TRB^3

Elementary Science Teacher Resource Book

A PROFESSIONAL DEVELOPMENT RESOURCE
FOR TEACHING
CORE CURRICULUM

GRADE 6

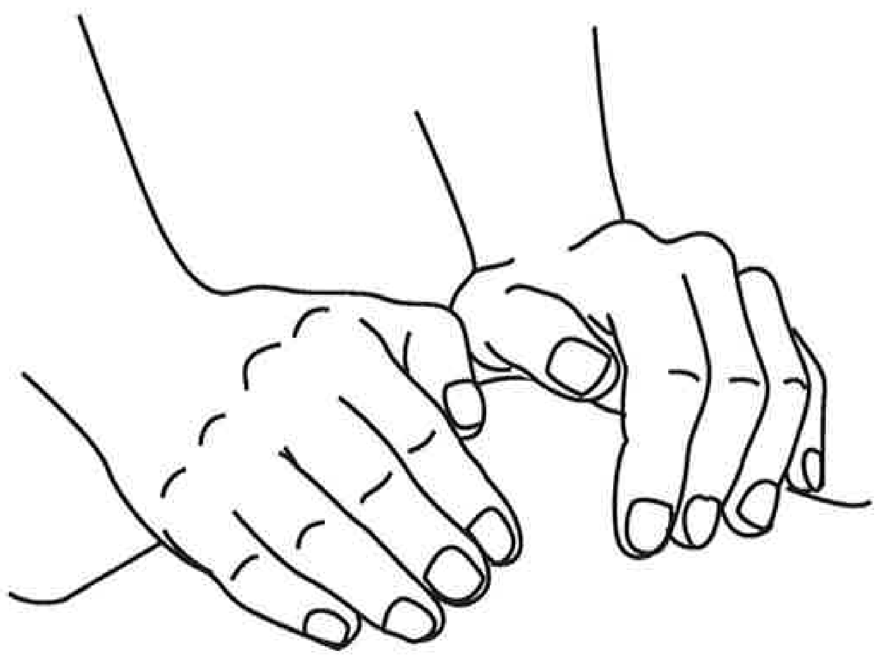
LITERACY -- STRATEGIES – ASSESSMENT

Utah State Office of Education

1. How to use the Teacher Resource Book

- **Student Reading**
- **Investigations**
- **Assessment**

Hands-On/Minds-On Science



How to use the Teacher Resource Book (TRB^{3})

The Teacher Resource Book (TRB^{3}) is designed to be your textbook in teaching science curriculum to your students. This book covers all the objectives of each standard and benchmark. If taught efficiently, a student should do well on the End-of-Level (CRT tests. The TRB^{3} is designed for teachers who know very little about science, as well as for teachers who have a broad understanding of science. Teachers who know very little about science can use this book each day to teach all objectives of each standard. Teachers who are well-acquainted with science can use this book to teach the core standards and objectives, but also can supplement the lessons by using many of their own materials. It is very important that the lessons presented from this book be taught to all students since much thought has gone into each benchmark, objective and lesson. Benchmarks are taken from the National Science Benchmarks Document and coordinate with National Science Standards.

This is the 3rd publication of the Teacher Resource Book for the State of Utah. It needed to be rewritten for several reasons: 1) New ideas and strategies have been developed and taught in summer Core Academy for teachers. 2) Since the last publication there have been many upgrades in technology, new approaches in effective teaching of inquiry processes and better ideas for presentations of science materials. 3) The first Teacher Resource Book used hands-on experimental inquiry processes. The TRB^{3} is designed to build reading and writing skills needed for science literacy, as well as experiential activities using assessment to guide and inform instruction.

Each science standard is divided into three parts to assist teachers in "smarter" teaching. (1) The first part includes student background information for teachers to use with students in shared or guided reading groups. In shared reading groups, the teacher or student can read the background information aloud and explain it to the students as she/he reads. In guided reading groups, the students can read the information aloud. The teacher can listen and reinforce, or question learning concepts. In both ways, students receive the technical reading instruction they need for understanding the benchmarks and concepts of science. 2) The second part is composed of activities that teach objective so students will understand science concepts of each standard.

3) The third part gives assessments for teachers to use for pre and post testing of each standard, or to retest students who need additional time on a particular standard. Test items include multiple choice, performance assessments and other short essay questions. Rubrics are included.

What does it mean to have a standards-based curriculum in science?

"Piecemeal changes are unlikely to lead to significant and lasting curriculum reform. What is needed is a coordinated K-12 plan that guides the curriculum-building process."

American Association for the Advancement of Science, Project 2061, 1993, p. 381

Research and Best Practice

Standards are goals specifying what students should know and be able to do at certain milestones in their education. A standards-based curriculum specifies how students and teachers will meet those goals – the specific concepts, and order, and sometimes the instructional materials to be used. Voluntary national standards for science education were developed by the National Research Council, on behalf of the National Science Teachers Association and several other organizations, and the American Association for the Advancement of Science's Project 1061. The National Science Education Standards (1996) and the Benchmarks for Science Literacy (1993) were their respective publications. Both documents define what students should know and be able to do to ensure high school graduates become scientifically literate adults. Another national project, The New Standards Project's Performance Standards for Elementary, Middle, and High School, defines performance standards that specify "how good is good enough," and how students can demonstrate their understanding.

National standards were developed through extensive consensus-building processes involving teachers, school administrators, science education researchers, and scientists. National standards do not, however, prescribe a single approach to teaching science. Local schools determine the way the science content is organized, emphasized, and taught. As of 2000, 49 states had or were adopting state standards, guides, or frameworks for science education, and most had begun to align these expectations with statewide student assessments. Some of these documents are very specific, offering learning goals for each grade or course; others are more general, with milestones for spans such as K-3, 4-6, 7-8, and graduation. The degree of alignment between standards and tests is currently being assessed on criteria such as concurrence of content, depth, and breadth of knowledge required, and balance of representation and emphasis.

The translation of standards into classroom activities is a complex under-taking, requiring content to be taught in increasing levels of complexity from kindergarten to grade 12, and yielding a complete program covering all standards. The curricula often exemplify the criticism leveled against American curriculum by TIMSS research. This curriculum study assessed the U.S. science curriculum as being "a mile wide and an inch deep" in comparison to other countries where students performed well on achievement tests yet studies far fewer topics.

Kreuger, Alice & Sutton, John, eds. (2001). EdThoughts; What We Know About Science Teaching and Learning. Aurora, CO: McREL. Used by permission of McREL>

Classroom Implications

Teachers provide the interface between standards and standards and students, by designing learning experiences, selecting instructional materials, and assessing student progress. Not only must teachers make long-term plans to "cover" all the standards, but they are also responsible for creating daily lessons that develop student understanding while accommodating diverse needs. The teacher does not do this in isolation, for what students have learned in the previous years and what preparation they need for future classes must also be taken into consideration.

Some strategies for addressing standards include these changing emphases taken from the *National Science Education Standards:*

Less Emphasis On:	More Emphasis On:
Knowing scientific facts and information	Understanding scientific concepts and developing abilities of inquiry
Studying subject matter disciplines (physical, life, earth disciplines in the context of sciences) for their own sake	Learning subject matter
	inquiry, technology, science in personal and social perspectives, and history and nature of science.
Separating science knowledge and science process	Integrating all aspects of science content
Covering many science topics	Studying a few fundamental science concepts
Implementing inquiry as a set of processes	Implementing inquiry as instructional strategies, abilities, and ideas to be learned.

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How do we determine what students should know and be able to do in science?

In a standards-based curriculum, teachers design learning experiences to enable all their students to reach the level of understanding or skill described by applicable standards.

Research and Best Practice

What knowledge and skills should a scientifically literate high school graduate have? Scientists, teachers, and education researchers answered this question, and received reactions and comments from thousands of their colleagues during the production of the *National Science Education Standards (NSES)* and the *Benchmarks for Science Literacy*. Both documents recommend essentially the same content and principles. The *NSES* organizes science content into seven areas: Scientific Inquiry, Life Science, Physical Science, Earth and Space Science, Science and Technology, Science and Personal and Social Perspectives, History and Nature of Science, and Unifying Concepts and Processes. This organization is based on a combination of factors – including cognitive development theory, the classroom experience of teachers, and the organization of schools – and is not necessarily a recommendation of how the curriculum that is delivered to students should be organized.

National standards describe what all students should achieve by the time they reach three or four milestones between kindergarten and 12th grade. These examples from the NSES illustrate the milestones for the development of a life science concept:

> **Grades K-4:** All animals depend on plants. Some animals eat plants for food. Other animals eat animals that eat the plants. (p. 129)
> **Grades 5-8:** For ecosystems, the major source of energy is sunlight. Energy entering ecosystems as sunlight is transferred by producers into chemical energy through photosynthesis. That energy then passes from organism to organism in food webs. (p. 158)
> **Grades 9-12:** Energy flows through ecosystems in one direction, from photosynthetic organisms to herbivores, to carnivores and decomposers. (p.186)

States and districts, influenced by national standards, define their own specific and measurable standards to guide instructional materials selection, test designs, teacher accountability measures, and graduation requirements. For example, the *Texas Essential Knowledge and Skills*, grade 6, concept 6.8, requires that:

> *He student knows that complex interactions occur between matter and energy. The student is expected to: (A) define matter and energy; (B) explain and illustrate the interactions between matter and energy in the water cycle and in the decay of biomass such as in a compost bin; and (C) describe energy flow in Living systems including food chains and food webs."*

Classroom Implications

In a standards-based curriculum, teachers design learning experiences to enable all their students to reach the level of understanding or skill described by applicable standards. Given the diverse backgrounds and interests of students in any classroom, teachers are challenged to present the content in an engaging and accessible manner and to make frequent assessments of the student's understanding.

In designing optimal learning experiences, especially given the amount of material to be covered in a relatively short amount of time, teachers should strive to use problems or questions that integrate several standards, provide opportunities for student investigation and provide assessment opportunities that do not interrupt the learning process.

Studying standards for student achievement is a critical element in the education of teachers, integrating the need for a solid understanding of science content with experience in an array of instructional strategies specific to science education. Ongoing professional development in both content and pedagogy is best done in connection with the classroom practice and in collaboration with other teachers. In this way, teachers can practice how to determine what a student knows – using actual student work and interviews – and share ideas on providing instruction that will enable students to achieve the standards. Scientists can often be of help in providing content-rich professional development and giving updates on new information and applications.

Research on how children learn has brought to light common misconceptions in several science content areas. These incomplete or incorrect understandings make sense to children and can be difficult to overcome and replace with a scientifically correct explanation. Telling or showing rarely changes the student's misconception. The best solution is an interaction between the student and a phenomenon or experimental result that directly challenges inaccurate thinking. A classroom environment in which students explain their thinking and are challenged to provide evidence for their explanations also helps produce sound conclusions.

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What is the importance of reading and writing in the science curriculum?

Many of the process skills needed for science inquiry are similar to reading skills, and when taught together reinforce each other.

Research and Best Practice

Reading, writing, and science are, or should be, inseparable. Many of the process skills needed for science inquiry are similar to reading skills, and when taught together reinforce each other. Examples of skills in common are predicting, inferring, communicating, comparing and contrasting, and recognizing cause and effect relationships. In language as well as science learning, students analyze, interpret and communicate ideas. These are skills needed to evaluate sources of information and the validity of the information itself, a key factor for scientifically literate citizens. *Becoming a Nation of Readers* suggests that the most logical place for instruction in most reading and thinking strategies is in the content areas rather than in separate lessons about reading.

Student's comprehension of text improves when they have had hands-on experiences with a science concept. Prior knowledge, which is developed and enhanced through science inquiries, is the strongest predictor of student ability to make inferences from text. In a four-year study of elementary students who participated in an active, inquiry-based science program, a direct correlation was shown between higher language test scores and years of participation in the science program.

Writing skills are important to science learning. Students must organize and communicate their observations and data, argue logically, and structure coherent conclusions. Science journals and reports are natural vehicles for increasing writing competence.

Science content has been found to be particularly effective for engaging language learners. Inquiry-based science instruction has been shown to increase vocabulary, not only that directly related to the science content but fluency as measured on standard language tests. One study showed up to four months language growth as a result of a five-week summer elementary science academy. Success serves as a motivator, too, stimulating reading, writing, and oral communication to pursue science inquiry in greater depth.

Classroom Implications

Motivating and engaging students to speak, ask questions, learn new vocabulary, and write down their thoughts comes easily when they are curious, exploring and engaged in science inquiry. Integrating literacy activities within the teaching of science helps clarify content concepts and can make science more meaningful and interesting to the student. Teachers can use a wide variety of literature, including trade books, texts and fiction. Non-fiction trade books often cover a topic in great detail and use extensive illustrations. Fiction works successfully with young learners by embedding cognitive learning in imaginative stories. The National Science Teachers Association provides annual lists of outstanding new literature and multimedia materials, and teacher guides for science instructional materials often provide lists of relevant books.

Asking students to record data and conclusions in a science journal or to articulate and defend their views about science-related issues provides excellent opportunities for students to clarify their thinking and develop communication skills. Other examples of integrating writing in the science class are recording and describing observations, developing class books on science topics, creative writing on a science topic, or writing persuasive letters on an environmental issue. In middle and high schools, teachers can plan lessons and discuss progress in multidisciplinary teams in order to meet curriculum goals in science and language (as well as mathematics and social science).

For language learners, instruction in science can be enhanced by the use of hands-on materials. Interacting with materials and phenomena enables language learners to ask and answer questions of the materials themselves and use the materials as visual aids in conversation with the teacher and peers. Visual and auditory clues should be plentiful-charts with pictures of materials and key procedures, for example. Teachers should select vocabulary carefully, repeat key words often, refer to charts with the written words, and avoid the use of synonyms. Work in pairs or small groups makes native language support by peers or instructional aides more feasible.

For all students, science teachers can help students increase their comprehension of science texts by activating their prior knowledge through brainstorming, discussion get a topic, asking questions, and providing analogies. Specific attention to vocabulary is often necessary to enable comprehension of science texts. Teachers should introduce new vocabulary and use a graphic organizer, concept or semantic map, or collaborative peer study techniques to develop understanding of new words.

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What are the most important considerations in selecting instructional materials?

Given the relationship of the quality of instructional materials to student achievement, it is important to pay sufficient attention to the selection of quality of materials.

Research and Best Practice

Instructional materials for K-12 school science include textbooks, laboratory manuals, kits, software, CDs, trade books and other multi-media materials. They are a primary source of classroom science learning and also play a profound role in the education of teachers, since professional development is often structured around these materials. The process used to select science materials is critical to providing students and teachers with a solid foundation for improving achievement.

Key steps in the process of selecting instructional materials for science education are: establishing a review/selection committee; determining selection criteria; selecting an evaluation instrument; and evaluating and selecting materials. The process may be done at the district, school, department, or even the classroom level. Most decisions must be ratified by an administrator or school board. Many states review materials and restrict districts and schools to choosing among approved materials.

In a school or district with science standards in place, the most important selection criterion is that the instructional materials develop the student understanding called for in the standards. Quality instructional materials will enhance student understanding; promote students' active involvement; have high expectations for all students, with guidance for teaching diverse learners; incorporate scientific inquiry; use an appropriate learning sequence; include assessment instruments and methods; and reflect current research in science education. Reviewers familiar with the discipline and the standards must carefully study both content and instruction. When standards exist, the relevant content must be present or the materials should not be used.

Given the relationship of quality of instructional materials to student achievement, it is important to pay sufficient attention to the selection to quality materials. The capacity to recognize high-quality materials can be developed through professional development in science content, research-based teaching methods, and learning theory. Sufficient time and resources should be provided for the selection process. Professional development specific to the instructional materials is needed for optimal use and often takes as long as three years for teachers to master. Finally, the process and the selections themselves should be evaluated. Data from evaluating the entire selection process can improve the next cycle.

Classroom Implications

Since many teachers base this lesson plan on the materials provided, the science content of the materials should match curriculum standards. The more closely instructional materials adhere to the goals of state and national standards, the more likely students are to succeed in achieving those goals. It is also important to check the content of the materials for accuracy, asking scientists to assist in this review if possible.

The organization of science materials and programs should include cohesive units, multi-day lessons, and tasks that allow students time to explore and investigate in-depth science ideas. Materials should develop understanding and abilities in science inquiry, and should emphasize connections within and among curriculum areas such as language arts, mathematics, history, or art. Suggestions for enriched or advanced work are helpful.

Materials should give students opportunities to be active learners through an investigative, problem-solving approach that engages them in the use of the science process skills. Materials should ask students to communicate orally and in writing, both with one another and with the teacher. Technology and manipulatives should help students explore scientific ideas, analyze and interpret data, calculate numerical results, and solve problems. Students should reflect on and evaluate their work.

Instructional materials should provide suggestions for scientific investigations. The suggestions should elicit, engage, and challenge students' thinking, and suggest a variety of methods that give all students an opportunity to learn. In-depth content resources can update or enhance the teacher's understanding.

Student assessment should be integrated into the instructional program, using activities similar to learning activities. The materials should use multiple means of assessment, and suggest ways to assess students individually or in small groups – through observations, oral and written work, student demonstrations or presentations, and student self-assessment. Conceptual understandings and procedural knowledge should be frequently assessed through tasks that ask students to apply information about a given concept in novel situations.

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