Informal Science Learning in Afterschool Settings: A Natural Fit?
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Introduction:

Efforts to increase interest and achievement in STEM learning have once again risen to the forefront of concerns for the well-being of the United States in the face of an increasingly technologically advanced world. In August of 2007, the president signed into law a bill called the "America COMPETES Act," which stands for "America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science." One of its major goals is to increase opportunities for K-12 students to develop interest and competence in science and technology. In June of 2007, the American Physical Society called for doubling the number of physics majors at US colleges and universities "to address critical national needs including k-12 education, economic competitiveness, energy, security, and an informed electorate" (APS News, 2007). Clearly, the country needs to think critically about how to promote science learning among American students.

In this report we will examine the potential of afterschool science programs as a means to advance science learning and attitudes towards science among children and adolescents. We will review research on afterschool programs and their capacity to be productive learning environments, as well as more specific evaluations of their effectiveness in promoting science learning. In addition to discussing the effects of

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afterschool programs on youth who participate in the programs, we will analyze the qualities of afterschool programs that produce the best results. Together, these various parts try to produce an answer to the question whether afterschool programs that currently reach millions of children and youth across the nation could be one of the most significant delivery systems for sustained informal science learning.

In our review, we include a range of different types of studies, from those that use randomized design to in-depth ethnographic case studies. While it is often necessary for policy and funding to demonstrate clear effect sizes and conduct strict cost-benefit analyses, qualitative data is often better suited to analyzing the deeper layers of science learning taking place in programs.

On the surface the fit between afterschool and science learning appears to be clear. The number of afterschool programs has been growing rapidly as a result of increased public and private support. Meanwhile, the country is faced with an urgent need to increase science education. Moreover, there is also a philosophical overlap between the mission of afterschool time and the mission of informal science learning, both emphasizing cooperative learning and authentic, hands-on activities (Ash & Klein, 1999; Eccles, 2000, Noam et al 2003). Yet, although there have been evaluations of specific afterschool science programs, a comprehensive review of the literature on afterschool science programs is missing. Particularly in light of the growing numbers of afterschool programs and the push for more and better science instruction, engagement and interest, in the US, an in-depth examination of the evidence for science learning in afterschool programs represents an essential step. Our paper is divided into the following seven sections:

1. Defining Afterschool Science Programs
2. Theoretical Arguments for Science in Afterschool Programs
3. Evaluation of Afterschool Science Programs
4. Evaluation of Learning in Afterschool Programs
5. Best Practices in Afterschool Programs
6. Best Practices in Afterschool Science Programs
7. Conclusions and Recommendations

Defining Afterschool Science Programs

The focus of this report is afterschool programs for school-aged youth (ages 6 through 18). We tried to limit the studies we reviewed to those focusing on afterschool programs, although in some cases we expand this focus to out-of-school time (OST) because of a dearth of literature in the area of afterschool, particularly in science-specific afterschool. While afterschool, as the name implies, refers only to the time students spend in programs after the school day, OST also includes programs that take place in the time before and after school as well as during the summer. Yet there is much variance even among programs that fall in the category of afterschool science. Afterschool science programs may take place anywhere, from schools to community centers to universities, indoors and outdoors, in cities, towns, and rural areas. The time students attend can also vary greatly, some programs taking place every day with others meeting as little as a few times per month. Finally, the way students spend their time in an afterschool program can also vary. Some programs may look more like a traditional class where program leaders teach mini-lessons and students practice skills, while others may be spent conducting projects in the community to improve people's quality of life.

But even acknowledging the diversity of programs, there are certain unifying qualities that make afterschool science a unique setting a unique social practice that merits its own study. In many ways, afterschool science exists between worlds, or as we have described elsewhere for afterschool in general, as an intermediary space (Noam et al., 2003). In terms of science, it falls between the world of classroom science (the primary setting for formal science) and the world of museum science (the primary setting for informal science). In terms of approach, it falls between the world of school (with a primary focus on academics) and the world of youth development (with a greater focus on social-emotional development and engagement). We believe that it is important to carve out a place for afterschool science as its own entity, one that strategically uses its unique place in the landscape of opportunities for youth.

Although afterschool science borrows from both classroom science and museum science, it also differs from both of them in some key ways. It is generally agreed upon, at least in theory, to be less formal and more learner-directed and hands-on than classroom science (e.g., Eccles, 2003; Noam et al., 2003). But even such seemingly simple division is not clearcut, as school science classrooms can possess these informal qualities as well. Nevertheless, these are qualities that are more commonly associated with the field of informal science, which usually is housed in museum settings or science centers, than formal science. Unlike science museums, however, afterschool science programs typically serve a wider population. While schools often bring students to museums, greatly expanding their reach, these visits are usually a special event, rarely occurring more than once or twice in a year. Those who come regularly are often limited to youth who already have an interest in science or whose families bring them to museums on weekends. Afterschool programs are frequently able to reach a less privileged population. In fact, the National Center for Education Statistics found that Black, non-Hispanic children are more likely than White, non-Hispanic and Hispanic children to participate in center or school-based K-8 afterschool programs (U.S. Department of Education, 2004). While museums have greatly expanded their reach through impressive outreach programs, in-house workshop exhibitions, and even their own afterschool programs, locating informal science learning in afterschool programs across the country, as well as in museums, could allow millions more kids access to sustained informal science experiences. It should be noted, however, that although afterschool science programs and science museums are both promoting informal science learning, there are often differences in implementation. For example, afterschool science programs are more likely to employ a curriculum. Additionally, though afterschool programs usually try to allow a greater degree of student choice than schools, the activities are still far less voluntary than in a museum context.

There is also an ongoing debate about where afterschool should fall on the continuum between school and youth development settings. On one side of the spectrum, there are those who view afterschool time as part of the realm of schools and promote afterschool as an extension of school. The argument follows that in an age of accountability when many students are failing to meet state academic standards, afterschool is a time that can be used to further the goals of schools by working to furnish students with the content and skills need to meet those standards. On the other side of the spectrum are those who view afterschool as part of the realm of youth development. Under this perspective, afterschool's purpose is to ensure the healthy development and well-being for the children and adolescents in its care. This means developing personal and social assets in physical, intellectual, psychological, emotional, and social development domains (Eccles, 2003). The focus in programming is much more on providing a physically and psychologically safe environment with supportive relationships and a sense of belonging and less on the acquisition of specific skills and knowledge. In fact, in some ways the division has become much more extreme than might seem necessary based on the missions of school and afterschool. Many schools deeply value the social-emotional development of their students and understand the importance of a safe environment and supportive relationships are in any setting for youth. Unfortunately, particularly in the face achievement tests that are linked to schools' funding and survival, it becomes more and more difficult for schools to find the time and resources to focus on anything that is not directly connected to academic achievement. At the same time, although in theory intellectual development is a component of youth development, many in the field have turned away from academic learning as a result of the political climate that places such a strong emphasis on test scores. In this environment, the focus on academics quickly overshadows attempts to focus on other domains that are important to youth development. In an attempt to preserve their identity and values, many proponents of youth development have turned their backs entirely on academic learning to focus solely on physical, psychological, emotional, and social development.

In terms of afterschool science programs, this division translates into a debate over what the intended outcomes of such programs should be. Those who view afterschool as part of the territory of schools aim to see the focus on raising students' grades in math and science classes and their standardized test scores in the same subjects. Those who view afterschool as part of the territory of youth development aim to see the focus on developing students' self-efficacy, confidence, and interest in science.

Yet we propose that both of these approaches overlook important products of afterschool science programs. Instead of focusing only on school measures of academic achievement that are not really under the control of afterschool staff or abandoning the process and content of learning altogether for a focus on interest and attitudes, afterschool programs can focus on whether students are acquiring useful scientific skills and understanding tied directly to the teaching and learning that occurs in afterschool programs.

If we are seriously recognizing afterschool as a different space than school and youth development settings, then it should be evaluated according to its individual goals. The challenge is for afterschool science programs to create intentional learning goals, informal in nature, but solid in terms of science, and then for evaluators to find a way to assess students' achievement of these specific goals. These assessments may take the form of tests that specifically target the program learning goals or they may make use of performance-based assessments or portfolios where students produce evidence of their skills and understanding through more authentic tasks than traditional tests allow. Under this model, it is important that evaluations be chosen according to individual programs' expected outcomes instead of more distant measures of program effectiveness.

We believe that by measuring specific, high-quality science learning that takes place in programs, afterschool has the opportunity to cut across the debate between school-based measures and youth development measures of program effectiveness. Moreover, this approach can reconcile the two perspectives by focusing on the development of academic skills in an environment that is in line with youth development principles and measuring. In fact, by establishing afterschool science programs as a delivery system for high quality informal science education, afterschool programs cannot help but embrace youth development philosophy, since informal science education and youth development emphasize similar principles.

Theoretical Arguments for Science in Afterschool Programs

We described earlier that there is much overlap in the philosophies of afterschool programs and informal science education. Youth development literature describes positive youth development and afterschool settings as student-centered with ample opportunities for belonging and relationship-building. They are also settings for skill-building that are authentic and hands-on (e.g., Eccles, 2003; Noam et al., 2003). Similarly, characteristics of informal science include being hands-on, learner-directed, interactive, in the context of a social group, and consisting of cooperative activities and real-world tasks (e.g., Ash & Klein, 1999). Informal science settings ideally are places where students can together engage in authentic scientific inquiry and discovery that can lead, not only to discoveries about science, but also to discoveries about self and others. As a report from the National Conference on Science After School states, “There is a tremendous synergy between the goals for youth development...and those of inquiry-based science education. In both cases, students are at the center of the learning and development process. Students engage with the world in authentic ways, grapple with real-world problems, and develop conceptual understanding through interactions with peers and adults" (Coalition for Science After School, 2004).

The strong overlap of philosophy and goals can also be seen in an increasing number of studies in science learning that are showing the importance of connecting science learning with students' lives. This is particularly true when working with low-income and minority youth. One of the major obstacles to teaching science in the United States is students' perception of science as disconnected from the reality of their worlds and therefore impractical and boring. Though most scientists would agree that the purpose of science is to help explain the world we live in, students often view science as existing as an abstraction in the science classroom, having little or no bearing on—and therefore no use in—the world where *they* live. This perceived disconnection between the classroom and students' worlds outside school can lead students to disengage from school science altogether. (Bouillion and Gomez, 2001). This state of affairs that is far too common in schools around the country appears to be contributing to the alienation and lack of interest in science and science careers demonstrated by many American students.

For this reason, researchers in science education are calling for a method of teaching science that intentionally connects science to students' lives. In a study of students' perceptions towards science, Zacharia & Calabrese-Barton (2003) examine students' attitudes towards "Critical School Science," a model where scientific concepts arise from community problems, and teaching and learning science involve taking action to address those problems. They found that in a school with mostly minority and low-income students, students felt positively towards Critical School Science, but negatively towards more traditional models of science, while in schools with lower percentages of minority and low-income students student felt positively towards both types of science. This study indicates that making science more deeply embedded in community issues could increase students' interest in science, particularly among students in disadvantaged communities. Moje et al. (2001), documenting the clash between competing school and community discourses in a science classroom, argue for the necessity of constructing a "third space" for science learning that bridges the classroom and the community. They state, "In many ways, the construction of congruent third spaces in classrooms requires the deconstruction of boundaries between classroom and community, especially for students who are often at the margins of mainstream classroom life." Moje et al. recommend bringing together students' home lives and school lives by creating spaces where students' everyday Discourses are intentionally brought into the classroom to enhance scientific learning instead of to compete with it.

The attempt to bridge students' school-world and home-world resonates strongly with the field of youth development, as well as the field of afterschool. Afterschool programs are in a unique position to exist as an intermediary space, navigating between schools, families, and communities (Noam, 2001; Noam, Biancarosa, Dechausay, 2003). John and Leacock (1979) argue that teaching and learning can often be more effective when taking place in the community instead of schools precisely because they can occur without involving a conflict between incongruous worlds. By situating itself in the afterschool setting, science greatly increases its capacity to meet its goal of connecting to students home and community lives. For one, afterschool programs are frequently physically located in community organizations instead of in schools. In addition, because afterschool programs are often less formal than schools, they are at greater liberty to invite families and communities to participate in programming (Noam, Biancarosa, Dechausay, 2003). Moreover, afterschool programs' emphasis on cooperative learning is frequently more culturally attuned to students' of Latino, Native American, and African-American backgrounds, whose cultures can clash with the individualistic, teacher-centered nature of most schooling in the United States (Au, 1980; Davidson, 1999; Erickson & Mohatt, 1982).

Yet the link between afterschool and informal science learning extends even beyond parallels between philosophy. Each field has certain needs that can be filled by a mutual alliance. Typically, afterschool is looking to include a focus on academics but to avoid becoming an extension of school. Informal science, with its focus on hands-on, cooperative learning, is a perfect opportunity for afterschool to support academic learning, without sacrificing their mission of promoting social-emotional, cognitive, and physical development in their participants. The field of informal science can also benefit from the partnership. Informal science has long been housed primarily in museums but is looking to expand its reach to a space where people could interact with science in a more consistent, extended time frame. The afterschool setting provides a place where informal science can have a greater impact (through higher "dosage") without losing its informal feel. Lucy Friedman, president of The After School Corporation, writes, "While both the afterschool and science fields are at a crossroads, association with the other enhances the potential for each to flourish" (Friedman, in Walker et al., p. 75).

It has also become more important to find new venues for science learning as time spent on science in schools decreases. A report conducted by the Center for Education Policy found that, as a reaction to high stakes testing in math and literacy under NCLB, 28% of elementary schools had cut science class time an average of 75 minutes per week in order to increase instructional time in mathematics and English (McMurrer, 2007). In districts where at least one school was identified as in need of improvement under NCLB, these figures jump to 43% of schools cutting science an average of 91 minutes. Even when science is included in high stakes testing (as it is expected to be in the upcoming year), it will more likely result in increased time spent on test preparation than increased time spent on project-based learning and exploration. In the same study, researchers found that most schools reported revising their curricula to focus on the material covered in the state tests and including test preparation as a reaction to the tests. In light of these developments in the realm of school science, it becomes increasingly important that we offer students additional settings where they can experience science in different ways.

Unfortunately, historically, relationships between school and afterschool programs—particularly community-based afterschool programs—have often been characterized by mutual mistrust and conflict. In a report based upon 10 years of research studying approximately 120 youth-based community organizations throughout the United States, McLaughlin (2000) explains, “Adults working with youth organizations frequently believe that school people do not respect or value their young people. Educators, for their part, generally see youth organizations as mere “fun” and as having little to contribute to the business of schools. Moreover, educators often establish professional boundaries around learning and teaching, considering them the sole purview of teachers." If we want to better serve our youth, there is an obvious need for rethinking the relationship between schools and afterschool programs, particularly for afterschool programs that have an academic focus such as science afterschool programs.

In *Afterschool Education*, Noam, Biancarosa, and Dechausay (2003) outline different models of relationships between schools and afterschool programs in an effort to create better relationships, management connections, and interesting curricula and materials. On one extreme, there is the model of "unified" programs that are the equivalent of what is now called extended day programming. Under this model, afterschool can become essentially indistinguishable from school since they take place in the same space and are usually under the same leadership (of the school principal). On the other extreme lie "self-contained" programs. These programs intentionally choose to be separate from schools or under the roof of non-school organizations. They take place in a different location and provide students often with an entirely different experience than school. Between these two extremes lie three other models: "associated," "coordinated," and "integrated," each connecting afterschool with schools at different levels of intensity. Noam et al. also outline the different ways these connections can take place, dividing them into interpersonal, systemic, and curricular domains. The curricular domain is perhaps the most significant one in our discussion of relationships between afterschool science and school science (although it is obviously influenced by factors such as physical location, philosophy, and interpersonal relationships). We can use these models of afterschool-school relationships as a foundation for more specific models describing the spectrum of relationships between afterschool informal science and school science. We propose three basic types for this relationship.

Under our first type, the afterschool curriculum is closely connected to the school curriculum. Afterschool coordinators and staff know on a week-by-week basis the material teachers are covering in class and can directly connect it to afterschool activities. Afterschool science is essentially an extension of school science but with a more informal feel. The benefit of this model is that afterschool and school science are integrated and the connection between the two is explicit. Under the second model, afterschool science programs connect their activities to the general school science curriculum and standards but not to what students are learning in class on a daily or weekly basis. This model avoids some of the ideological differences between the formal science of schools and informal science of afterschool programs, while allowing afterschool to support students' learning in schools. It also has logistical benefits, since it does not require the same level of planning and day-to-day communication between schoolteachers and afterschool staff. Finally, under the third model, afterschool science is entirely disconnected from school science. Afterschool should make sure that participants are engaging in high-quality science experiences, but it is actually undesirable for students to connect afterschool science to school science. By keeping the two worlds separate, afterschool programs can provide students with an alternate entry point into science if they have already been turned off from school science.

All three of these models can result in highly successful afterschool and science programs. However, it is important that afterschool science programs choose which model to employ with a clear understanding of what are the benefits of each and what is required for successfully implementation. Moreover, an awareness of which model of relationship they are employing can allow them to take full advantage of the benefits of that particular model. In our review of afterschool programs, it appears that most programs fall under the second model, teaching towards general school science standards without connecting to specific classroom lessons. This is perhaps because it is a way afterschool science programs can support school science while avoiding the conflict or competition that may arise between school and afterschool programs when they become more closely connected, as well as the high level of planning and coordination that is required for close collaboration.

Evaluation of Afterschool Science Programs

There are many reasons to believe that science learning and afterschool have much to gain from coming together. But what is the evidence that the union is working? Is there research evidence of science learning occurring in out of school time?

There are currently a very limited number of peer-reviewed journal articles evaluating science-focused afterschool programs. But it is significant that an increasing number of programs are devoting a significant amount of resources to commission independent evaluations. The following discussion of the evidence includes a combination of such evaluations and of peer-reviewed studies. Moreover, since the literature on science learning in afterschool programs is sparse, we will include in our review some studies that examine "out-of-school-time." Out of school time consists of afterschool programs as well as summer programs. It should be noted, however, that there are obvious differences in the time and intensity of summer programs (usually involving full days and sometimes nights) versus afterschool programs (typically 2-3 hours per day).

Even with limitations in quality and quantity of the research in science learning during afterschool, the evidence that we do have is extremely promising. Studies show that afterschool programs can have positive effects on participants' attitudes towards science, their grades, test scores, and graduation rates, and their specific science knowledge and skills (Gibson and Chase, 2002; Building Science and Engineering Talent, 2004; Frochl, 2004; Project Exploration Youth Programs Evaluation; Ferreira, 2001; Harvard Family Research Project; DeHaven and Weist, 2003; Jarman, 2005; Campbell et al., 1998, as cited in Fancsali, 2002; Building Engineering and Science Talent, 2004; Brenner et al, 2001; Johnson, 2005; Fusco, 2001; Jeffers, 2003).

The evaluative research on afterschool science programs reflects the current controversy over whether afterschool programs lie in the realm of youth development or the realm of school, or somewhere in between. Evaluations conducted from more of a youth development/informal science perspective focus largely on participants' attitudes towards science, measuring levels of interest in science and science careers, confidence in science, and sense of self as a science learner (Gibson and Chase, 2002; Building Science and Engineering Talent, 2004; Frochl, 2004; Project Exploration Youth Programs Evaluation; Ferreira, 2001; Harvard Family Research Project; DeHaven and Weist, 2003; Jarman, 2005). Evaluations coming from a school perspective are more focused on school-based measures of STEM learning, such as standardized test scores, grades, and graduation rates, and continued involvement in school science in high school and college (Campbell et al., 1998; Building Engineering and Science Talent, 2004; Brenner et al, 2001). Finally, a third model that has yet to be developed in great depth but that we will argue is perhaps the most appropriate for science learning in afterschool time, is one that measures, quite specifically, if high-quality science learning is taking place (Johnson, 2005; Fusco, 2001; Jeffers, 2003; Saltz et al., 2004). It focuses on the extent to which students are participating in authentic scientific activities, learning science skills and habits of mind, and making sense of the physical/natural world. This model cuts across the division between a youth development orientation and a school orientation. Instead of turning its back on learning and academics altogether, as has been a common reaction in the youth development world, this model acknowledges that academic learning has a place in afterschool. Yet, it avoids turning the focus to raising grades and test scores, which can very quickly consume a program's mission and leave little space for anything else. For this third type of programming and assessment there is very little data so far and we will return to this point in our concluding section.

Evaluations of Science Afterschool Programs from a Youth Development Perspective

We will begin by reviewing studies that evaluate students' attitudes towards science. For many programs, a central tenet in their mission is the goal of increasing interest and confidence in science. This is an important goal, considering that in the United States, all students, but particularly urban students, show low levels of interest in science and that interest in science decreases in middle school and high school (Zacharia and Calabrese-Barton, 2003). Improving students' attitudes towards science can have a significant effect on those students' lives. This phenomenon is perhaps best exemplified in the words of a student who participated in Project Exploration, a youth science program focusing particularly on groups that are traditionally underrepresented in science. Hasson, a 16-year-old student who had spent a year in the program stated, "I already feel successful. [Participating in Project Exploration] feels like an accomplishment already. If I can do this, what else can I do? I think I have a future in science. Before, I didn't really think much about it" (Project Exploration Youth Programs Evaluation, 2006). Clearly, increasing interest and confidence in science is an important outcome of science focused out of school programs and one that should be included in program evaluation.

Gibson and Chase (2002) conducted a controlled study that focused on the outcome of sustained interested in science. The study examined the effects of a 2-week long summer science program for middle school students that employed inquiry-based instruction. Using stratified random sampling they selected a group of students to participate in the program, a group of students who applied for the program but were not selected to participate, and a group of students who did not apply to participate in the program. By following these groups over a 5 year time period they were able to determine not only if the 2-week program had an immediate effect on participants' attitudes towards science, but also if this interest was sustained over time. This was particularly important in light of the well-documented fact that interest in science decreases in middle school and high school among students in the United States (Zacharia and Calabrese-Barton, 2003). Gibson and Chase found that in all three groups interest in science decreased over the 5-year period of time. But they found that students who participated in the 2-week science program retained a more positive attitude towards science and higher interest in science careers than the other two groups. In fact, while at the start of the study both groups that applied to the program had the same level of interest (above the level of those who didn't apply), by high school the group who had applied but not been selected to participate in the program had the same level of interest in science as those who didn't apply at the start. In this study we see evidence of a cause-effect relationship between participation in an out-of-school science program and long-term interest in science and science careers. The report focuses on the role an inquiry-based approach to teaching science played in increasing students' long-term interest in science. In interviews conducted with participants several years after they complete the program, students pointed to the hands-on, inquiry-based nature of the program as what they best remembered and what they most enjoyed. Participants described their memories of collecting tadpoles and bugs in a pond and dissecting frogs, sheep's brains, and cows' hearts and "having fun" with science. But the program did more than just providing students with fun activities. These activities were carried out in a context that encouraged inquiry-based learning. 32% of students interviewed noted how the staff created a positive atmosphere for learning, an atmosphere where they felt comfortable asking questions and voicing opinions. One student explained, "You get to talk to people, discuss things, explain your ideas, you have an opinion, you speak about it, and you have freedom. Learning is fun if you're in the right environment."

A large number of other studies also indicate that participation in STEM-focused programs leads to more positive attitudes towards science, particularly among girls. For example, several non-comparative studies on Operation SMART, a STEM-focused afterschool program for girls aged 6-18, showed increased levels of confidence and comfort with math and science immediately after the program (Building Science and Engineering Talent, 2004). Like the program discussed above (Gibson & Chase, 2002), Operation SMART's curriculum consists of hands-on, inquiry-based activities such as using forensic skills to discover a crime, mapping the food chain by dissecting owl pellets, or learning the science behind lip gloss and body glitter. Project Exploration, an afterschool program that primarily serves groups underrepresented in the sciences—80% low-income, 90% minority, and 73% female—has remarkable statistics on their participants' sustained interest in science: 25% of all their students and 35% of their female students major in sciences in college (Frochl, 2004; Project Exploration Youth Programs Evaluation). Project Exploration serves students in the Chicago Public Schools, and an alliance with the school district appears to be strategic in allowing its services to reach a traditionally underserved population. Based on data from focus groups where students were asked how they first heard about the program, teachers appear to be primary source. Project Exploration programs include a variety of different types of out-of-school support, from classroom instruction, to authentic, hands-on projects, to mentoring services. For example, in the Junior Paleontologists program, students participate in 2 weeks of classroom work at the University of Chicago and then go on a paleontology field research expedition in Montana for a week. In addition, during the school year they receive mentoring, tutoring, and leadership development opportunities throughout high school.

Other programs choose to focus on a specific feature that they believe to be key in increasing attitudes towards science, mentoring appearing to be one such feature. In a program in which African-American middle school girls worked on projects with female engineers, a study revealed that participating girls held more positive attitudes towards science class and science careers after participation in the program (Ferreira, 2001). This study emphasized the importance of female mentors in STEM fields in changing the girls' attitudes towards science (with the caveat that to be most successful mentors must not only have subject-area expertise, but also have pedagogical knowledge of cooperative learning strategies). Two other studies of summer science programs for girls showed similar positive results. An evaluation of SECME RISE (Raising Interest in Science & Engineering), a 3-year study aimed at increasing middle school girls' confidence in math and science and decreasing the attrition in high level math and science classes that occurs during the transition from middle school to high school, reported that 86% of participants planned on pursuing careers in STEM and 52% had changed their career plans as a result of their participation in SECME RISE (Harvard Family Research Project). Again, an important component of the program was that each participant was given a female mentor, most of whom were Latino and African American college students studying engineering. These mentors were described as functioning as big sisters or moms to the girls, and many participants explained that seeing female engineering students were "attractive young ladies who wore nice clothes and had boyfriends" changed their perception of women in science. Another study of a summer math and technology program for Girls Math and Technology Program for middle school girls that placed a similar emphasis on female role models also showed increased confidence in math based upon pre- and post-test data (DeHaven and Weist, 2003).

Evaluations of Science Afterschool Programs from a School Perspective

There also are some studies that approach afterschool evaluation from the perspective of schools and evaluate afterschool programs based upon changes in school-based measures such as test scores, grades, and graduation rates. Studies of the following programs have shown positive effects using school-based measures. It should be noted, however, that none of these programs are purely afterschool programs. Both of the programs that take place after school (as opposed to during the summer) also include in-school components (such as separate classes). Although far more data is needed before coming to any conclusions, this could indicate that for afterschool science programs to significantly affect school-based measures, it may be necessary to include school interventions as well as afterschool interventions.

One study that looked at school-based measures was an evaluation of Gateway, an afterschool math and science program for minority high school students (Campbell et al., 1998). Gateway falls under an extended day model of afterschool, but it also includes components other components, such as academic summer programs and separate mathematics and science classes during the school day that consist only of Gateway students. The study of Gateway included a matched control group of students who were not in the program. They found that participants had greater high school graduation rates, better SAT scores, and were more likely to take Regents exams in math and science classes than students in the control group. 92% of students who completed Gateway's high school program attended college. They also tend to go to college where the mean SAT scores are higher than their own scores. Although Gateway's results show that programs supporting schools can have significant effects on important school-based measures, it is important to note that, since Gateway consisted of many different forms of support (afterschool, summer, and in-school), we cannot attribute the effects solely to the afterschool component of the program.

Another program that was evaluated based on grades and standardized tests was the MESA (Mathematics, Engineering, Science Achievement) Schools Program. This program is designed to assist underserved students in middle and high school to be successful in math and science studies towards the end of increasing numbers of students from underrepresented ethnic groups to pursue careers in mathematics-based professions. The program included components such as academic tutoring and counseling, peer supports (such as study groups and scheduling the same classes), field trips, and summer internships and campus-based summer programs. The results of a study conducted in 1982 showed that MESA students had higher grade-point-averages than non-MESA students and that by senior year, MESA students had taken more mathematics and science courses than non-MESA students. Interestingly, participants had higher verbal but not mathematics scores on their college entrance exams (Building Engineering and Science Talent, 2004).

A 3-year evaluation of an academic summer program examined the programs' effect on student attitudes as well as on standardized test scores (Brenner et al., 2001). The program, called the Gervitz Summer Academy was an experimental summer academic enrichment program. The Summer Academy resembled school classes and taught to district curricular standards, but in a more experiential and integrated way than most school curricula. They used science as a unifying theme to teach language arts, math, and science. In the evaluation, they found significant differences in interest in science and science careers and confidence and motivation in science. There were also improvements in students' science test scores (SAT9), but not in students' math test scores. In addition, they failed to find significant differences in a study that compared the change in students' test scores to a control group (with exception of students of limited English proficiency in their second year where they did find significant results). Although the overall lack of apparent effects could be simply due to problems in the study where the control group changed significantly over the course of the 3-year study, the report also points to the limitations of using standardized tests as a measure of the learning that took place in the program. They explain, "It was mandated by the school district and the funding agencies that we had to use standardized test scores as documentation of the benefits of the program. It is somewhat unrealistic that a five-week program would be able to greatly influence the scores on a test that is designed to measure a school year of learning." They also point to the fact that the SAT9 tests, particularly the mathematics test, focused on basic skills when the program curriculum was geared towards conceptual learning and the integration of math, science, and language arts.

The problem of using standardized test scores as a measure of afterschool learning is also noted by Kane (2004). He discusses the question of what are reasonable expectations of test impact for afterschool programs. He points out that an entire year of classroom instruction is estimated to raise achievement test scores a quarter of a standard deviation. By this measure, an afterschool program providing students with an hour of instruction 5 days per week could be expected to raise test scores .05 standard deviations (assuming there is 100% attendance everyday). The Gervitz program chose to focus on a limited number of curricular standards given the short amount of time that they had (5 weeks), but as a result only a few questions on the standardized test pertained to the material they had covered. In the third year of the program the teachers decided to design a mathematics test based on their own curriculum and found positive gains in the students' scores.

Evaluations of Science Afterschool Programs from an Afterschool Perspective

The teachers from the Gervitz program decided to move from model of measuring afterschool learning effects based upon traditional school-effectiveness measures such as standardized tests to the third model we propose: evaluating afterschool science programs using measures that are more closely aligned with the science learning that was actually occurring in the program. Although there were very few peer reviewed journal articles evaluating programs based on such measures, there are a growing number of unpublished independently commissioned program evaluations that show specific learning students acquired in afterschool programs, measured through interviews and surveys with students and teachers, pre-and post-test data, and observations.

An evaluation of Kinetic City After School (a program developed by the American Association for the Advancement of Science) assessed the specific science content knowledge that students took away from the afterschool program (Johnson, 2005). The program is based on Project 2061: Benchmarks for Science Literacy learning goals and pedagogy. It includes a variety of research activities and hands-on activities and games as well as an interactive website with science adventures, all geared towards the science benchmarks. The program assessment contained a pre- and post-test based upon the programs learning goals (Johnson, 2005). They also had the students complete a creative writing activity based on a science reading and incorporating their understanding of the scientific concepts covered in the program. Mean scores for both components of the evaluation increased after completion of the program, indicating that students did acquire content knowledge as a result of participation in the program. In a follow-up controlled study, Johnson compared the effects on program participants who had access to an additional computer-based component of the program (the Kinetic City website) and program participants who did not have access to the computer component. In the study, students at three sites were able to use the website while students at one site were not. They found that the inclusion of the website component of the program led to significantly greater positive impact on students' science knowledge.

An evaluation of NYC First, an afterschool robotics program for high school students in New York Public Schools, examined the learning that took place in the program, looking at learning for learning's sake, without attempting to connect it to curricular standards or test scores (Jeffers, 2003). Based on observations and extensive interviews with students, teachers, mentors, principals, they assessed student learning. It should be noted, however, that the learning Jeffers documents was mostly self-reported. In NYC First, students developed knowledge and skills in a broad range of areas including engineering, computer programming, graphic design, web design, and marketing and fundraising, depending on their role in the team. Moreover, through participation in the program students also developed critical thinking, interpersonal skills and leadership skills. Through interviews with students, it became clear that cooperative learning was taking place in the program. The report states, "Students consistently reported that whenever a team member was interested in something they didn't know how to do, the more skilled students would teach them, as would coaches and mentors." The report also describes specific learning they observed in one team: "When one team was working on variations of their drive train, for instance, one of the participants set out to learn spreadsheet software and used it calculate and compare the effects of different gear ratios. Students rarely seemed to be focused on learning for its own sake, but, instead, were motivated by the desire to complete the task at hand." Although knowledge of spreadsheets would hardly come up on a standardized test, it is clearly an example of significant learning taking place.

A study conducted in New York City in 2001 examined the learning that takes place in an afterschool program run out of a low-income housing facility (Fusco, 2001). Using a "Critical Science" model (in the language of Zacharia & Calebrese-Barton), the students developed and implemented a plan to turn an empty lot into a community garden. Instead of evaluating learning based on test scores, Fusco used a product-oriented model of assessment, comparable to portfolio assessment in schools. She showed how different steps the students took during the community garden project served as evidence of meeting a variety of middle school science performance standards including standards relating to science connections, scientific thinking, scientific tools and technology and scientific communication. This method of completing projects that demonstrate various competencies has long been used in special education classrooms, but is increasingly gaining respect as a valid way of assessing learning in all settings. It seems particularly appropriate for the afterschool science setting with its focus on project-based learning.

A study of Service at Salada, an afterschool science service-learning program for middle school students, took an approach that we believe to be an effective way of evaluating science afterschool programs (Saltz et al., 2004). What they chose to measure was framed by the expected outcomes of the program. These outcomes included: "The students will be able to implement a scientific protocol, explain the restoration process of the Salt River, create a map to meet the needs of an investigation, use GPS and other E-technologies to conduct investigations, as well as write up, present, and defend their results." Another stated, "The students will be able to demonstrate responsibility in a working group and positive attitudes about community service, identify decision makers in their community, and show an awareness of urban ecology issues." They then created observation inventories, focus groups, and student surveys that were designed to measure if these specific outcomes were being met. Based on this report, all of these student outcomes were met. These outcomes also are a strong example of how afterschool science programs can embrace science learning alongside youth development principles, and how evaluations can avoid the division between school measures and youth development measures by evaluating programs based on the specific learning goals programs set for themselves.

The current research on the effects science-focused afterschool programs is clearly encouraging about the role afterschool programs can play in promoting STEM learning. Moreover, as a venue for informal science learning that reaches a much broader population of youth and for more sustained periods of time than traditional informal science venues (such as museums or science centers), these encouraging results about afterschool's role in STEM learning take on an even greater significance. There are numerous studies showing that afterschool science programs can have a strong impact on interest in science and science careers among children and adolescents. Studies also indicate that select programs have achieved some degree of success in influencing graduation rates, grades, and test scores, although the evidence in this area is not as strong. Finally, afterschool science programs have the capacity to provide youth with opportunities to engage in high quality, challenging science that result in STEM learning. Evaluations show that through participation in science afterschool programs students have increased science content knowledge, learned scientific skills, and developed their ability to think scientifically. Yet the field of study of afterschool science programs is still young and quite immature. Based on the existing literature, it definitely holds great potential. Yet if we want to take full advantage of the potential afterschool holds to increase STEM learning in the United States, it will be necessary for the field not only to greatly expand the body of literature, but also to clarify what are the outcomes that we are hoping to achieve. We believe that focusing the outcomes on the specific science learning that takes place in the each individual program (as opposed to placing the focus on standardized test score or interest in science careers) is the most fertile ground for afterschool science programs. By doing so, afterschool science programs can cut across the debate between school-based outcomes and youth development outcomes and take advantage of afterschool's unique place in the world of youth and education.

Evaluation of Learning in Afterschool Programs

We have discussed the evidence for informal science learning in afterschool programs and the various outcomes that have been demonstrated. We will now turn to the setting of afterschool itself and examine what kind of learning outcomes the setting has produced. A working knowledge of the potential of afterschool as an effective large-scale setting for learning to occur can inform our understanding what we may expect from afterschool science programs as they expand their reach. The study of afterschool is also more developed than the study of science afterschool programs and therefore we have access to more complex meta-analyses as evidence instead of solely relying on individual program evaluations (although, as we will discuss, the field of afterschool is also quite new and still in the process of growing).

The bulk of the research on afterschool programs has occurred in the last two decades. This increase in research corresponds with a rise in governmental and public support of afterschool. Politicians, parents, and educators are increasingly viewing afterschool programs as an important developmental context in American childhood and adolescence. Federal funding for these afterschool programs has also surged recently. Funding for the 21st Century Community Learning Centers (CCLC: federal programs providing afterschool care) rose from $0 in 1994 to $40 million in 1998 to $1 billion in 2002 (U.S. Department of Education, 2003). Most recently in 2007 the House of Representatives voted to increase funding to $1.1 billion (Afterschool Alliance). Along with this increase in funding, there has been an increase in participation of afterschool programs. In 2005, 40% of all students in grades K-8 were in at least one weekly non-parental afterschool care arrangement (National Center for Education Statistics). School-based or center-based programs were the most common afterschool care arrangement, at 20%. With such a broad reach, afterschool holds the potential to provide, on a large-scale, enrichment opportunities that were once reserved only for those whose parents had the means to provide them. In fact, at the 21st Century Learning Centers, more than half the participants are of minority background and from low-income schools. Furthermore, those students who attend most frequently are more likely to be black, from single-parent homes, low-income, and on public assistance. This means that afterschool programs often have access to the most at-risk populations.

Despite the fact that the surge in attention and the federal funding for afterschool initiatives is a relatively new phenomenon, afterschool programs have been present in many American schoolchildren's lives for quite some time, first emerging at the end of the 19th century. But throughout the years, afterschool has been recreated time and again to serve different purposes, adapting to the perceived needs and concerns of various time periods. These purposes have included protection, enrichment, socialization, acculturation, problem remediation, and play (Halpern, 2002).

A confluence of elements has led to the most recent increase in interest in afterschool. The advent of welfare reform—demanding that women to leave their homes and work—put pressure on the government to provide a safe place for children to spend time while their mothers were at work. Others embraced afterschool for its potential as an enriching environment that could equalize the playing field between children of low-income and high-income families. Now in the face of No Child Left Behind policies and many students who are not meeting state standards, afterschool is an opportunity to provide students with the extra support they need to be successful in a world of high stakes testing (Lauer et al, 2004). In fact, under NCLB, students who fail to meet benchmarks are eligible for supplemental educational services (SES) during out-of-school-time, encouraging the use of OST as a means to raise test scores. Politically, afterschool has become a bipartisan issue that representatives of all parties are proud to claim as their own.

Currently, people are looking to afterschool programs to increase test scores, close the achievement gap, increase students' motivation levels, and prepare students with the skills necessary for success in our 21st century workforce. In fact, in some ways, the initial excitement over the potential of afterschool led people to expectations that were not entirely realistic, expecting afterschool could achieve in 1-2 hours per day what public schools have not been able to accomplish in 7-8 hours per day. Moreover, these expected outcomes were often not aligned with program goals. Yet afterschool can make up a significant amount of time in a child's experience, often 10-15 per week and, perhaps more importantly, it is a unique setting that offers a different environment and therefore different possibilities than the traditional places children spend time: home, school, and possibly the street.

Before we discuss the effects of afterschool programs, we want to briefly describe what a generic afterschool program might look like. In general, the way afterschool programs structure their time is quite similar. Usually there are three main blocks of time: one devoted to homework help and tutoring, one consisting of enriched learning experiences (such as journalism or service-learning) that are not necessarily connected to school, and one filled with non-academic activities such as sports, arts, or play (Noam, Biancarosa, Dechausay, 2003). As an informal setting where students can learn, explore, and discover outside of the formal classroom context, afterschool programs have the potential to be a valuable component of the education provided to our nation's children. But it is important to critically examine the research that has been performed on afterschool programs to discern what exactly afterschool can realistically hope to achieve and how it can be most effective. So what is the evidence for learning in afterschool programs?

In 2003 the Nellie Mae Foundation published a report by Beth Miller on the effects of afterschool on early adolescents (10-14 years old). The report used data from a variety of studies including qualitative and quantitative studies and those with and without control groups, while incorporating developmental theory. In the report, Miller explains that there are a variety of ways that participation in afterschool programs can promote school success including: 1. Engaging in activities that allow them to learn new things and practice knowledge gained in school 2. Engaging in reflection, planning, decision-making, and problem-solving, 3. Increasing the sense of themselves as learners, 4. Building meaningful relationships with adults, and 5. Finding a "border zone" between the cultures of home and school. Based on the studies she reviewed, Miller found that afterschool programs can have a positive effect on academic performance, motivation to learn, social skills, and risky behaviors such as drug and alcohol use. She also pointed to an important finding about afterschool. Generally, in afterschool programs, "those who need the most benefit the most." Students with infrequent school attendance, low test scores, Limited-English-Proficiency students, and low-income students have been shown to reap the greatest benefits, particularly using school-based measures such as test scores and attendance. If participation in afterschool programs can support these vulnerable populations, then investment in afterschool programs is a worthwhile societal endeavor.

Other meta-analyses were much stricter than Miller in their criteria about what constitutes valid evidence for the effects of afterschool. A review that RAND published in 2005 critically examines research on out of school time (Bodilly and Beckett, 2005) and bases their conclusions only on highly controlled quantitative studies. The majority of the studies they reviewed were dismissed as inconclusive because of weak experimental design. They do, however, point to two promising studies that met their criteria for experimental design. Both of these studies controlled for factors such as selection bias and attrition, two factors that often confound attempts at concluding cause-effect relationships between program participation and participant outcomes. One study is an evaluation of the Carrera-Model Teen Program (Philliber, Kaye, Herrling, 2001; Philliber et al, 2002). This program's major goal is to promote healthy sexual practice. It runs 5 days per week during the school year and its services include career education, academic tutoring, arts, sports, and family life and sex education. The study showed that participants in the program showed less risky behavior than the control group. They had lower rates of pregnancy, lower rates of unprotected sex and lower rates of sex in general. Females participating in the program were also less likely to have sex under pressure. The results show that afterschool programs can lead, not only to increased knowledge or skills, but to behavior change as well. The other study is more closely related to academic learning. It is an evaluation of Upward Bound, a program aiming to increase college attendance and success for students who traditionally are less likely to attend college. Most Upward Bound programs include two components: a summer program where high school students take classes and earn work experience at a college campus and weekly follow-up during the school year. Students participating in Upward Bound showed higher educational expectations, earned higher grades and more credits, were more likely to graduate, and were more likely to attend a college or receive training after graduation compared to students not participating in Upward Bound (and this study controlled for selection bias and attrition). Moreover, they found that the effects were strongest for students who began Upward Bound with the lowest educational aspirations, that is, like the Nellie Mae analysis, they found that the strongest effect was on the students who needed the program the most.

In response to the push to use afterschool for the purpose of raising test scores for students who are not meeting standards for math and reading scores under NCLB, in 2004 McREL produced a study that specifically examined the effects of afterschool on low-achieving and at-risk students (Lauer et al, 2004). They identified published and unpublished research and evaluation studies from after 1984 that addressed the effective on reading or mathematics achievement of a program, practice, or strategy delivered outside the regular school day for low-achieving or at-risk K-12 students. They conducted a meta-analysis of these studies, including only studies that employed a control or comparison group (although, it should be noted, Bodilly and Beckett claim the study did not meet their standard in controlling for selection bias and attrition). Based on their meta-analysis, they found small significant effects for reading and math, with a slightly larger effect for math. When they disaggregated the data based on the grade level receiving the intervention, they found useful information about at what age interventions could be targeted to obtain the greatest results. They found that reading interventions had the greatest effect in lower elementary school (K-2) while for math interventions had the greatest effect in high school. Although all the effect sizes they found were statistically small, they reveal the potential of afterschool programs as a means to increase academic achievement for students who are not meeting educational standards.

In 2003 and 2004, the government commissioned Washington-based research company Mathematica to collect data about the effects of the 21st Century Learning Centers (U.S. Department of Education, 2003; Dynarksi et al, 2004). The Mathematica study is the only experimental study (with a control group) of a large-scale, nationally implemented after-school program. The study is largely known for its lack of positive findings about the effects of afterschool, yet it also included some evidence that afterschool can be effective for racial groups traditionally falling at the bottom of the achievement gap. It is important to note, however, that students in the control group could be (and many were) participating in afterschool programs that were outside of the 21st Century Learning Centers, and therefore the evaluation is not of the effectiveness of afterschool, but of the effectiveness of the 21st Century Learning Centers (a federally-funded afterschool program). While the study found no significant academic results in most of the areas they examined (including tests scores, grades, homework completion etc.), some effects were revealed when the data was disaggregated by race and separated between elementary school and middle school. They found no impact on academic achievement in any group in elementary school, nor on academic achievement for white students in middle school. But they did find that Black and Hispanic students in middle school, who went to the Learning Centers showed slight increased math grades and decreased absence and tardiness during regular school hours. In addition, based on teacher reports, participation, effort, and attentiveness increased in the classroom among Black students. Although the majority of the results from the 21st Century Learning Centers were discouraging about the impact of this nationally implemented program, these findings indicate that afterschool may be able to play a role in addressing the achievement gap. Moreover, as these studies were conducted in the first and second year of the existence of these Learning Centers, it would be interesting to revisit the programs now that increased training, better curricula, and a more mature field might lead to better results.

In summary, an examination of the research on the effects of afterschool programs reveals a limited degree of success. There is still a definite need for more studies, particularly studies of high-quality, more mature programs that are based on best practices that have been compiled by the field. Nevertheless, based on an extensive review of the existing literature, it becomes clear that afterschool can be an effective setting for learning to take place. Moreover, examining together all the major meta-analyses in the field of afterschool reveals a striking finding: all reports include some evidence that populations of students deemed to be "at-risk" are the same students who benefit most from afterschool programs. At the 21st Century Learning Centers, Black and Hispanic students were the main groups who showed positive outcomes. Moreover, the students who were most likely to attend the Learning Centers on a regular basis were Black, from single-parent households, low-income, and on public assistance. In the McREL report, they looked solely at students who were not meeting benchmarks and they found that those students made small, but significant, gains in test scores. In the RAND report, the main academic study that met their criteria for demonstrating a cause and effect relationship found that students with the lowest academic aspirations at the start of the program made the greatest gains. Finally, the Nellie Mae report also came to the conclusion that underprivileged groups benefited the most from afterschool programs. These findings are very promising for science afterschool programs. A major benefit of afterschool programs as a venue for informal science learning compared to science museums is that they can reach a much wider spectrum of people. While science museums are often frequented by more privileged youth, afterschool programs generally have a higher percentage of minority and low-income youth—the same groups that are severely underrepresented in the sciences. The evidence that underprivileged youth reap the greatest benefits of afterschool programs is indeed promising, indicating that afterschool science programs could potentially have a significant impact on these groups' achievement in the sciences.

While these meta-analyses that examine the effectiveness of afterschool programs are useful in giving us a general sense of if these programs are working, looking at afterschool as a generic category without distinguishing between specific qualities of programs has limited worth. Different programs aim to achieve different outcomes and measuring outcomes that are not aligned with individual program goals can distort results. Moreover, measuring the net effect of programs that vary in quality can overlook significant results in programs that work. Studying the effects of afterschool without examining specific practices within programs is simply not sufficient. The next section discusses which practices in a program produce the most effective results.

Best Practices in Afterschool Programs

We have now examined research on the effects of afterschool science programs and the effects of more generic afterschool programs. While this research is important in its ability to provide information about whether such programs are worth investing in, it is equally important to examine the specific features in these programs that led to such results. In this section, we will look at research investigating best practices in afterschool programs.

An established body of research about what makes a high quality afterschool program becomes even more important as afterschool programs' funding becomes increasingly dependent on their ability to demonstrate positive effects. While more money has become available for afterschool programs, more accountability is being demanded of the programs. It is not enough simply to be a program where kids can spend their afternoons; instead every program must demonstrate itself to be a ***high-quality*** program. Now every program in need of funding has to create an evaluation system to show that their program is producing worthwhile outcomes. Under this pressure, the field must respond with evidence-based research that can identify which characteristics in an afterschool program tend to produce the best results. Moreover, even for those who view afterschool simply as a way to keep kids off the street, the issue of quality is essential. In a 10-year study of 120 youth programs, McLaughlin describes her findings: "Most of the effective organizations in this study are overflowing, with waiting lists of eager youth...However, in these same communities, other youth organizations go empty and resources unused because young people assess their programs as uninspired and their settings impersonal. They head instead for the streets or empty homes. Youth will not migrate to just any organization" (McLaughlin, 2000).

So how can we discover the secret ingredients of these successful programs? To do so, we must look beyond the studies that tell us simply if a program has a positive effect to the studies that examine qualitatively or quantitatively the mechanisms behind those effects. Which specific aspects of a program are responsible for a large effect size in student learning? Again, there currently are a limited number of high-quality studies on best practices in afterschool programs. As a result, in our recommendations, we have included research and theories from related fields such as education and youth development, with the long-term goal to eventually build a more comprehensive body of research from studies on afterschool. Yet, even taking into account the limitations of our existing research base, there is a considerable degree of consensus about what components lead to a strong afterschool program, whether the program is focusing on art, literacy, or science. Research reveals a number of characteristics that are fundamental to strong afterschool programs.

Extensive meta-analyses of characteristics associated with successful programs were conducted by Bodilly and Beckett (2005), Miller (2003) and Beckett, Hawkin & Jacknowitz (2001). Upon review of these meta-analyses, the following characteristics emerge as important aspects of effective afterschool programs (although every one of these dimension does not need to be present to create a high-quality program).

- Supportive emotional climate
- Safe and healthy environment
- Low youth-to-adult ratios (no larger than 15: 1, according to Beckett, Hawkin & Jacknowitz, 2001)
- Clear goals/mission
- Frequent assessment/evaluation of programs
- Appropriate content and pedagogy
- Integration of families and community partners
- High expectations and positive social norms
- Variety of activities
- Stable, trained staff

§ Space availability

The After School Corporation (TASC), an intermediary organization in New York City, conducted studies that specifically examined programs that produced good academic outcomes (Reisner et al., 2004). In their study, among programs funded by TASC, they examined relationships between specific project activities, program practices and relationships, staff qualifications, and professional development opportunities, to find out how project design and implementation influenced academic outcomes. Related to project activity, they found that participants made greater academic gains both in programs that offered a high intensity of academic and cognitive activities as well as in programs that offered a high intensity of fitness, sports, and recreation activities. In terms of staffing practices, they linked academic gains with programs (1) where the site coordinator had a teaching license, (2) where project staff was required to submit lesson/activity plans, and (3) where at least 25% of project staff had a 4-year college degree. Similar to the meta-analyses discussed above, Reisner et al. emphasized the importance of staff quality. But they also suggested the importance of need for a strong academic focus in activities if the program hopes to impact academic achievement. Interestingly, it is also important to include athletic activities, supporting the ideas that strong programs have a variety of activities available. It should be noted about the study that there were some characteristics of the program that were shared across all TASC programs and therefore could not be assessed, such as being school-based, 5 days per week, with a full time coordinator and more than 100 kids in a program.

In a follow-up study conducted by Birmingham et al. (2005), based again upon improvement in math and literacy test scores, they identified ten high performing TASC-funded programs and identified characteristics common to all the programs. Again, in consensus with other studies, they found that each program provided a broad variety of enrichment opportunities, included intentional relationship building, and had strong leadership and a trained staff. Additionally, they noted that all these successful programs created opportunities for skill-building and mastery in their activities.

Another report reviewed the data on learning in afterschool through the lens of socio-cultural learning theory (Honig and McDonald, 2005). They reexamine reports on learning outcomes of afterschool programs guided by the question of how ground level program implementation and student participation could predict those outcomes. Instead of focusing on more general program structure and design, they tried to investigate youth's daily experiences in these programs. Their results are based on a review of almost 200 documents, looking for patterns between the effectiveness of the program (in terms of learning outcomes) and specific factors in program implementation that they hypothesized would be important determinants of learning based on socio-cultural learning theory. In their review, they found evidence that programs that encouraged social interactions and group engagement tend to be more effective than those where students work individually (such as during homework time) and that many effective programs allowed youth to participate in genuine, meaningful work, such as organizing community projects, having an integral role in the functioning of the program itself. They supported the use of mentors or "apprenticeship relationships," but emphasized the need for mentors who demonstrate mastery in a certain skill or subject area and are accessible and available for students. They also found many effective programs, particularly one afterschool science program, employed inquiry-based learning, allowing youth to be "co-

constructors of knowledge." Finally, they found that often having a strong, valued identity (such as in Girl and Boy Scouts) can be effective, especially when these identities are linked to acquiring skills and expertise in specific areas. This study is promising in its attempt critically examine specific aspects of program implementation that are often overlooked in studies examining program outcomes and goals.

A recent report published in 2007 by Durlak and Weissberg also focused on the specifics of program design and implementation. Using a promising research strategy, Durlak and Weissberg isolated specific practices utilized by some programs and compared the effect size for programs that employed these practices and programs that did not. In the study, they examined only programs that had as part of their mission to "promote personal and social skills." However, they measured the effect of the programs on participants' (1) feelings and attitudes (2) behavioral adjustments and (3) school performance. The authors found that participation in these programs had an overall positive and significant effect on youth. Significant positive effects were seen in all three areas examined, including significant effects in test scores and grades. In the second part of the study, they chose four evidence-based strategies utilized—*sequenced* activities, *active* learning, *focused* teaching and *explicit* goals (all of which were related to personal and social skills)—and disaggregated the data for programs that employed all four of these evidence-based strategies versus those that did not. They hypothesized that if students actively engaged in a sequenced set of activities to achieve a focused objective relating to explicitly-stated skill development, learning would be more likely to occur. Their findings sustained their hypothesis: they discovered that all of the programs employing these evidence-based strategies demonstrated significant effects in all three areas studied (feelings, behavior, and academics) while all of the programs that did not use such strategies failed to show significant effects in any of the three areas. In fact, the mean effect size for academic achievement was 10 times higher in magnitude for programs employing these four evidence-based training strategies than for programs that did not use these strategies.

This study is a significant testimony as to what can happen when high quality interventions using evidence-based procedures occur during the afterschool hours. Yet it should be noted that although the programs took place after school, the title of the paper "The Impact of After School Programs that Promote Personal and Social Skills" is not sufficiently precise since not all of the interventions included in the study took place in generic afterschool programs. Instead, some of the programs contained components based in cognitive-behavioral therapy, exceeding the bounds of a typical afterschool program. But the study nevertheless can lend valuable insight both into the potential reach of the effects of afterschool time as well as the potential for evaluations that measure the effectiveness of specific strategies in teaching and learning. Additionally, Durlak and Weissberg's study shows the way programs do not necessarily need to choose between youth development outcomes and school performance outcomes. Instead, high-quality programs that use evidence-based strategies can have significant effects in a variety of areas, from self-esteem to test scores.

In "Community Counts: How Youth Organizations Matter for Youth Development," McLaughlin shared her findings from 10 years of research on 120 youth-based organizations across the country that function outside of school hours and came to similar conclusions about the importance of including both school-based and youth development outcomes. She found that the most effective of these programs shared being "intentional learning environments" that were "youth-centered, knowledge-centered, and assessment-centered" and being "caring communities." To be youth-centered means that the program is built around youths' strengths and responds to their diverse skills and interests, and involve student voice. To be knowledge-centered means that there is embedded curriculum in almost all that students do, and activities have a clear focus, challenging content, and high-quality instruction. The assessment that takes place is not so much through tests as through constant oral feedback and recognition as well as culminating events and public displays so students can take pride in their work. Finally, to have caring communities, the program must create a safe, supportive community with clear rules and responsibilities, trusting relationships, and provide youth with social capital in the form of relational resources and connections. From McLaughlin's assessment, it appears that the most successful youth organizations emphasize knowledge and learning while incorporating youth development principles, as we have recommended for afterschool science programs.

Creating a body of literature on specific practices that lead to successful afterschool programs is an important step in increasing the effectiveness of afterschool programs. While more studies are necessary, evidence clearly demonstrates that there are certain qualities that make afterschool programs more effective. Although in the next sections we will be focusing on best practices in afterschool science programs, a great deal can be learned from research on which qualities make for an effective afterschool program. For to have a successful science afterschool program, not only is it important to have high-quality science activities, it is also important to address the underlying characteristics of a high quality afterschool program, such as a safe, emotionally supportive, and relationally-rich environment.

Best Practices in Afterschool Science Programs

Because science learning in afterschool is still a new field, little data has been collected on which types of programs are most effective in promoting science learning. We include this section on best practices in afterschool science programs despite the fact that there is not a lot of research because we believe this is an important area to develop. Although much can be gleaned by examining research on best practices in afterschool and best practices in school science, further research is needed to establish which factors are most important in creating effective afterschool science program.

One of the few attempts at identifying such aspects was created by the Southwest Educational Development Laboratory's (SEDL) National Partnership for Quality Afterschool Learning. Based on observational data from their experiences with many different afterschool programs, SEDL has developed an extensive Afterschool Training Toolkit for creating high quality afterschool programs that focus on different subject areas. They assert that the most effective afterschool science programs incorporate the following eight principles.

- Designed for all students
- Intentional and standards-based
- Active, interesting, and relevant to students
- Reflect current research and practices
- Age-level appropriate

- Integrate skills from different subjects
- Incorporate staff training in science
- Based in ongoing assessment of student needs and progress

Among these principles, we can see much overlap with dimensions of effective afterschool programs. There are a few recommendations specific to science programs, such as integrating skills from different subjects, and being active and relevant to all students. But for the most part, these principles could be applied to any type of afterschool program, showing again the natural fit between science learning and productive afterschool programming. High quality informal science learning is also high quality afterschool programming, though of course only one component. Informal science learning does not have to be extensively modified to fit afterschool programs; it is, in fact, the epitome of one type of "intentional learning" that makes up effective afterschool environments.

In a case study of urban minority students in a science afterschool program, Basu and Calabrese-Barton (2006) came to more specific recommendation for science afterschool programs, particularly when working with an underprivileged population. Their goal was to understand how to develop a strong, sustained interest in science among urban minority students. The students in the case study were 6th and 7th graders from the "high-achieving" sections of their grade (based upon the preference of the school). They found that students developed such interest when afterschool science programs 1. Connected science experiences with students' visions of their futures, 2. Included science activities that reflected student voice and enacted student views on the purpose of science, and 3. Created environments that supported social relationships that students valued. From this study we can see that there are specific measures an afterschool science program can take to help develop sustained interest in science.

We can also glean information about effective qualities of afterschool science programs from evaluations of the overall efficacy of afterschool science programs (discussed in the previous section). Multiple studies demonstrate that programs that use mentors, particularly among females, can have a strong impact on students' attitudes towards science and science careers (Ferreira, 2001; DeHaven & Weist, 2003; Harvard Family Research Project). It can also be important during afterschool time to recognize the importance youth place on social groups and construct a learning environment that reflects this, using small groups and cooperative learning (Basu & Calabrese-Barton, 2007; Fancsali, 2002). Research also indicates that connecting science learning to students' lives and communities can be effective in promoting interest as well as learning (Basu & Calabrese-Barton, 2007; Zacharia & Calabrese-Barton, 2003; Moje et al, 2001).

A common thread to all these characteristics is that they are all prototypical afterschool characteristics (mentoring, cooperative learning, connecting to communities). This is important to note because it would be very easy, in an attempt to increase science learning in afterschool programs, to drop many of these qualities so as to make more room to teach content. It appears, however, that some of the aspects of afterschool science programs that seem least relevant to academic science (such as mentoring or an emphasis on social groups) are actually key components in an effective afterschool science program.

Conclusions and Recommendations

In this report, we have discussed the theoretical alignment between afterschool and informal science learning. We have examined research on generic afterschool programs as well as science-specific afterschool programs. Although research on science in afterschool is a young field and as a result the data is sparse, we have found a growing number of studies evaluating afterschool science programs. Studies show that afterschool science programs can make important contributions to students' understanding of STEM concepts and their ability to think scientifically and use scientific tools. They also can be effective in improving students' attitudes towards science and towards themselves as science learners. Finally, in a limited number of cases, programs have increased test scores, grades, graduation rates, and the percentage of students studying math and science in college. Currently the evidence is limited to data from individual program evaluations, but it nevertheless demonstrates that afterschool science programs can have significant effects on science learning.

Based on these results, we believe that afterschool can be an effective delivery system for informal science learning. It is true that by placing informal science learning in afterschool settings (especially those that occur in schools under an extended day model), they run the danger of being subsumed by schools and therefore by a formal science approach. But we believe the potential of afterschool as a setting for informal science is too great to pass up because of these risks, particularly in light of the significant overlap in the missions of the two fields. In addition, afterschool programs not only can allow more sustained experiences with science than museum visits can, but also there is evidence that they reach a larger audience, with a majority of their participants from underprivileged groups. It should be noted, however, that while the data about the populations served by afterschool programs comes from research in the general field of afterschool (and therefore largely from generic programs) most of the current research that examines informal science learning in afterschool programs comes from studying science-specific afterschool programs. This discrepancy is significant; although science-specific programs are likely to reach a wider audience than science museums, they do not necessarily serve the same population as the generic afterschool programs. For example, it is possible that participants in a science-specific afterschool programs come from more privileged backgrounds than those in 21st Century Learning Centers. Moreover, there are many more generic afterschool programs in the country than science-specific afterschool programs. This means that they have a greater capacity to deliver education to the public. If we want to understand the full potential of afterschool programs to function as a large-scale delivery system for informal science learning, we must expand the research to include informal science learning in generic afterschool programs. A promising first step has already begun: a three-year study investigating the nature of informal science that occurs in typical afterschool programs around the country is already in process, funded by the National Science Foundation.

There is also a need for more research about what program qualities and practices are most effective in promoting science learning in afterschool settings. Based on the existing research we have about afterschool science programs, we can begin to identify some practices that appear to be especially effective in afterschool science programs, such as connecting science to students' lives, providing them with mentors, and using cooperative learning groups. We also can transfer research on best practices in generic afterschool programs to afterschool science programs. Currently, however, research on best practices in afterschool science is undeveloped. We recommend field-building studies that will expand our research base from promising results within individual programs to the identification of factors that cut across programs. In the long run, we hope to create a set of best practices of afterschool science programs that can be applied across programs. We recognize the extensiveness of this task since so many variables are involved, such as curricular choices, staff training, management issues, space, and many others. But we believe it is a worthwhile investment if we want to make afterschool an effective setting on a large scale for informal science learning.

A related issue is the question of what afterschool science programs hope to accomplish. Should they focus on increasing engagement and interest in science activities, aspirations for STEM-related careers, science content knowledge, the ability to think scientifically, graduation rates, grades, test scores, or something entirely different? As is the case in any new field of research, there are many different terms that are being used that lack generally accepted definitions. Although it is entirely possible and often desirable to include numerous outcomes as goals, it is necessary to distinguish between them to allow for more clarity around what one hopes to accomplish. A report from the National Science Foundation (Friedman et al., in preparation) will provide a foundation for this by proposing a framework for evaluating impacts of informal science education may also be applicable to afterschool science programs. The authors outline five general areas in which informal science education may have an impact on participants: 1. *Awareness, knowledge, or understanding* of STEM concepts, processes, or careers, 2. *Engagement or interest* in STEM, concepts, processes, or careers, 3. *Attitude* towards STEM-related topics, 4. *Behavior* resulting from engagement (particularly relevant to environmental or socio-political projects), and 5. *Skills* development and reinforcement.

It is likely that this type of explicit identification and division of goals will make it possible for afterschool science programs to approach their various goals with greater intentionality, which we believe is critical to the success of the field. For example, if a program goal is to promote interest in science careers, instead of merely exposing students to science, one could take them to visit different science laboratories and provide mentors who were in science and engineering careers. Too often, programs evaluators have tried to measure outcomes that are not aligned with individual program goals, and this can distort their results. We see a need for a coordinated system where programs intentionally design activities around specific goals, and researchers align their evaluations around those same goals. In this way, afterschool science programs will be able to demonstrate large-scale, meaningful impacts on science learning among youth.

Although there is surely much progress to be made in this new field, the various strands of theory and research presented in this paper show a very hopeful picture. A new and significant space for informal science is emerging, and it is the rapidly expanding setting of afterschool. Incorporating creative and challenging informal science into a setting that is eager to increase high-quality learning will create a mutually beneficial relationship, particularly in light of the considerable philosophical overlap between the two fields. Museums and other organizations need partnerships to reach more children with higher possibilities for dosage. Afterschool is a setting that can reach children and youth of all backgrounds, especially those underrepresented in the sciences, in a sustained and consistent manner. Up until now, the partnership has been primarily with schools, focusing on field trips and teacher training. This connection should continue to be strengthened, but a new connection between afterschool and informal science should also be formed. Our work and review has convinced us that the union between informal science and afterschool education is, indeed, a natural fit. To make out of this union a truly strong marriage, full of life, exploration, and learning, is the work of this decade and beyond. If we are successful, the resultant scientific learning and understanding as well as interest and engagement in science and science careers will reach across millions of children and youth around the country.

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