Chapter 2: Background on Hands-on Science

In this chapter we provide background information on hands-on science that will help shape our analysis. Specifically, we provide the definition of hands-on science, a typology of the instructional approaches used with it, and a history of its promotion including the current policy debate over its role in science education.

We define hands-on science noting that it does not represent a completely new idea in the literature but broadens the meaning from past terms such as “lab”, to encompass a wider range of settings from the lab to the classroom, or “experiment”, to include a wider variety of activities that may not be actual experiments, such as observing or measuring.

We offer a typology of the instructional approaches that can be used with hands-on science. These approaches fall along a continuum based on teacher and student roles. That there are many approaches increases the complexity of linking hands-on science and student achievement.

A history of the promotion hands-on science shows that we are currently in the midst of a time of debate over its use due to a recent historical trend supporting its use and new initiatives, some of which continue this support while others are attempting to temper that support. From a policy perspective, this makes it a good time to consider the issue as to whether there is empirical evidence supporting either the current rise in support or the reconsideration of its use.
**Definition**

Traditionally, the terms “laboratory” or “experiment” have been used to describe practical work done by students during science class in place of such other methods of instruction as lecture, reading, recitation, worksheets, teacher demonstration and more recently, computer simulation. These two terms are somewhat limiting for two reasons. First, many students, especially in primary and middle school, do not have access to a laboratory but perform hands-on science activities in their regular classroom. Second, students may carry out hands-on activities that are not actual experiments, for example observation and measurement\(^2\). The term “hands-on science” includes all such hands-on activities carried out by students be they experiments or not and be they done in the classroom or in a laboratory. The term captures a broader array of student activities we want to investigate and avoids some of the limitations created by the narrow definitions of traditional terms. The term defines a specific method of instruction, based on activities carried out by students, but its use does not preclude other instructional methods for it is often used in conjunction with them. But as class time is limited, the greater the use of hands-on science the less time is available for other methods.

**Instructional Approaches for Hands-on Science**

Different instructional approaches can be used with hands-on science. Which approach is considered most appropriate has varied over time. And even when one approach dominates, teachers will use the others as well in their classrooms. This

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\(^2\) Science modules containing both lesson plans and the hands-on materials to be used by students became available beginning in the 1960s, see more details in the history section, contributing to the use of a broader term “hands-on science.” They include many non-experimental activities and have made it easier for teachers to implement hands-on science within a regular classroom.
variation in primacy among and combination of the approaches adds another facet in considering the relationship of hands-on science to student achievement. Here we describe the major instructional approaches for hands-on science, which include: verification/demonstration, discovery, exploration, inquiry, and process skills.

Overall hands-on science has primarily been used to verify or demonstrate a phenomenon in support of direct teaching. Usually the phenomenon is described first in lecture or by the textbook and the students then carry out a well-specified (by the teacher or lab manual) activity that allows them to see the phenomenon or some aspect of it. The other instructional approaches to using hands-on science recognize the usefulness of verification in making an abstract concept concrete and consider it a complementary approach. The verification approach has been criticized on two counts. Its overuse may waste time on repetitive actions. Its recipe manner allows students to only follow directions and watch the results without having to use their own abilities to understand what should happen, how to do it, and what it means (NEA 1920, AAAS 1997).

The discovery approach, in contrast to verification, provides students with materials to work with but little direct guidance on what to do or what is expected to be found. Discovery has two goals. First, it is expected that students will discover phenomena on their own and will understand and remember them better by doing so than if they were shown. Second, the act of discovery will convey how science is carried out in practice (Bruner 1960). Discovery has received both practical and theoretical criticism. In practice, discovery proved too difficult for students to implement on their own. The need for increased guidance by teachers led to a name change in the approach to “guided discovery” (Hodson 1996). Additionally, its applications are limited in that
some concepts cannot be discovered by students in school settings (e.g. the atomic theory of matter). Discovery has also been criticized from a philosophy of science perspective in giving a false view of science as using only inductive thinking (Hodson 1996).

The exploratory approach to hands-on science may appear similar to the discovery but is actually more closely linked to the verification. Students are first given materials to handle with little guidance or expectations. The goal is to make them comfortable with the topic, stimulate their interest, and encourage them to raise questions. Following the exploration phase, they receive direct instruction in the topic. Unlike discovery, there is no expectation that the students will discover the underlying concepts, though they may identify issues and questions that can be addressed during direct instruction.

The inquiry approach, like discovery, also contains the two goals of learning specific concepts as well as developing the capacity to carry out inquiries on one’s own. The later goal involves teaching the student the set of thinking and doing skills plus their overall use in problem solving while addressing a specific topic, often of student choice to increase student interest. The teacher’s role is to provide support and guidance especially through questioning rather than leadership though this fluctuates with the ability of the students. Inquiry differs from discovery in that it recognizes the use of both inductive and deductive methods. It differs from the process skills approach (described below) by its attempt to teach an overall method that incorporates process skills rather than addressing them separately. Students do not have to discover all knowledge on their own. Hands-on science is just one technique that can be used in inquiry. Unlike the verification approach, inquiry hands-on science activities are not recipe in nature, the
outcome is not to be known ahead of time, and the student is to have an active role in designing, carrying them out and interpreting the results. In practice, inquiry is a difficult and time-consuming approach which demands great skill and knowledge from the teacher and is difficult to package in a standardized curriculum.

     The process skills approach attempts to teach individual processes used in science without regard to any specific science topic or discipline. Hands-on science is the primary technique used in teaching those processes that require hands-on activity, e.g. measurement. The process skills approach came under attack in later years based on arguments that content was non-excludable from process because of the need for content in problem solving, because of the difficulties in transferring process skills from one context to another, and because students did not appear able to assemble the individually taught skills into an overall ability to problem-solve (Champagne, Klopfer, Gunstone 1982; Hodson 1996). Teaching process skills remains a goal of science education and they continue to be taught both separately and in conjunction with content matter. A recent thread in this approach is the proposal to teach the history and philosophy of science as a way of instructing students in the overall process used by scientists and to show that the processes used may vary by the type of field and scientist (Matthews 1994).

     In sum, there are different instructional approaches to using hands-on science and a teacher may use any combination of them over the course of the year. Historically, the emphasis on each has varied. Today, inquiry is the primary approach proposed but we continue to find the other approaches in use both in the classroom and in the new curricula aligned with the current efforts at science education reform (see History section
below). In Chapter 3 we further discuss how the variation in instructional approaches affects the research on the relationship of hands-on science to student achievement.

**History of the Promotion of Hands-on Science**

We are currently in the midst of a time of rising support for the use of hands-on science as well as a time of reform in science education, a reform that is reconsidering of the role of hands-on science. It is an opportune moment to consider whether the assumption of the positive relationship of hands-on science to student achievement holds and should continue to be given great weight as reform occurs.

The level of promotion of hands-on science has swung widely over time due to varying causes. The arguments behind hands-on science cycle through different periods: past arguments are ignored then resurrected. Similarly, the instructional approaches to using hands-on science have varied in their acceptance. The debate over how to use hands-on science is often hidden by the issue of whether to use it, but swings within the former are just as wide as those of the latter. This section documents the historical changes in both the promotion of hands-on science and the instructional approaches to its use. This history focuses on attempts to promote the use of hands-on science and it is important to remember that throughout the period covered, commentators have noted the primacy of textbooks, lecture and recitation and the lack of hands-on science in the classroom (Deboer 1991).

The issue of hands-on science in the classroom is not a new one. The debate over it can be traced back to the struggle to introduce science into the primary and secondary curriculum that took place during 1800s. At the beginning of the 19th century, primary
school (which then included grades 1-8) focused on reading, writing and arithmetic and secondary school focused on Greek and Latin. Supporters of this classical curriculum argued that generalized mental exercises (such as memorizing words or doing proofs) increased mental capacity while providing a humanistic and refined education.

Proponents of science in the curriculum tried to both expand upon and supplant this reasoning with three arguments. First, learning science was argued to be a better form of mental exercise for it required a wider range of mental abilities to not only memorize facts but to organize them into generalizations and use them in inductive thinking. Second, at this time there developed a new view of learning which saw it as a process by which neural connections were built and strengthened by organizing sense perceptions and building generalizations from them. To succeed, learners had to receive information in an organized manner plus have it repeated in different contexts and combinations. Successful education then required both effort and organization, and science education would provide a means for this organization. Third, science education was proposed as useful in everyday life. On one hand, it would provide information directly relevant to the student’s life and work, such as information on maintaining good health or increasing crop production. In addition, it would provide a system of thought, using inquiry to discover facts, that the student would use throughout their life independent of a teacher. These arguments proved successful and by the end of the 19th century the question switched from whether or not to include science in the curriculum to how much science and which disciplines to include (Deboer 1991).

The proponents of science education considered the science laboratory central to their view of education in contrast to the predominant use of memorization and recitation...
from textbooks. Almost all the arguments used today in support of student hands-on science were first offered in the 1800s. These arguments touched upon children’s abilities, improved understanding, skills and long-term learning. Young children were thought to easily accumulate facts and the simple relationships between them through sense impressions. Students would better understand the meaning of written words through definite images of the phenomena. Reasoning and learning skills, such as making inferences and judgements and verifying them, would be learned through observation and experiment. Through such student investigations, personal understanding would occur rather than only memorization, the material would be retained longer, and students would become independent learners. (Huxley 1899, Spencer 1864, Youmans 1867). Formalized approaches to using hands-on science followed, for example the techniques of Johann Pestalozzi, which focussed on the study of natural objects, and those of Johann Herbart, which included a first step of pupil experience with the natural world (Deboer 1991).

While the proponents of science education in the 19th century agreed on the centrality of the science laboratory they did not agree on how hands-on science should be used. Rather they formed two continuums over its use and these remain today. The first continuum considers the instructional approach for using hands-on science and was clearly set out by Smith & Hall in 1902 though additions were made over time. At one end is an instructional approach called discovery in which through laboratory activities students would discover both facts and concepts individually and independently of the teacher so as to become independent learners. At the other end is the teacher or lab manual-directed use of hands-on science to verify principles, to illustrate them and make
them more vivid in the minds of students. In between are two other approaches. Under the exploratory approach, students first explore a topic through hands-on activities then return to teacher directed instruction. Second, through an inquiry approach students answer questions by generating their own investigations with the assistance of the teacher who guides them through questioning.

The second continuum concerns the goals of science education: what type of science knowledge is to be taught and, as a result, what uses can it be put to. At one end is science as a structured body of knowledge, logically organized and primarily concerned with facts and the underlying principles and theories. The goal is to give the student a firm grounding in the basics of science. At the other end is a very applied education linking science either with meeting individual needs (e.g., understanding proper nutrition or providing employment-related technical applications) or addressing societal issues, such as pollution. The applied approach is also concerned with practicality as a way of increasing student interest in science by making it relevant to daily life. In between is the goal of teaching students how to use the skills and techniques of science as an investigative process. These skills can help a student contribute to the body of scientific knowledge and form a tool the student can use in daily life, be it for personal decisions, at work or in an attempt to solve societal problems.

While there was not full agreement along either continuum, early proponents of science education proposed that students spend much of their time in the laboratory. For example, in 1892 a committee of ten college and school leaders was appointed by the National Educational Association to determine college entrance requirements including the best method of instruction in both high school and college. The committee
established conferences in each subject area. The Conference on Physics, Chemistry and Astronomy determined that the majority of elementary school science should be done through experiments and that 50% of the work done in high school should be carried out in the lab. The Conference on Natural History determined that 60% of the time should be in the laboratory and the entire course should focus on the observations made in the lab (Deboer 1991). Not all science proponents supported the idea that science education should take place primarily in the lab. For example, Edwin Hall (Smith & Hall 1902) while a firm supporter of teaching through the laboratory, argued that it contained too many flaws to be used alone. He saw learning occurring too slowly in the lab and students focusing on the mechanical part of the experiments while ignoring the hard thinking that had to be done to understand the point of them. For him, the laboratory was only one technique that should be combined with lectures, recitation, demonstrations and numerical problem solving.

The rise of progressive education (1920s – 1950s) led to a shift in important ways along the second continuum and a decline in the importance of the laboratory. The goal of developing an individual’s intellectual skills shifted to the goal of developing individuals who would contribute to society. Science was to have direct consequences for everyday life (NEA 1920). The switch to a focus on applications to everyday life was also based on changing instruction to meet student interests to increase student motivation and to connect new knowledge to what the student already knew. Previously, everyday applications had been considered useful for increasing student motivation to learn and illustrating concepts but now they became the focus of science education.
The change in focus affected science education in several ways. Teaching through themes, problem solving and technical applications was promoted with less attention to basic principles. The idea was to organize the material in a way interesting and understandable to the student rather than as the discipline organized it. During this period, the general science course was created in part to provide wide exposure to students who were not completing high school, in part as a way to try to attract more students to specialized courses, and also as a way to implement the new approach to teaching. The disciplines, represented by subject oriented courses such as biology or chemistry, were resistant to change and proponents of the new approach saw the general science course as a way around them. In addition, this period saw the creation of the junior high school and general science courses were extended into 7th and 8th grades (Deboer 1991).3

While the new approach also favored direct experience with natural phenomena, the laboratory no longer retained the central role in instruction. Instead, it became one of a number of techniques along with demonstration, lecture, field trips, projects and problems. Laboratory activities were criticized as time wasting, repetitive work and time could be better spent on developing ideas or posing problems or questions that students would be interested in answering (National Society for the Study of Education 1932). Teacher demonstrations were promoted as a more effective method for providing real world examples (Black 1930; Carpenter 1925) and were adopted by school

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3 One further development during this period that would affect the use of hands-on science was the introduction of the standardized test. Welcomed in part for its ability to differentiate students and its expected ability to determine best teaching methods (such as teacher demonstration versus student lab), a major effect was to focus attention on content mastery which was easier to measure. From that time to today, proponents of hands-on science have argued that such content-oriented tests fail to measure the benefits of hands-on science for student understanding of concepts and their application.
administrations seeking to reduce expenditures. As a result, the use of student labs declined over this period (NSSE 1932).

After World War II, a combination of declining enrollments in secondary science courses plus the competition with the Soviet Union led to a bifurcation of efforts. Greater emphasis was placed on programs to attract talented students into the field of science through discipline oriented courses (PSRD 1947; U.S. Office of Education 1953). At the same time, there were further efforts to revise science education toward the more applied coursework for the majority of students in both secondary school and college who were not expected to work in any scientific field. The latter revisions attempted to also include the discipline oriented courses, mainly chemistry and physics, in secondary school to make the courses more relevant to life situations (NSSE 1947). Additionally, new general science courses were created with such titles as “Consumer Science”, “Fused Physical Science”, and “Survey Science” (NSSE 1947). A series of courses known as “Life Adjustment Education” was developed for the purpose of replacing traditional subjects such as science and English with courses on life skills (U.S. Office of Education 1951).

The reduced or non-academic focus of the applied and life skills courses led to criticisms and a renewed involvement of scientists in the development of science courses. For example, in 1956 a group of scientists at MIT formed the Physical Science Study Committee (PSSC) under a small NSF grant and began to develop a high school science course (Deboer 1991). The launching of Sputnik by the Soviet Union led to a major federal role in the development of new science courses. Under the 1957 National Defense Education Act, about $700 million dollars was provided to improve science
education from 1958-1975. NSF was made the lead agency and it turned to scientists at universities or professional societies for the development of new science courses (Matthews 1994).

A host of new curriculum was developed over this period. In physics, the PSSC published its text and lab manual in 1960, today it is in its 7th edition, and later developed a junior high course called Introductory Physical Science published in 1967. In biology, the American Institute of Biological Sciences organized the Biological Sciences Curriculum Study (BSCS) which published a series of texts in the mid-1960s and continues to operate today. In chemistry, the American Chemical Society developed two courses: 1) the Chemical Bond Approach, and 2) CHEM study aimed at a wider range of students. For earth science, the American Geological Institute established the Earth Science Curriculum Project, published in 1967, and Princeton University’s Secondary School Science Project published Time, Space and Matter in 1966 aimed at 9th grade. Three curricula were also developed for elementary school: 1) Science – A Process Approach (SAPA) was developed under the American Association for the Advancement of Science in 1967, 2) Elementary Science Study was developed by the Educational Development Center in 1969, and 3) Science Curriculum Improvement Study published in 1970 and continued today by the Lawrence Hall of Science at the University of California at Berkeley.

In reaction to past curricula, these new curricula contained much fewer technical applications and many were discipline structured. All included a large student hands-on science component. The physics, biology and chemistry curriculums all contained separate lab manuals. The earth science and elementary curriculums were centered
around student activities. In some cases, the curriculums came with the materials necessary for the activities thereby addressing the lack of a lab or materials in a school.

These materials did have a widespread effect (though not an overwhelming one) on science education. A 1977 survey of school districts found that about 50% were using new biology materials and less than a quarter were using the new physics and chemistry materials. Overall, about 60% of districts were using one or more of the new curricula for students in grades 7-12 and about one-third of the districts were using new elementary curricula (Weiss 1978).

There was no common instructional approach to how hands-on science was to be done in these new curricula. The same differences in approaches identified at the turn of the century were apparent. The Chem Study course lab program and the Elementary Science Study were based on the discovery approach (Merrill & Ridgeway 1969). Jerome Bruner, chairing a 1959 NAS conference on new developments in science and math teaching, had given his support to the discovery approach seeing it as a way to learn the discipline the same way scientists learned it (Bruner 1960). The BSCS was geared to the inquiry approach in part because of Joseph Schwab who played a major role in its development and argued that scientific knowledge changed over time through inquiry and students would better view science in this way if they practiced inquiry as well (Schwab 1962). SAPA was a wholly process oriented curriculum which focused on techniques used in science (e.g. observation, measurement) rather than any specific discipline or facts. SCIS was based on a technique known as the learning cycle which began with the exploratory use of hands-on science to raise student questions leading to direct teaching.
of the concepts students had experienced and ending with student application of the concepts to other situations (Karpus 1977).

The new curricula also did not solve the disagreement over how much time should be spent on hands-on activities. Shulman and Tamir (1973) list the many different opinions voiced on this topic and note that proposals ranged from half of class time to not very often.

The new curricula represented a greater federal role in science education increasing the importance of the issue of hands-on science as a national public policy issue. While much of the previous debate and action over hands-on science had occurred within the education community and at the state, district and school level, the federal government now had taken a major role in supporting the development and promotion of curricula containing a significant hands-on component for national use.

By the mid-1970s there was a turn away from these nationally supported curricula. In part politically-motivated, in part based on the failure to increase enrollment in science courses (Deboer 1991), and in part with the realization that developing curricula does not ensure they are correctly implemented especially if logistical support and adequate training of teachers are not also provided (Arons 1983). In response to the discipline-orientation of many of the curricula, there was a resurgence toward making science relevant to students’ lives and focusing on socially-relevant issues such as the environment. A scientific literate student who could use science concepts, process skills, understood that value judgements were made in science and understood the links between science, technology and society was proposed as the goal of science education. Students should be able to understand the daily world and have the tools to learn more (NSTA
1971, Hurd 1970). One branch of the science literacy approach, known as Science-
Technology-Society, called for the organization of the science curriculum around social
issues (Hofstein & Yager 1982).

The scientific literacy approach become embodied in two national efforts to reform science education both supported by the federal government. These efforts included the further step of addressing what content should be taught and how to teach it.

In 1985, the American Association for the Advancement of Science began a long-
term effort known as Project 2061 to turn U.S. education toward a scientific literacy
approach. For AAAS, scientific literacy encompasses: important scientific facts,
concepts, theories, scientific habits of mind, the nature of science, connections to math
and technology, the impact of science on individuals and its role in society (AAAS 1997).
In 1989, AAAS published Science for All Americans which set out its view of the
information a scientifically literate person should know and in 1993 it published
Benchmarks for Scientific Literacy which lists specific knowledge and skills to be
learned in sets of grades (e.g. k-2, 3-5, 6-8, 9-12) from kindergarten to high school in
order to create science literate students. Project 2061 promotes teaching through the
inquiry approach. Hands-on science is to make up a minority of the teaching methods
used and to be employed possibly no more than once a week (AAAS 1997 chapter 1B).
When used, hands-on science is to be geared primarily to the inquiry approach in order to
teach scientific inquiry (AAAS 1997 chapter 1B) with some additional use as a method to
provide concrete examples of phenomena (especially for younger students) and to
practice use of tools (especially for measurement) (AAAS 1989, chapters 12 & 13).

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4 During the 1980s, the middle school replaced the junior high in many parts of the country. Middle schools included grades 5-8 or 6-8 rather than the junior high school’s 7-8 or 7-9.
In a separate project, the National Research Council began developing its own set of science education standards for pre-college education in 1991 and in 1996 released the National Science Education Standards. Like the Benchmarks, these standards include topics to be covered within certain grade levels (K-4, 5-8, and 9-12) plus somewhat broader standards on teaching, professional development, program and system standards. Like the Benchmarks, the Standards promote scientific literacy and the use of hands-on science under an inquiry approach (NRC 1996, chapter 3).

Neither the NRC nor Project 2061 are involved in the actual development of curricula nor have they yet set out a clear practical approach to teaching through inquiry (including how to teach hands-on science) that can easily be implanted in a new curriculum. Project 2061 has moved further along this pathway and has begun to review science curricula, starting with commercial textbooks using a set of 23 criteria, one of which has a clear link to hands-on science5. Over the next several years, it is expected that the current reform efforts will refine and consolidate their approaches including the role of hands-on science and the suggested approaches for its use.

The late 1980s also saw the return of NSF as a major actor in the creation of new science curricula and promotion of their adoption. Going beyond its approach of the 1960s in which curricula focused on 1 or several grades, NSF supported the development of curricula that would encompass elementary through middle school (grades K-8). As its first step, NSF funded three organizations to develop activity-based, primary school (K-6) science curriculum. These included: 1) the National Science Resources Center (a

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5 The criteria falls under the Category “Engaging Students with Relevant Phenomena” and reads: Providing vivid experiences: Does the material include activities that provide firsthand experiences with phenomena when practical or provide students with a vicarious sense of the phenomena when not practical? (AAAS 1999).
program founded by the Smithsonian Institution and the National Academy of Sciences), 2) the Lawrence Hall of Science at the University of California-Berkeley, and 3) the Education Development Corporation of Newton, Massachusetts. These three separate organizations have developed a series of science modules centered around student hands-on work and their adoption is expected to reduce lecture and the use of textbooks (NSRC 1997). These grade-level modules cover specific science topics using a hands-on science approach (none of the modules includes a textbook though two have now developed supplemental readings to go along with the activities). The modules come with the majority of materials necessary to do the activities (like some of those developed in the 1960s) thereby making a laboratory unnecessary. They are now sold through commercial publishers. NSF’s second step has been to provide additional funding to all three organizations to develop modules for grades 7 and 8 and these are undergoing pilot testing at this time.

Interestingly, in contrast to the AAAS and NRC’s proposed use of the inquiry approach with reduced emphasis on hands-on science, the new curricula are heavily hands-on oriented and include a combination of directive, exploratory and process skill approaches along with the inquiry approach. The cause of this divide is partly due to the practical nature of curricula development (it is easier to make a module including materials and activities that are directive or exploratory), partly due to the as of yet failure to operationalize the inquiry approach to the point that it can be packaged in a curriculum used by large numbers of teachers, and partly due to the high level of importance hands-on science retains in the minds of developers and teachers.
In order to help implement the science standards and new curricula, NSF began in 1990 to establish several programs to foster reform of science education at the state, city and district level that include support for the adoption of the new curricula, professional development in their use and other teaching practices that are assumed to support the goals of the National Science Education Standards. These programs include the Statewide Systemic Initiative (grants to 25 states and Puerto Rico), the Urban Systemic Initiative (grants to 20 cities with many children living in poverty), and the newer Rural Systemic Initiative, and together have received over $100 million in funding from NSF (Mervis 1998; Williams 1998). These initiatives foster the adoption of the Standards and new curricula in part by supporting teacher professional development in their use and funding their purchase.

Currently, then, the federal role in science and in regards to the promotion of hands-on science has expanded though not in a coordinated fashion. On one hand, there is a continuation of federal support for the development of new curricula, covering a broader range of grades than before, having a predominant hands-on science focus often provided in a non-inquiry mode. On the other hand, there is now significant federal support for developing and implementing a strategy for the reform of science education including specific attention to content and teaching methods. Along the continuum of instructional approach, current science education policy is in the middle with the theoretical focus on inquiry. Along the continuum of goals of science education science education policy has tilted more toward daily life with the emphasis on scientific literacy. The combination of inquiry and scientific literacy has leads to a view of hands-on science

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6 For example, the new NSF-supported modules developed by the Lawrence Hall of Science address a set of process skills in every content module as well as having two modules that focus specifically on two
as one of many tools that can be used in support of teaching inquiry and scientific literacy. Therefore, attention to promoting hands-on science is to be both reduced and redirected towards making it fit into the new strategy for science reform.

Through the expanded federal role in science education, hands-on science has become a national public policy issue both indirectly, through federal support of the development of new curricula having a hands-on focus, and directly through federal support of efforts to establish national content and teaching standards that de-emphasize the role of hands-on science. Determining the type of association between hands-on science and student achievement would contribute to the resolution of the current conflict between the present theoretical and applied forms of current science reform and fostering a more united federal role.

process skills, measurement and variables, in a content free manner.
Summary

In this chapter we have chosen the term hands-on science to reflect the current trend in public science education towards student activities performed in the classroom that may or may not be full experiments. A number of different instructional approaches can be used with hands-on science. These have risen and fallen in favor over time but a teacher may use any or all in combination in the classroom. Similarly, the promotion of hands-on science has varied in strength over time. The most recent trend has been a rise in the promotion of hands-on science which has been continued in the development of new curricula but is also being tempered by current science reform. Due to the differences in the current view of hands-on science and their implications for science reform, it is an opportune time to consider the link between hands-on science and student achievement.