Nature of Science benchmark imply integration across the curriculum as well. Further, connections can be made within the instruction of many of the content standards. For example, study of the Earth (Benchmark 4b) provides opportunities for connections to geography (social studies) and observing, measuring, and analyzing weather patterns (math). Diversity of Life (Benchmark 5a) can be linked easily to human-environment interaction (social studies), grouping and classification (math), and reading for literary experience and personification (reading). The complete list of Benchmarks is listed in table 1.

**Table 1, Benchmarks for Science Literacy**

1. The Nature of Science	A. The Scientific World View B. Scientific Inquiry C. The Scientific Enterprise
2. The Nature of Mathematics	A. Patterns and Relationships B. Mathematics, Science, and Technology C. Mathematical Inquiry
3. The Nature of Technology	A. Technology and Science B. Design and Systems C. Issues in Technology
4. The Physical Setting	A. The Universe B. The Earth C. Processes that Shape the Earth D. Structure of Matter E. Energy Transformation F. Motion G. Forces of Nature
5. The Living Environment	A. Diversity of Life B. Heredity C. Cells D. Interdependence of Life E. Flow of Matter and Energy F. Evolution of Life
6. The Human Organism	A. Human Identity B. Human Development C. Basic Functions D. Learning E. Physical Health F. Mental Health
7. Human Society	A. Cultural Effects on Behavior B. Group Behavior C. Social change D. Social Trade-Offs E. Political and Economic Systems F. Social Conflict G. Global Interdependence
8. The Designed World	A. Agriculture B. Materials and Manufacturing C. Energy Sources and Use D. Communication E. Information Processing F. Health Technology
9. The Mathematical World	A. Numbers B. Symbolic Relationships C. Shapes D. Uncertainty E. Reasoning

10. Historical Perspectives	<ul style="list-style-type: none"> <li>A. Displacing the Earth from the Center of the Universe</li> <li>B. Uniting the Heavens and Earth</li> <li>C. Relating Matter and Energy and Time and Space</li> <li>D. Extending Time</li> <li>E. Moving the Continents</li> <li>F. Understanding Fire</li> <li>G. Splitting the Atom</li> <li>H. Explaining the Diversity of Life</li> <li>I. Discovering Germs</li> <li>J. Harnessing Power</li> </ul>
11. Common Themes	<ul style="list-style-type: none"> <li>A. Systems</li> <li>B. Models</li> <li>C. Constancy and Change</li> <li>D. Scale</li> </ul>
12. Habits of Mind	<ul style="list-style-type: none"> <li>A. Values and Attitudes</li> <li>B. Computation and Estimation</li> <li>C. Manipulation and Observation</li> <li>D. Communication Skills</li> <li>E. Critical-Response Skills</li> </ul>

*Benchmarks for Science Literacy, Project 2061, 1993*

The benchmarks as listed by Project 2061 clearly demonstrate that mathematics and technology are not only to be integrated with science, but are an inescapable part of science. Mathematics is the language of science and technology is the means through which we can continue the study of science.

Other connections are not explicitly stated but are almost as obviously implied in the language used. In addition, the Habits of Mind (Benchmark 12) are another nod from AAAS in support to an integrated curriculum. Values and Attitudes (12A) tend to encourage a connection between science and social studies. Computation and Estimation (12B) make a direct correlation between science and math. Manipulation and Observation (12C) show the integration of science and technology. And Communication Skills (12D) call for interdisciplinary instruction of science and language arts.

Project 2061 was not the only group to tackle the issue of science education reform. The National Academy of Sciences charged the National Research Council, its operating agency, to establish a committee to create standards for science content, teaching, and assessment. *The National Science Education Standards* in 1996 was the result of the work of this committee. The *Standards* were a complete and comprehensive vision of how the educational system needs to change in order to give every student an opportunity to be scientifically literate. (See Table 2) These standards include teaching standards, professional development standards, content standards, program standards, and system standards.

**Table 2, National Science Education Standards**

<p>Science Teaching Standards describe what science teachers should know and be able to do.</p>	<ul style="list-style-type: none"> <li>• Planning of inquiry-based science programs</li> <li>• Actions taken to guide and facilitate learning</li> <li>• Assessments made of teaching and learning</li> <li>• Development of learning environments for science</li> <li>• Creation of communities of learners</li> <li>• Planning and development of school science program</li> </ul>
<p>Professional Development Standards present a vision for development of teachers' skills and knowledge.</p>	<ul style="list-style-type: none"> <li>• Learning of science content through inquiry</li> <li>• Integration of knowledge and pedagogy of science</li> <li>• Development of lifelong learning</li> <li>• Coherence and integration of professional development programs</li> </ul>
<p>Assessment Standards provide criteria against which to judge quality of assessment practices.</p>	<ul style="list-style-type: none"> <li>• Consistency of assessments with decisions they are designed to inform</li> <li>• Assessment of achievement and opportunity to learn</li> <li>• Match between technical quality of data and consequences of actions taken</li> <li>• Fairness of practices</li> <li>• Soundness of inferences made</li> </ul>
<p>Science Content Standards outline what students should know and be able to do.</p>	<ul style="list-style-type: none"> <li>• Unifying concepts and processes</li> <li>• Science as inquiry</li> <li>• Physical Science</li> <li>• Life Science</li> <li>• Earth and Space Science</li> <li>• Science and Technology</li> </ul>

	<ul style="list-style-type: none"> <li>• Science in Personal and Social Perspective</li> <li>• History and Nature of Science</li> </ul>
Science Education Program Standards describe the conditions necessary for quality school science programs.	<ul style="list-style-type: none"> <li>• Consistency of science program with other standards</li> <li>• Inclusion of all content standards in a variety of curricula</li> <li>• Coordination of science and math</li> <li>• Provision of appropriate and sufficient resources</li> <li>• Provision of equitable opportunities for all</li> <li>• Development of communities that encourage, support, and sustain teachers</li> </ul>
Science Education System Standards	<ul style="list-style-type: none"> <li>• Congruency of policies</li> <li>• Coordination of policies within and across agencies</li> <li>• Continuity of policies over time</li> <li>• Provision of resources</li> <li>• Equity embodied in policies</li> <li>• Possible unanticipated effects of policies</li> <li>• Responsibility of individuals to achieve the new visions portrayed by the standards</li> </ul>

*National Science Education Standards, National Research Council, 1996*

Of the National Standards, those related to Science Content are the ones that align to the Project 2061 Benchmarks. A more in depth study of the standards reveals a number of similarities across the content standards to the benchmarks. For this reason, we can assume the same about integration supported by the standards as we did for the benchmarks. Within the text describing content standards, calls are made to “orchestrate discourse among students about scientific ideas” (implying a connection between science and language arts/communication); and to emphasize “learning subject matter disciplines in the context of inquiry, technology, science in personal and social perspectives, and history and nature of science” (implying connections between science, technology, and social studies). Further support from the standards is present in the Science Education Program Standards. These standards state that the following are necessary for quality school science programs:

- *The inclusion of all content standards in a variety of curricula that is developmentally appropriate, interesting, and relevant to student's lives, organized around inquiry, and connected with other school subjects.*
- *The coordination of the science program with mathematics education.*  
[NRC, 1996]

These standards (particularly standard B) explicitly state NRC's support of the integration of science across the curriculum areas. "Student achievement in science and in other school subjects such as social studies, language arts, and technology is enhanced by coordination between and among the science program and other programs. Furthermore, such coordination can make maximal use of time in a crowded school schedule." (NRC, 1996, page 214) Program Standard C reiterates the Benchmarks' stance that mathematics and science are necessarily and eternally linked and that this should be true in instruction. The Standards further state support of a change in emphasis from "treating science as a subject isolated from other school subjects" to more of an emphasis on "connecting science to other school subjects, such as mathematics and social studies." (NRC, 196, page 224)

The Benchmarks for Science Literacy, The National Standards for Science Education, and other reform projects including the Scope, Sequence, and Coordination Project (through which the National Science Teachers Association established guidelines for restructuring school science experiences for grades 6-12 in 1989) share a common vision as to what science education and instruction should look like if it is to lead to scientifically literate citizens. In terms of what students should learn, all support the key idea that instruction should provide a conceptual

framework that will enable students to see the connections between different topics. “Science should not stand alone, isolated from other subjects; but should be integrated with the rest of the curriculum and the real world of fascinating phenomena and human concerns.” (Sneider, 1997, page 37)

### Benefits of Integration on Science Learning

Integration of science across the curriculum is supported by the standards and by the experts. Teachers who are committed to meeting state and national standards are may argue the importance of teaching science through an interdisciplinary approach in an effort help students meet those standards. However, there are other theoretical and pragmatic reasons to do so.

An argument can be made that the way we learn science and the skills we need to “do science” are similar to the way we learn and the skills we need for other subject areas. For example, Casteel and Isom found that learning science and language is reciprocal. (1994) That is, learning science can be described as a process similar to learning language, from questioning and setting a purpose to analyzing and drawing conclusions, and reporting/ communicating results. Therefore, teaching them together will necessarily enhance learning of both

A tight schedule allowing designated and segmented times allotted for each subject does not help students to see connections between subjects nor does it allow them to see the purpose of learning the skills they are taught. Following such a schedule can lead to what has been called inert knowledge; knowledge that can be delivered on request but that is not used spontaneously in solving real problems. By

contrast, the integration of subjects requires that children use their skills and knowledge in multiple contexts.

Students in elementary school need to read, write, and communicate. But they must also read, write, and communicate *about* something, not just for the sake of doing it. Science can provide the purpose for reading, writing, and communication.

Previously, it was mentioned that science literacy is more important now than it ever was prior to the Information Age. It may once have been the case that proficiency with basic reading, communication, and math calculations was sufficient to be a productive, employable adult. That is likely the reason that tests like the ITBS and SAT included only verbal and mathematics sections. It is now true that more and more knowledge of science and technology are needed to succeed in the “real world” and test creators are responding to that. Science proficiency is increasingly being evaluated on national and state assessments at certain grade levels. If science is going to be tested using the same high-stakes examinations by which language arts and mathematics are currently assessed, we are starting students at a disadvantage if we don’t teach science well in elementary school. By integration, we can meet national science objectives in a way that supports the objectives of the other subjects.

All teachers know the problem of time. There is not enough time in the school year (much less the school day) to meet all of the standards of every subject area. By integrating science with other subject areas when appropriate, the teacher can accomplish the objects of two or more subject areas at the same time. The perception held by many parents, teachers, and administrators is still that teachers should spend most of their time on reading, writing, and arithmetic (remember the 3 R’s). For

those proponents of the so-called “back to basics” ideals, they can kill two birds with one stone by using science activities and concepts as the basis for their work in other subjects, thereby emphasizes the 3 R’s without the exclusion of science.

There is so much to be learned in science that no one can teach everything that students need to know. It is more useful if students are taught to learn on their own. When subjects are integrated at the concept and process levels, students see how knowledge in one area is connected to knowledge in another area; which will be helpful when they start to learn something new.

#### Best Practices in Integration

Having read up to this point in the report, a number of teachers would say “I do teach science across the curriculum. I have for years.” They will point to thematic units they have created and taught with themes like Apples or The Seasons or Dinosaurs (a favorite unit among primary teachers and students). But curriculum integration includes more than just the interweaving of subjects, as when students have to read about dinosaurs, count dinosaurs, and locate the places where dinosaurs lived on a map. Curriculum integration requires the interweaving of concepts and skills. Many important concepts in science have counterparts or similar concepts in other subject areas. The concept of a web, for example, is one that is useful in science (food web, interdependence of living things) and equally valid in, say, social studies (personal network of family and friends, interdependence of people). Students understand the idea of interdependence on a deeper level if they see it reoccurring in different lessons. Students classify in science (animal classification,

types of rocks and minerals, etc.). They also classify in language arts (parts of speech, phonics).

Another point that should be raised here is that integration is the goal. There are a few subtle levels along the continuum that strive for the goal. Correlation, for example, would be likened to “level 1.” To correlate two or more subject areas is to identify to the students similarities between them or ways that one can be used to assist the other. An example of correlation would be to locate the biomes of the earth on a map of the world. You are still in science class but you are using a social studies skill that may have been previously taught (in social studies). Students may (or may not) get the connection but it is demonstrative of the interdisciplinary nature of the “real world.” “Level 2” might be described as connection. Connection is when you use skills or activities in one to enhance or extend the other. For example, having students read to perform the task of completing an investigation of the effects of mass on the height of a swinging pendulum is a science activity that connects an important reading skill. The goal is clearly scientific understanding here, though, not reading fluency; even though reading fluency in expository texts is enhanced by default. Again, this is likely to occur in a science class with the teacher connecting to language arts. In this case, however, students are more likely to see the connection – that is, you can’t do science without knowing how to read. The final level would be integration. Integration would be seamless; students would not know what subject (class) they were in. Integration would involve planning that is the result of collaboration of teachers from the relevant subjects or of a self-contained teacher referring to the standards of all subjects. Integrated experiences would be designed to

help students see relationships and would be coherent. They would not simply add up to a collection of miscellaneous topics (which is why the Bears and Apples units don't make it). When integrating, the lesson or unit should meet important goals or objectives in both science and the other subject(s).

The simplest and least intrusive way to teach science across the curriculum is to correlate and connect. This can be done by picking and choosing from the multitude of science process skills as they are needed and/or pertinent to the other subject areas or by selecting appropriate content from the other subjects that goes along with science content being taught. The next level – that of integration -- would be to create an interdisciplinary theme that is centered on a big idea in science. These themes should identify some ways of thinking that cut across many fields of study and should be designed to help students gradually understand and be able to use the themes. The *Benchmarks* document identifies “Common Themes.” The National Standards list “Unifying Concepts and Processes.” Any of these could be used to organize instruction across the curriculum. For further purposes of this report, these concepts, processes, and themes will be referred to as “The Big Ideas” in Science. (see Table 3)

**Table 3, The BIG IDEAS in Science**

<b>Systems, Order, and Organization</b>	<b>Evidence, Models, and Explanation</b>	<b>Constancy, Change, and Measurement</b>
<b>Evolution and Equilibrium</b>	<b>Form and Function</b>	<b>The Physical Setting</b>
<b>The Living Environment</b>	<b>The Human Organism</b>	<b>Human Society</b>
<b>The Designed World</b>	<b>The Mathematical World</b>	<b>Historical Perspectives</b>
<b>Scale</b>		

Compiled by Gooden from *Benchmarks for Science Literacy* and *The National Science Standards*

These big ideas contain concepts and skills that do cut across not only disciplines within the study of science but also other subject areas.

Performance tasks, by their very nature, require students to apply knowledge of many subject areas to the solution of a problem. Use of performance tasks (for both instruction and assessment) is another method for teaching science across the curriculum. In addition to the connectedness of subject areas inherent, performance tasks also provide real-life applications for students. And research and practice tell us that students understand, remember, and use abstract concepts far better when they discover their relevance in real life. A task in which students learn about the ecology of a geographic area and then have to use their knowledge to solve a problem of whether or not to build a resort community on the site is an example of performance task that integrates science, social studies, and language arts.

### **The BIG IDEAS Across the Curriculum**

#### **Science and Language Arts**

“An underlying element of all literacy learning in general is ‘thinking.’ In combined writing and reading instruction, learners engage in a greater society of experiences that lead to better reasoning and higher-level thinking than is achieved with either process alone (McGinley, 1988). Since thinking is a critical part of meaning construction, classrooms that actively foster meaning construction through reading and writing will produce better thinkers (T. Tierney and Shanahan, 1991).” (Cooper, 1997) Therefore, reading and writing should be an integral part of all content areas.

As has been previously mentioned, learning science and language arts is reciprocal. The same processes used to learn science are used to learn language arts.

Many elementary teachers' strengths are in language arts. (Akerson, et al., 2000; Dickinson et al., 1997) The Standards for the English Language Arts (International Reading Association and the National Council of Teachers of English) recommend that language arts serve the goals of purposeful communication through reading, writing, speaking, and listening (IRE/NCTE, 1996). We've already seen that science education reform recommends that students communicate through written and oral interactions, which are applications of the language arts. (NRC, 1996) For these reasons and others, science and language arts can be (and in some cases should be) integrated. "It is possible to use language arts to support science learning and to use science as a purpose for learning language arts. Interdisciplinary teaching can help teachers meet objectives for both language arts and science and still prepare our elementary students for the tests they must take." (Akerson, 2001)

Themes, as mentioned, are one way to integrate science and language arts. Just as there are BIG IDEAS in science, the Standards for the English Language Arts provide some BIG IDEAS as well. With the understanding that Reading is also one of the language arts but that it will be covered individually in a following section, here is a list of the big ideas in language arts as interpreted from the IRE/NCTE standards.

1. Communication with a variety of audiences for a variety of purposes
2. Writing for a variety of audiences and purposes.
3. Conducting research
4. Use of a variety of resources to create and communicate knowledge
5. Understanding for and respect of diversity
6. Competency in English to develop understanding of content

7. Participation in literacy communities

8. Use of spoken, written, and visual language to accomplish students' own purposes

These ideas are broad in scope. But they lack the aspect that allows for thinking that cuts across different content areas (with the notable exception of #6). Therefore, using science themes that incorporate language arts is more advisable than the other way around.

Beyond the use of themes, other opportunities for cross-curricular study exist. Writing is one way to communicate data to others. Writing in science is one way to meet national standards in both science and language arts. Using workbooks is one example of a way to do this. When keeping workbooks to record their work in science, students are also meeting writing standards (according to the Mid-continent Research for Education and Learning, 2000) by *discussing ideas with peers, drawing pictures to generate ideas, writing key thoughts and questions, rehearsing ideas, and recording reactions and observations* (grades K-2). Another strategy involves the use of graphic organizers. Children in grades 3-5 meet language arts standards by *grouping related ideas, taking notes, brainstorming ideas, and organizing information according to type and purpose of writing*. A third strategy is the use of scrapbooks. Scrapbooks are collections of pages that children create to provide additional details about a topic they have studied. It is a useful way to learn more about a topic for which there are many examples that can be used to illustrate a concept.

Communication (language arts) is the way that students “show what they know.” By speaking, writing, debating, drawing a diagram, students communicate to us how well

they have learned the concept. When put this way, teaching science without language arts seems ridiculous.

### Science and Reading

“Every teacher must be a reading teacher.” (Billmeyer, 1996) Reading is arguably the most important subject students learn in school. Basic math proficiency is, perhaps, the only rival that reading has in perception of importance. It is a communication art but is treated as a separate subject from the other language arts. It is also an integral part of science learning.

Beyond the fact that students need the ability to read and get meaning from what they’ve read to do almost anything in school beyond grade 3, students need instruction in the skills needed to read and comprehend content-based text in science. The text features of a chapter in the science text are not the same as those in a literature selection.

As mentioned in the language arts section, reading and doing science are similar processes drawing on the same cognitive base. Both are interactive-constructive endeavors that require critical thinking and reasoning. The same skills that make good scientists also make good readers. Good scientists and good readers must engage prior knowledge, form hypotheses, establish plans, evaluate understanding, determine the relative importance of information, describe patterns, compare and contrast, make inferences, draw conclusions, generalize, and evaluate sources. (Armbruster, 1992/93) Acquiring science information, understanding scientific procedures, and conducting experiments demand application of a variety of literacy skills. “Because of the reciprocal relationship between science and reading, teaching them together can be mutually beneficial. Research shows, for instance, that the study of science helps develop

language and reading skills and strengthens the logical processes necessary for effective content reading.” (Wellman, 1978)

In addition, again as in language arts, there are standards that are addressed that would overlap with science standards if they were taught in tandem. Science benchmarks challenge students to “stay informed about scientific discoveries around the world,” (Project 2061, 1993, page 16) “read simple table and graphs,” (page 297) “locate information in reference books,” (page 297) and “use and correctly interpret relational terms.” (page 297) All of these call for reading skills. The reading standards call for students to read a wide range of print and non-print texts to build an understanding of texts, of themselves, and of the cultures of the US and the world; to acquire new information; to respond to the needs and demands of society and the workplace; and for personal fulfillment. (IRA/NCTE, 1996)

Two ways integration between science and reading can be accomplished are (1) teaching reading through science and (2) reading about science. There is some overlap here and the primary differences exist in terms of who is doing the teaching (the science or reading teacher) and when the instruction is occurring (during science class or during reading class). When teaching reading in science, teachers should consider strategies such as using specific before-during-after reading strategies as appropriate to the science text; responding to stance questions providing text support; use of Anticipation Guides; use of the K-W-L strategy (which Akerson suggests become the T-W-L with the T standing for what students think they know and to which the author of this report would add a second W representing where the students can find out); and the specific and direct teaching of the fundamental differences in text features between expository and narrative

materials. On the flip side we have reading about science, which would include opportunities students have to read about science subjects in their reading text. Trade books are a useful tool in broadening both the reading skills and the science knowledge of an elementary student. They are often easier to read and comprehend than textbooks and they focus on one topic rather than many. Students seem to prefer them because of their short length and attractive appearance. And, since they don't take as long to write, they are usually more up to date when it comes to new thinking and discoveries in the field. "Trade books serendipitous to a curricular topic can make the difference between a passive reader who quits when the bell rings and an active, life-long, self-motivated reader/learner." (Sebesta, 1989, page 114)

Other forms of literature can be of assistance as well including poetry and fiction texts. Sally Chadbourn warns, however, that the use of nonfiction trade books should both precede and outnumber poetry and fiction texts. Since statistics show that of the reading students will do as adults, 85% will be expository, a similar percentage should be considered when selecting texts for reading instruction. (Chadbourn, 1999) She also contends that by reading aloud the nonfiction, you can model the writing plan or text structure of good authors in science writing or what young authors need to replicate in their own writing about science.

Here, it should be stated that in either of the above situations, reading should supplement science experience, not replace it. For this reason, reading alone is not sufficient to teach science effectively any more than reading science related texts exclusively is enough to teach reading well.

The big ideas in reading (like those in the other language arts) don't really lend themselves to theme integration in the true sense but are listed below for consistency in writing.

1. Reading a variety of texts for a variety of purposes
2. Reading a wide range of literature from many periods and genres
3. Applying strategies to acquire meaning from texts
4. Responding to reading in global understanding, personal response, developing interpretation, and critical analysis stances

When teaching science and reading together, it is important to: (1) identify your purpose for reading; (2) select the appropriate text; (3) remember the science and; (4) decide whether connecting or integrating will enhance learning on either side. In conjunction with science, your purposes for reading might include reading for literary experience or for enjoyment but are more likely to be to perform a task or to be informed. The purpose for reading points to the type of text selected. When reading to perform a task, a set of procedures for conducting an investigation would be a likely choice for print material. An article from a magazine or the science textbook would be a better choice for reading to be informed. Whether you're teaching reading in science or using science to teach reading, **DON'T FORGET THE SCIENCE**. Some literature books, for example, are pleasing to students and often used by teachers to relate to a science theme. Unfortunately, many of them contain misconceptions and miscues about their subjects. If these books are the sole literary extenders of a science unit, students are likely to come away with those same wrong ideas the author displayed (even if they learned the

correct information through science instruction). However, if the teacher used these materials as an opportunity for science learning, he or she could have the students identify what is “wrong” in the book and support their selections with facts from a trade book or from their unit notes. In doing so, not only do you sidestep a landmine but you also have a pretty good informal assessment.

### Science and Math

“Because mathematics plays such a central role in modern culture, some basic understanding of the nature of mathematics is requisite for scientific literacy. To achieve this, students need to perceive mathematics as part of the scientific endeavor, comprehend the nature of mathematical thinking, and become familiar with key mathematical ideas and skills.” You might think that the above quote comes from the National Council of Teachers of Mathematics or from a similar group of math education advocates. You might be surprised to learn it comes from *Science for All Americans*. (Project 2061, 1990) It is no accident that both the nature of mathematics and the mathematical world are included as benchmarks of science. Nor is it a coincidence that NCTM’s *Handbook of Research on Mathematics Teaching and Learning* (1992) was used as a resource to create some of our current national science standards. Mathematics is the science of patterns and relationships. Mathematics is the language of science. Mathematics represent the *how* and science the *why* and *what* of inquiry. The processes of mathematics (problem solving, reasoning and proof, communication, and representation) are often mutual and inclusive of the processes of science.

Put simply, math and science go together. The integration of science and math is, therefore, not only easy but also imperative for the elementary teacher.

Meaningful integration of knowledge is a major recommendation coming from the nation's professional science and mathematics associations. AAAS strongly recommends the integration of mathematics, science, and technology. NCTM places strong emphases on the applications of mathematics such as are found in science investigations. Research tells us that mathematics becomes more meaningful, hence more useful, when it is applied to situations that interest students. The extent to which science is studied and understood is increased, with a significant economy of time, when mathematics and science are integrated. There is improved quality of learning and retention, supporting the thesis that learning which is meaningful and relevant is more effective. Motivation and involvement are increased dramatically as students investigate real-world situations and participate actively in the process. (AIMS Education Foundation, 1981)

Connecting science and math can be done in either of two ways. One method is to use mathematics as a tool for doing science. Using this approach, teachers instruct and apply mathematics within the context of classroom experiences in science. Mathematics is then seen as a useful and necessary means of representing observations that have been made and working out problems that have presented themselves. This makes students more intrinsically motivated to learn math algorithms. "Learning mathematics in abstract before seeking to use it has not proven to be effective." (*Benchmarks*, 1993)

Another method is to teach mathematics as a science in and of itself – the science of patterns. From the constructivist point of view, an understanding of mathematics depends on experiences in the real world and logical thinking. For the purposes of general science literacy, students need to understand in what sense math is the study of patterns and relationships, become familiar with some of those patterns and relationships, and learn to use those patterns and relationships in their daily life. (Project 2061, 1993)

Unlike those of the language arts, the big ideas in mathematics (compiled from the NCTM Principles and Standards for School Mathematics) can be used for integrated theme study that cuts across curricular objectives.

1. Number and Operation
2. Algebra
3. Geometry
4. Measurement
5. Data Analysis and Probability
6. Problem Solving
7. Reasoning and Proof
8. Communication
9. Representation

Opportunities for connecting science and mathematics are obvious in content standards like Data Analysis and Probability when you are teaching math as a tool for science investigation. The mathematics objectives within this standard [formulate questions that can be addressed with data and collect, organize, and

display relevant data to answer them; select and use appropriate statistical methods to analyze data; develop and evaluate inferences and predictions that are based on data] read very similarly to the Science as Inquiry standard.

Measurement is a content standard that can be addressed within a number of science investigations. In addition, process standards (with incidentally cut across all mathematics disciplines) like Reasoning and Proof could easily cut across content in science as well; as could Communication, which could be expanded to include the inclusion of language arts, reading, science, mathematics, and social studies (which we'll get to soon).

Science and mathematics, although traditionally treated as discrete intellectual entities, are not separated in the world outside of the elementary classroom. "Integrated instruction not only promotes the presentation of the subjects in a realistic and relevant context, but also provides opportunities for imaginative and personal connections between students and subject matter, which serve to further enhance understanding and motivation." (Eichinger, 2001, page 2)

### Science and Social Studies

Science and social studies are the stepchildren of the daily schedule in most elementary schools. With the back-to-basics heavy skills focus, less and less time is being allotted to either subject in favor of more time for uninterrupted literacy blocks and extended math lessons. The practical reason for integrating science and social studies is clear. Since you won't have time to do both

individually every day, you'd be better off teaching them together in integrated units.

There are other reasons as well. Science process skills such as observing, classifying, collecting data, measuring, predicting, and inferring are also applicable to social studies. We use classification in history and geography almost as often as we use it in biology and physics. Identify these cross-curricular connections to students.

You will also recall that a number of benchmarks and standards in science address social studies concepts including history, geography, and civics. Within the Nature of Science benchmark, NRC states “progress in science and invention depends heavily on what else is happening in society, and history often depends on scientific and technological developments” and that “scientists can bring information, insights, and analytical skills to bear on matters of public concerns.” Within the Science Enterprise benchmark, they state that “No matter who does science and mathematics or invents things, or when or where they do it, the knowledge and technology that result can eventually become available to everyone in the world.” (page 17) Any of these science concepts could be used to address social studies ideas. For example, a unit on ecology could speak to life science, physical science, geography, and government.

As you might expect, there are standards in social studies as well. And from these standards, one could extract a list of big ideas; and the list follows.

1. Culture
2. Time, Continuity, and Change

3. People, Places, and Environments
  4. Independent Development and Identity
  5. Individuals, Groups, and Institutions
  6. Power, Authority, and Governance
  7. Production, Distribution, and Consumption
  8. Science, Technology, and Society
  9. Global Connections
  10. Civic Ideals and Practices
- [National Council of Social Studies *Curriculum Standards for Social Studies*]

Any number of these big ideas could be used to guide an interdisciplinary theme using science and social studies. Time, Continuity, and Change, for example, are evident in the lives of people of the world as well as in nature.

Integrated units and performance tasks are the primary strategies in which to teach science and social studies together. Connecting the skills and crossing the content areas with the big idea themes are two methods to plan for integrating science and social studies.

### **Cautions to be Considered**

#### **Are we really integrating?**

As has been discussed, there is a difference between simply “putting things together” from different subjects and true integration. Integration means to combine things in such a way that together they form a unified whole; the aim is to interweave subjects so that children’s understanding embraces several subjects as if they were one. (Howe, 2002) Integration is

the goal, but correlating and connecting are better than nothing; as long as it is understood that you are striving for something more.

Should we be integrating all the time?

“Students actual learning experiences can occur in totally integrated contexts, or in segregated subjects, or (more likely) in a great variety of possible mixes of both – as long as they result in the achievement by all students of the science literacy goals.” (Project 2061, 1993) The experts would probably agree that this statement could be made with any of the content areas in place of the science literacy goals and still be true. So why bother with integration? We’ve discussed some of the reasons and benefits in this report. But the implication has also been made that there are times in some subject areas when skills or content need to be taught alone and separate from other areas. For example, we discussed the benefits of science and reading integration. But there are some science concepts that need to be experienced in the lab to be learned, not read about. Additionally, there are times when science should probably be left out of the lesson. If a student doesn’t know how to add, data analysis as part of a science investigation seems pointless before the direct lesson on addition.

So we don’t want to integrate all the time; but when? Before you decide to plan or teach an integrated unit or lesson, you should address the following criteria identified by Howe (2002):

- **Does the lesson or unit meet important goals or objectives in both science and the other subject(s)?** It serves no purpose to include

unimportant facts or something far outside of the science curriculum just to have an integrated lesson.

- **Does the integrated lesson or unit do a better job than you could do in a single-subject lesson or unit? Does it lead to more understanding or a higher level of performance of a skill? If not, why are you doing it?**

## **Examples of Effective Integration**

Now that we've discussed the why-to's of cross-curricular integration in science, let's get to the how-to's. The following are specific examples of integrated tasks that can be used in your classrooms immediately (once you've collected the materials, of course).

### **Tool for Integration: Anticipation Guide**

The Anticipation Guide is an invaluable tool for teaching and learning in science and reading. When introducing or researching a science topic using expository texts, an anticipation guide provides a before and after reading check for both students and teachers. A sample anticipation guide for the text Pillbugs by Donna Schaffer is shown as appendices 1, but they all follow the same basic format and are easy to create using any book or chapter or article that you have as a resource.

1. The teacher selects the text that is applicable to his or her needs.
2. The teacher reads the text.
3. The teacher notes any interesting and/or important facts.
4. The teacher creates a list of a grade level appropriate number of statements, some of which are true and some of which are false from the text.
5. Using the format, the teacher creates an anticipation guide for students.
6. The teacher then distributes the guide to students BEFORE introducing the text.
7. Students use their prior knowledge and best guesses to identify the true and false statements, recording their answers in the BEFORE or ME column.
8. The teacher can facilitate a class discussion of the students' responses. Responses can be recorded and tallied for later reference (bringing in an additional math

component). Statements that are particularly intriguing to students may be highlighted.

9. Anticipation guides are collected and stored.
10. Students read the text.
11. Anticipation guides are redistributed.
12. Now students identify the true and false statements on the AFTER or AUTHOR side of the sheet. Students should either record on the sheet or discuss aloud the page numbers and/or text evidence to which they referred to come up with their answer.
13. If initial responses were recorded, they can now be compared to the post-reading response.

The use of the anticipation guide allows students to tap into their prior knowledge, which makes the reading more meaningful to them. It also encourages the use of text support to justify answers. It reinforces effective reading skills while building interest in and knowledge of science concepts. Intermediate students can even be instructed in the creation of their own anticipation guides.

#### Integrated Lesson Plans: Physical Science in a Bottle

We didn't really get into integration of science with special areas but these activities are excellent for doing just that. In Musical Bottles, the driving physical science concept is sound—its properties and definition. But students are also encouraged to play and create music. (See appendix 2) There are also potential connections to math (patterns present in the pitch of sound) and reading (The Magic School Bus Inside the

Haunted House is an excellent resource that assist with the whole musical instrument-science tie-in). In Mystery Bottles, the physical science concepts could be solutions, suspensions, and mixtures or density; depending on the sophistication of your audience. In teaching these concepts, students also explore areas of math and art. Assessments using language are also utilized.

#### Primary Performance Unit: Someone's in the Kitchen with MATTER

A performance task, by its very nature, is a cross curricular effort. In addition, they allow you to instruct and assess simultaneously. This makes them easy to use, but more challenging to create. The teacher's guide, student resource, and response booklets will be available to view during the presentation.

The first unit is a primary unit dealing with the concept of states of matter. The final challenge is for students to come up with a recipe for steam using what they've learned about how the addition and deletion of heat affect the state of matter in which water exists. The addition of the big book Kitchen Science adds reading to be informed to the list of integrated concepts involved. Other opportunities for reading for a variety of purposes are inherent.

#### Intermediate Performance Unit: Remains to be Seen

The second unit is an intermediate unit focusing on what fossils tell us about the earth's past. Through a simulation students do the work of a paleontologist. Again, a video segment is mentioned, but not necessary to the successful completion of this unit.

### Intermediate Performance Unit: The Great Cereal Box Giveaway

As was mentioned earlier in the paper, all the reasons that justify teaching science across the curriculum are true of the other content areas. In this unit, students use math and science process skills as well as knowledge of economics to solve the problem of how to best spend their money.

### Intermediate Performance Unit: How to Make a Sandwich and See the World

In the final unit, students use geography skills to enhance a recipe for their favorite sandwich. There's reading, social studies, writing to inform and writing to express personal ideas. There's even a little science – health and nutrition to be specific.

### **Cases from the Real World**

What should you expect when you teach science across the curriculum in your classroom? Don't ask me. But what follows are some real cases from real classes in real public schools in Maryland. These teachers and students were kind enough to let me into their world to interrupt their science instruction with some of my “zany” ideas.

### Emergent Themes

- Almost to the person, teachers were already unconsciously integrating science across the curriculum...they had to. On average, science was allotted only 90 minutes a week in the primary classes and about 150 minutes a week in the intermediate classes. The only problem as they saw it was that they weren't “doing” science well. They were reading about science topics in reading. They sometimes wrote about science in language arts. Discussions came up about

nature, animals, the ocean, chemical reactions, weather, and insects regularly. [I found it interesting that neither the students nor the teachers recognized that insects were, in fact, animals.] But when it came to science instruction, they relied (heavily) on what was provided to them by the school district which was largely literature based, rarely supported by provided materials, and always time consuming. So time consuming that science was often regulated to even less than the allotted time to make room in the schedule for the 2-½ hour uninterrupted literacy block and hour-long math block.

- Teachers were pleased with the resources that were provided them and found them both useful and relevant to multiple learning outcomes (in many subject areas) to which they were being held accountable.
- Materials were still a problem. The anticipation guides were easy to implement immediately because the school district had recently purchased classroom sets of trade books on all subject areas studied for all grade levels. Books were available. Non-consumable items such as the video for *Remains to be Seen*, and the big book *Kitchen Science* were a problem. The teachers did not have them and they were not able to get them from libraries or other sources. So they had to be flexible when their use was called for. This was easier for the veterans who are used to having to do this for many lessons. Consumable materials such as plastic baggies and food coloring were expenses that came from teachers' own pockets. This was viewed as a negative but teachers admitted that the same thing would be true if they were teaching science without integration. They also stated that the items selected for the activities were not too expensive.

- Teachers noted the interest level of the students was greatly increased by the connections to science. Students who didn't like to read or write were more likely to do so in response to the performance tasks.
- Teachers noted the critical response stance of students' reading responses was increased through the use of the anticipation guides, which forced more critical analysis of the reading text than simply assigning students pages.
- Although teachers on the whole said they would use these strategies themselves, they feared that they would not be able to fully integrate on their own. They could, at best, promise to connect science to other subject areas.

#### Implications for Future Practice

Teachers want to teach well. Teachers want to teach science well. Teachers recognize the need for integration in terms of economy of time and student interest in science. However, either their own lack of knowledge of strategies or their comfort level with science concepts themselves keep them from achieving true integration on their own. It is the responsibility of science educators to (1) create and disseminate useful and useable integration tools and; (2) train pre-service and in-service teachers to create their own tools. In doing so, we both increase pedagogical content knowledge and increase student proficiency in science and across the curriculum.

# Appendix

## ANTICIPATION GUIDE

### Pillbugs (by Donna Schaffer)

**Directions:** Read each sentence below. If you think the statement is correct, write true on the line under the word BEFORE. If you think the statement is incorrect, write false. Read the selection. Based on evidence from the text, decide if each statement is proven true or false. Record your response and the page number on which you found supporting information on the line under the word AFTER.

**BEFORE**

**AFTER**

\_\_\_\_\_ After a pillbug hatches, it is in the manca stage. \_\_\_\_\_

\_\_\_\_\_ Pillbugs got their name because they look like pills when they are rolled up. \_\_\_\_\_

\_\_\_\_\_ Pillbugs are insects so they are related to flies and moths. \_\_\_\_\_

\_\_\_\_\_ A male pillbug will lick the head of another pillbug to make sure it is a female. \_\_\_\_\_

\_\_\_\_\_ Pillbugs grow by shedding their exoskeleton. \_\_\_\_\_

\_\_\_\_\_ To raise pillbugs, all you need is some dirt. \_\_\_\_\_

## Appendix 2



### **Physical Science in a Bottle**

The following activities can be used easily to review and/or assess student conceptions of physical science concepts using recycled glass and plastic bottles, water, food coloring, funnels, and other materials.

#### Musical Bottles

Unifying Concept: Evidence, Models, and Explanation

Theme: Energy

Strand: Physical Science (Physics)

Grade: 2-5 (depends on focus)

MLOs:

- 5.3.14 identify things that vibrate and make **sounds** (i.e., musical instruments and voices). (MLO 5.4)
- 5.5.14 *explain that energy is needed to make objects vibrate.*
- 5.8.14 describe behaviors (i.e., **reflection, refraction** and absorption) and properties (i.e., **wave length, frequency, amplitude, velocity**) of different kinds of waves. (MLO 5.7)

Indicator: Students will recognize that the pitch of sound is dependent upon the quantity of matter being vibrated.

#### **Vocabulary**

sound	hear
vibration	loud
soft	high
low	instrument
music	pitch

#### **Materials**

5 glass bottles, filled to different heights with water, for each group of students; red, blue, green, yellow and orange food coloring; wall charts (2); glue; 6" x 8" paper strips for each student; student work page for each student; metal, wooden, or plastic dowels for each group; 1 toy xylophone for demonstration.

**E** Show the students a toy xylophone and ask them to describe it. They will  
**N** notice the colors, but keep trying until someone observes the size difference  
**G** in the metal plates. Play the xylophone to demonstrate high and low pitch.  
**A** Tell them that small objects vibrate fast and large objects vibrate slowly.  
**G** [Duration: 5-15 minutes]  
**E**

**E** Place the five bottles, each with a different level of water, on the tables in  
**X** front of students and ask the students if the bottles will make a sound if  
**P** they are hit with a dowel (if you don't have dowels, an unsharpened pencil  
**L** may be used). The students should say "yes." Allow students to explore  
**O** making sounds with their bottles.  
**R** [Duration: 15-30 minutes]  
**E**

**E** Show the graph and ask students to predict which bottle will make the  
**X** highest sound or pitch. (Review the word pitch from a previous lesson on  
**P** vibration.) Have the students record their predictions on the first wall  
**L** chart. Use markers or self-sticking dots on the graph.  
**A** Have several students demonstrate on the bottles by hitting them to cause  
**I** vibration. Help them to hear that the bottle with the most water in it (blue)  
**N** has the highest pitch. Be sure to point out that the more water, the higher  
the pitch. Record actual results on the second wall chart.  
Reread the text Sound by Lisa Trumbauer. Focus the reading on the  
sections that deal with pitch (highness or lowness of sound).

Discuss with students what they think causes pitch. Lead students to see that when matter is vibrated, the more matter there is, the higher the pitch will be. Demonstrate with rulers and rubber bands from the previous lesson if necessary. Connect this truth to the musical bottles. When we hit the bottles, what moved or vibrated? [water] Which bottle had the highest pitch? [blue] Why? [it had the most water]

**[Duration: 1 class session]**

**E** Now tell students that we are going to make music in a different way, by  
**L** blowing on the bottles to produce sound. Have students predict what they  
**A** think will happen this time in terms of the pitch of sound the bottles will  
**B** emit. If you wish to have a second set of prediction and actual wall charts,  
**O** make sure you have four prepared instead of two. After predictions are  
**R** made, challenge students to support their predictions with information  
**A** gleaned from the previous investigation. Allow students to blow on the  
**T** bottles to produce sound. [Make sure you demonstrate first because some  
**E** students will have difficulty producing sound by blowing.] Record the  
 actual results. Which bottle had the highest pitch when we blew on them?  
 [red] How can that be? Review the results of the first investigation, what  
 was vibrating, and which bottle had the highest pitch. Compare that to  
 the second investigation. What was being vibrated this time if it wasn't the  
 water? [air] Which bottle has the most air? [red, the one with the least  
 amount of water] Which bottle has the highest pitch when blowing on the  
 air? [red]  
 Read or show the video of [The Magic School Bus Inside the Haunted House](#)  
 by Joanna Cole. Afterwards, allow students to make their own "invented  
 instruments." Then, have them write about how their instrument makes  
 high and low sounds. [The answer should mention vibration and matter (or  
 some acceptable variation of the word matter). The excellent answer will  
 also use the words pitch, increase and decrease.]

**[Duration: 2 class sessions]**

**E** Play the song "Twinkle, Twinkle, Little Star" on the bottles by hitting  
**V** them with dowel. Show students the pattern of bottles that plays the  
**A** song. [G,G,O,O,R,R,O; R,R,O,O,Y,Y, G] Work with students to have  
**L** volunteers play the song. Then remind them of the pitch of the different  
**U** bottles and which colors you would hit for higher and lower notes.  
**A** Pass out the worksheets and have the children color the water in the  
**T** bottles to match the colors of the real bottles. Distribute the paper  
**E** strips. Challenge students to cut out the bottles and glue them in a  
 pattern strip for a simple song (example, "Happy Birthday" or "Row, Row,  
 Row Your Boat.") Sing or play the songs first and discuss the pitch of the  
 different notes. Then have the students work in pairs or in groups to create  
 the pattern.  
 Have students play the songs for the class for a self assessment. As students  
 listen to each other's renditions; encourage the use of vocabulary words for  
 feedback. [The first note you played was too low. You need to move closer  
 to blue.]

**[Duration: 1 class session]**

**Teacher Notes**

"Listen and Move" (an audio tape game)  
 is an excellent activity for use during your  
 sound unit. (correlates to PE)  
 Poetry is an excellent LA activity to connect  
 to sound.

**Resources**

[Sound](#) (Trumbauer)  
[The Magic School Bus Inside the  
 Haunted House](#) (Cole)

**Mystery Bottles**

Unifying Concept: Constancy, Change, and Measurement

Theme: Systems and Interactions

Strand: Physical Science (Chemistry)

Grade: Primary

MLOs:

- 4.3.4 create mixtures and separate them based on differences in properties.

Indicator: Students will describe a mixture as two or more objects which are combined but which still retain their own properties.

**Vocabulary**

dissolve	mixture
solute	solution
solvent	liquid
solid	matter

**Materials**

plastic bottles, vegetable oil, measuring cups, funnels, food coloring, water, pitchers, news-paper, paper towels

**E** Prepare a sample Mystery Bottle for each table. Keep the ingredients out of  
**N** sight. Allow students in turn to hold, shake, and talk about the bottles.  
**G** Ask children to make as many discoveries as they can about the bottles.  
**A** Ask questions like: What can you tell us about the bottles? What happens  
**G** when you shake it? What happens when you turn it upside down? Do you  
**E** think we could make one of these? How do you think we could do it?  
Make a list of the children's observations and discoveries.

**[Duration: 15 minutes]**

**E** Demonstrate how to make a Mystery Bottle. Then give students time to  
**X** make their own working in groups. If you have extra bottles, children can  
**P** make their own individual bottles to take home. It is not crucial for them  
**L** to follow the directions exactly. They can vary the steps and still have a  
**O** successful experience. Directions are as follows and should be posted on a  
**R** chart to encourage Reading to Perform a Task:  
**E**

1. Fill one measuring cup with 4 ounces (125 ml) of water.
2. Squeeze a few drops of one food color into the cup. [At this point in the demonstration, ask students to describe what is happening to the water and what they see.]
3. Pour the colored water into the bottle using one funnel. [Ask what is happening and what does the water look like now?]
4. Pour 4 ounces (125 ml) of oil in the other measuring cup.
5. Using a clean funnel, pour the oil into the bottle of colored water. [Ask children to describe what they see.]
6. Screw the top (tightly!) on the bottle.

After students have made their group or individual bottles, encourage them to experiment – turning their bottles upside down, on their sides, rolling them around, shaking them, etc.

**[Duration: 1 class session]**

**E** Using open-ended questions, lead a discussion that will promote discoveries  
**X** about how the liquids interact:  
**P** What happens when you shake the bottle? What if you let it settle for a  
**L** while? What happens if the bottle is on its side? What if you hold it upside  
**A** down?  
**I** From the discussion, come up with a list of key words that the children  
**N** used in their descriptions (such as water, oil, mix, pour, layer, etc.)  
Record these words on your Science Vocabulary poster or on chart paper.  
Be sure these words come from the students not the teacher or the textbook.  
Introduce the scientific vocabulary by reading/posting the following sentences:

*A mixture is made when two or more things are combined together.*

*The mixture formed by water and food coloring is called a solution.*

*Food coloring dissolved in the water.*

*Oil and water will not mix together into a solution.*

*When they are put together, oil will separate to the top and water will separate to the bottom.*

[Other vocabulary words listed like solvent and solute should be used in conversation/discussion but are not necessary for the students to know or remember.]

Compare the words the students used with the more scientific words. See if students can replace the underlined words with their own vocabulary and still have the sentences make sense.

Have students write two things they learned in a journal.

Create a classroom dictionary of "solution" words suggested by the students.

Write one word on a piece of construction paper or tagboard and allow students to illustrate that word. (It would be ideal to have as many words as you have students so that they can each illustrate one page.) When all of the pages are illustrated, alphabetize the words and bind the book. Give it an attractive cover and creative title. Encourage everyone to use these words in discussions about solutions

throughout the unit.  
Read Liquid Levels on pages 12 and 13 of Science Book of Water.

**[Duration: 5 class sessions]**

**E** Complete Activity A attached allowing students to draw a diagram of the  
**L** Mystery Bottles before and after exploration.  
**A** If you think your class is ready, begin to discuss why water and oil do  
**B** not mix. Read from a trade book or explain to students about DENSITY.  
**O** Liquids of different densities (like oil and water) do not mix. Density  
**R** means the mass of a substance per unit of volume. In this case, an equal  
**A** amount (volume) of oil, weighs less than the same amount of water.  
**T** Therefore, oil is less dense than water and will float on it.  
**E** Students may extend their understanding of sink and float by testing small  
items inside the Mystery Bottles to see if they sink or float in water and if  
they sink or float in oil.

**[Duration: 30 minutes]**

**E** Complete Activity B where students will use words from a word bank  
**V** in a cloze activity that describes what they learned about the Mystery  
**A** Bottles.

**[Duration: 30 minutes]**

**L**  
**U**  
**A**  
**T**  
**E**

**Teacher Notes**

Density is a concept that confuses students.  
Do not try to cover it too technically with  
students of this age group.

Other liquids with different densities that  
can be demonstrated to not mix include  
syrup, honey, dishwashing liquid, vinegar.

**Resources**

Science of Liquids