SCIENCE IN AFTERSCHOOL

Literature Review

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SERVE Center
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Advancing Research, Improving Education

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SCIENCE IN AFTERSCHOOL LITERATURE REVIEW

Prepared By

Karen Falkenberg, Ph.D.
Patricia McClure, Ed.D.
Errin M. McComb, Ph.D.

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Developed by the
SERVE Center at UNCG
PO Box 5367
Greensboro, NC 27435
www.serve.org

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I. INTRODUCTION

Afterschool programs have become part of the daily experience of thousands of children in our country. With the increase in the number of working parents and the attention given to high rates of juvenile delinquency and other high-risk behaviors children engage in, parents are increasingly realizing the importance of a safe place for their children to stay after the school day ends. Furthermore, the potential for positively impacting children's development has become an important reason for children to be enrolled in afterschool programs. With the ever-increasing pressures for academic accountability and school improvements, afterschool programs are seen as an important strategy for improving student outcomes.

Afterschool programs are operated by various groups and have myriad sponsors. "The philosophy, goals, and components of the [afterschool] programs may vary as much as the supporting groups" (Shumow, 2001, as cited in Olszewski-Kubilius & Lee, 2004, p 8). As is commonly known, afterschool programs have a wide variety of goals, not all of which are academic in nature and frequently focus more on youth development or support. Only recently, as the afterschool movement has evolved as a field (Friedman, 2005) has there been an increased awareness of the need for greater accountability and measure of afterschool impact on students who are provided services through participation.

Afterschool services represent a tremendous investment in terms of the time children spend in programs and the funding that is invested to provide the services. Although it is difficult to determine the total resources allocated by federal, state, and local governments, private organizations, and foundations, the federal government's investment from 2001 through 2006 in the 21st Century Community Learning Center alone has been over $5 billion (U.S. Department of Education, 2006). Furthermore, the federal government has invested millions more in funding the Safe and Drug-Free Schools program, Safe Schools/Healthy Students, childcare and development block grant funds, and the Cooperative Extension Service. Clearly, the country has invested significant resources in afterschool programs.

With the significant investment of resources comes an increasing need to document the impacts of the programs. Although research to date has been limited in terms of the quality of design and scope of variables examined, there does appear to be a pattern of results that indicate afterschool programs can positively impact student outcomes. Studies show that students who participate in afterschool programs achieve higher grades and higher standardized test scores than did students who did not participate in afterschool programs (Hamilton & Klein, 1998; Huang, Gribbons, Kyung, Lee, & Baker2000; Schinke, Cole, & Poulin, 2000; Tierney, Grossman, & Resch**,** 1995; White, Reisner, Welsh, & Russel, 2001). Other outcomes such as improved attitudes toward school, higher expectations for school achievement, better work habits, and higher attendance rates, especially for low-income students, have also been documented (Brooks, Mojica, & Land, 1995; Posner & Vandell, 1994; Schinke, Cole, & Poulin, 1998; Tierney et al., 1995).

Research has linked participation in youth development and afterschool programs with reductions in negative behaviors, such as alcohol use, drug abuse, and violence, as well as increases in positive behaviors, such as better relationships with peers and improved conflict resolution skills (Beuhring, Blum, & Rinehart, 2000; Pierce, Hamm, & Vandell, 1999). The Center for Research on the Education of Students Placed At Risk (CRESPAR) conducted a review of research on 34 extended-day and afterschool programs (Fashola, 1998), which concluded that these types of programs do seem to have positive impacts on children.

Not only do these programs seem to positively benefit students, but families also support the use of such programs. The Afterschool Alliance found in the *America After 3 PM* (2004) survey that families of over 22 million children want afterschool programs and 6.5 million were enrolled in programs in 2004. In the past decade, the No Child Left Behind Act (NCLB) and high-stakes state tests have focused more attention on student academic achievement. Consequently, afterschool providers are increasingly important in the overall academic and social development of children. Afterschool providers are rising to meet the need of increasing the academic content of their programs. The challenge is to provide academic support in an engaging way so that students opt to attend afterschool programs.

Parents support organized, structured activities during the out-of-school hours. In the report, *All Work and No Play?*, a slight majority (54%) of parents wanted afterschool programs for their children that "focus on other things [other than academics] that capture their interest." This presents a challenge to afterschool providers to create programs that meet these different expectations, are fun and engaging and at the same time supportive of student academic growth. Thus, afterschool science programs have the potential to provide rich learning experiences for youth who attend.

Science in Day School

Some elementary schools and middle schools have excellent inquiry-based, problem-based, and/or project-based science programs. However, most children do not attend these schools (Weiss, Pasley, Smith, Banilower, & Heck, 2003), and results from state, national, and international tests reflect this reality. Not only do most students not benefit from inquiry science, the actual time allotted for science has been reduced (Center on Education Policy, 2006; Goldston, 2005; National Science Teachers Association (NSTA), 2003). The NSTA attributed the decrease in the number of students who passed the 2003 science ACT on an increasing neglect of K-12 science teaching as schools place increasing emphasis on reading and mathematics (NSTA, 2003). In a recent survey (Center on Education Policy, 2006), twenty-nine percent of the seventy-one districts surveyed report that, since NCBL was implemented, time for science has been reduced in order to make more time for reading and mathematics.

National Standards and Benchmarks

The National Research Council (NRC) of the National Academy of Science and the American Association for the Advancement of Science (AAAS) have helped to define what children should know and be able to do in science at different developmental ages. The National Academy of Science published the *National Science Education Standards* in 1996, and the American Association for the Advancement of Science published Project 2061: *Science for All Americans* in 1989, *Benchmarks for Science Literacy* in 1993, and the *Atlas of Science Literacy* in 2001. These publications are excellent resources for afterschool professionals seeking to strengthen or implement a science program in their centers.

In addition to science content standards, the National Science Education Standards also address teaching standards, professional development standards, assessment standards, program standards, and system standards. While these resources are not curricula, taken as a whole, these standards and benchmarks can provide theory, approaches, and strategies for helping students achieve science content and skills.

NCLB and State Science Standards and Assessment
Under NCLB, states are required to "set standards for every grade level achievement and - to develop a system to measure the progress of all students and subgroups in meeting those state-determined standards" (US ED, 2004). As a result of NCLB, states have adopted science standards. Federally mandated testing for reading and mathematics is now in effect, and science testing is required to begin in 2007.

National and International Science Assessment
Three assessments—National Assessment of Educational Progress (NAEP), Trends in International Mathematics and Science Study (TIMSS), and Programme for International Student Assessment (PISA)—are used to judge how U.S. students are progressing in science, mathematics, and reading literacy as compared to students in other countries.. "While there are similarities among the assessments, there are notable differences in terms of frameworks (more so in science), item content, and item format" (NCES, 2004, p. 5). Not surprising then, these different assessments report varying results for U.S. students. However, each suggests that U.S. students, particularly poor students, need to improve in science knowledge and skills, and afterschool programs have the potential to assist in this effort.

Considerations for Science in Afterschool
In planning a science program for afterschool, special consideration should be given to how children learn science. The National Research Council (NRC) studied and synthesized research of the learning process (2005; 1999). The Council found that:

1. Students come to the classroom with preconceptions about how the world works. If their initial understanding is not engaged, they may fail to grasp the new concepts and information or may learn them for purposes of a test but revert to their preconceptions outside the classroom.

2. To develop competence in an area of inquiry, students must (a) have a deep foundation of factual knowledge, (b) understand facts and ideas in the context of a conceptual framework, and (c) organize knowledge in ways that facilitate retrieval and application.

3. A metacognitive approach to instruction can help students learn to take control of their own learning by defining learning goals and monitoring their progress in achieving them.

To an afterschool instructor this means to 1) engage students' prior knowledge and understanding; 2) recognize and facilitate development of the essential link between a child's factual knowledge base and a conceptual framework; and 3) help students develop self-monitoring techniques through a culture of questioning, respect, and risk taking.

In considering science in afterschool, research was reviewed and is presented in this document on how students learn science; how science is assessed, particularly inquiry science; recommended practices for afterschool science; and current afterschool science programs. In the section on how students learn science, the seven principles on how people learn are outlined in detail. Due to the current emphasis on Science assessment under NCLB there is a separate section on Assessment and the importance of assessing and guiding student learning through asking probing questions. Research is presented to support the five recommenced science practices—investigating science through inquiry, exploring science through problem- and project-based learning, integrating science with other content areas, engaging families and using community resources, and tutoring in science for content and skill development. In the last section, a few notable afterschool science learning opportunities and afterschool science curricula materials are summarized.

II. METHODOLOGY

The goal of the literature search process was to conduct as broad and exhaustive of a search to yield studies, articles, and resources related to science content and programming in afterschool. The search was completed between December 2005 and February 2006 and the majority of the references were published between 1992 and 2006.

There is a very limited selection of studies addressing science in afterschool. Due to the limited research base, we broadened our search to include the key science practices and programs that are recommended for use in afterschool. Most of the practices have an extensive and unique literature base that supports their use with students.

Databases such as ERIC, Wilson Web, and PsychINFO were searched using combined key words relevant to science education and afterschool. Both the results of the search, as well as reference lists from the resources located, were used to provide support for the toolkit and literature review development. Research journals, the World Wide Web, and predetermined websites deemed likely to have information related to science and afterschool were also searched and leads to other sources followed. Finally, informal networks of persons with knowledge or expertise related to the subject matter were queried.

III. HOW SCIENCE IS LEARNED

Cognitive and developmental scientists' studies in the past four decades have uncovered new information on and understanding about how people learn and the characteristics of an academic environment that supports student learning. Their research "has increased our understanding of human cognition, providing greater insight into how knowledge is organized, how experience shapes understanding, how people monitor their own understanding, how learners differ from one another, and how people acquire expertise" (NRC, 2002b, p. 117). Furthermore, research on brain development and learning has shown that there are seven brain-compatible fundamentals to learning—emotional wellness and safe environment; the body (nutrition/health), movement, and the brain; relevant content and student choices (including links to prior knowledge); time on task, time for comprehension, and opportune timing; enrichment for all kids; timely assessment and feedback; and collaboration with peers and adults (Erlauer, 2003; Jensen, 1998).

There is much debate over the fundamental issues surrounding the best use of time and the most appropriate strategies for enhancing student learning in afterschool settings (Seidel & Aryeh, 2002). There is no debate, however, on the need to provide opportunities for students to learn in afterschool settings. Research on how people learn is not location specific; it is believed that this research has relevance to afterschool programs as well as day school classrooms.

How People Learn

It is increasingly clear that for many people, much of what is taught in our K-12 science classes and how it is taught does not correspond to the current research on how people learn. Unfortunately, many teachers today continue to teach science at a superficial memorization level and do not teach science in ways that support deep student learning. There are myriad reasons for the mismatch between what research suggests is best for student learning and what teachers actually do. One reason for this is that teachers typically teach in a manner similar to how they were taught (Ball, 1988). Another is that many teachers, particularly at the elementary and middle grades, do not have strong science content backgrounds (Anderson & Mitchener, 1994; Falkenberg, 2002); nor do they interpret data and graphs as scientists do (Bowen and Roth, 2005). It is hoped through this synthetic review that afterschool providers and science educators may gain insight into new strategies for enhancing science education in afterschool programs.

Students come to the learning environment with preconceptions about how the world works, some of which can be erroneous, and as students learn, they construct new understanding. If, however, their prior conceptions do not align with the new content and those preconceptions are not engaged, students may fail to grasp new information and their preconceptions may remain unchanged. It is also recognized that to develop competence in science students must have (a) deep foundation of usable factual knowledge, (b) understand facts and ideas in context of a conceptual framework, and (c) organize knowledge in ways that enable them to retrieve it and apply it. All of this is supported by the strategy of metacognition in which students learn to and do take control of their own learning by defining goals and self-monitoring their progress toward the goals (NRC, 2000a). The research on how people learn encompasses seven principles for learning and four perspectives on the learning environment.

Principles for learning

The research originally presented in *How people learn: Mind, brain, experience and school* (NRC, 2000a) and later in *Learning and understanding: Improving advanced study of mathematics and science in U.S. high schools* (NRC, 2002b) indicates that there are seven principles of learning. The following information illuminating these seven principles is excerpted from *Learning and understanding: Improving advanced study of mathematics and science in U.S. high schools* (NRC, 2002b). It provides a set of implications for educators who want to enhance conditions for student learning.

Principle 1: Learning with understanding is facilitated when new and existing knowledge is structured around the major concepts and principles of the discipline. Research on the differences between experts and novices has indicated that experts have a unique way of organizing information to facilitate retrieval. They "chunk" information into groups of data and concepts; for example, an electrical engineer can look at a complicated circuit diagram and recognize meaningful patterns of information such as a capacitor, where a novice would see a disconnected set of circuit components. Learning with understanding for students occurs when concepts and facts are organized in "big ideas" (NRC, 2002b)

Principle 2: Learners use what they already know to construct new understandings. People construct meaning of new information by relating it to what they already know or believe. If students' existing knowledge is not engaged, research has shown that students will frequently construct their own interpretation of the new information through their existing viewpoint, even if that viewpoint is erroneous. Teachers, therefore, need to solicit students' knowledge and pre-conceptions as they work with the students to build new understanding that is accurate and enduring.

Principle 3: Learning is facilitated through the use of metacognitive strategies that identify, monitor, and regulate cognitive processes. Metacognition, or, the skill of self-monitoring one's thinking, is an attribute of successful learners. "Experts have highly developed metacognitive skills related to their area of expertise" (NRC, 2002b, p. 122). It is known that students can be directly taught to be metacognitive and that this can have a positive affect on learning.

Principle 4: Learners have different strategies, approaches, patterns of abilities, and learning styles that are a function of the interaction between their heredity and their prior experiences. Howard Gardner has suggested that intelligence, as it is typically understood, is limited. He has espoused a theory of eight multiple intelligences as a way to broaden the "typical" definition of intelligence (Gardner, 1983). In *So each may learn: Integrating learning styles and multiple intelligences* (Silver, Strong, & Perini, 2000) the authors make the point that all students have strengths in certain intelligences and have particular learning styles. It is important to recognize that each student is unique and that his or her way of learning will vary. "Educators need to be sensitive to such differences so that instruction and curricular materials will be suitably matched to students' developing abilities, knowledge base, preferences, and styles" (NRC, 2002b, p. 123).

Principle 5: Learners' motivation to learn and sense of self affects what is learned, how much is learned, and how much effort will be put into the learning process. People are naturally motivated to learn. What they choose to learn, however, may not be in line with the goals set forth by the teacher and the curriculum. Learners of all ages are more motivated when they can see the usefulness of what they are learning and when they can use that information to do something that has an impact on other" (NRC, 2000a, p. 61)

Principle 6: The practices and activities in which people engage while learning shape what is learned. Learning is a social activity that is influenced by the circumstances in which we learn and with whom we learn (Brown, Collins & Duguid, 1989; Clancy 1997; Gee, 1997; Kirshner & Whitson, 1997; Lave & Wegner, 1991). In essence, knowledge is acquired and given meaning by the context in which it occurs and by the activities used to produce it (Ethell & McMeniman, 2000). Therefore, learning experiences cannot be decontextualized because the context is inextricably entwined with the content (Falkenberg, 2002). If, then, a goal of education is to teach students so that they can transfer new knowledge, it is important that "learning involve applications and take place in the context of authentic activities (NRC, 2002b, p. 128)."

Principle 7: Learning is enhanced through socially supported interactions. This important principle provides guidance on how educators place students with others to learn and has deep implications for the tracking students into certain courses or career pathways. Students need an opportunity for extended conversations and need to be able to interact with others who will support and challenge them (NRC, 2002b).

Environments for Learning

As noted in *How students learn: History, mathematics, and science in the classroom*, the principles for learning can be organized into four environments that are a "framework for thinking about teaching, learning and the design of classroom and school environments" (NRC, 2005, p. 13-20). Those four are explained below.

- Learner-centered—"encourages attention to preconceptions and begins instruction with what students think and know." The students' families, communities, and cultural values are considered as well as their abilities.
- Knowledge-centered—"focuses on what is to be taught, why it is taught, and what mastery looks like." Learning is organized around core concepts, "foundational ideas of a discipline."
- Assessment centered—"emphasizes the need to provide frequent opportunities to make students' thinking and learning visible as a guide for both the teacher and the student in learning and instruction." Teachers question and seek to understand student perceptions, monitor student progress toward mastery, and design instruction to meet student needs. Students have opportunities to reflect, revise, and improve their thinking.
- Community-[centered]—"encourages a culture of questioning, respect, and risk taking." Implicit and explicit classroom norms support core learning by allowing students to express ideas, to question, to make mistakes, and to take risks.

Together, the seven principles of how people learn and the four perspectives on the learning environment can guide the work of educators as they strive to enhance their students' chance to learn successfully. This research is not gender or culturally specific. Effective learning environments support students of both genders, and are appropriate across races, ethnicities, socio-economic status, and abilities or special needs.

How Students Learn Science

Research indicates that the body of evidence on how people learn can be translated and refined to individual disciplines including the sciences. However, it may need to be contextualized to the specific content area, e.g., "some metacognitive strategies need to be taught in the context of individual subject areas" (NRC, 2005, p.17). In general, these seven principles and the research on learning environments can be viewed as the best information available on how students learn and the ways in which educators can support that learning.

To address the misalignment of the growing research base indicating how people learn science with traditional methods for teaching science, the American Association for the Advancement of Science (1993) and the National Research Council (1996) developed policy statements (Anderson, 2002; Bybee, 1997) for standards on what students should learn in science and how they should learn it. It was recommended that inquiry be an integral component of a student's science education (AAAS, 1993; NRC, 1996, 2000a, 2000b). Using scientific inquiry has been recognized as a way to support how students learn (NRC 1998, 2000a, 2000b, 2005). "Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world" (NRC, 1996, p. 23). Inquiry teaching techniques are discussed in more detail in Section V.

One significant reason for the use of inquiry is to allow students to confront preconceptions and misconceptions that they may hold about a particular science topic. Many students develop their own ideas on natural phenomena before they are taught in school and often; those conceptions are inadequate or incorrect (Driver, Squires, Rushworth & Wood-Robinson, 2005). For example, many students believe that the reason it is warmer in the summer is because the earth is closer to the sun, rather than because of the tilt of the earth. Those ideas can be difficult to change through conventional teaching strategies (Wandersee, Mintzes, & Novak,1994). Inquiry pedagogy, particularly the conceptual change model, has been shown to increase students' awareness of their inaccurate views (Stephans, 2003).

Additionally, within the inquiry process, as students have a chance to articulate their findings and challenge other students' explanations, they have a chance to reconstruct their own knowledge (Roseberry, Warren & Conant, 1994 as cited in NRC, 2000b). Finally, inquiry allows students to learn with understanding and thereby be more able to transfer their knowledge to new situations (NRC, 2000a; 2000b).

According to the literature, there are additional benefits to teaching science through inquiry. Students conduct increasingly open-ended experiments and formulate complex questions about the content being taught (Hofstein, Shore & Kipnis, 2004), draw conclusions (Cuevas, Lee, Hart, & Deaktor, 2005), and develop positive attitudes toward science (Chang & Mao, 1999). The use of inquiry particularly influences the achievement in and attitude toward science for African-American males (Kahle, Meece & Scantlebury, 2000). Similar results have occurred with the use of inquiry in students with emotional disabilities (McCarthy, 2004) and students with diverse linguistic and cultural groups (Cuevas, et al., 2005; Klentschy, 2001; Lee, Deaktor, Hart, Cuevas & Enders, 2005). Research has shown that the use of inquiry can particularly support the learning of disadvantaged students who derive greater benefits than other students (Bredderman, 1983) and minority and female students (Klentschy, 2001; Shymansky, Hedges, & Woodworth, 1990). Furthermore, one significant urban study of 8000 middle school students showed "statistically significant increases on curriculum-based test scores for each year of participation [in an inquiry based science curriculum]. Moreover, the strength of the effects grew over the years" (Marx, Blumenfeld, Krajcik, Fishman, Soloway, Geier, & Tal, 2004). Afterschool is a particularly appropriate venue for inquiry; students may be able to explore science concepts more deeply and over a longer period of time without the typical time pressures of the classroom.

IV. RESEARCH ON ASSESSMENT IN SCIENCE

There is little research on assessment in afterschool science, however a familiarity with what is known about assessment in science education will benefit afterschool instructors in planning and implementing effective lessons. Until recent years, assessment of science education was not a major concern in K-12 education because very little science was taught. However, now with increased attention to science and recognition that science instruction is important in preparing students for today's society and job market, science inquiry and the assessment of science inquiry are now seen as crucial in schools (Harlen, 2000; Hein & Lee, 2000; NRC, 2003). The National Science Education Standards (NRC, 1996) emphasize that

> Assessment processes that include all outcomes for student achievement must probe the extent and organization of students' knowledge. Rather than checking whether student have memorized certain items of information, assessments need to probe for students' understanding, reasoning, and the utilization of knowledge (p. 82).

Under the No Child Left Behind Act, mandatory science testing will begin in 2007. In many districts, teachers are striving to both include more science teaching and testing in their classrooms. They are guided by national (AAAS, 1993; NRC 1996), state level and in some cases district level standards for what students should know and be able to do in science. This section on assessment will highlight the difference between testing and assessment as it pertains to the classroom and afterschool programs; it will not focus on high-stakes, large scale testing.

It is important to be able to assess student learning in science and for many people, assessments are synonymous with pencil and paper tests that are multiple choice and short answer. Tests of this format do have their purpose in science classrooms, but are not suitable for afterschool settings. Moreover, tests are a narrow aspect of assessments. "Assessment is a more modern and more inclusive term than the traditional 'testing'. It provides the connection between teaching and learning; it lets us know the result of any educational activity" (Hein & Lee, 2000, p.99). There are a wide variety of assessment strategies that gauge student knowledge and skills, and the purposes and strategies employed differ depending on when they are used. Three major assessment processes addressed here are diagnostic, formative and summative assessments.

Diagnostic assessments are used to determine student knowledge before beginning a task. Most people are familiar with "pretests," a common diagnostic assessment. Teachers and afterschool science providers also can use a K-W-L method in science in which each letter stands for a specific aspect of learning: K (What do know or what do you think you know?), W (What do you want to know?) and L (What have you learned?). Beginning a lesson with the K and W is a diagnostic assessment. These types of assessments reveal students' pre-conceptions and knowledge, allowing instructors and teachers to adjust their lessons accordingly.

Formative assessments, on the other hand, are used during the progression of a unit or set of lessons to indicate levels of student understanding and to allow a teacher or afterschool science provider to better know where a student needs help (Boston, 2002; Hein & Lee, 2000). There is evidence that good teaching includes formative assessment (Harlen, 2000). Formative assessments may include observing students, asking students probing questions and listening to their answers, asking them to demonstrate process skills, or listening to discussion between students as they work on a lesson (Harlen, 2000; Virginia Education Association, 1992). The purpose of formative assessments is to provide teachers and afterschool science providers with information on how well students are grasping the content and allow for effectively planned subsequent lessons and science experiences. Formative assessments can raise student achievement (Black &William, 1998). Most instructional activities can be turned into formative assessments. It is particularly important to use formative assessments in afterschool science experiences. Instructors should be skilled in asking students open-ended probing questions and in motivating students to work at higher levels.

Traditional tests are typically summative—those assessments that come at a natural stopping point in the curriculum such as the end of a semester or major topic–and are designed to show levels of student proficiency that will be assigned a letter or numerical grade. Summative assessments are, therefore, evaluative in nature. Other summative strategies include formal lab reports and formal presentations such as those given at a science fair.

Both formative and summative assessments are components of effective instruction and are used to gauge students' process skills, concept attainment and attitudes. There are multiple methods to conduct formative and summative assessments. In addition to pencil and paper tests or quizzes, other common methods of science assessment are learning logs, science journals/notebooks, reflections, videos, demonstrations, investigations, oral presentations, and model construction. Most of these are easily carried out in an afterschool setting.

Two other forms of assessment are a) those that use performance tasks, a.k.a. "performance assessments" or "authentic assessments" and, b) portfolio-based assessments. Performance tasks often require students to solve real-world or genuine problems i.e., those for which the answer is not readily available to the student in a book or teacher's manual. These assessments are often a part of problem-based teaching and learning, a pedagogy that will be addressed in section V. Performance assessments typically include public presentations, demonstrations, and written work. Portfolio-based assessments are based on the accumulated work of a student over an extended period of time and may include a wide variety of submissions including writing samples, drawings, and constructed models. Both performance and portfolio assessment models may be formative, but are frequently summative. Research suggests that authentic assessments enhance students' retention of new information, support students' independence during learning, and help students to perform well on standardized tests (Engle, Pulley & Rybinski, 2003).

The science education community encourages "embedded assessments". These assessments are "specific activities that can be used to assess students' progress" (Hein & Lee, 2000, p. 102) and are often a natural extension of the classroom activities that would have been planned such as building a series or parallel circuit during a unit on electricity. This type of assessment should be non-intrusive and integrated with learning activities (Kulm & Stuessy, 1991). Science curricula developed over the past 20 years with funding from the National Science Foundation have embedded assessments. Research has shown that embedded assessments lead to improvement in student learning in science (Treagust, Jacobowitz, Gallagher, & Parker, 2001). Many curricula developed through support of the National Science Foundation with these embedded assessments are a natural fit with afterschool science programs.

Dynamic Science Assessment (DSA) is a relatively new form of assessment and is used for investigating students' conceptual change in a specific content area. Dynamic assessment is a phrase coined by Feuerstein (as cited in Magnusson, Templin, & Boyle, 1997) and "is used to predict how a child will perform independently in the future" (Magnusson, et al. 1997, p. 100). In a DSA students observe actual science phenomena and are asked to develop theories to explain those critical events or phenomena.

One major purpose of any assessment is to gauge and support student learning. "Recent research implies that learning can be improved when teachers use curricula and instructional strategies that allow for frequent and ongoing assessment of students' understanding as it develops and is restructured over time during learning" (Treagust, et al. 2001). This cyclical nature of instruction, assessment, and feedback can be effective in supporting student learning, if students receive timely feedback from the teacher's assessments in relation to his or her progress. The information should be closely related to the work and how the student can improve and should not be a comparison between students (Harlen, 2000). Assessments can also support improved student learning if teachers make use of the assessment data to alter their teaching practices and lessons (Treagust, et al., 2001).

Combining pre-tests, formative assessments, embedded assessments, and summative assessments provide the clearest picture of student achievement (Hein & Lee, 2000). Current research on assessment in science indicates that students benefit from having clear assessment criteria at the outset of the learning process that can guide as well as motivate students toward successful problem solving (Toth, Suthers, & Lesgold, 2002). It may be possible for afterschool science providers to discuss these multiple assessment strategies with the day school science teacher.

Care must be taken in deciding what to assess, how to assess it, and the frequency of the assessments. Students take note of what is assessed and use it to cue their expectations for what they believe teachers view as important in science. "Assessment and learning are so closely related that if all the outcomes are not assessed, teachers and students likely will redefine their expectations for learning science only to the outcomes that are assessed" (NRC, 1996, p. 82). Formative assessments, stressed as excellent strategies in afterschool science programs, can be an integral part in reinforcing the importance of science as a field of study. More importantly, the afterschool provider must have an awareness of student understanding and content mastery. Misconceptions must be addressed in a community-centered environment of open questioning, risk-taking, and support.

Science, taught in an inquiry manner, with more investigations, experiments and discourse among students to support their data and conclusions, should be assessed using a wide variety of strategies and student products. A goal should be to more closely mirror the work of scientists by using and assessing authentic inquiry (Chinn & Malhotra, 2002). This, however, can bring on a unique set of assessment challenges (Hein & Lee, 2000) including time, equipment and in some cases, monetary resources. Because a case has been made, however, that teaching in an inquiry manner can support student learning, the assessment challenges should not be a deterrent to this kind of science teaching.

Current work in educational research is now focusing on linking the assessments of classroom teachers to large-scale assessments with the intent to lessen the gap between the two. Indicators show that there is often little reliability between classroom assessments and their ability to predict success on large-scale measures (NRC, 2003). High-stakes, large scale assessments are mandated by the No Child Left Behind legislation, and there are no clear linkages between national and international tests such as the National Assessment of Educational Progress (NAEP) and the Trends in International Mathematics and Science Study (TIMSS) (NCES, 2004). All educators recognize the importance of classroom assessments as an important component of measuring student learning, assessment research will continue in the future.

V. AFTERSCHOOL SCIENCE EDUCATION PRACTICES

One major emphasis of science embedded in afterschool practices is increased student learning and achievement within the school day. It is also important to provide science rich experiences to prepare our children to become scientifically literate and to live in a highly technological world. Research has shown that "an important prefix to producing scientifically literate adults is actively involving kids in doing science when they are young" (Loucks-Horsley,Kapitan Carlson, Kuerbis, Clark, Melie, Sachse, & Walton, 1990, p. 2). Involving students in "doing science" may also be used as a way to teach critical thinking skills (Loucks-Horsley et al., 1990).

In this section relevant research on five afterschool science education practices are highlighted: *investigating science through* ***inquiry****, exploring science through* ***project-*** *and* ***problem-based learning****,* ***integrating science*** *across the curriculum, engaging* ***families*** *and using* ***community*** *resources, and* ***tutoring*** *for science content and skills development*. There is limited research on science education in afterschool programs; therefore the following literature review includes primarily research conducted in classroom settings. These results are presented to provide an overview of research on science education practices, and it is inferred that these results are applicable for afterschool settings.

Inquiry

Scientific inquiry should not be confined to the classroom during the academic day; it should be part of an afterschool's program that embeds scientific content and should be a part of every child's science instruction regardless of race, gender, socio-economic status, disability, ethnicity, or English language proficiency. Inquiry is appropriate strategy for a broad range of students including students with learning disabilities and English Language Learners. Scruggs and Mastropieri (1993) showed "significantly higher learning for an inquiry-oriented approach with students with learning disabilities" (as cited in Anderson, 2002). Significant evidence from Amaral, Garrison and Klentschy (2002) shows that the use of inquiry science teaching with rural English language learners in grades K-6 increased student achievement scores in science, writing, reading and mathematics. Most significantly, their research indicates that the longer the students were involved in the program, the higher were their achievement scores. Chang and Mao (1999) have demonstrated that using inquiry science teaching methods with a group of students produced significantly higher student achievement scores than scores that were obtained by students in a control group who did not receive opportunities to learn via inquiry. Furthermore, "providing students with authentic opportunities to conduct science inquiry is expected to enhance students' abilities to successfully evaluate complex scientific ideas" (Trumbull, Bonney, & Grudens-Schuck, 2005, p. 880).

Many American students do not experience science instruction through inquiry. Instead, science is taught through the memorization of disconnected facts and definitions to be recalled for tests. In numerous science classrooms around the country, science instruction includes learning "the scientific method", a step-by-step procedure to do experiments that is thought by many teachers to simulate what scientists do in a laboratory. Science instruction should include learning facts and scientific content and at times it includes procedural laboratory experiences. However, scientific inquiry in the classroom or in afterschool programs is an experience that more closely mirrors how actual scientists do their work through scientific inquiry: studying the world around them, engaging in thinking and investigating processes (AAAS, 1993; NRC, 1996, 2000b).

Inquiry, as carried out in the classroom or in afterschool, is more than a way of teaching. "It encompasses not only an ability [of students] to engage in inquiry but an understanding of inquiry and of how inquiry results in scientific knowledge" (NRC, 2000b, p. 13). The engagement in inquiry should allow students to "be able to design and conduct scientific investigations" (NRC, 2000b, p. xv). There has been much debate about what inquiry teaching in the classroom should include and what it should look like, but the essence is that "inquiry teaching and learning strategies . . . enable scientific concepts to be mastered through investigations" (NRC, 2000b, p. xv).

The Exploratorium in San Francisco, recognized for its leadership in classroom scientific inquiry, provides an instructive explanation for the inquiry process. The information below comes directly from the Exploratorium's website (A Description of Inquiry, Retrieved December 17, 2005: http://www.exploratorium.edu/IFI/about/inquiry.html)

> Inquiry is an approach to learning that involves a process of exploring the natural or material world that leads to asking questions and making discoveries in the search for new understandings. Inquiry, as it relates to science education, should mirror as closely as possible the enterprise of doing real science.
>
> **The inquiry process** is driven by one's own curiosity, wonder, interest or passion to understand an observation or solve a problem.
>
> **The process begins** when the learner notices something that intrigues, surprises, or stimulates a question - something that is new, or something that may not make sense in relationship to the learner's previous experience or current understanding.
>
> **The next step** is to take action - through continued observing, raising questions, making predictions, testing hypotheses and creating theories and conceptual models.
>
> **The learner must find** her or his own pathway through this process. It is rarely a linear progression, but rather more of a back and forth, or cyclical, series of events.
>
> **As the process unfolds,** more observations and questions emerge, giving occasion for deeper interaction and relationship with the phenomena - and greater potential for further development of understanding.
>
> **Along the way,** the inquirer collects and records data, makes representations of results and explanations, and draws upon other resources such as books, videos and the expertise or insights of others.

Making meaning from the experience requires reflection, conversations and comparison of findings with others, interpretation of data and observations, and the application of new conceptions to other contexts. All of this serves to help the learner construct new mental frameworks of the world.

Teaching science using the inquiry process requires a fundamental reexamination of the relationship between the teacher and the learner whereby the teacher becomes a facilitator or guide for the learner's own process of discovery and creating understanding of the world.

A further clarification on inquiry as it should be implemented in the classroom or afterschool program is found in Table 1 (NRC, 2000b). The five essential features can be varied by the amount of teacher direction or learner independence that is appropriate for the specific students and learning outcome. This guideline allows a teacher or afterschool science instructor to carefully provide increasingly more open-ended scientific research experiences for students.

Table 1. Essential Features of Classroom Inquiry and Their Variations

Essential	Variations			
. Learner engages in scientifically oriented questions	Learner poses a question	Learner selects among questions, poses new questions	Learner sharpens or clarifies question provided by teacher, materials, or other source	Learner engages in question provided by teacher, materials, or other source
2. Learner gives priority to evidence in responding to questions	Learner determines what constitutes evidence and collects it	Learner directed to collect certain data	Learner given data and asked to analyze	Learner given data and told how to analyze
. Learner formulates explanations from evidence	Learner formulates explanation after summarizing evidence	Learner guided in process of formulating explanations from evidence	Learner given possible ways to use evidence to formulate explanation	Learner provided with evidence
4. Learner connects explanations to scientific knowledge	Learner independently examines other resources and forms the links to explanations	Learner directed toward areas and sources of scientific knowledge	Learner given possible connections	
. Learner communicates and justifies explanations	Learner forms reasonable and logical argument to communicate explanations	Learner coached in development of communication	Learner provided broad guidelines to use to sharpen communication	Learner given steps and procedures for communication

More…………..……………Learner Self Direction………..……..……………..Less
Less ……………….….Direction from Teacher or Material…………..………More

Reproduced here from National Research Council (2000b). Inquiry and the National Science Education Standards: A Guide for Teaching and Learning. Table 2-6. p 29.

In afterschool science programs, just as is suggested in science classrooms, instructors can best manage inquiry science experiences and support student learning by carefully evaluating the appropriate level of student independence during science inquiry and through repeated investigations, and begin to allow more opportunities for students to be self-directed. As students become more self-directed, teachers give less guided instruction. However, it is not suggested that students with limited science inquiry skills be given less direction than is optimal. This can lead to student frustration, limited learning, and issues with materials and student safety. In the table above, the five essential features may each vary in learner self direction. For example, students may need more help in formulating explanations from evidence than they do in communicating and justifying explanations.

<u>The 5 E's learning cycle model</u>
Sequencing the various components of inquiry is accomplished through a learning cycle. Atkin and Karplus first proposed a 3 stage learning cycle—exploration, invention, and discovery—in the 1960s based on the work of Piaget (Atkin and Karplus, 1962 as cited in Maier & Marek, 2006; Bybee, 1997), and this was used in the Science Curriculum Improvement Study (SCIS) inquiry-based materials. Bybee and Biological Science Curriculum Study (BSCS) have extended that work into a more operationalized way of instructional design for inquiry called the "5E's learning cycle"; a process by which students have the opportunity to become engaged with a particular topic; are encouraged to explore more in-depth about that topic, work to develop a deeper understanding of the topic through refection, explanations, discussion, and sense making; extend or apply what they have learned to new areas; and evaluate or assess for understanding by posing questions & answering questions at every step in the process (Bybee, 1997; Powell, Landes, & Taylor, 2005; Trowbridge, Bybee & Powell, 2004). Although others—Dewey, Kolb, Juch, Kelly, Pfeiffer and Jones, and Eisenkraft—have proposed various learning cycle models (Eisenkraft, 2003; Greenaway, 2002; Kolb, 2006; Kolb 1984;), the 5E model is commonly used in science education. Versions of the learning cycle are used in major science curricula including BSCS, Full Options Science Study (FOSS), Science and Technology for Children (STC). There are five phases of the 5E learning cycle model.

- Engage
- Explore
- Explain
- Extend (often called Elaborate)
- Evaluate

Students become engaged in scientific inquiry when they are given the opportunity to identify the relevance of a topic to their lives and have an opportunity to consider what they know about a particular topic (Saul & Reardon, 1996). *Engagement* may also come via an interesting question or a discrepant event (Friedl & Koontz, 2005). Students are then guided to formulate questions about that topic, and work to *explore* a deeper understanding of the content. Students may design and/or carry out experimental procedures to collect data. They then analyze the data, draw conclusions and defend those conclusions through meaningful discourse (AAAS, 1993; NRC, 1996). The *extend* or *elaborate* phase occurs as students' research naturally leads to more and deeper questions to explore (Bybee, 1997; Trowbridge et. al, 2004) and "ties directly to the psychological construct phase called the 'transfer of learning' (Thorndike, 1923 cited in Eisenkraft, 2003). The fifth "E", *evaluate,* is an ongoing diagnostic process, which includes formative and summative assessments. Both teacher and the student take active roles in evaluating student understanding of content and skill development. See the Assessment in Science, section V, for a more complete description of formative and summative assessment methods such as student journals or learning logs, embedded assessments, presentations, and open-ended questions that are appropriate for afterschool programs.

It is critical that this type of rich exploration and concept attainment be provided to all students. Equitable practices support the increased achievement in science for all students regardless of ability, gender, race, ethnicity, English language proficiency or socio-economic status. There is scant research on the impact of afterschool science on the knowledge, skills and dispositions related to science for students participating in those programs. However, research has shown positive impact on female students (Fancsali, n.d.; Ferreira, 2001a, 2002; Froschl, Sprung, Archer & Fancsali, 2003); underrepresented populations (School Board of Broward County Florida, 1999; Fancsali, n.d), and poor children (Brenner, Hurdley, Jimerson, & Okamoto, 2001) Specific results available for individual programs are presented in Section VI. Afterschool settings can be very appropriate for engaging students in inquiry science.

Project- and Problem-Based Learning (PBL)

Although there is little research to support the use of PBL in afterschool programs (Seidel & Aryeh, 2002), there is evidence to validate its effectiveness as a tool for student learning within the school day. Some research is available that indicates students learning through PBL can score as well as or better on standardized tests than those who are taught through more traditional methods (Rivet and Krajcik, 2004; Schneider, Krajcik, Marx, & Soloway, 2002).

We infer that the student success from PBL in day school settings should carry over to afterschool. In fact, the afterschool setting is an ideal place for children to develop problem-solving skills, tackle authentic problems and enhance subject-matter knowledge (Krajcik, Blumenfeld, Marx, & Soloway, 1994). Krajcik and others refer to this type of learning as project-based science or PBS; however in this review, the term PBL is used. PBL is a form of inquiry; in it students construct their own knowledge by actively working with ideas situated within a context and within the social group working together (Brown, Collins, & Duguid, 1989; Lave & Wenger, 1991). Afterschool science instructors who opt to use PBL should refer back to Table 1 to consider the five essential features of inquiry and the level of guidance appropriate for the students involved before undertaking a PBL investigation.

To contrast the approaches which can actually be quite similar in form, PROJECT-based science education results in an artifact or student product. This can include science fair experiments and displays, reports, seminars, videos or other student presentations. PROBLEM-based science instruction, on the other hand, is community-based or "case"-based. In community-based PBL, teachers use community problems as a driver of the learning experience with the final result intended to be an invention or an innovation addressing a challenge faced by the school community or local society. Community-based PBL is also known as PROJECT-based by some educators. The unifying principle is "a driving question or problem around which central concepts within the curriculum can be integrated" (Krajcik et al., 1994). Case-based PBL has its roots in institutions of higher education in which the learner is taught through "cases" or "case study", (University of Delaware http://www.udel.edu/pbl/ and University of Buffalo http://ublib.buffalo.edu/libraries/projects/cases/). Recent science education work indicates that cases can be specifically designed for and used successfully with middle and high school science students (Emory University http://www.cse.emory.edu/prism/index.html). To date, this technique has not been widely researched or used at the elementary level.

<u>Community-based PBL</u>

In PBL that is community based, (or PROJECT based in some circumstances) there are five essential features of instruction. Krajcik et al. (1994) explain that projects

a) engage students in investigating an authentic question or problem that drives activities and organizes concepts and principles;
b) result in students developing a series of artifacts, or products, that address the question/problem;
c) allow students to engage in investigations;
d) involve students, teachers, and members of society in a community of inquiry as they collaborate about the problem; and
e) promote students using cognitive tools.

Students might examine a problem that begs for intervention or improvement in the community and its environment. For example, here are some problems students have tackled.

- Grandmother cannot take her medications correctly.
- The classroom does not have enough storage space.
- Fresh vegetables are not available in our neighborhood.
- The nursing home surroundings are gloomy.
- A creek needs to be restored in our community.
- The butterflies that migrate through our community need to be counted and gardens established to insure their survival.
- Our streams have been over fished.

Criteria are available to assess whether a question or a problem is a good one for students to use in their investigation. Afterschool educators ask: Are the questions or problems are relevant to the students? Do students have opportunities to engage in scientific content? Is the problem realistic and important? Are the questions or problems feasible given the student and instructors' resources, time available and skill set? Use of PBL should allow the students' learning experience to move beyond the school walls into the community (Seidel & Aryeh, 2002).

The students work in teams to clarify and refine the problem and its terms and to collect information from the people who will benefit from the solution. The student group then identifies the specifications and constraints that will impact their possible solutions. Teams develop and present several options to the teacher and other student teams for review and critique. After narrowing down their ideas, the students select one solution to pursue. They adapt, modify, and field test their plan or prototype. Evaluation and redesign take place until the solution is ready for implementation and judgment by the person or people who will benefit from the solution.

Case-based PBL
PBL cases can be written for students, but it is suggested that afterschool programs take advantage of the cases that are already available that have been designed by scientists and science educators. Some that are specifically written for middle and secondary students are available through the Center for Science Education at Emory University (http://www.cse.emory.edu/prism/products/cases/). In general, a case is a "story" that has characters and is intriguing to students. According to the University of Buffalo (http://ublib.buffalo.edu/libraries/projects/cases/teaching/good-case.html) good cases

- Tell a story,
- Focus on an interest-arousing issue,
- Are set in the last five years,
- Create empathy with the central characters,
- Are relevant to the reader,
- Are conflict provoking and force decisions,
- Are generalizable, and
- Are short.

The case is written in scenario form, meaning that there are intended breaks at points of tension when students won't know all of the information they need. It is similar to a television "mini-series" in that the breaks come at a point of high intrigue and the viewer (or in this case, the student) really wants to know more. The scenario is intended to generate questions in the students' minds and once the scenario is read, the students identify the data that they learned from the scenario, the questions they have generated because of the data in the scenario, and the research they need to do to find answers to their questions. Instructional time is provided for the inquiry and research and then the next scene in the case is read and the inquiry process continues.

PBL strategies are pedagogies that result in increased student motivation and this may be true particularly for females (Burkam, Lee, & Smerdon, 1997). They are learning opportunities that are more relevant and have far more opportunities for creative and critical thinking; they include increased opportunity to develop the skill of "learning how to learn" (http://www2.imsa.edu/programs/pbln/tutorials/intro/) more than do traditional teaching approaches. The PBL approach to learning science mirrors actual problem solving and provides a way to assess student learning by demonstrating understanding rather than fact-acquisition. The "ill-structured problems" (http://www.score.rims.k12.ca.us/problearn.html) require students to define and refine, develop explanations, seek and use information from a variety of sources, as well as develop solutions they can defend.

PBL differs from more traditional pedagogical strategies in that it requires more time, more resources and more student independence (D'Amico, 1999). Project based experiences and community based PBL are, by their nature, more open-ended than traditional learning experiences, and they require the teacher to proactively anticipate issues with students' ability to work independently as well as students' science content misconceptions. Providing students with a set of guidelines for carrying out investigations and a method of self-assessment is critically important to developing good work habits. One study suggests that teachers build in intermediate accountability between the beginning and end of the project, confer regularly with students on their progress to assess progress and provide guidance, and incorporate student work habits into the final assessment (D'Amico, 1999). This may not be a significant issue for afterschool science instructors if no grades are awarded but the need for close monitoring, clear rules, and guidance is still evident (Seidel & Aryeh, 2002).

Afterschool science programs can provide an opportunity for students to develop entries for competitions including science fairs and invention fairs. Other science activities once considered classroom science enrichment now find a home in afterschool settings in interest groups and clubs. Long-term science projects are rich afterschool experiences. The potential for using critical thinking and other higher-order thinking skills makes PBL a powerful approach for afterschool science programs that enhance the classroom science.

One significant outcome for students in afterschool programs that implement PBL is the possibility of increasing student interest in learning for those who have become disengaged and for the possibility of those same students validating their own self-worth and abilities (Seidel & Aryeh, 2002).

Integrating Science

Science is a field rich in opportunities for integrating and reinforcing knowledge of and skills in other content areas. The National Science Education Standards (NRC, 1996) stress the need for students to investigate the world around them, which suggests the need to use equipment (technology) and to apply mathematical skills. Those same standards stress the need for science students to be able to support their evidence and conclusions through public discourse, which suggests the need to use language arts and writing skills. For example, the study of Earth Science is easily connected to geography and social sciences, and cultures and people are integral components in the history of science. In nearly every area of science, it is possible to link the science to other content areas and the need to use skills that cross disciplines.

Mathematics is often called the language of science and the science of patterns and relationships. Science and mathematics are inextricably linked. The American Association for the Advancement of Science (1990, p. 15; 1993, p. 23) states that, "… 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."

The National Council of Teachers of Mathematics (NCTM) content and process Standards (2000, 2004) are supported by the study of science. In science, students seek to understand patterns, relations, and functions; represent and analyze mathematical situations and structures using algebraic symbols; use mathematical models to represent and understand quantitative relationships; and analyze change in various contexts (Algebra standard). Science students study the physical world using geometry and spatial sense.

Similarly, measurement and the understanding of units are fundamental to science. Data collected in science investigations must be analyzed using statistics and probability. The mathematics process standards—problem solving, reasoning and proof, communication, connection, and representations—are applied with increasing depth as students study science. Mathematics is applied in the study of the physical world—science.

Science is also closely linked to English language arts. Standard 7 of the Standards for the English Language Arts (1996) states, "Students conduct research on issues and interests by generating ideas and questions, and by posing problems. They gather, evaluate, and synthesize data from a variety of sources (e.g., print and non-print texts, artifacts, people) to communicate their discoveries in ways that suit their purpose and audience." This is the essence of science inquiry as stated in the National Science Education Standards (1996, p23).

> Inquiry is a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already know in light of experimental evidence; using tools to gather, analyze, and interpret data; posing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations.

In addition to mathematics and English language arts, the National Standards for Arts Education calls for understanding the relationship or making connections between various art forms and disciplines outside the arts—Dance Content Standard #7, Music Content Standard #8, and Visual Arts Content Standard #6. Even through standards for the arts, mathematics, science, and English language arts have commonalities and lend themselves to integrated studies, the typical schedule for day school can artificially compartmentalize the various content areas. For example, students may learn language arts in period 1, math in period 2, social studies in period 3, science in period 4, etc. These imposed boundaries can segment learning in ways that misinform students about the connections between the disciplines. Many classes are taught "without the rich conceptual coherence needed to make the knowledge useful in explaining real-word phenomena" (Anderson & Roth, 1989, p. 273). Afterschool programs have an opportunity to present the content areas in a more blended manner that better reflects what is known about how students learn. One group suggests themes such as "Cooking from Many Kitchens" in which science, math, and social studies naturally intersect or "Community Unity" where a community garden and a recycling center were started and maintained. Information about the unity projects was disseminated through a newsletter and skits developed by the children and educators (Bergstrom & O'Brien, 2001).

Good reading and writing skills are critical to good science and can be integrated into science from the outset of an afterschool science investigation to its conclusion. "Reading, writing, and science are, or should be inseparable. Many of the process skills need for science inquiry are similar to reading skills, and when taught together, reinforce each other" (Krueger & Sutton, 2001, p. 52). Many researchers have recognized this connection (Ediger, 1998; Lucas & Burlando, 1975; Mechling & Oliver, 1983; Rivard & Straw, 2000; Wellman, 1978). Often, students have some knowledge of a given topic but need additional resources to gather information as the inquiry proceeds. In the explore phase of the learning cycle, students can research information through expository texts and the Internet. An afterschool instructor can assist students in learning the difference between primary and secondary sources of information as they gather evidence. In a PBL experience, students may interview members of the community and record their findings. Writing opportunities in science should take on many forms (Ediger, 1998, 2001) and should be used to document evidence, questions, and feelings. In fact, documenting feelings has been known to lessen disenfranchisement of low achievers in science (Hanrahan, 1999). Palinscar and Magnusson (2000) have found that fourth-grade students' reading and writing skills improved when they used a fictitious scientist's journal (actually written by the research team) to accompany their science investigations. Guthrie, Wigfield, and VonSecker (2000) found Concept Oriented Reading Instruction (CORI), which integrates reading with inquiry science, increased student motivation for reading compared to student motivation with more traditional reading instruction.

Numerous educational researchers have learned that "writing can play a powerful role in the learning of science" (Treagust, et al., 2001, p. 139). As noted in Treagust et al. (p. 139)

> When students write about their observations and findings from experiments, they organize their thoughts better, and they sharpen their interpretations and arguments. Further, writing enables students to express their intellectual and emotional reactions to science phenomena in a variety of forms.

In the explain phase of the inquiry, students write and express thoughts through text whether on paper or on the computer. Rivard & Straw (2000) report that "analytical writing is an important tool for transforming rudimentary ideas into knowledge that is more coherent and structured. Furthermore, talk combined with writing appears to enhance the retention of science learning over time" (p. 566). This is in alignment with research suggesting knowledge construction is a socially mediated event (Brown, Collins & Duguid 1989; Lave & Wenger, 1991; NRC 1996, Vygotsky, 1978). Moreover, Baker and Leary (1995) suggest that females desire more interactions with peers and this discourse may enhance females' interest or comfort in science. The extend phase of the learning cycle leads into more questions which will require more reading, researching, and writing.

Reading and writing can naturally be integrated into science. It is also the case that science can be integrated into reading. All elementary schools strongly emphasize reading, writing and language arts instruction, and in most schools it occurs first in the day. However, many elementary teachers are not comfortable with science content and so the texts chosen for students to read are not related to science; many selections are fiction. It is known that informational texts are not used frequently in elementary schools (Duke, 2000; Duke, Bennett-Armisted, & Roberts, 2003). This is in contrast, however, to children's preferences. Most children prefer informational text (Kletzien & Szabo, 1998). Many excellent tradebooks on science topics are available for use in reading and educational research indicates that children who have more experience with informational texts seem to progress better academically (Caswell & Duke, 1998). Afterschool science programs are a natural fit with the linking of reading, writing, and science through investigations.

When the content areas are integrated there is a positive benefit for both science and reading skills. There is evidence that inquiry science curricula that provide students with interactive investigations followed by reading experiences improve reading and language arts skills (Lowery, 1998; French, 2004). Stoddart, Pinal, Latzke, and Canaday (2002) assert that inquiry science can support language acquisition for students whose first language is not English. In a rigorous research study (Valle Imperial Project), Klentschy (2001) documented increasing gains in reading and writing for each year that his school district's elementary students (primarily lower SES, rural, English language learners) participated in their inquiry based science program that included a significant use of tradebooks and journal writing. Student achievement in Klentschy's Valle Imperial Project was measured by the use of the SAT-9.

Although much of the literature on integration of other content areas with science is in reading and language arts, many organizations continue to work together to achieve an agreed upon set of goals for science and mathematics teaching and learning (Kennedy, 1998; National Center for Improving Student Learning & Achievement in Mathematics & Science (NCISLA), 2004). Science investigations support the use of mathematics skills and technology. In science inquiry, elementary school students measure, compute, use fractions, decimals, ordered pairs, represent data in bar graphs, and estimate. Middle school student convert between metric and English units; use fractions, decimals, computational skills (addition, subtraction, multiplication, division); graph using various types of graphs such as pie charts, and line graphs; begin simple statistical analysis; and look for patterns. At the high school level, students use more sophisticated mathematics skills in higher-level courses such as chemistry, physics, and Advanced Placement science courses. Students at this age express relationships between variables as functions and use statistical analysis to interpret graphs and relationships between quantities. At elementary and secondary levels, students use mathematics to make predictions, to create hypotheses, and to draw conclusions.

Aspects of the content standards in science that are directly connected to mathematics include problem solving, skill building and mathematical sense making. Kennedy (1998) asserts there are myriad differences between the national standards for science and mathematics but that they are "remarkably similar in their tenor" (p. 252). In a review at the elementary level of a specific unit, Chalufour, Hoisington, Moriarty, Winokur, and Worth (2004) developed a schematic showing the overlap in mathematical skill and content knowledge for elementary children as espoused by NSES and the NCTM. The unit was an elementary investigation using blocks to build structures; it is reproduced in Figure 1. The figure shows common content and process goals in science and mathematics in the center of the diagram. At the elementary level where teachers often teach both subjects, it is often easier to integrate the two content areas. This is unlike the case at middle and high schools where the two subjects are not normally integrated unless teachers work together to make that happen.

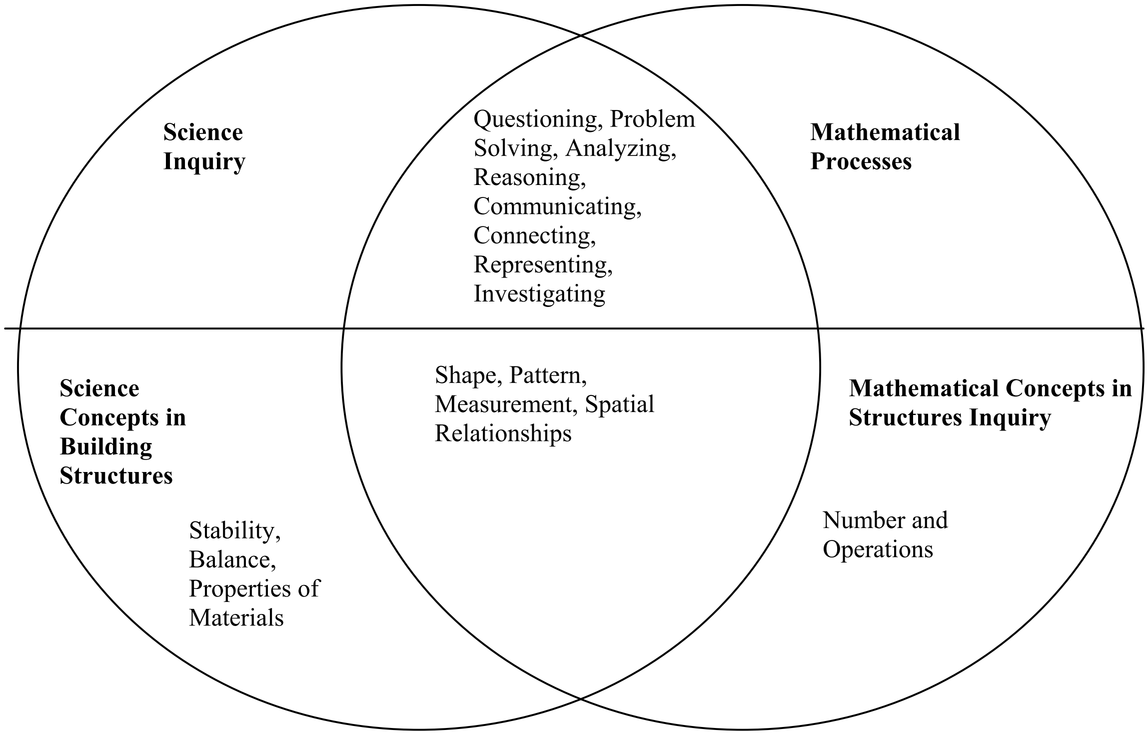

Figure 1. The integration of science and mathematics concepts for an elementary unit on structures. Reproduced from Chalufour, Hoisington, Moriarty, Winokur and Worth (2004)

In a review of the current research, there is not a significant body of evidence on the impact science and math integration have made on student knowledge and skill acquisition (Frykholm & Glasson, 2005). In one small study, Judsen and Sawada (2000) present data from an action research project in which middle school students learned more statistics than a control group through an inquiry science unit that involved the generation and analysis of data. The control group of students learned statistical concepts in a more traditional manner. In other studies of reasoning and data analysis using real-world aids data, researchers found that middle school students were able to develop sophisticated reasoning and statistical analysis skills (McClain, Cobb, and Gravemeijer, 2000; NCISLA, 2004). Although the research is scant, there is no reason to suppose that the integration of science and mathematics should hinder the learning of either content area and afterschool staff are encouraged to find ways to develop science skills through mathematics and vice versa. Indeed, science and mathematics standards are inextricably intertwined as indicated above.

Ways to integrate content areas in afterschool programs include organizing the curriculum around thematic units and interesting real-world problems or projects. In the sections ahead, information will be provided on specific programs and initiatives that support science in afterschool. Most of these provide opportunities for integration of many content areas with science.

Community/Informal Science and Parental Involvement in Afterschool Science Activities

Informal science providers

The importance of informal science providers and parents in afterschool science programs cannot be overestimated. In this narrative, a parent is taken to mean biological parent, relative, or other significant adult deeply involved in the life and care of a student. An informal science provider is any organization established within a local community that has a purpose of offering opportunities for science experiences and knowledge growth to the general public. Some common examples of informal science providers are science centers, museums, zoos, nature centers, biological gardens, aquariums, 4-H, Scouts, and local, state, and national parks. They may be deemed informal, but in actuality, are really more "free choice" (Falk, 2001) as individuals seek these offerings according to their individual interests; they are not compulsory as schooling is. Learners "choose, control and collaborate in their own learning. Thus it builds on the learners' and their partners' interests with purpose or curiosity" (The Center for Informal Learning and Schools (CILS), n.d., p. 1).

Considering that learning is a socially mediated event, community involvement deepens community relationships and signals to the children of a community an acknowledgement that the afterschool learning is worthwhile. In high quality afterschool programs, students are able to interact with adults that they might not otherwise meet, be "creators and not merely consumers of science curriculum" (Rahm, 2002, p.180) and, in optimal circumstances, have an opportunity to extend their learning through an internship with a community organization. "Afterschool programs have become many children's 'new neighborhood'" (NIOST, 2002, p. 3).

A synergistic relationship exists between informal science providers and afterschool programs; one goal of all informal science providers is to serve the community that it resides within. One goal of afterschool programs is to better utilize local resources to assist in student education. Collaboration between "school districts and informal science centers and museums can provide programs that stimulate teacher and student interest and guide them on the path to lifelong learning" (McLeod & Kilpatrick, 2001, p. 59). Another common goal of afterschool programs, particularly for first generation urban students, is youth development where science is a means to an end for action and entrepreneurship rather than an end unto itself (Rahm, Moore & Martel-Reny, 2005). The appeal of science in afterschool and informal settings is now "widely recognized" (Jones, 1997; Rahm, 2004); it serves many purposes and research on informal science opportunities for youth is showing positive outcomes beyond those measured by academic criteria.

How do afterschool programs begin their collaboration with informal science centers? What under girds the partnership? According to Frankel (1996), "when a partnership is developed in response to an expressed need, the result is a transformative experience" (p. 10). Informal science providers offer myriad resources including field trips, curricular materials, on-site activities, and resource materials (National Institute for Out-of-School Time (NIOST), 2002). Although all informal science providers have limited funding, it may also be possible for an afterschool science program to receive support in planning an initiative with a provider including one in which afterschool instructors receive training and professional development in science and the use of the center's resources. It should be mentioned that the Internet is a supplemental rich resource for afterschool science programs to complement materials and experiences found at informal organizations. Films and high quality television broadcasts, a fair number of which have been supported by public television, philanthropic organizations, and the National Science Foundation, can also round out the informal center offerings.

There are also many high quality informal science programs for students and teachers. The following list, adapted from the work of McLeod and Kilpatrick (2001) and expanded to include centers and museums, is a selected sample indicating the variety and strengths of the programs. A detailed review of a number of these informal science programs as well as selected afterschool science programs are presented ahead in section VI.

Program	Description
NASA	Offers a wide variety of programs and experiences on space science for students. Space Camp opportunities are available to groups able to travel to their specific camp locations. NASA has a strong, national, program for science teachers.
The Boston Children's Museum	The Culture, Art, Technology, and Science project promotes an interest in science among students in afterschool programs by using multidisciplinary activity kits that afterschool instructors can rent. Afterschool program directors, teachers, and children work with museum staff to create innovative activities for the kits.
The Chicago Academy of Science	One of the most important science outreach programs offered is Science on the Go! Educators on staff at the academy teach in classrooms in the Chicago public schools using engaging, interactive science, math, and technology learning materials.
The Exploratorium	Offers professional development for day school and after school educators as well as a variety of online and print resources for teaching mathematics and science. Mentorships and leadership opportunities are available to educators and students.
The Franklin Institute	Offers weekend and summer programs for African American students in grades 7-11 since 1993. PACTS (Partnerships for Careers in Technology and Science) provides development, mentorship, and leadership opportunities.
The Lawrence Hall of Science	For 35 years, the mission of the Lawrence Hall of Science (LHS), at the University of California at Berkeley, has been to develop model programs for teaching and learning science and mathematics, and to disseminate these to an ever-increasing audience. The Hall is a resource center for children, parents,

	educators, and policymakers seeking to improve the understanding and increase the enjoyment of science and mathematics.
The New York Hall of Science	Services 250 students each year in grades 2-8 who live within walking distance of the museum. The students participate in afterschool clubs and get homework help and science-based inquiry experiences. Each club hires and trains teenagers with cultural backgrounds similar to those of the students in the clubs to assist club members by asking good questions and guiding students in investigating science concepts.
The Orlando Science Center	Principals appoint teachers to become trained science ambassadors. The 350 ambassadors connect the school community to the science center's activities and programs. Ambassadors may also lead week long inquiry-based, hands-on thematic science programs for students.
The Science Place	The Outreach School Programs at the Science Place help teachers develop students' interest in science through out-of-school programs. The programs take place at the school site. The Science Place staff makes presentations to smaller groups of students. Teachers can receive professional development in science content.
YouthALIVE!	Youth Achievement through Learning, Involvement, Volunteering and Employment funded from 1990-1999 by Wallace-Reader's Digest Funds though many programs are still in operation. Multiple strategies for different age groups. Younger students (10-13) participate in afterschool, weekend and summer enrichment, older students (14-17) work within museums as exhibit explainers, demonstrators, and outreach workers for pay.

Parent and family involvement

Family involvement, in combination with teacher support and a sense of belonging, can have a positive impact on the educational experience for the student (Gutman & Midgley, 2000; Hebert, 2002; Logsdon, 2003). Research also shows that out-of-school and extracurricular activities support students' commitment to their talent areas in adolescence and supports social networks between the parents of participating students (Olszewski-Kubilius & Lee, 2004). Surprisingly, family groups are the most underutilized partners in current educational reform efforts) even though most parents like to have specific ways of becoming involved with their child's education (Shymansky, Yore, & Hand, 1999). Another outcome of increased parental involvement is the opportunity for parents themselves to learn science content along with their children.

Parents can be strong partners with afterschool science programs though the type of involvement may be different depending on the ages of the students. At the elementary level, parents may assist with class and afterschool activities. For example, "*Playtime Is Science* stresses that teachers and parents know more science than they think, and so can play an important role in helping children gain interest, confidence, and competence (Campbell, Bachmann, Campbell-Kibler Associates, & Sprung, n.d.)." Students and parents engage in scientifically relevant content and skills through activities such as making oobleck, investigating forces through ramps and motion (which can include time on the playground) and making and tossing bean bags. In the *Science PALs* (Parent, Activities and Literature) Program elementary children are given a take home bag with a tradebook, simple materials, and an instruction sheet to do investigations at home with parents (Shymansky, et al., 1999). *Science and Children*, a publication of the National Science Teachers Association has a regular column called "The Home Zone" that provides interesting science investigations for children at home. As students age, however, "the crux of family-school involvement at the middle and high school level is determining the kinds of adult interactions that not only allow teenagers to have autonomy and respect but also meet the needs of families and schools. … Involvement at the secondary level is often much less visible, though just as valuable" (Ferguson & Rodriguez, 2005, p.1). At any age, though, "the most effective source of attitudes toward science and mathematics is the family. The family can socialize either a very positive or a very negative attitude toward science" (Miller, 1989, cited in Shymansky, et al., p. 3).

Wanting parental involvement doesn't insure that it will happen; educators realize that not all parents are comfortable in afterschool programs. They have little time to participate, and they may be distrustful of schools (Peterson, 1989). Engaging parents first and foremost requires that they are respected as equal partners and that their potential contributions be recognized as valuable (Ferguson & Rodriguez, 2005). Depending on the afterschool programmatic needs, it is wise to engage parents to plan their effort in conjunction with the afterschool staff. In other circumstances, schools and parent involvement programs in science are available and can be used to build an effort on site.

There are many ways for parents to assist in afterschool science efforts. Some may have expertise related to the science content. Others may lend extra help in preparing science investigations, monitoring students, and cleaning up. Importantly, including families in the design of an afterschool science program or one of its components can increase parental buy-in and support. Another outcome of increased parental involvement is the opportunity for parents themselves to learn science content along with their children. More information on developing parental involvement can be found in books, journals and on the Internet (Davidson, 2003; Nitzberg & Sparrow, 2001; Peterson, 1989). These resources include information on pulling the right partners together, setting goals, spreading the word to the community, and having an event or events. Family Science Nights are a common and popular way of bringing parents, educators, and children together for an engaging and learning-filled experience (McClure & Tapia, n.d.; Scaife & Scaife, (2002); Watts, 2001).

Tutoring

With the passage of the No Child Left Behind Act, schools and communities are developing alternative strategies to improve student learning and student achievement scores. Tutoring, the provision of individualized academic assistance to individual students, has gained increasing attention as a possible means for helping students improve their performance, not only within the traditional school day but also after school dismisses. 21st Century Community Learning Centers program, funded under No Child Left Behind, provides afterschool services to assist students in improving their academic performance. Tutoring is often a key element of 21st Century Community Learning Center programs, as well as a key component of Supplemental Educational Services.

Given the limited research-base on science tutoring, it is necessary to draw upon a variety of literatures to provide a starting point for describing research on the impact of tutoring. This section provides a review of the tutoring literature in general, including a review of research conducted on tutoring programs designed to improve students' performance. This document begins with a description of the background of tutoring programs in general and describes the different types of tutoring methods.

<u>Background of Tutoring Programs</u>

Improving the educational outcomes for students who are at-risk for academic failure has long been a priority for parents and educators in our country. Tutoring, implemented in various forms, has been an important strategy used to help at-risk children improve their chances for success in school. Tutoring has the potential to help students improve their academic performance in two ways: through instruction related to the content or subject matter, and through relationships that emerge during the tutoring experience (Rohrbeck, Ginsburg-Block, Fantuzzo, & Miller, 2003). One-on-one instruction is seen as an effective way to increase student mastery of academic subjects. Working with individual or small groups of students provides educators the opportunity to clarify concepts, determine when children have truly mastered understanding of the material, and respond to students' individual needs. However, data suggest that teachers may not have time to deliver instruction on an individual basis within their regular school curriculum (McIntosh, Vaughn, Schumm, Haager, & Lee, 1993; Moody, Vaughn, & Schumm, 1997). Tutoring, in an afterschool setting, can provide the opportunity for the one-on-one instruction that may be lacking within the regular school curriculum (Elbaum, Vaughn, Hughes, & Moody, 2000).

In addition to helping students learn specific content, tutoring can offer students the opportunity to develop relationships and social-emotional skills that promote success in school. When the tutor is an adult, students may find that their tutors act as a mentor or role model and provide supportive relationships, in addition to the instruction they might provide related to academic content (Hendry, Roberts, Glendinning, & Coleman, 1992; Jekielek, Moore, & Hair, 2002; Rhodes, Grossman, & Resch, 2000). When well-implemented, these relationships have been found to have a beneficial effect on the development of youth (DuBois, Holloway, Valentine, & Cooper, 2002). Settings that use other students as tutors in peer-assisted learning can utilize the potential for peers to positively impact students' socialization, perhaps enhancing the student's motivation to achieve (Light & Littleton, 1999; Rohrbeck et al., 2003; Steinberg, Dornbusch, & Brown, 1992; Wentzel, 1999). Tutoring potentially can help students improve their academic proficiency by increasing their knowledge and by providing opportunities for personal relationships that increase their motivation to apply their knowledge to improve their academic achievement.

Tutoring Research

Tutoring programs vary greatly. Specifically, programs may vary by who is doing the tutoring, where it is done, and how it is structured. Research has indicated that high-quality, frequent and consistent one-to-one tutoring may be the most effective afterschool activity for improving academic achievement (Fashola, 1998; Lauer, Akiba, Wilkerson, Apthorp, Snow, & Martin, 2004). One-to-one and small-group tutoring from well-trained staff allow(s) afterschool programs to target students' individual strengths, weaknesses, and interests by providing direct, diagnostic mathematics instruction and mentoring. This type of tutoring is most effective when tied to the school day, allowing children to practice and reinforce what they are learning in the classroom (Elbaum et al. 2000; Fashola, 1998). Tutors, who can be peers, often receive training to provide intervention of such quality (US DOE, 1995; Lauer et al., 2004; Grossman et al., 2002).

Peer and cross-age tutoring can be defined as the "acquisition of knowledge and skill through active helping and supporting among status equals or matched companions". There are three commonly cited benefits of peer and cross-age tutoring: the learning of academic skills, the development of social behaviors and classroom discipline, and the enhancement of peer relations (Greenwood, Carta, and Hall 1988). Researchers have also identified improvements in self-esteem and one of its components--internal locus of control. It is important to note that all such benefits apply to both tutor and tutee. The peer and cross-age tutoring research shows a moderately beneficial effect on tutees achievement and a smaller but significant effect on their attitudes toward subject matter. Looking at the effects on academic achievement, math achievement effects were stronger than reading effects for both tutors and tutees. Tutees' achievement improved more in more structured programs of shorter duration and when lower-level skills were taught and tested on locally developed examinations (Greenwood et al., 1998).

Both tutors and tutees have been shown to benefit academically from peer and cross-age tutoring in elementary mathematics (Britz, Dixon,& McLaughlin, 1989; Fantuzzo, 1989). Math skills addressed in this research included ratio, proportion, and perspective taking, among others. Effects on affective outcomes in mathematics research were less conclusive; although there is evidence that peer tutoring can increase the formation of friendship bonds between partners. Many of the students in this research were low achievers, mildly handicapped, or socially disadvantaged.

Researchers have also noted significant beneficial effects on the language arts achievement of tutors (Rekrut, 1994) and especially tutees (Palincsar & Brown, 1986; Wheldall & Colmar, 1990; Barbetta, Miller, Peters, Heron, & Cochran, 1991). Language arts areas examined include story grammar, comprehension, identification of sight words, acquisition of vocabulary, and general reading skills. Most of this research involved elementary students (some were middle-school students), and positive results were found for both short- and long-term tutoring.

Research studies in the areas of peer and cross-age tutoring in science, social studies, health, and art are too few to permit firm conclusions about the achievement effects of these practices--indeed, some of this research did not address achievement outcomes. However, some positive achievement outcomes were noted (Maheady, Mallette, & Haper, 2006; Maheady, Sacca, and Harper 1987; & Anliker, Aydt, Kellams, Rothlisberger, 1997).

VI. REVIEW OF AFTERSCHOOL PROGRAMS AND SCIENCE

Science in the afterschool setting is an area ripe for investigation. "The research tells us a great deal about effective afterschool programming but not which components are good for which subgroups [e.g., gender, race/ethnicity, disability, immigrant, socioeconomic, and first language status]" (Fancsali, as quoted in Froschl et al., 2003). Other pressing factors that heighten the need for better understanding of afterschool science programs are myriad. Results over the last decade from international tests including the Program for International Student Achievement (http://www.pisa.oecd.org/) and the Trends in International Mathematics and Science Study (http://nces.ed.gov/timss/) show that American students fall behind their peers in science achievement in many countries around the world at a time when the world is becoming increasingly dependent upon science, math, engineering and technology (NCES, 1997, 2000) During the school day, science is sometimes not taught in elementary schools (or it is relegated to limited instructional time) due to a primary focus on mathematics and language arts achievement (Center on Education Policy, 2006); middle school teachers may not have strong content knowledge in science (Allen & Lederman, 1998). To achieve greater accountability for teaching science, federally mandated (NCLB) testing in science will begin in 2007. Additionally, there are an ever increasing number of students in afterschool settings.

Afterschool programs can help strengthen students' science content, skills, attitudes, and aspirations though skill development, enrichment experiences, mentoring, and inquires that intrigue, provide content knowledge and allow students to understand how science is integral to human existence. There are some data, albeit limited, that show afterschool programs' impact on students as it relates to science (Afterschool Alliance, 2001). However, most afterschool program evaluations do not focus on science. Some meta-analyses of afterschool programs have recently been completed (Kane 2004; Lauer et al., 2004) and there are many results for programs geared toward mathematics and literacy (Afterschool Alliance, 2005). Neither the meta-analyses nor the math and literacy studies are included in the summaries of programs below.

The main purpose of this review was to ascertain the impact of selected afterschool programs on students' skills in, knowledge of, and attitudes toward science. Documents reviewed were most often program evaluations because there is a paucity of experimental research available. The summary of afterschool science programs below is limited because of the scope and/or focus of the evaluation data reported by the programs reviewed. Where program evaluation data are available, there is a lack of standardization on what is reported. Evaluations of afterschool programs face several challenges as noted by Froschl, et al. (2003, p. 2).

a) keeping track of participants for a long enough time to evaluate
b) developing instruments sensitive enough to measure program outcomes and determine if changes in youth attitudes, behaviors, and knowledge result from exposure to the program or other factors such as school and home environments
c) establishing an appropriate comparison group
d) finding resources for evaluation

The lack of standardization in the programmatic evaluations used for this literature review is reflected in the variety of the summaries below. Some of the 19 program evaluations were descriptive in nature. Others sought to determine if their programs were functioning as designed and primarily reported on programmatic logistics such as attendance. Neither of those types provided insights into impact on students. Those that did report impact on students may include only affective measures (motivation, self-esteem, and dispositions toward science); most do not report changes in students' achievement as measured by their knowledge of or skills in science. Some measure student impact by changes in course enrollment (e.g., more students taking more rigorous science course). Data collection methods varied as well. Most evaluations provide results from self-reporting gathered through interviews and surveys of students, teachers/afterschool staff, and parents. In some cases, data are from teachers' observations of students. Few evaluations relied on statistical controls and nearly all are non-experimental. Many of the evaluations used in this literature review were conducted by a person or organization outside of the program itself, but a few are self-report evaluations. Often, one can only infer the impact that the program may have had on the students it was designed to serve.

Based on the reports outlined below, many believe that afterschool science programs can make a difference for students. Those who participate in high quality afterschool programs "particularly those from lower socioeconomic levels, have better peer relations, emotional adjustment, grades, and conduct in school compared to their peers who are not in such programs" (McLeod & Kilpatrick, 2001); although it was not always possible to gauge that impact on students, as it related to science, through the evaluations as they were written. However, a few clearly show, through rigorous means, significant impact on students' science knowledge, skills and attitudes. The summaries below are in alphabetical order by program name. These were identified from various sources including the Education Development Center, the Harvard Family Research Project, and the Afterschool Alliance. The descptions may provide ideas on increasing science-programming options for afterschool providers.

<u>21st Century Community Learning Centers Massachusetts</u>
The Office of Academic Support in the Massachusetts Department of Education reports in its FY2003 evaluation of the 21st Century Community Learning Centers & After-School and Out-of-School Time Programs (Resnick, Church, Surr & Miller, 2004) that more than 12,800 children and youth participated in or received services from over 258 sites across the state under its After School and Out-of-School grant program. On average children attended 66 hours of programming (with some receiving upwards of 500 hours). Data were collected from sites using the Survey of After-School Youth Outcomes (SAYO) developed by the Department of Education and the National Institute of Out-of-School Time (NIOST). SAYO surveys were collected from more than 7700 school-day teachers and over 10,000 afterschool staff members. Pre- and post-outcome data were collected from over 4,300 students in the area of math and/or English Language Arts. The results from three programs are presented below.

Through the state's 21st Century Community Learning Centers School Year Program, more than 6,000 children and youth participated receiving on average 119 hours of programming (some with over 400 hours). SAYO surveys showed youth gains in all nine of the tool's outcome areas with the greatest percentage in homework, initiative and communication skills (as rated by school-day teachers). Student gains in math and/or English Language Arts were statistically significant in 56-100% of students tested, depending on the outcome measure used. Three districts tested science outcomes; all reported a "significant increase" in students' science test scores.

In the state's 21st Century Community Learning Centers Summer Program, more than 3,000 children participated in 48 sites across Massachusetts receiving, on average, 75 hours of programming (with some receiving over 185 hours). SAYO outcomes (from over 2,700 surveys) showed positive gains in all five of the tool's outcomes areas for youth who participated with the greatest percentage improvement in the areas of learning skills, initiative, and peer relations (as reported by summer program teachers).

Through the Enhanced Programs for Children and Youth with Disabilities, 752 additional students at 66 sites participated, averaging 92 program hours per participant, over the course of the school year. Student impact from this effort was not reported.

<u>21st Century Community Learning Centers Owensboro KY</u>
According to Illback and Birkby (2001), the Owensboro Public Schools 21st Century Community Learning Center project served 662 urban students K-12 in 2000-2001 and 1,223 students in 2001-20002. The program had a number of extensive components including afterschool programs, extended day assistance, day care, parenting workshops, access to school technology for students and parents, recreation and enrichment activities, substance abuse prevention and intervention, career and employment counseling and expanded learning opportunities for Emotional or Behavioral Disorders students when school was not in session.

The evaluation sample included students, parents, teachers, staff and key informants in the Community Learning Centers; data were collected from written communication, interview/focus groups, surveys, observations and secondary sources such as student referrals in 2001. Science opportunities were less common than youth development, literacy and sports. About two-thirds (67%)of the students believed they were doing better in school as a result of participating in the program and a majority of parents (86%) felt their children were doing better in school. Teachers reported similar results to the students and the parents. A second evaluation was completed in 2002 with similar results. No specific impact on students' science knowledge, skills or attitudes was reported.

<u>4-H and the Wonderwise 4-H Project</u>
The 4-H Youth Development Program (4-H) has as it purpose to "empower youth to reach their full potential through working and learning in partnership with caring adults" (Harvard Family Research Project, n.d., p. 1). "Head, Hands, Heart and Health" are the major foci of 4H initiatives. Over 7 million students across the country participate; they may reside in rural, suburban, or metropolitan areas. They are involved in afterschool, weekend, summer/vacation programs and may receive comprehensive services support. One of the 4-H science projects is Wonderwise.

According to Frerichs and Spiegel (2003) and Spiegel, Rockwell, Acklie, Frerichs, French, & Diamond (2005), the Nebraska 4-H program spearheaded *Wonderwise Women in Science*, a 3 year, National Science Foundation funded project to disseminate science workshops and materials to 4-H partners in 10 states impacting 23,000 (52% rural and farm) youth and 6600 adults. One major focus for this project was to feature women scientists of color in a series of learning kits. The kits were disseminated by the

University of Nebraska State Museum and targeted upper elementary level classroom students. Workshops across the 10 states introduced the kits to 4-H personnel who then used them with 4-H children participants. Another goal of the project was to identify appropriate modifications to use these classroom kits more effectively in an afterschool setting. Anecdotal data indicate that the youth and adults who participated, particularly girls, found the materials interesting. Specific outcomes for children were not reported.

After-School Science PLUS

"After-School Science PLUS (AS+) (formerly Playtime is Science PLUS) takes the concepts and activities of Playtime Is Science and applies them to after school settings (Campbell & Acerbo-Bachmann, 1998)." *Playtime in Science* is "an equity-based, early childhood, parent involvement project that uses fun, hand-on developmentally appropriate science activities to bring science to a broader range of students and parents" (Campbell & Acerbo-Bachmann, 1998, p.1). The program is now being used in afterschool centers where it has increased the amount of science in the afterschool program (whether afterschool staff has received training or not). Data indicate that children who are involved in afterschool programs that use *Playtime in Science* have a more accurate understanding of the purpose of science and are more apt to say that "everyone" is involved in science (Campbell & Acerbo-Bachmann, 1998).

After-School Plus Program (Hawaii)

Hawaii's Department of Education began the After-School Plus Program in 1990 and evaluated it in 1991 (Marx & Seligson, 1991). Harvard Family Research Project (2002) indicated that the project was still in operation in 2002 with 175 sites across the state. The 1991 evaluation was a non-experimental design using survey from 168 of 171 sites. Sixteen representative sites were chosen for site visits that year. Data were collected through interviews and focus groups with children, parents, staff and other stakeholders. Evaluators spent 2 days at each site using a structured observation protocol. Also, surveys were sent to program staff for completion. (Return rate was 98%). The majority of the sites offered science activities, usually on a monthly basis in addition to other structured experiences unrelated to science. The evaluation revealed that developmentally appropriate activities and child choices were weak program areas. No other information was provided on science aspects of the program or its impact on students' knowledge, skills or attitudes in science.

Ben Carson Science Academy

In 1995, the Morehouse School of Medicine initiated the Benjamin Carson Science Academy (BCSA), a science and mathematics enrichment program for 4th through 8th graders in the Atlanta area. The goals of the Academy are to promote scientific knowledge and health careers among minority students who will, in turn, serve the primary health care needs of underserved communities. The Academy has developed an educational pipeline through which students can participate in science and mathematics enrichment, and students are encouraged to enroll in upper level science and mathematics courses upon reaching high school. The BCSA is comprised of an intensive four-week Summer Science Camp and a Saturday Academy that meets during the fall and spring. The program has a cultural component and a parental component.

Highlights from a 2002 evaluation report indicate that since 1995, the BCSA has hosted a total of 19 different sessions (8 sessions of the Summer Science Camp and 11 sessions of the Saturday Academy); participants in the program are predominantly African American, and nearly half of the participants are female. A total of 709 different students have attended at least one session with over 40% of students attending more than one session. The program has sustained continued growth since its inception. In 1995, 32 students attended the program, and in 2002, 237 students attended the program. Over the 19 sessions, the BCSA has provided over 70,000 hours of instruction to students. Participants in the program showed significant gains in knowledge of health careers after participating in the fall 2002 session (Morehouse School of Medicine, 2006).

Broward County Saturday Science Program

The Saturday Science Program in Broward County Florida began in 1989 with intent to increase science and mathematics skills in underrepresented. It has motivated students in the county and has the ultimate goal to increase minority students' matriculation at universities to study science or engineering. Saturday Science is a joint effort of the School Board of Broward County and Broward Community College, and is conducted in conjunction with a number of collaborating partners including Florida Atlantic University, Montgomery Watson and SECME (The School Board of Broward County Florida, 1999). (For more information on SECME see http://www.secme.org/ and their summary below.)

The program offers Saturday classes twice a month through its Saturday Science Program. During the fall term the curriculum emphasizes science; in the winter, the focus is engineering; environmental issues are the main thrust for the spring and summer. The classes are designed to increase skills of middle and high school high-ability minority students and to give them a competitive advantage in registering for higher level placement classes in science, math and computer science in grades 9-12 (e.g., Advanced Placement courses). Another intended outcome is to provide participants with an introduction to new career opportunities and meet role models in those careers.

Students in Saturday Science are able to have dual enrollment in their high school and Broward Community College if they meet the academic criteria. Students can earn up to 14 college credits through Saturday Science. Saturday Science students are also encouraged to enroll in SECME. In the 1998-1999 AY, the Saturday program had 24 teachers and 680 students who completed the program. Data indicate that approximately 30% of the students completed 3 consecutive years with Saturday Science between 1996 and 1999. The total percentage of students who continued for 2 years was 55%. The majority of students in the program in 1999 were Black (73.4%) followed by Hispanic (11.5%), White (7.3%), Asian (6.7%) and Multiracial (1.1%). Females participated at a higher rate (62.7%) than males (37.3%)

An evaluation of the Saturday Science Program indicated, through surveys and interviews, that most parents felt that their child had increased academic performance and confidence. Course enrollment records showed Saturday Science students to be more likely to enroll in advanced science and math courses than was typical for the district. The number of Saturday Science students enrolled in higher level courses (81%) was significantly more than non-Saturday Science students (25.2%). Similarly, almost twice the number of Saturday Science students had enrolled in Advanced Placement (AP) or International Baccalaureate (IB) courses (4.3%) than non-Saturday Science students (2.5%). Data also show that there was a statistically significant difference in student

GPAs in science courses for Saturday Science students. All surveyed students indicated intent to pursue a science or engineering major in college.

Community Science Workshops (CWS)

"Community Science Workshops are community centers devoted to providing local youth with opportunities to engage in their own project and to pursue their own firsthand learning" (St. John, et al., 2000, p.1). They are community centers that started in 1994 with funding by the National Science Foundation and are staffed by adults and older youth as a place for children (mostly 8-12 years old) as an alternative to common urban community problems like gangs, drugs and violence. In 2000 there were 12 Workshop sites throughout California. Each site is somewhat unique depending on the staff and the community but each has "exhibits" for students to investigate, "tinker with," and take apart. The sites are also sourced with a rich collection of tools and materials for experimentation. "Learning for oneself" is a key philosophical point of view in the centers. In 2000 Inverness Research Associates documented a five-year evaluation study of the centers. Data for the evaluation was collected through site visits; interviews with youth participants, parents, teachers and community members; and site director surveys. Inverness also participated in several site director workshops and special events. The statistical data reported are for the period from June 1998 through June 1999.

Slightly more than half of the children are male (55%) and many are Hispanic (61%) though the centers do service African American (19%), Asian/Pacific Islander (10%), White (6%), and Native American (4%) students. Seventy-seven percent of the children are considered "underserved" and are from low SES families (95%). Students who participate say they value having a safe place to come to after school and on weekends as they investigate with friends. They also noted the positive relationships they formed with adults. The "average" workshop site served 154 children each year through 4 different programs. Drop in programs have many (68%) of the students attending nearly every day to build and investigate. Special focus programs have a set theme or one project (e.g., dissection). Outreach programs are those that the site leaders take into the community (schools, parks, etc.) and there are field trip programs that are provided for school groups. In sum, the total participant contact hours over the time of the data collection was 192,461 hours per year (multiplying the number of children by the number of program hours).

Design It! Engineering in Afterschool Programs

The *Design It*! curriculum was developed by Education Development Center (EDC), Inc. and refined by a group of 6 science centers around the country through funding by the National Science Foundation. The program runs as a collaborative effort between the science centers and local afterschool programs. "The curriculum consists of a series of design projects that challenge children to build working models of small functional machines and toys" (NIOST, 2002, p. 7). Simple, inexpensive materials (flashlights, straws, dowels, paperclips, rubber bands, etc.) are used to carry out the designs and investigations; students are supported as they develop skills and problem solving strategies. *Design It!* collaboration teams have recognized the need for logistical planning and the training of staff members and community volunteers who are not comfortable with the investigative curriculum. No formal evaluation of the program's effectives has been done. However, the NOIST (2002) publication, *Designing Partnerships Between Science Centers and After-School Programs: Lessons from Design It! Engineering in*

After School Programs), provides valuation information on identifying partners, building a relationship with them, providing training, and funding and evaluating the partnerships.

Earth Force

"Earth Force is a national organization that gives youth the civic skills and knowledge to create lasting solutions to environmental problems in their community (Earth Force, 2004). Thirty-nine thousand middle school students participated in Earth Force programs—Community Action and Problem Solving (CAPS), Global Rivers Environmental Education Network (GREEN), and Earth Force After School—in 2003-2004. The Center for Youth and Communities (CYC) at Brandeis University has conducted Earth Force program evaluations since 1997. The 2003-2004 student surveys reveal that 74% of the students report an increase in the skills needed to effect changes in their community; 78% report a better understanding of environmental issues; 76% report that their experience was "good" or "excellent"; and 76% report that their Earth Force experience makes them want to learn more. In addition, Earth Force educators report increases in their levels of environmental knowledge (97%), increase in their belief that young people can make a difference (97%), and increase in their own commitment to improving the environment (73%). Furthermore, educators were more aware of community resources, and their satisfaction with teaching increased.

Gervitz Summer Academy

Brenner, Hurdley, Jimerson and Okamoto (2001) report that the Gervitz Summer Academy began at four elementary schools in the Santa Barbara (CA) School District in 1998 with the intent to provide enrichment curricular activities in science, math, and language arts. It was not intended to be remedial in nature. The learning opportunities were tied to the district curricular standards but used a more inquiry, hands-on, experiential learning strategy and focused on the content that the students would learn in the upcoming school year rather than review what they had just finished the previous school year. The academy utilized fieldtrips, extensive projects and practical activities within an integrated curriculum that included science themes tying each of the curricular areas together. The program was five weeks long and serviced approximately 120 students (located as 15 students per class with one teacher and one aide). The children in attendance were more likely to be eligible for free or reduced lunch than the district (district percentages were between 35% and 67%; ranges for the students in Gervitz were not reported). Similarly, the number of Limited English Proficiency students was higher than was average for the district (school LEP ranges were 27% to 67%; ranges for the students in Gervitz were not reported).

The evaluation sample (N= 221) matched student in the program using age, gender, standardized math achievement scores, language proficiency, and free lunch status with those who did not attend Gervitz (Brenner, et al, 2001). Student motivation was measured with the Children's Academic Intrinsic Motivation Inventory and a short form of the Classroom Environment Scale. Teachers were surveyed for student motivation. The size for the science evaluation was N=94. Again, data were collected from a control group. Science content knowledge was measured via released items from the Third International Mathematics and Science Study of 1996.

Brenner et al. (2001) report that students from Gervitz demonstrated increased intrinsic motivation in the fall after the summer program, and continued to be more motivated in science than the comparison group in the following spring. Students perceived themselves as more competent in science and by the third year of their participation were more likely to aspire to become a scientist than the control group. The Gervitz students showed significant improvement on the SAT9 scores; the strongest effect was found on low SES students.

<u>Girls at the Center (GAC)</u>
The Girls at the Center program is a girl-centered, inquiry-based science curriculum that grew out of collaboration between The Franklin Institute and Girl Scouts of America. It encourages family involvement in 4th to 6th grade girls' science learning. This NSF funded program provides opportunities for girls and adults to investigate the world through inquiry science activities. The At-home GAC Packs encourage active participation of families; Discovery Days events cultivate collarboative science learning between the girl and her adult partner; and Family Science Fest is a culminating event to celebrate science learning experiences (Franklin Institute, n.d.; Girl Scouts of Santa Clara County, n.d.).

<u>Girls, STEM and Afterschool</u>
This is not a specific program but, instead, is a summary of research reported by Fancsali (n. d.) on Science, Technology, Engineering, and Mathematics (STEM) Afterschool programs. Many data are available to document the gender gap in STEM beginning in middle school and continuing through higher education. This includes the number and rigor of courses taken through high school and higher education as well as the attitudinal differences about STEM subjects and occupations. The programs noted here were included in Fancsali's summary because "research and evaluation has shown some evidence of success in terms of achieving desired program outcomes" (p. 11). Interested readers are encouraged to research these programs further.

- After-School Science PLUS (previously noted in this report)
- Austin Youth River Watch Program: an afterschool program for at-risk middle and high school students focusing on the water quality in the Colorado River. Students are paid for conducting water-quality tests, making presentations on their data and providing tutoring sessions
- EUREKA!: a summer and school-year program for girls of color and from low-income families offered by Girls Inc.'s Operation Smart that takes place on a college campus.
- Fifth Dimension: a computer-based, afterschool program for elementary children. Participants progress through a "maze" of tasks, including computer games and educational activities.
- Gateway to Higher Education Program: for minority high school students for extended day during the school year. It includes a rigorous academic curriculum with specific science and math classes, information and support for college applications and internships, and enrichment experiences in science and the arts.
- Hands On Science Outreach (HOSO) is a nonprofit organization dedicated to raising children's awareness of and interest in science and math at an early age (PK-6). HOSO offers community-based, science enrichment programs for children from pre-kindergarten (age 4) through sixth grade. The programs provide activities, instructor training and hands-on materials that go home with

the children. HOSO originated in Maryland in 1980 and now registers children in 33 states, the District of Columbia and several foreign countries. The development of HOSO programming was supported, in part, by the National Science Foundation

- Mathematics, Engineering, Science Achievement (MESA): offers academic and financial counseling, student-centered classes and enrichment activities for California middle and high school students. Participants in the program were much more likely to complete advanced high school math, chemistry and physics courses than the average student.
- SAY YES to Family Math/Science: is an afterschool program for elementary children and their families in New York City run by the National Action Council for Minorities in Engineering (NACME). The goal of the program is to motivate students and parents to explore and experience math and science in a fun environment. This program has shown positive effects on parents as well as students.

National Aeronautics and Space Administration (NASA)

NASA has a significant educational outreach effort and commitment to the science, technology, engineering and mathematics education of American children. Their staff works with museums and planetaria around the country and produces hundreds of educational products including posters, activity guides, and educator guides. According to Walker, Wahl & Rivas (2005) NASA has four major initiatives: Educator Astronauts, Explorer Schools, Explorer Institutes, and Science and Technology Scholarship Programs. Most of the NASA programs are designed for middle school age students and older and most programs are designed for use during the school day. Walker, et al. recognize the need for NASA's programs to be adapted to the afterschool format in states where astronomy is not in the curriculum and cite several that show utility in afterschool. Those include the Mars Student Imaging Project which is linked directly to the Mars Odyssey Mission; the GLOBE Program, a teacher and student global project in which participants collect data and upload it to a world-wide data base; and Life on Earth…and Elsewhere? an astrobiology curriculum for middle school students.

A demonstration project from September 2003 to June 2004 selected three forms of afterschool programs to use with partners in an attempt to better understand the use of NASA materials and programs in an afterschool setting. One afterschool setting was coordinated by an independent community-based organization (CBO), a second was a public school collaborating with a CBO, and the third was a local affiliate of a national youth-serving organization. Six sites served 240 students in this pilot project. The children ranged from 6-12 years in age and served predominantly Latino and African-American populations in Brooklyn, Bronx and Queens. Data from surveys, personal student journals, and interviews in the pilot project indicate that the children had a high level of interest in science and that inquiry-based experiences were rated most highly by the children surveyed. A recommendation based on the data has been made to NASA to proceed with adapting their curricula for use in afterschool settings and to partner with organizations that can effectively provide space science experiences to children.

National Inventors Hall of Fame® Club Invention® Afterschool Program

This is a national enrichment effort for informal learning that has a developed curriculum consisting of six 5- to 8-week units. Each unit involves students for 90 minutes, once a week. Students in grades 2 through 6 engage with such topics as flight, optics, mechanics, crime solving (forensics), and simple machines. Goals of the program are to impact student science knowledge, attitudes and application of scientific principles learned.

A non-experimental collective case study method was used to evaluate the program between December 2003 and February 2004. Instructors reported that they were very pleased with the quality and completeness of the materials, the connections to classroom curricula, and the creative, inquiry investigations they prompted. Group size impacted the logistics in finishing the units, including time over-runs, if groups were too large. Data indicate that students were enthusiastic about the experiences (Harvard Family Research Project, n.d; The Bureau of Research Training and Services, 2004.).

New York City (NYC) FIRST! (For Inspiration and Recognition of Science and Technology)

Dean Kamen, inventor of the personal transportation motor-device Segway, began NYC FIRST! in 1992 to inspire students to become involved with science and technology. He dreamed that enthusiasm for science and technology within a school could rival that seen for Friday night football or basketball games. FIRST! began as a single event with 28 teams and has grown to a national event with over 800 teams competing for honors on the "technological field", complete with teams bringing their own cheerleaders and band. The core activity is a technological invention in robotics.

New York City's FIRST! effort requested an evaluation by EDC in the fall of 2002 of its program in 5 city high schools. All but one of the schools has a higher percentage of minority students than the average NYC public high school and eligibility for free lunch was reported to be 41%-82% in this sample. Key findings reported by Jeffers (2003) from 3100 student surveys showed that students reported improved skills and attitudes toward science and technology. A high level of engagement and team responsibility in NYC FIRST! students were observed. Students gained knowledge and skills in engineering, design, graphic design, mathematics, computer programming, writing, animation, web page design, marketing, and fundraising. Students also acquired interpersonal skills and critical thinking skills. Schools involved increased their visibility and image through media coverage.

San Jose Children's Discovery Museum's Discovery Youth (DY) Afterschool and Weekend Program

"Discovery Youth emphasizes young people receiving both educationally-rich content and sharing this information with others by creating digital media projects, producing videos and animations, and facilitating activities for younger children in the Museum's ZOOMZONE" (Moghadam, 2004, p. 6). Discovery Youth's purpose is to provide technological experiences to youth so that they can express their findings from a yearlong, self-managed project.

ASSESS evaluated the DY program between fall 2003 and spring 2004 by measuring 35 students with pre- and post-tests, as well as surveying and interviewing staff, parents, and a selected group of 10 students (Moghadam). A random assignment experimental design was not possible due to erratic student attendance; effect sizes were not calculated. Parents reported that students had improved technological skills such as using equipment—computers, digital cameras, & scanners—and software—Microsoft Word, Adobe Photoshop, Adobe Illustrator, and web development software. Students reported positive feelings about the program, increased self-esteem, and improved ability to interact with adults and other students.

Science Clubs for Girls

EDC (2003) reported that in 1994, the Science Clubs for Girls began as an offshoot of a parent committee from the King Open School in Cambridge, MA, which had formed to address gender equity. The purpose of the clubs is to interest girls in science and mathematics at a young age and continue to support them through middle school via informal learning experiences in physical science and engineering that are connected to real-life applications. During club meetings, women scientists from academic and medical fields participated as club leaders. In 2003 there were 35 volunteer scientists and more than 160 girls enrolled in grades K-7. There is a particular focus on recruiting girls who are not normally represented in science, i.e., those from minority populations. Each club has 8-12 girls and is led by one or two female scientist(s)/mentor(s) and one or two junior assistants (typically an eighth-grade girl). Club meetings are 9 or 10 sessions, once a week for an hour after school. Girls are offered a stipend to ensure their continued involvement. The Science Clubs provide opportunities for parents and teachers to become involved. Evaluation of this club's impact was not available.

ScienceQuest

ScienceQuest, initiated in 2002 and funded by the National Science Foundation, is a strategy for organizations around the country who want to support small groups of students (ages 10-14) in a true, 12-week, scientific inquiry. Students work with adult support to frame up a question that interests them, carry out their research and present their findings through the development of their own website. ScienceQuest provides materials to the adult coaches who help guide their students to a topic that can be researched (EDC, 2003). No results were reported for student outcomes.

SECME and SECME RISE (Raising Interest in Science & Engineering

SECME, headquartered at the Georgia Institute of Technology and established in 1975, is a non-profit organization devoted to increasing the pool of minority students prepared to enter and compete in post-secondary studies in science, mathematics, engineering, and technology (STEM). Originally SECME stood for "Southeastern Consortium for Minorities in Engineering; today it has grown beyond the Southeast and engineering. SECME now links 40 engineering universities with 107 school systems in 18 states, the District of Columbia, Grand Bahamas, and Uganda; and 70 corporate and government investors. Each summer minority students have the opportunity to participate in a summer leadership institute; parents can participate in a parenting academy; and K-16 educators can attend professional development. Partnerships include NASA Glenn Research Center, NASA/SEMAA, NASA Kennedy Space Center, National Space Biomedical Research Institute, NASA-Morehouse School of Medicine, Miami Museum of Science, and Fernbank Science Center. In addition to the summer institutes and professional development activities, SECME sponsors special competition events for students such as the mousetrap car and bridge building contests. Afterschool and day school students participate in the events. On such example is the SECME RISE (Raising Interest in Science & Engineering) project which began in 1998 and is aimed at increasing middle school girl's confidence in learning mathematics and science (Harvard

Family Research Project, n.d.-d; Miami Museum of Science, n.d.). For more information about SECME, see http://www.secme.org.

Water Educational Training Science Project (Project WET)

Project WET was designed to enhance elementary teachers' and their students' knowledge of and attitude toward science through an interdisciplinary program in water resource issues. The project, developed by Eastern Michigan University faculty was designed for use in afterschool clubs. Children in the clubs were culturally diverse and many live in poverty (Moore-Hart & Liggit, 2002). Pre-service teachers attended workshops and received curricular and experimental materials before the clubs started. The club meetings, held monthly for 75 minutes along with a host teacher from the school and the pre-service teacher(s), were geared for students from the ages of 8 to 10. Curriculum was designed around the 5E's learning cycle (for more information on the 5E's learning cycle see previous Section V. on inquiry) and included an engagement with a storytelling or reading, followed by an exploration, explanation and evaluation. Students used writing to compare/contrast, analyze and synthesize knowledge. The curriculum included literature selections and biographies of underrepresented people in science.

Moore-Hart and Liggit (2002) report that the evaluation of the Project WET, from September 1999 to May 2000, included 27 pre-service undergraduate students and 291 elementary children from 10 school districts. Data were collected through observations, interviews, surveys, student writing samples and pre- and post-science attitude surveys. Results indicate that pre-service teachers increased their science content knowledge about wetlands, improved their management and organizational skills with hands-on learning experiences, and became more familiar with the writing process and strategies to facilitate that with students. Children improved their science content knowledge on wetlands and their attitude toward science. They also improved in ability to write extended responses to scientific prompts (Moore-Hart, Liggit & Daisey, 2004).

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