Coalescence of Research: Urban Advantage as a Learning Organization Structured to Support a Culture of Inquiry

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COALESCENCE OF RESEARCH: URBAN ADVANTAGE AS A LEARNING ORGANIZATION STRUCTURED TO SUPPORT A CULTURE OF INQUIRY

by

Marianne Williams

A dissertation submitted to the Graduate Faculty in Urban Education in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York 2016
This manuscript has been read and accepted for the Graduate Faculty in Urban Education in satisfaction of the Dissertation requirements for the degree of Doctor of Philosophy

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THE CITY UNIVERSITY OF NEW YORK
Abstract

COALESCENCE OF RESEARCH: URBAN ADVANTAGE AS A LEARNING ORGANIZATION STRUCTURED TO SUPPORT A CULTURE OF INQUIRY

by

Marianne Williams

Adviser: Nicholas M. Michelli

This dissertation is a mixed methods study of the Urban Advantage Program- a Middle School Science Initiative formed by the New York City Department of Education and the American Museum of Natural History (AMNH) in collaboration with New York City’s science culturally rich institutions – the Bronx Zoo, the Staten Island Zoo, the Hall of Science, the Brooklyn Botanic Garden, the Queens Botanical Garden, the New York Botanical Garden, and the New York Aquarium. Unprecedented in size and scope, UA brings together the largest school system in the largest city in the United States in a partnership with eight large independent science cultural institutions toward supporting teachers and students in implementation of science inquiry. The purpose of this study is to elucidate how the program is structured to support all stakeholders involved. The main argument is that UA is a learning organization when viewed through the lens of Senge’s Learning Organization Theory. Senge argues that all learning organizations incorporate and enact five disciplines, also known as component technologies: systems thinking, personal mastery, mental models, building shared vision, and team learning (Senge, 1990). The findings of this study map UA practices and structure directly onto each of the five disciplines. Systems thinking is evidenced in the program design, policy and direction and involves two change leaders at the helm. Using one partner institution as a unit of analysis personal mastery is evidenced via interviews and observations of a partner and lead teacher. Mental models of UA teachers and lead teachers are surfaced through a survey and interviews. Building shared vision is evidenced in a two day retreat of UA in 2011 as well as a Middle School Leadership Institute held at AMNH in the spring of 2009. Arguably, team learning is present throughout all of UA activities, however is markedly evident in the evolution of a UA designed tool, the Rubric for Long-Term Science Investigations. UA changed the rubric incorporating the changes in the national standards including National Science Education Standards, Common Core Standards, and Next Generation Science Standards. Analysis of the rubric changes involved rubrics from a ten year period. A reflective rubric designed for use by UA teachers to evaluate student long-term investigations brought to an annual Science Expo held at AMNH in 2011, was a tool used to analyze 112 student work projects as well as teacher understanding of the component parts of an inquiry investigation. The analysis was submitted to UA shortly after it was completed and was used to inform professional development and instructional practices. While a UA National initiative, using the UA model is already underway for Middle School Science in several cities, recommendations for further research include examining the UA model for use in NYC for high school students and for other disciplines including ELA, Social Studies and Art.
Dedication

This dissertation is dedicated to my partner, Jeannine M. Jacobs, without whose support my doctoral work would have been impossible. Her unwavering encouragement carried me through a seemingly endless adventure. I also thank my daughter, Quetcy Jacobs-Williams and my sister and nieces, Susan, Kasey, and Keri Kempton, the loves of my life, for whom I work hard on a daily basis.
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Chapter One: Introduction

Study Background and Rationale

Science teachers in New York City may draw from a number of sources for teaching support materials and professional development opportunities in their science content areas. They may take advantage of a number of grant opportunities, as well as participate in one of New York’s many professional science organizations, including the Science Council of New York City (SCONYC), Science Teachers Association of New York State (STANYS), or National Science Teacher Association (NSTA). Additionally, they may learn about professional development opportunities in the sciences through the New York City Department of Education (NYCDOE) website. Often, teachers must independently seek out and evaluate these materials and opportunities.

My Positionality and Emergent Interests

When I was working at a school that services Grades 6-12, I was assigned an eighth grade honors “Living Environment” class by the school principal. However, my previous science teaching experience applied only to the high school level. When I began looking for resources for the eighth grade science exit project, I came across a professional development opportunity called the Urban Advantage Program advertised on the NYCDOE website. I was excited to discover this opportunity, having previously felt disadvantaged by a lack of professional development programs offered at the building level or offsite that were supported by my principal. Through the Urban Advantage Program, I found the support and materials I needed to develop an eighth grade science exit project. I was also introduced to a group of professional science educators who were committed to improving science education through a program that fills the gaps left by the NYCDOE restructuring efforts on science leadership at the
middle school level. Unfortunately, there is no such similar program that serves the high school level.

The Urban Advantage (UA) Program supports middle school science teachers in all aspects of science inquiry teaching, including providing materials, vouchers for entry into science cultural institutions, and ongoing professional development. During my first two years as a participating UA teacher, I became increasingly interested in and intrigued by how the structure of the program effectively meets the needs of a diverse body of NYCDOE teachers and their students, in the context of standardized testing and accountability. In subsequent years, I became interested in how the program was structured to support the development of a professional learning community of diverse science educators from both informal and formal science institutions, who incorporate the changes and improvements in science education recommended at the national level. As a participant-observer fully immersed in the program, I developed research questions regarding the Urban Advantage Program, both from an individual teacher’s viewpoint, as well as from a broader systems perspective.

Many science teachers shared dissatisfaction with the lack of professional development opportunities at the building level. Those that do exist were either not directly applicable within the science classroom or not sustained. Ideas and practices shared over a one or two-day professional development program may sound valuable and useful, but they may be difficult to implement or sustain. Sustained professional development allows for discussion, reflection, and revisions through follow-up after implementation. The professional learning community requires ongoing professional development in order to make sustainable changes in teaching practices. This is especially true for teachers implementing changes to science inquiry teaching and learning.
UA provides the resources and support that middle school science teachers need to successfully implement science inquiry and long-term investigations. The program provides sustained support that enables teachers to continue to improve their practice and benefit from a well-established professional learning community of like-minded individuals committed to providing the best possible science inquiry learning experiences for their students. UA is committed to assisting teachers throughout their journey—from their first year as part of UA and onward, throughout their years of involvement—by providing a variety of professional development opportunities that address teachers’ individual concerns and needs. Additionally, as a learning organization, UA has continued to evolve according to changes in National Standards, including the Next Generation Science Standards and Common Core Standards.

Overview of the Study

This case study, conducted using a mixed methods approach, utilizes a systems perspective to explore Urban Advantage that is based on a theoretical framework derived from Senge’s fifth discipline. Research methods include a survey, interviews, fieldwork, participatory-observation of professional development and program events, document analysis, and student work analysis. Mental models have been an important area of research for learning organizations in general, but teachers, in particular, can affect the change process. As a learning organization, UA is structured to support continuous improvements in order to reach its stated goals. UA’s success, illustrated in both internal and external evaluations, is due in large part to its reliance on prior research on learning organizations’ effective practices, professional development, student and family engagement, and pedagogical practices. However, as is the case within other learning organizations, employee mental models—in this case, those of teachers—can either impede or improve practice. Part of this study is dedicated to exploring
participating teachers’ perceptions of and experiences with the implementation of inquiry in the context of high stakes testing and accountability in the New York City Public School System, as well as the ways in which they balance their responsibilities and navigate occasionally competing demands. To that end, interview questions and the survey were structured to reveal teacher’s mental models of inquiry on teaching and learning. Not surprisingly, UA teachers cite commonplace challenges for science teachers in implementing science inquiry. This data will prove to be informative as a starting point for addressing issues to enact change.

**Purpose and Need for the Study**

Prior research has examined learning organizations, professional development for enacting science inquiry learning, the effects of high stakes testing on pedagogical practices, and partnerships between formal and informal education institutions. This study explores each of these components within the context of the NYCDOE and the accountability movement. The study aims to demonstrate that the UA program is a well-designed learning organization that bridges the informal-formal education divide and can successfully overcome the many challenges to providing support for middle school teachers for their successful implementation of long-term science inquiry investigations, including high stakes testing and competing interests, such as English language arts (ELA) and mathematics for middle school students. The study demonstrates that UA, as a learning organization, has evolved and weathered the “dance of change” incited by the National Science Education Standards, Common Core Standards in ELA and Mathematics, and Next Generation Science Standards by successfully incorporating the new standards into its professional development and developed tools, including the Investigation Design Diagram (IDD), Developing a Science Explanation Tool (DSET), and UA Rubric for Long-term Science Investigations. All three UA tools have been improved in order that the
program may continue to meet the needs of both students and teachers. Teachers are trained to use UA tools to effectively scaffold learning and develop both formative and summative assessments of student implementation of science inquiry long-term investigations.

**Research Questions**

This study addresses the following main research questions and sub-questions:

1. How is UA structured to consistently support a conception of science education?
   a. What are the elements of its structure?
   b. Which approaches appear to inform the structure?
2. How are the mental models of participating UA teachers related to their implementation of science inquiry projects?
3. How does the implementation of inquiry by UA teachers compare to National Science Education Standards?
4. How do UA’s project goals compare to the Next Generation Science Standards and Common Core Standards?
In 2014 New York City Department of Education Chancellor, Carmen Farina, was quoted in the *Daily News* as saying, “I really believe if we get middle schools right, the rest is going to be a piece of cake.” (Daily News, Jan. 3, 2014). Several years prior (2011), Michael Fullan said, “When in doubt, it’s better to examine your practice and that of others who seem to be getting somewhere than it is to reach for the bookshelf. New work on understanding the brain bears out this idea. We know that the brain is best fed through experience. When people experience something new, it connects with their feelings first, then their minds. When this leads to new behavior, the latter sticks because it has emotional meaning. This is why I have stressed going from practice to theory.” As is often the case with morally charged policy issues—welfare reform provides one such example—false dichotomies have replaced fruitful conversation. If someone supports a teachers’ union, then she must not care about the students. If someone is critical of a teachers’ union, then he must not care about the teachers. If someone is in favor of charter schools, then she must be opposed to public schools. If someone believes in increased testing, then he must condone the corruption of our liberal society’s most cherished educational values. If some is opposed to increased testing, then she must be opposed to accountability. Numerous examples illustrate that neither side seems capable of listening to the other. The data can appear as divided as the rhetoric. New York City’s Department of Education provides so-called irrefutable statistics that prove that school reform is working, while opponents of reform provide equally irrefutable statistics that prove reform is ineffective. The task of disentangling overlapping factors is daunting: Are certain schools struggling because they have been inundated with students from failing schools that have closed? Are high school graduation rates up because pressures to increase graduate have coerced teachers and principals into passing
students who are not yet ready for college? (Mahler, 2011).

**Structure of the Literature Review**

This literature review is structured around the contexts that influence the Urban Advantage Program and its participating teachers:

1. Bronfenbrenner’s (1990) ecological systems theory on child development
2. Organizational learning (Senge, 1990)
3. Family engagement
4. Professional development: Difficulty of modifying pedagogical practice
   a. Teachers tend to teach the way they were taught
   b. National reform initiatives for modifying teachers’ practices toward a student-centered inquiry approach
   c. Balancing teacher-directed and student-centered instruction in an era of testing and accountability for middle school teachers: Hugging the middle
   d. Moving from a teacher-centered to student-centered inquiry approach requires sustained professional development and collaborative inquiry teams
   e. Professional learning sustainability structures
5. Rubrics
   a. Construction and use of scoring rubrics
   b. Instructional rubrics: Rubrics as instructional tools
6. Middle school science education in the context of the politics of New York City school reform
   a. Recommendations made by the City Council to improve science education
   b. The effect of mayoral control remains contested, despite changing leadership
c. Bloomberg’s placement of non-educators in leadership positions that direct education

d. Mayor DeBlasio and Chancellor Farina restore NYCDOE science leadership positions

**Bronfenbrenner’s Ecological Systems Theory of Child Development**

Context is everything. In order to understand an organization’s purpose and effectiveness, the contexts in which it operates must first be elucidated. The Urban Advantage Program (UA) can be conceptualized as a system of overlapping interrelationships, according to Bronfenbrenner’s ecological systems theory (Bronfenbrenner, 1990). Bronfenbrenner’s theory of child social development places the child in the context of all possible influences and interactions that affect his or her development. Bronfenbrenner’s theory can be applied to the development of science inquiry skills and concepts among middle school students participating in UA. While Bronfenbrenner employed the family as the unit of analysis, I use the Urban Advantage Program as the unit of analysis. Bronfenbrenner extended the domain to include all contexts in which a family exists and which influence childhood development. These are known as microsystems, mesosystems, exosystems, and macrosystems. In the current analysis, the microsystem includes parents, UA science teachers, parent-coordinators and peers. The mesosystem level refers to UA lead teachers, partner science cultural institutions and resources provided by UA as social services. The exosystem, or extended family, includes the New York City Department of Education and New York City Council. Finally the macrosystem is comprised of the National Science Education Standards and National Science Organization, which impact attitudes and ideologies about science inquiry and engagement. This level also includes the current move toward implementation of the Common Core Standards and Next Generation Science Standards (See Figure 1).

The strength of Bronfenbrenner’s theory is that it is all encompassing, multi-dimensional,
and multi-directional. It allows for an examination of childhood development in the context of “family,” which refers to multi-layered interactions with others, organizations, society, and culture. Most importantly, it illustrates that factors affecting development are constantly changing. The theory explicates the dynamic changes in environmental contexts that operate directly on the child and contribute to his or her development. It leaves out no contextual impact on the family. The multi-directional nature of Bronfenbrenner’s theory does not privilege one interaction, relationship, or context over others; but therein lies its weakness: How can a researcher operationalize a multi-layered, multi-directional theory? I faced the dilemma of placing the Urban Advantage program and the participating teachers I consulted within all operating contexts, including science education in the New York City Department of Education, high-stakes testing and accountability, the National Science Education Standards, partnerships with science or cultural institutions, professional learning communities, organizational change, professional development, learning theory, and teacher beliefs and mental models, as they relate to the effectiveness of science inquiry instruction implementation.
Organizational Learning: Peter Senge’s Five Disciplines

Senge focused on decentralizing the role of leadership in organizations in order to enhance the capacity of people within them to work productively toward a common goal. According to Senge, learning organizations are groups of people who continually enhance their capability to create or produce. Learning organizations share five component technologies that
illustrate mastery of certain basic disciplines, commonly referred to as the five disciplines.

Senge argued that learning organizations effectively meet continuous challenges, are sustainable, and weather the “dance of change” by understanding, utilizing, and practicing five core disciplines to meet their goals: systems theory, mental models, team learning, personal mastery, and shared vision. Each discipline is a series of principles and practices that are studied and integrated into the lives of people in learning organizations, and each comprises a crucial element for individuals within learning organizations to learn.

Since its conception, the Urban Advantage program was designed with systems theory in mind. The program takes into consideration the concerns, needs, and logistical issues of all stakeholders involved in working with students to complete inquiry based, long-term science investigations. It utilizes one or more of the eight science cultural institutions partnered with UA and the NYCDOE, including students, parents, teachers, parent coordinators, NYCDOE building level administrators, NYCDOE central office administrators, lead teachers, and partner institutions, including professional development providers.

Mental models, according to Senge, “are deeply ingrained assumptions, generalizations, or even pictures or images that influence how we understand the world and how we take action.” Mental models are often seen as impediments to change in organizations because people are often not consciously aware of them and how they affect their behavior. To counteract this, Senge argued that necessary “learningful conversations” allow people the space to surface their thinking and invite feedback from others (Senge, 1990).

Team learning is almost self-explanatory. According to Senge, “when teams are truly learning, not only are they producing extraordinary results, but the individual members are growing more rapidly than could have occurred otherwise.” He continued, “team learning is vital
because teams, not individuals, are the fundamental learning unit in modern organizations. This is where the rubber meets the road; unless teams can learn, the organization cannot learn” (Senge, 1990).

Personal mastery is “the discipline of continually clarifying and deepening our personal vision, of focusing our energies, of developing patience, and of seeing reality objectively. As such, it is an essential cornerstone of the learning organization—the learning organization’s spiritual foundation. An organization’s commitment to and capacity for learning can be no greater than that of its members. The roots of this discipline lie in both Eastern and Western spiritual traditions, and in secular traditions as well.” (Senge, 1990) Although mastery is often defined as the achievement of a level of proficiency, personal mastery suggests that an individual is committed to ongoing self-improvement and lifelong learning.

Building shared vision refers to the process of achieving a shared picture of the future, which an organization references in order to create and achieve its goals. It emphasizes a spirit of genuine commitment among all members, rather than coerced compliance to a dictated vision statement from leadership (Senge, 1990). In the context of UA, building a share vision effectively supports the implementation of science inquiry that results in exit projects. One way that this shared vision is enacted is by providing professional development. Much of the existing literature has suggested that professional development fails to change teacher’s beliefs and pedagogic practices from a teacher-centered, direct-instruction approach to one focused on student-centered inquiry. Thomas, Pedersen, & Finson (2001) employed the “Draw-A-Science-Teacher-Test Checklist” (DASTT-C) to explore teachers’ mental models and beliefs, based on the hypothesis that teaching style “may arise from their personal beliefs and self-efficacy about science teachers and their perceptions regarding the work of scientists.” DASTT-C compares
science teachers’ beliefs about teaching with students’ perception of scientists. The aim is to
determine if a relationship exists between a teachers’ teaching style and the students’ perception
of scientists. Using nonparametric correlational methods, the researchers found no significant
correlation between teachers’ teaching styles and students’ perception of scientists.

By employing Senge’s concept of mental models and building on Thomas et al.’s (2001)
study, I have developed four related questions on the impact of teacher beliefs or mental models,
on instructional practices: First, how do teachers’ beliefs about science inquiry instruction affect
the quality of students’ exit projects? Second, how do teachers’ beliefs about science inquiry
instruction affect the implementation of science inquiry, as outlined in UA’s goals for
professional development? Third, what are the particular mental models that affect the
implementation of science inquiry instruction? Finally, are there other contextual elements that
affect participating teachers’ implementation of science instruction? An understanding of UA
teachers’ mental models, with regards to science inquiry, as well as an understanding of the
contextual elements that may be impediments to the implementation of inquiry marks a critical
step toward improving professional development, teaching, and ultimately, change.

Family Engagement

Many administrators and teachers argue from personal experience that students’
academic performance improves, they are more motivated to learn, and more likely to behave
well if they receive parental support at home and have parental involvement in their education.
However, increasing parental involvement, especially when parents fail to initiate increased
involvement, has been challenging. This is especially true for many NYCDOE students, who are
economically disadvantaged and lack full support from parents. Research studies validate
teachers and administrators’ experiences and link higher parental involvement to better grades
and decreased dropout rates. Anderson and Minke’s study (2007) highlighted parental motivations for being involved in their children’s education. Four variables—parents’ view of their efficacy, role constructions, resources, and teachers’ invitations—were shown to impact parental involvement in education, both at home and at school. Parents are more likely to become involved if they perceive that teachers and schools welcome their involvement. This fact informs outreach strategies such as those deployed by UA, including family science nights, family science days at partner institutions, and offering vouchers for family visits to partner institutions.

Some studies have also shown that teachers’ perspectives on parental involvement can negatively impact parent participation in school-related activities. Christianakis (2011), for example, highlights educator perspectives on the importance of parental involvement, activities to engage parents, opportunities for collaboration, as well as tensions between educators and parents. A review of research on parental involvement, which has been historically lower in poor inner-city schools, also revealed that teachers and school administrators tend to perpetuate structural classism and racism by presuming that minority communities do not value education. The majority of teacher respondents considered parental involvement to be a form of “help labor” that addresses their needs in under-resourced classrooms and supports academic enrichment activities. Furthermore, teachers also expected parents to initiate parental involvement in their child’s educational activities.

Epstein and Sanders (2006) argued that, despite legislation requiring improved strategies to increase student skills and achievements, most colleges and universities lack a focus on school, family, and community partnerships. While such partnerships support student learning and success, teachers’ limited understanding of that interrelationship may diminish the likelihood
of their engagement with families and community organizations to solicit support. This study highlights the need for programs like UA, which builds family outreach and engagement into its program and paves the way for teachers to acknowledge the positive connections and the means to achieve them.

Kaya and Lundeen (2010) illustrated that by providing both parents and their children with positive experiences in science, parental involvement in student science education increases, in comparison with other subjects such as ELA and mathematics. Such opportunities address parents’ lack of familiarity with or confidence in addressing science topics and provide positive experiences in science. UA facilitates such outreach activities as family science nights, family science days, science expos, and parent-child activities at partner institutions. In light of New York City Schools Chancellor Carmen Farina’s recent mandate that schools commit to parent engagement, UA’s outreach strategies may pave the way for teachers and schools to engage parents in their children’s science education. This is likely to result in improved middle school student performance on the New York State Intermediate Level Science Examination.

**Professional Development: Difficulty of Changing Pedagogical Practices**

A common adage is that teachers tend to teach the way they that were taught. A thorough longitudinal study of pedagogical practices in American classrooms between 1880-1990 revealed that, for much of United States history, the majority of teachers have engaged in teacher-centered instruction at both the elementary and secondary level (Cuban, 1993). Although teachers are beginning to embrace a hybrid approach that features elements of both teacher-directed and student-centered instruction (Cuban, 2009), much research has illustrated that many teachers continue to model the classroom teaching techniques that they encountered when they were students. This is true of all subject areas, and not just science. Many teachers have encountered
teacher-directed, textbook-driven instruction during their own K-12 education (Tobin, Briscoe, & Holman, 1990). This has shaped, not only pedagogical practices, but also teacher’s beliefs about science teachers, science, and scientists (see, e.g., Nespor, 1987; Moseley & Norris, 1999; Pajares, 1992; Simmons et al., 1999). A didactic, teacher-directed approach based primarily on lecturing is commonplace in most college courses, as well—both in science methods courses and other subject areas (Raizen & Michelsohn, 1994; Spodek, 1988). Although supporters for reform initiatives in science education have advocated for change and encouraged teachers to move toward a student-centered inquiry approach, the traditional method of teacher-directed instruction persists in many classrooms.

**National reform initiatives supporting student-centered inquiry approach.**

An initiative to modify pedagogical practices to embrace a student-centered inquiry approach has been influenced by the release of the National Science Education Standards (NSES) in 1996. Inquiry is emphasized throughout the NSES and is envisioned as an important component of K-12 pedagogy that should be incorporated into assessment standards, professional development standards, teaching standards, and science content standards. A developing emphasis on inquiry, as it is related to instructional practices, is outlined in Table 1.
Table 1: Inquiry in Instructional Practices from National Science Education Standards (1996)

<table>
<thead>
<tr>
<th>LESS EMPHASIS ON:</th>
<th>MORE EMPHASIS ON:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activities that demonstrate and verify science content</td>
<td>Activities that investigate and analyze science questions</td>
</tr>
<tr>
<td>Investigations confined to one class period</td>
<td>Investigations over extended periods of time</td>
</tr>
<tr>
<td>Process skills out of context</td>
<td>Process skills in context</td>
</tr>
<tr>
<td>Emphasis on individual process skills such as</td>
<td>Using multiple process skills—manipulation, cognitive, procedural</td>
</tr>
<tr>
<td>observation or inference</td>
<td></td>
</tr>
<tr>
<td>Getting an answer</td>
<td>Using evidence and strategies for developing or revising an explanation</td>
</tr>
<tr>
<td>Science as exploration and experiment</td>
<td>Science as argument and explanation</td>
</tr>
<tr>
<td>Providing answers to questions about science content</td>
<td>Communicating science explanations</td>
</tr>
<tr>
<td>Individuals and groups of students analyzing and</td>
<td>Groups of students analyzing and synthesizing data after defending conclusions</td>
</tr>
<tr>
<td>synthesizing data without defending a conclusion</td>
<td></td>
</tr>
<tr>
<td>Doing few investigations in order to leave time to</td>
<td>Doing more investigations in order to develop understanding, ability, values of</td>
</tr>
<tr>
<td>cover large amounts of content</td>
<td>inquiry, and knowledge of science content</td>
</tr>
<tr>
<td>Concluding inquiries with the results of the experiment</td>
<td>Applying the results of experiments to scientific arguments and explanations</td>
</tr>
<tr>
<td>Management of materials and equipment</td>
<td>Management of ideas and information</td>
</tr>
<tr>
<td>Private communication of student ideas and conclusions</td>
<td>Public communication of student ideas and work to classmates</td>
</tr>
<tr>
<td>to teacher</td>
<td></td>
</tr>
</tbody>
</table>

In 2000, the National Research Council released an addendum to the NSES on Scientific Inquiry entitled Inquiry and the National Science Education Standards: A Guide to Teaching and Learning. An emphasis on inquiry was further supported by the National Research Council’s report on How People Learn (Bransford, Brown, & Cocking, 2000). This research was intended
to be directly applied to science education to address how students learn. The National Research Council subsequently released a committee report on this topic (Donovan and Bransford, 2005). The National Science Teacher Association (NSTA) concurrently published an exemplary science monograph series to address best practices for implementing science inquiry (2005). Research for the series commenced in 2001 with the establishment of an advisory board composed of many of the science educators who had developed the NSES. Contributors sought “exemplars of the NSES More Emphasis conditions as a way to evaluate progress toward the visions of the NSES” (Yager, 2005). A nationwide call for papers about exemplary programs ensued. Selections from the submissions prioritized authors who provided evidence for the effects on student learning. The study resulted in three publications on science teaching: *Exemplary Science in Grades PreK-4, Exemplary Science in Grades 5-8: Exemplary Science in Grades 9-12,* and *Standards-based Success Stories.* A fourth publication about professional development practices that support science inquiry-based instruction was also released, entitled “Exemplary Science: Best Practices in Professional Development” (Yager, 2005). In an assessment of this series, Yager (2005) concluded that substantial evidence has illustrated that progress is being made toward the NSES’s implementation. The National Research Council continues to promote inquiry-based science instruction and increasing teacher awareness on the latest research. Exemplary studies include Michaels, Shouse, & Schweingruber (2007); Duschl, Schweingruber, & Shouse (2007); Bell, Lewenstein, Shouse, & Feder (2009); and Fenichel and Schweingruber (2010).

**Balancing middle school teacher-directed and student-centered instruction in an era of testing and accountability: Hugging the middle.**

In an era of testing and accountability, teachers are challenged to prepare students for
state standardized tests, while at the same time provide meaningful and engaging instructional activities. Teachers balance the two oft-competing demands by practicing a hybrid of teacher-centered instruction—also known as direct-instruction—with student-centered instruction in what Cuban coined “teacher-centered progressivism” (Cuban, 2009). Although most middle school teachers acknowledge the importance and effectiveness of an active, student-centered pedagogy that includes “cooperative learning, experiments, demonstrations, simulations, Socratic seminars, reciprocal teaching, discovery learning, debates, learning centers, role-playing, service learning, group projects, independent study, and hands-on learning projects,” (Faulkner and Cook, 2006), many admit that state testing leads them to prioritize teacher-centered instructional methods, including lectures, worksheets, and whole-class discussion.

In concurrence with other education advocates (See Meier & Wood, 2004), Jerald sought to educate teachers on alternatives to narrowing their instructional strategies in order to achieve good test scores (2006). He argued that many teachers mistakenly assume that teaching to the test is the only way to elicit high student scores on state exams. He stated that, not only is teaching to the test unnecessary, but it is also harmful. The current emphasis on standardized testing and accountability has narrowed the curriculum and deprived students of a broad education founded on critical thinking (Jerald, 2006; Meir and Wood, 2004). Other studies highlight the high occurrence of cheating due to the high stakes of testing and warn educators to prepare for different degrees of cheating take place (Amrein-Beardsley et al., 2010).

**Professional development and collaborative inquiry teams for student-centered learning.**

Several researchers have elucidated best practices for professional development for science teachers. These prioritize teacher involvement in collaborative inquiry teams (See
Johnson, 2007; Jeanpierre, Oberhauser, & Freeman, 2005; Johnson, 2006). Unfortunately, much professional development does not utilize best practices or include true collaborative inquiry. Darling-Hammond, et al. (2009) conducted a longitudinal study of 40,520 teachers across the United States to determine to what extent America’s public school teachers are offered the recommended professional learning opportunities embraced in other countries. Their aim was to establish benchmarks for assessing progress in professional development. The study asked, “If much is already known about effective professional learning, then what is the status of professional development for America’s public school teachers?” The study showed that public schools in the United States have begun to recognize and respond to the need to provide support for new teachers. More than nine out of ten United States teachers have participated in professional development, consisting primarily of short-term conferences or workshops. However, while teachers ideally take part in professional development of up to fifty hours in their subject area in order to improve their skills and enhance student learning, most professional development opportunities in the United States are much shorter in duration. Significant variation in both teacher support and opportunities for professional learning was also found among participating schools and states. United States teachers further reported low levels of professional collaboration in curriculum design and practice sharing, and existing collaboration tends to be weak and lacks focus on strengthening teaching and learning. Teachers also reported that much of the professional development opportunities available are not useful. They listed their top priorities for professional development as content learning (23%), classroom management (18%), teaching students with special needs (15%), and using technology in the classroom (14%). The study further revealed that teachers do not get adequate training for teaching special education or limited English proficiency students.
Unlike the United States, where teachers are often responsible for covering the cost of professional development opportunities, other industrial nations belonging to the Organization for Economic Cooperation and Development (OECD) tend to provide teachers with significantly more professional learning opportunities, at no cost to them. While United States teachers may participate in workshops and short-term professional development activities that are at similar to those offered in other nations, they are far behind teachers in other nations in their access to productive, collaborative communities. Nations that outperform the United States on international assessments invest more heavily in professional learning and allocating teachers’ work hours to ongoing, sustained teacher development and collaboration. Furthermore, United States teachers have limited influence in crucial areas of school decision making.

The Darling-Hammond study reached the following conclusions on professional development for teachers:

- Sustained and intensive professional development for teachers is related to student achievement gains.
- Collaborative approaches to professional learning can promote school change that extends beyond individual classrooms.
- Effective professional development is intensive, ongoing and connected to practice; focuses on the teaching and learning of specific academic content; is connected to other school initiatives; and builds strong working relationships among teachers.

Several case studies have revealed progress in providing effective professional development to science teachers on inquiry-based instructional practices (Yager, 2005). Buczynski and Hansen (2010), for example, conducted a study to examine the connections between teachers’ experiences in an intensive math and science professional development
program and the translation of their experience into elementary classroom pedagogy. They addressed the following research questions:

1. Are teachers implementing inquiry-based instruction in their classrooms in response to the professional development they are receiving? If not, why not?

2. Are students’ scores improving on science achievement assessments in professional development teachers’ classrooms?

Buczynski and Hansen found that after eighty hours of professional development, teachers began to exhibit a deeper understanding of science content and stronger commitment to inquiry-based learning activities. Furthermore, student assessments showed a trend toward higher achievement scores. The study also showed that teachers who participated actively at school experienced stronger benefits from professional development. Other studies have shown that, despite the availability of effective professional development, teachers exhibit varying levels of ability to implement standards-based inquiry instruction. This is due to such variables as teacher beliefs, experience levels, and administrative support for professional development (Johnson, 2007).

The New York City Department of Education (NYCDOE) generally supports professional development and collaborative inquiry for schools, but it fails to provide training specifically for science instruction. Some principals have supported the development of professional learning communities in their schools—sometimes called a community of learners—in which groups of teachers and administrators utilize a collaborative inquiry approach. In fact, using an inquiry approach to improve and inform practice has become the norm, rather than the exception. Furthermore, the idea of creating teacher communities dedicated to inquiry-based learning is not new (Wells, 1994); but the context for education has
changed due to the NCLB and a focus on standardized testing and accountability. Thus, it is not unusual for professional developers, administrators, and teachers to refer to Love’s 2009 publication on a collaborative inquiry approach to inform professional community development. In fact, Page Keeley, former President of the National Science Teacher Association, endorsed Love, et al.’s earlier study on this topic (Love, Stiles, Mundry, & DiRanna, 2008). She stated that the book “provides specific cases and strategies schools have effectively used to implement collaborative inquiry.” More recently, professional development that utilizes collaborative inquiry has been designed specifically for science and mathematics teachers (Loucks-Horsley, Stiles, Mundry, & Hewser, 2010). This work has become the gold standard among education stakeholders, as evidenced by the frequency with which it is referenced by prominent members in the science education community. Loucks-Horsley, et al.’s study emphasized the need to continuously monitor professional development programs, use approaches that are tailored to participant groups and contexts, and build sustainable cultures. The NSES (1996) directly addressed the importance of an inquiry approach in professional development, as outlined in Table 2.
Table 2: Inquiry in Professional Development Standards from National Science Education Standards (1996)

<table>
<thead>
<tr>
<th>LESS EMPHASIS ON:</th>
<th>MORE EMPHASIS ON:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmission of teaching knowledge and skills by lectures</td>
<td>Inquiry into teaching and learning</td>
</tr>
<tr>
<td>Learning science by lecture and reading</td>
<td>Learning science through investigation and inquiry</td>
</tr>
<tr>
<td>Separation of science and teaching knowledge</td>
<td>Integration of science and teaching knowledge</td>
</tr>
<tr>
<td>Separation of theory and practice</td>
<td>Integration of theory and practice in school settings</td>
</tr>
<tr>
<td>Individual learning</td>
<td>Collegial and collaborative learning</td>
</tr>
<tr>
<td>Fragmented, one-shot sessions</td>
<td>Long-term coherent plans</td>
</tr>
<tr>
<td>Courses and workshops</td>
<td>A variety of professional development activities</td>
</tr>
<tr>
<td>Reliance on external expertise</td>
<td>Mix of internal and external expertise</td>
</tr>
<tr>
<td>Staff developers as educators</td>
<td>Staff developers as facilitators, consultants, and planners</td>
</tr>
<tr>
<td>Teacher as technician</td>
<td>Teacher as intellectual, reflective practitioner</td>
</tr>
<tr>
<td>Teacher as consumer of knowledge about teaching</td>
<td>Teacher as producer of knowledge about teaching</td>
</tr>
<tr>
<td>Teacher as follower</td>
<td>Teacher as leader</td>
</tr>
<tr>
<td>Teacher as an individual based in the classroom</td>
<td>Teacher as a member of a collegial professional community</td>
</tr>
<tr>
<td>Teacher as target of change</td>
<td>Teacher as a source and facilitator of change</td>
</tr>
</tbody>
</table>

The NYCDOE has required each school to form inquiry teams that use data to drive instruction. However, the structure and function of such inquiry teams varies from school to
school, and inquiry team membership is defined at the principal’s discretion. The NYCDOE
defines collaborative inquiry as “a sustained process of investigation and action by a group of
educators that empowers teachers to improve student achievement and close the achievement
gap”. This commitment is challenged, however, by the emphasis on measuring student
achievement by standardized test scores. The NYCDOE further states, “collaborative inquiry
can look very different in different contexts,” but continues, “…there are some common threads
across all teams mainly teachers evaluating the effectiveness of their collective work through the
lens of student work and data” (schools.nyc.gov).

Professional learning sustainability structures.

The Urban Advantage model addresses professional learning sustainability at the
individual teacher, school, or school system levels. Studies on teacher effectiveness and
continual learning have shown that veteran teachers, or teachers late in their careers, are at a
greater risk of becoming less effective. Day and Gu (2007) examined how professional,
personal, and workplace conditions impact a teacher’s commitment to teaching and long-term
effectiveness. While the study examined 300 teachers in England, it has applicability to US
teachers as well. The authors identified six professional phases in the life of a teacher: 0-3, 4-7,
8-15, 16-23, 24-30 and over 31 years of teaching. Each phase exhibited distinct characteristics.
In concurrence with other studies, Day and Gu found that teachers are most receptive to learning
early on in their careers, but learning decreases over time, as teachers becoming more
experienced. A program like UA, which offers differentiated professional development
opportunities such as curriculum topic studies or activities like “Looking at Student Work,”
allows teachers to continue their individual growth beyond building teacher identity and
managing classroom behaviors and procedures. UA also provides a social and professional
network for sustaining schools’ instructional improvement programs. UA schools facilitate administrator, parent coordinator, and teacher networking for collaborative work to improve school support for students.

Coburn, Russell, Kaufman, and Stein (2012) addressed how teachers’ advice networks support sustainability in the case of ambitious instructional reform. The study focused on an urban school district’s two-year program to introduce a mathematics curriculum that was student-centered and applied conceptually based teaching. This is analogous to science reform efforts focused on student-centered, inquiry based teaching and learning. The study looked at capacity building activities, including professional development, school-based coaching, and co-planned instruction. After the district withdrew support for the program, the teachers’ social networks became crucial for sustaining the reforms related to instructional approaches. Similarly, UA supports sustainability by encouraging both lead teachers and other science teachers from participating schools to develop professional networks with other UA schools.

Rubrics

The construction and use of scoring rubrics.

Rubrics are assessment tools that outline evaluation criteria. Rubrics often articulate gradations of quality for each criterion, from excellent to poor (Goodrich 1997; Popham, 1997). Holistic rubrics are used to evaluate a student’s overall process, product, or performance without giving a score to component parts of the process, product, or performance. Analytic rubrics score each component part of a task separately and then total each part to obtain a final score (Moskal, 2000; Nitko, 2001). Although using an analytic rubric is more time consuming than a holistic rubric, it offers substantial benefits to both the teacher and student. The specific feedback on each individual component can be used to focus on areas for improvement for both
students’ future performance, as well as teachers’ future instruction. One of the greatest attributes of a rubric is its capacity to inform practice (Mertler, 2001; Nitko, 2001).

Mertler (2001) developed guidelines for designing scoring rubrics based on an analysis of existing literature that include the following steps:

1. Identify the learning objectives to be addressed by the task.
2. Identify specific observable attributes that students should demonstrate in their product, process, or performance.
3. Brainstorm characteristics that describe each attribute, specifying above average, average and below average performance.
4. Holistic rubrics should include thorough narrative descriptions for excellent work and poor work and incorporate each attribute into the overall description. Analytic rubrics, on the other hand, should feature thorough narrative descriptions for excellent work and poor work for each individual attribute.
5. Holistic rubrics should describe intermediate levels of performance on the continuum for collective attributes, while analytic rubrics should describe intermediate levels of performance on the continuum for each attribute.
6. Collect samples of student work that exemplify each level.
7. Revise the rubric as necessary.

Several studies have noted that instructional rubrics can help teachers to improve instruction. However, flaws in rubric construction have also been cited and can limit their effectiveness. Popham (1997) pointed out four common flaws that render rubrics all but useless: These include task-specific evaluative criteria, excessively general evaluative criteria, dysfunctional detail, and equating the test of the skill with the skill itself. Like other assessment
types, rubrics are subject to scoring errors and biases. Suskie provided an extensive list of possible unintentional scoring errors and biases when using rubrics, including leniency, generosity, severity, and central tendency; halo effect, contamination effect, similar-to-me effect, first-impression, contrast effect bias; and rater drift. A leniency error occurs when an evaluator grades work at a higher level than other evaluators. Generosity errors occur when an evaluator tends to grade at the high end of the scoring guide. To the contrary, severity errors occur when an evaluator tends to only use the low end of the rating scale. Central tendency errors occur when evaluators tend to only use the middle of the rating scale. The halo effect bias refers to an evaluator’s tendency to allow positive student characteristics, such as prior work, articulateness, personality, likability, etc., to influence his or her score. The related contamination effect bias presents when negative characteristics, such as poor handwriting or teacher prejudices negatively impact scoring. Similar-to-me and first-impression bias are self-explanatory. Contrast effect bias occurs when the evaluator compares students to each other, rather than the standards set by the rubric. Lastly, rater drift refers to an evaluator’s unconscious or unintentional diversion of the scoring criteria over time (Suskie, 2004).

**Rubrics as instructional tools.**

Despite design and scoring challenges, rubrics are beneficial, not only as grading tools, but also as teaching tools. Andrade (2005) defined instructional rubrics as those created and distributed by a teacher to students and used for self-assessment, peer assessment, and teacher assessment. According to Andrade, rubrics are more than evaluation tools: they also impact teaching and learning. Rubrics guide teacher goals, clarify learning goals, inform instructional design, communicate goals to students, present feedback to students, measure student progress toward goals, and allow judgment of the final products relative to the goals set (Andrade, 2005).
While research has shown that providing feedback to students improves their learning (Black and William, 1998), it is also very time-consuming, according to teachers. Andrade argued that by employing good rubrics, teachers may provide focused, constructive feedback with efficient use of their time (Andrade, 2005). Andrade cautioned against teaching practices that limit the effectiveness of rubrics, however, including distributing rubrics to students without careful explanation, assuming that rubrics can replace high quality instruction—students still require modeling, feedback, and opportunities for discussion and revision of their assignments—or failing to employ rubrics in peer-assessment or self-assessment. Additionally, Andrade cited the need for addressing validity, reliability, and fairness in rubric design and scoring (Andrade, 2005).

A nationally recognized program originally developed for middle school students has provided specific guidelines for the effective use of rubrics to improve learning. The National Research Council cited the assessment system used in the Science Education for Public Understanding Program (SEPUP) developed at the University of California, Berkeley’s Lawrence Hall of Science as an exemplary model for measurement. SEPUP’s creators argued that by “Using Rubrics to Foster Meaningful Learning,” teachers may clarify learning goals, provide feedback, help students to improve their understanding, focus on learning, rather than grades, and monitor their own progress. Based on extensive research, field-testing, and communication with teachers, the creators of the program outlined specific suggestions for using rubrics to enhance learning (Siegel, Hynds, Siciliano, & Nagle, 2006).
Middle School Science Education and the Politics of New York City School Reform

In 1992 and 2004, the City Council made several recommendations to improve Science Education in New York City public schools. In 2004, the Council identified six problems and recommendations for each:

- Problem 1: There are too few qualified science teachers
  - Recommendation 1a: Toughen requirements for elementary science teachers
  - Recommendation 1b: Offer science teachers more money
  - Recommendation 1c: Provide more professional development for science
  - Recommendation 1d: Hire science coaches

- Problem 2: Elementary science instruction barely exists
  - Recommendation 2a: Evaluate principals on quality of science instruction
  - Recommendation 2b: Institute a coherent, integrated curriculum

- Problem 3: Secondary schools do a poor job of teaching science
  - Recommendation 3a: Try “Physics First” approach in high school
  - Recommendation 3b: Staff all secondary schools with lab specialists
  - Recommendation 3c: Develop plan to increase advanced science classes

- Problem 4: Science facilities are insufficient
  - Recommendation 4: Prioritize the modernization of science labs

- Problem 5: Outside resources are not used effectively
  - Recommendation 5a: Bring more private dollars for science into schools
  - Recommendation 5b: Strengthen partnerships with science institutions

- Problem 6: Science education is not a high-profile, high-priority issue
  - Recommendation 6a: Analyze and disseminate science test scores
Recommendation 6b: Increase parental involvement

Unfortunately, little progress toward addressing most of the identified problems has been made. An exception has been a sixty million dollar K-8 Science Core Curriculum Initiative, which resulted in a coherent curriculum, professional development, and materials for both elementary and middle school science (schools.nyc.gov/science). Additionally, since its formation in 2004, UA continues to be supported by the City Council and has grown substantially in both size and budget. UA is one of the few programs that embodies and enacts these recommendations—specifically regarding strengthening partnerships with science institutions and increasing parental involvement. UA is limited to middle school grades six through eight. Therefore, few of the recommendations made for other grade levels have been enacted in secondary schools where science facilities, budgets, and materials remain woefully inadequate.

The effect of mayoral control and changing leadership on education.

The effect of mayoral control remains contested, despite changing leadership from Chancellor Klein to Black, Walcott, and Farina. While a business model, accountability, and data-driven instruction remain in place, these are mitigated by the restoration of instructional support units in the NYCDOE such as the Division of Teaching and Learning. Michael Bloomberg’s takeover of the public school system in New York City in June 2002 resulted in sweeping and radical changes in school structure, operation, budget, curriculum, instruction, assessment, and evaluation (Ravitch et al., 2009). Mayoral control during this time was highly contentious, and it remains so today (Cook, 2009). For example, Governor Cuomo recently refused to honor Mayor DeBlasio’s request to make mayoral control of the NYCDOE permanent. A collection of essays on New York City schools under Bloomberg and Klein
(Avitia, et al., 2009) represents a wide range of prominent advocates for the New York City Public School System, including educational scholars and policy experts, politicians, and parents who are intimately involved with the DOE. The contributing authors have criticized the way that Bloomberg controlled the DOE (Ravitch et al., 2009). Some reports outline positive results under Bloomberg’s administration, such as improved minority student achievement (Wong & Shen, 2003). These reports are likely biased, however: They have been based on data supplied by the NYCDOE and have been called into question in subsequent studies (Ravitch & Stern, 2006), or they were supplied by public relations personnel serving the mayor’s office or the NYCDOE (Ravitch et al., 2009). To counter this limitation, Joseph P. Viteritti, the Executive Director of the Commission on School Governance—who has generally favored mayoral control—stated that public hearings reveal support for an independent agency that would report school data. Recommendations were made for the city’s Independent Budget Office to release data on schools to help eliminate “spin” surrounding test scores (Samuels, 2009; Viteritti, 2009). However, Mayor Bloomberg did not allow this to take place while he was in office.

Numerous reports have cited the negative effects of mayoral control over the school system: These include decreased transparency and stakeholder input from principals, teachers, parents, and students (Ravitch & Weingarten, 2004; Samuels, 2009). Others have argued that the takeover has not resulted in major changes (See, e.g., Cibulka, 2001, 2003; Cuban & Usdan, 2002; Finn & Keegan, 2004). In a thorough and even-handed analysis of mayoral control in urban schools, Hess (2008) concluded, “mayor control is an uncertain bet and poses potential long-term problems but—if designed thoughtfully—holds promise for deeply troubled urban school systems (Hess, 2008). Thus, while the effects of mayoral control remain contested, the destabilization that restructuring has caused is clear.
Prior to Bloomberg’s school system takeover, New York City mayors have generally respected and relied upon the professional judgment and experience of educators. In 2002, when attorney Joel Klein was appointed to run the nation’s largest school system, the mayor sent a loud and clear message that the voices of experienced educators would be ignored. This trend continued with the highly contested appointment of Cathie Black, a publishing executive with no experience in education. In fact, the onset of mayoral takeover included a team of management consultants from McKinsey and Company. Most experienced educators, including administrative leaders and principals who were in office in 2002, have been replaced (Ravitch et al., 2009). During Bloomberg, Chancellor Klein, and Tweed’s tenure, the central office of the NYCDOE was staffed primarily with non-educators, including business professionals and lawyers who turned the education of New York City’s schoolchildren into a business enterprise, complete with data-tracking, efficiency experts, bottom-line assessments, and business competitiveness.

Arguably, Deputy Mayor Dennis Walcott’s appointment to Chancellor modified some of Bloomberg and Klein’s business practices. Walcott had extensive experience in education and was known for his quiet conciliation. Many hoped that the new chancellor, a life-long resident of New York City who was equipped with first-hand experience in the complexities of the multitude of political, social, racial, and geographic issues affecting education, would lead the DOE in a new direction (Halbinger, 2011). Chancellor Walcott has affected some positive changes for science education, as evidenced by his appearance as a guest speaker at the 2011 Expo and apparent interest in students and their exit projects. Before and after his speech, I observed Walcott speaking at length with many students about their exit projects. He took his time with each student and did not rush out, as other politicians and DOE employees have in the
Many in education think that a business model approach to education at the national level has maintained its traction and will continue to be prioritized. Debates suggest that students have been reduced to data and teaching and learning have been reduced to only that which can be measured and accounted for. There is ample evidence that standardization in education, measured by standardized testing will continue, despite protests by parents, teachers, and students. Research-based evidence provided by education professionals, including psychologists and professors who are concerned with the development of the whole child, highlights the negative impact of high-stakes testing and accountability on creativity, aesthetic experience, well-rounded education, and learning enjoyment (Ravitch, 2010; Cuban, 2009; Jerald, 2006; Meier & Wood, 2004). Science teachers who implement engaging, hands-on, inquiry based instruction do not, according to non-educators, directly prepare students for standardized tests. It is in this contested context that science teachers elect to participate in the Urban Advantage program.

Restoration of Science Leadership Positions

Importantly, during the latter years of Mayor Bloomberg’s tenure and major NYCDOE restructuring under Chancellors Klein and Walcott, the only NYCDOE science administrative positions that remained in place were the Science, Technology, Engineering, and Math (STEM) grant position and NYCDOE UA Liaison. Following the appointment of Chancellor Farina, an education veteran with fifty years of experience in numerous positions, the NYCDOE has once again undergone restructuring, including the re-establishment of the Division of Teaching and Learning. Leadership positions, including the Director of Science and citywide instructional heads for high school, middle school, and elementary school science, have been restored to
educators, and leadership has expanded to include the positions of Executive Director of STEM and a citywide instructional head for measurements of student progress (MSP) in science. With the restoration of science leadership positions, an enhanced citywide Grade 6-12 science scope and sequence has been provided to teachers for the 2015-2016 school year. The enhanced scope and sequence incorporates the Common Core Learning Standards, Next Generation Science Standards, and Excellence in Environmental Education Standards.
Chapter Three: Methodological Framework

This study employs a mixed-methods approach to examine the Urban Advantage Program (UA) from a systems perspective. Research methodology includes a critical ethnography directed toward understanding UA as a learning organization, based on observations of the structural elements that support its mission to implement middle school science inquiry. Field observations of UA activities and events were combined with a document analysis and an analysis of reflective exit project rubrics. One component of the research has been to identify the extent to which teachers are implementing inquiry learning, as evidenced by long-term investigations and exit projects. UA has designed a reflective rubric to evaluate students’ long-term investigations, as well as solicit teachers’ feedback (See Appendix A). This study has also aimed to uncover the mental models (to borrow from Senge, 1990) that UA teachers have developed on the implementation of science inquiry. To that end, research also includes interviews (See questions in Appendix B) and surveys (Appendix C) with participating teachers. Thus, qualitative research methods included interviews, field observations, and document analysis and quantitative research methods involved a survey, employment of a reflective exit project rubric, and statistical analysis, including t-tests and an analysis to determine variance (Picciano, 2004).

Document Analysis

The majority of documents analyzed are publicly available on the UA website. These documents present a longitudinal study of the program, from 2004 to the present. As a researcher, I was additionally granted access to UA documents that were not publicly available. I was also provided with the digital documentation for long-term investigations presented at the 2011 Science Expo.
Reflective rubric for UA’s long-term science investigations.

Students’ long-term investigation projects are known as work products that provide evidence of science inquiry capacity, as well as the effectiveness of the professional development teachers have undergone to implement science inquiry in the classroom. A scoring rubric for the exit project served as a guideline and measurement for each part of the inquiry project. Notably, UA administrators noticed discrepancies between the scores they (or their partners) gave, as compared with teachers. In an effort to understand teachers’ reasoning for their scoring, a reflective rubric was developed (Appendix A). An analysis of the reflective rubric reveals factors that have impeded the implementation of science inquiry, in order to improve the professional development provided to teachers. The reflective rubric is also one means to identify teachers’ perceptions on science inquiry, and the strengths and weaknesses identified in student projects may inform future professional development planning.

The Reflective Rubrics submitted by teachers who attended the Expo will be analyzed (N=112) according to the following criteria: First, scoring discrepancies between teachers, UA leaders or their partners, and the researcher will be identified. Specific areas of discrepancy will be noted and analyzed for patterns. The nine project areas, including title, question, hypothesis, background research, investigation design, procedure, data/results, discussion/conclusion, and literature cited, will be sorted according to areas of least-to-most discrepancy. A statistical analysis will include t-tests and an analysis of variance (Picciano, 2004). Second, ratings will be assigned to each category. Each of the nine project areas will be analyzed to determine which areas of the exit project are the least to most difficult for the students. The results will subsequently inform interviews with participating UA teachers. Third, reasons given for why each project was featured at the Expo will be compared against the students’ overall grades.
Projects were selected for the Expo based on four criteria:

1. The student(s) showed great initiative on this project.
2. The student(s) expressed a desire to attend the Expo.
3. The student(s) produced an exemplary project.
4. Other reason (explain).

Teacher Interviews

While twelve teachers initially consented to be interviewed for this study, eleven also submitted a reflective exit project rubric. Structured interview questions (Appendix B) addressed the same areas and issues as the survey. Unstructured interviews were also conducted with the NYCDOE UA liaison, a Director of the Education Division at one of the partner institutions, and a manager of teacher professional development at one of the partner institutions.

Participant Observer Analysis of UA Professional Development and Events

As a UA teacher for three years, I was both a participant and observer of the program. I attended professional development activities, family science days at various partner institutions, and the Science Expo. As a science department chairperson, I also attended some of the administrator breakfast meetings and all meetings held with UA administrators at my school. As a researcher, I additionally attended two consecutive years of the partner/lead teacher two-day professional development retreat, the Annual Black Rock Retreat.

Teacher Surveys

The research survey (Appendix C) was distributed to participating teachers who provided informed consent, using the website Survey Monkey. The initial group of teachers who participated in the survey (N=32) was filtered to include only those teachers who also submitted a reflective exit project rubric (N=17). The survey was directed at determining contextual
elements and teachers’ mental models that affect their implementation of science inquiry in the classroom. The survey addressed the categories outlined in Table 3.

**Table 3: Mental Models Identified in the Survey**

<table>
<thead>
<tr>
<th>QUESTIONS</th>
<th>DIRECTED AT TEACHERS’ MENTAL MODELS REGARDING:</th>
</tr>
</thead>
<tbody>
<tr>
<td>49-53</td>
<td>The effects of standardized testing on science instruction, whether directed by administrators or reported by teachers.</td>
</tr>
<tr>
<td>10-15</td>
<td>Inquiry, direct-instruction, and project-based learning.</td>
</tr>
<tr>
<td>20-21</td>
<td>UA teacher support from administrators and non-UA science teachers at their schools.</td>
</tr>
<tr>
<td>22-25</td>
<td>UA PD</td>
</tr>
<tr>
<td>26-31</td>
<td>The employment and ease of use of the UA tools ID and DSET</td>
</tr>
</tbody>
</table>

**Table 4: Instructional Practices Targeted in the Survey**

<table>
<thead>
<tr>
<th>QUESTIONS</th>
<th>DIRECTED AT TEACHERS’ INSTRUCTIONAL PRACTICES REGARDING:</th>
</tr>
</thead>
<tbody>
<tr>
<td>16-19</td>
<td>Students’ consistency in collecting, graphing, and analyzing data and completing lab activities How and to what extent students implement the essential features of inquiry (the 5 E’s), as defined by the National Science Education Standards (NSES)</td>
</tr>
<tr>
<td>32-48</td>
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</table>

**Validity**

In order to address the validity threat of researcher bias, Maxwell has advised that researchers acknowledge potential biases and how they aim to address these, as a key component of the research design. A common consequence of researcher bias is the selection of data that fits the researcher’s existing theory or preconceptions. I chose to examine the Urban Advantage Program because it is regarded as an exemplary model of a large-scale school partnership program—a view that I share as a teacher participant of the program. It is possible that I may filter or highlight the positive aspects of the program that I experienced. In order to counteract this bias, I have paid particular attention to discrepant evidence and negative experiences or criticisms expressed by research participants. I have also addressed my “positive” bias by
including a co-analysis of the interviews by a colleague who is not a UA participant. I have designed interview and survey questions to allow participants to freely express any negative experiences or criticisms of the program. An additional colleague who is not a UA participant also co-analyzed the long-term investigations presented at the 2011 Expo.

Maxwell outlined a checklist of validity tests that can be employed to rule out validity threats and increase the credibility of the conclusions drawn in a study. The validity tests that I applied include the collection of “rich data,” a test of respondent validity, and triangulation. I define data collected as “rich” because it involves numerous interviews, including multiple interviews with key participants; a survey; and detailed field notes describing observations made over a three-year period. The document analysis constitutes a ten-year, longitudinal study of the program. In order to rule out the possibility of misinterpretation I have also solicited feedback from a selection of participants. Triangulation will be strongest with lead teachers whom I interviewed and observed during meetings, at the Science Expo, and while providing professional development. They also participated in the survey and provided Expo reflective rubric results.

As an “insider” I have established relationships with the New York City Department of Education’s administrative liaison, representatives from one of the partner institutions, and two lead teachers. All of these relationships have initiated both formal and informal conversations about the program over a four-year period.

Limitations

A primary limitation of this study was that much of the data collected was self-reported by participants and may display positive bias. Since the continuation of the UA program depends upon financial support from the New York City Council and science grants, the positive
features of the program may have been emphasized and absorbed into the UA culture. An additional limitation involved the participant sample: I was unable to collect data from all stakeholders in the program. Parents, parent coordinators, and students were excluded in this study.
Chapter Four: Findings

The magnitude and vision of UA is succinctly stated in five words in the original design document: “shared responsibility, access, and equity.” Unprecedented in size and scope, UA brings together the largest school system in the largest city in the United States, with funding provided by the City Council and through partnership agreements for shared responsibility and access with eight large, independent science cultural institutions. Viewed through the theoretical lens of Senge’s five disciplines, Urban Advantage is a learning organization “…where people continually expand their capacity to create the results they truly desire, where new and expansive patterns of thinking are nurtured, where collective aspiration is set free, and where people are continually learning to see the whole together” (Senge, 1990). Senge outlines five disciplines, or component technologies that are practiced by true learning organizations. These include systems theory, personal mastery, mental models, building shared vision, and team learning. Each of these components is critical and equally important for building and sustaining an organization.

Systems thinking refers to the idea that any business or organization is made up of interrelated parts that effect each other and must be viewed as a whole, in order for the complex patterns of change to be understood, as well as for the organization to work effectively. According to Senge, “systems thinking is a conceptual framework, a body of knowledge and tools that has been developed over the past fifty years, to make the full patterns clearer, and to help us see how to change them effectively” (Senge, 1990). UA literature describes the program as a framework around six research-based objectives:

1. Professional development, including workshops for science teachers and school administrators.
2. Educational materials, including science materials and equipment for schools, teachers
and students.

3. Access to partner institutions through the allocation of vouchers for class field trips and family visits.

4. Outreach to families through public exhibitions featuring student work, family science events at institutions, and support for school-based family science nights.

5. Capacity building and sustainability through support for lead teachers and leadership institutes to develop science teams.

6. Assessment of program goals, student learning, and systems of delivery.

This description does not capture the dynamic relationships between UA participants and education stakeholders, nor does it reflect UA’s hierarchical structure. My first-hand experience as a participant teacher, interviews with teachers and partners, and document analysis have culminated in an interpretation of UA structure and dynamics illustrated in Figure 2.
Program Design, Policy and Direction

Change leaders.

There are two primary change leaders associated with UA’s program design, policy, and direction: Maritza McDonald is the current Senior Director of Education and Policy at the American Museum of Natural History (AMNH) and one of the creators of the UA Program. She has published on teacher education since 1991 and worked with AMNH since 1997. Her expertise is to “develop, implement, research, and evaluate partnerships with higher education and other ISE organizations.” She also has extensive experience as a “researcher and team coordinator for a national study of exemplary teacher education programs funded by Carnegie Corporation and led by Darling-Hammond” (See McDonald’s CV in Appendix D).

The Director of Gottesman Center for Science Teaching and Learning, James B. Short leads “the development and planning of professional development programs for teachers and school administrators, museum learning experiences for students, and educational outreach programs;” contributes “to strategic planning, proposal development, annual reporting, and budget management;” and supervises a “center staff of 25 science educators.” Short has extensive experience in designing and facilitating professional development. He is also “responsible for creating an education platform that has high visibility, influence, and presence in the science education and museum communities both locally and nationally” and for integrating “programs into the educational system in New York City, demonstrating that informal settings have a role in the city’s formal educational system,” as well as developing “partnership programs with public schools, non-profit organizations, and the New York City Department of Education” (Appendix E).


2004 program design.

The publication “2004: MacDonald Design for Shared Responsibility, Access, and Equity: Key Elements of the Project” outlines the initial UA program and its stakeholders. These include the following:

1. School/teacher selection characteristics and timeline

   • Three schools in each region
   • Two teachers per school
   • Medium-needs schools with preference given to science-focused schools
   • Teachers with demonstrated interest in science professional development
   • Commitment to student success in science
   • Commitment to disseminate training and resources from the project to colleagues
   • Commitment from school administrators

UA’s significant expansion since its commencement in 2004 is evidence of its ongoing success. When the program launched, 31 schools were identified as medium-needs schools. This has expanded to 177 schools representing a variety of institutions and communities, including District 75 special education schools. During the 2013-2014 school year, 177 public middle schools became UA schools, serving a total of 517 active middle school teachers and 51,351 middle school students. The program began by servicing only 8th grade students. It expanded to include 7th grade students in 2006 and 6th grade students in 2010. Today, teachers are differentiated as beginning UA teachers (UA Year One teachers), continuing UA teachers (UA Year Two-Ten teachers), and lead teachers who have undergone a rigorous selection process. The program also added parent coordinators in 2006 and demonstration schools in 2007.
Table 5: UA Participant Numbers

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<tbody>
<tr>
<td>Total active schools</td>
<td>31</td>
<td>111</td>
<td>129</td>
<td>156</td>
<td>147</td>
<td>174</td>
<td>156</td>
<td>138</td>
</tr>
<tr>
<td>New teachers</td>
<td>62</td>
<td>133</td>
<td>116</td>
<td>127</td>
<td>61</td>
<td>182</td>
<td>86</td>
<td>64</td>
</tr>
<tr>
<td>Continuing (&gt;Y1)</td>
<td>62</td>
<td>94</td>
<td>129</td>
<td>196</td>
<td>204</td>
<td>285</td>
<td>282</td>
<td></td>
</tr>
<tr>
<td>Total active teachers</td>
<td>62</td>
<td>195</td>
<td>210</td>
<td>256</td>
<td>257</td>
<td>386</td>
<td>371</td>
<td>346</td>
</tr>
<tr>
<td>UA lead teachers</td>
<td>21</td>
<td>20</td>
<td>21</td>
<td>21</td>
<td>21</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UA demonstration schools</td>
<td>12</td>
<td>8</td>
<td>8</td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UA students</td>
<td>5,500</td>
<td>18,722</td>
<td>21,016</td>
<td>27,541</td>
<td>24,793</td>
<td>37,582</td>
<td>37,822</td>
<td>34,829</td>
</tr>
</tbody>
</table>

Lead teachers collaborate with a specific partner school to provide professional development to new and continuing teachers. They are selected after a comprehensive application process that measures demonstrated effectiveness in implementing long-term science investigations with students and solicits a recommendation from someone who can attest to the candidate’s pedagogical knowledge and commitment based on observations during professional development activities. Lead teachers must commit to attending monthly meetings and a two-day annual retreat, provide support to any UA teacher on request, curate student work for and attend the annual Science Expo, and provide additional samples of student work on request. Lead teachers head demonstration classrooms and welcome visits from other UA teachers. Like all UA teachers, they also agree to participate in any research on UA activities conducted by the NYCDOE or UA and tend to feature heavily in such research.

Lead teachers are a critical component of the UA program: they serve as liaisons between the UA administrators and partners and the NYCDOE and have first-hand knowledge of students, the NYCDOE, and any changes that filter down to their schools and classrooms. They
have been cited as invaluable partners for NYCDOE employees, who are not classroom teachers. Lead teachers shape their content knowledge and vision of UA goals. One partner commented, “In my opinion, we can be the mentors and help them with the teaching, but the learning goes back and forth because they are the eyes and ears of the Department of Education and keep us updated, which is incredibly important when you are a partner with such a large institution which is really a bureaucracy.”

- A principal is responsible for signing a Memorandum of Understanding between UA and the participating school. The agreement outlines the following commitment: Schools occasionally participate in research and evaluation efforts. Research and evaluation activities include classroom observations, interviews with teachers and students, and the collection of artifacts, including samples of student and teacher work.

- Administrators attend in person or send a representative to all UA science leadership breakfasts held at the AMNH, support school-wide use of UA equipment, support participation by the parent coordinator at UA PC workshops, support teacher attendance at UA professional development sessions, support field trips to UA partner institutions, support research and evaluation efforts by granting access to classrooms, and attend UA events, including the citywide UA Science Expo held in June.

- Teachers attend 48 hours of professional development in Year 1 and 12.5-20 hours of professional development in subsequent years; use class trip vouchers at UA partner institutions; place per-student supply orders (the amount per student is determined according to funding); participate in research and evaluation efforts by sharing classroom practices and student work; and attend the citywide UA Science Expo in June.

- Parent coordinators (PC) promote family attendance at UA Family Science Sunday, use
family field trip vouchers and bus subsidies to visit UA partner institutions, attend PC
workshops, participate in research and evaluation activities, and promote family engagement
at the school through events such as Family Science Nights.

- Building-level administrative support for the overall program and teacher participants is also
  a critical component for UA to be successful.

  Principals help to “support inquiry-driven science education. According to the UA,
  “involving school administrators in a reform effort is critical to creating sustainability.”

  Principals make a commitment to support the teachers in implementing long-term science
  investigations, including agreeing to the time spent in classrooms and dedicated to class trips to
  partner institutions. In addition, the principal makes a personal commitment to attend the four
  leadership institutes held at the AMNH, “facilitat[es] conversations through the lens of UA on
  topics such as current research findings about how students learn science, [and] helps
  instructional leaders implement UA in their schools.” (Appendix F). According to the survey
  responses, 94% of teachers indicated that the administrators at their schools supported their
  participation in UA. However, 17.7% of teachers stated that administrators limited the amount
  of time their students could work on long-term science investigations or exit projects.

  Specific comments made by teachers regarding administrative support included the
  following:

  - “Great support!”

  - “Was told by administrators to attend UA because the school is part of the program and
    all science teachers should participate in such a helpful program.”

  - “Full support. We are a demonstration school.”

  - “A 1000 percent. Administrators see it (UA) as PD helping students with common core
standards. They love all the resources and the fact that students are in touch with the scientists. I get to take the students to the zoo.”

- “Allowed one class to take three class trips for their exit projects. Very supportive. They allowed me to go the National Science Teachers Association Conference.”

- Only one teacher expressed a negative response toward administrative support: “They don’t know how to support me. I need this or I want this, not from unwillingness but lack of knowledge. Perfect example: the principal spent all this money on books for a major unit and hid them in a closet and they were supposed to be used for the exit projects as research. So, now we are going to use Google.”

Resources for schools:

- Provide schools with resources and the supplies they need to support student investigations.

- A selection of and/or dollar allocation to purchase scientific equipment, videos, software, books, lab supplies, and other materials to support student investigation and exit projects.

- Curriculum resources produced by the institutions

UA provides a number of resources to teachers at participating schools in order to facilitate implementation of long-term science investigations in the classroom. These resources include science equipment valued at $2,500, including books, videos, software, and curriculum materials; $1,000 to each UA school in the first year and $5-$7 per student per year in subsequent years to cover basic lab supplies; and science journals for each student. For many teachers and schools, this is the only supplemental funding they receive to purchase science materials. These resources for science investigations are so vital that many teachers cite them as a primary motivation for joining and continuing in the UA program. Trips to partner institutions
include two visits to partner institutions to support exit project investigations. Class trips 
allow students and teachers access to multiple spaces to conduct investigations. Workshops 
provide teachers with the content and methodology needed to conduct these investigative field 
experiences. Teachers are provided with buses and class trip vouchers for two class trips to any 
of the partner institutions. Teachers are also provided with two teacher vouchers to visit the 
partner institutions to pre-plan visits. Each class trip voucher amounts to approximately $400, 
based on an average of $12.00 per student admission price to the partner institutions.

Students receive passports for themselves and one guest to accompany them on 
institution visits. The passports allow them free admission to any of the seven partner 
institutions. The purpose of the passports is to increase student visits to institutions in order to 
continue their investigations. Teachers and administrators also receive passes for free 
admissions to partner institutions. This allows teachers self-guided access to institutions and 
administrators to become familiar with the institutional resources that will be utilized during 
student investigations.

In order to promote family involvement in students’ science education, as well as their 
own engagement with science concepts, the UA provides three types of vouchers to partner 
institutions: student and family vouchers, family field trip vouchers, and family day vouchers. 
Two student and family vouchers are distributed to each student and up to three family members 
for free admission to any of the eight partner institutions. The vouchers, which carry an 
approximate value of $88 each, provide families with access to science institutions that they may 
not have considered visiting before, due to cost limitations. Additionally, each school is 
provided with three family field trip vouchers for each parent coordinator. Not only is the 
admission fee covered, but also two $500 bus allocations are provided per school to support class
trips. Finally, the UA organizes eight annual Family Science Days, for which UA students and their families are allowed free admission to partner institutions.

While Family Science Days and Nights were not included in the original program design, UA now encourages these activities as collaborative initiatives together with the Parent Coordinator and UA teachers.

**UA online resources**

The UA website connects teachers, educators, scientists, students, and families to share ideas and receive tips on facilitating successful exit projects. The website also provides information on the project, key documents, schedules and events, links to partner institution websites, and features reviews of high-quality student work. It was created, modified, and updated over the last ten years of the program’s implementation to become an invaluable resource for all UA program participants. As an online resource, it offers easy access to important materials, including contact information for all partners and partner institutions; the UA program calendar, with a list of UA and partner institution exhibitions and events and professional development topics and dates; the NYCDOE school year calendar; a complete list of UA participating schools from 2004 to the present; and additional resources for principals, teachers, students, parent coordinators, and families, as well as on long term investigations. The website also features documentary videos and photographs. The UA’s abridged two-page and complete eight-page brochure are also available on the website.

The “principal” tab on the website includes the following information:

- PD materials for the four leadership institute breakfast events
- Kick-off events information
- Standards and core curriculum, including:
Common Core State Standards
Next Generation Science Standards
NYC K-8 Science Scope and Sequence
NYS Science Standards
UA partner institutions alignment with the NYC K-8 Science Scope and Sequence

- Equipment ordering information
- Voucher and trip forms and information
- Suggested pedagogical and trade books
- UA recommended long-term investigation rubric

The “teachers” tab of the website features the following information:
- Standards and Scope and Sequence
- UA absence policy
- UA partner contact information
- UA At a Glance for continuing teachers
- Continuing Teachers Professional Development Course Catalogue 2014-2015, v1.8
- Investigation design and developing a scientific explanation
- Vouchers and trips
- UA rubric, poster design, and help for students
- Continuing teacher kickoff documents
- New teacher Cycle 1 documents
- FY 15 teacher order form
- Class information form
- Classroom/teacher support visit request
• Event visit request
• Lead teacher contact information
• Suggested trade and pedagogical books
• UA NYC NING forum

Student information on the website includes the following:
• Long term investigation help
• UA recommended long-term science investigation rubric
• Investigation sections
• The four types of long-term science investigations
• Secondary research
• Citation assistance
• Using your UA voucher

Parent Coordinator information on the website includes the following:
• UA at a Glance: Information for you and your families
• Parent coordinator resources
• Planning a family field trip
• Event visit request
• UA family trip bus request form

Family information on the website includes the following:
• How to use your student voucher at UA institutions
• Activities to complete at UA institutions
• FAQ’s for UA parents
• UA family guides (10 languages)
• Family Science Sunday 2014
• UA at a Glance for Families
  Information on long-term investigations includes the following:
  • UA investigation rubric
  • Investigation and poster layout help
  • Data for secondary research
  • Sample investigations from 2012-13
  • Sample investigations from 2011-12
  • Sample investigations from 2010-2011

Professional Development
• Sixty hours of training at participating institutions on developing and facilitating exit projects with students
• Qualifies as a graduate credit course
• Honorarium: $1200

Professional Development

UA professional development and teacher and administrator activities.

UA provides high quality professional development for teachers, lead teachers, partners, parent coordinators, and administrators. During the 2015-2016 school year, each new teacher will be provided with forty hours of professional development and each continuing teacher in year two or three of their participation in UA will participate in a two and a half hour kickoff sessions and an additional twenty hours of professional development. Continuing teachers beginning Years Four to Ten will be provided with a two and a half hour kickoff session and an additional ten hours of professional development. Lead teachers and partners will be provided
with professional development opportunities held throughout the year at AMNH, as well as at an annual two-day retreat hosted at Black Forest State Park. Workshops will be held several times during the year for parent coordinators, and the AMNH will host Science Leadership Days for administrators, including four annual breakfasts for administrators.

**Professional development for new UA teachers.**

Teachers new to the UA program attend a two-day Cycle 1 session. On the first day, teachers learn how to access UA resources, including how to order materials after receiving their stipends, booking class trips and buses, and using vouchers to visit cultural institutions. They receive suggestions for distributing vouchers to students and their families to visit the cultural institutions and learn about resources on the UA website. Teachers participate in an inquiry investigation about glacial striations in Central Park and are introduced to a pinball investigation. Each investigation provides teachers with two model inquiry activities to introduce to their students. As teachers walk through the two inquiry activities, they experience inquiry learning firsthand through well-designed activities that can be used as models to create further inquiry activities for the classroom. On the second day of Cycle 1, teachers complete the pinball investigation and are introduced to a protocol for assessing student work and the UA Long Term Investigation Rubric. Teachers receive clean copies of activities for immediate implementation in the classroom.

Cycle 2 professional development introduces teachers to four types of science investigations, the UA formative assessment, and instructional scaffolding tools, The Investigation Design Diagram (IDD) (Appendix F) and Designing a Scientific Explanation Tool (DSET, see Appendix G), are primary resources available at each partner institution to support the implementation of long-term science investigations with students.
Teacher evaluations have yielded very positive feedback about this professional development cycle activities. They present the overall UA program, both logistically and pedagogically to new teachers.

**Professional development for continuing UA teachers.**

Professional development offered to continuing teachers is differentiated into the four workshop: Level 100 workshops provide an introduction to one of four types of investigations: controlled investigations, field investigations, design experiments, and secondary research. Participants learn to utilize UA resources to inspire students to conduct long-term science investigations. Teachers are also introduced to science practice tools (IDD and DSET) and the techniques needed to plan and carry out a particular type of investigation, with a focus on a content area. Learning goals for this workshop type include the following:

- Increase teachers’ knowledge of and ability to teach students how to design experiments, which apply to one of the four types of UA recognized science investigations and link scientific investigations to the curriculum.
- Reinforce and build on the use of UA tools, including the IDD and DSET.
- Help teachers understand how to integrate UA institutional resources, including field trip learning experiences to support a specific type of investigation.
- Expose teachers to new science content knowledge and related pedagogical knowledge through an investigation that promotes science practices.

Participants in the Level 200 workshops explore techniques and scaffolding tools to help students develop strong scientific arguments around evidence gathered through a particular type of investigation. The workshops also draw connections between Common Core State Standards in ELA or math. Long-term science investigations are explored through tools such as the
Designing a Scientific Explanation Tool (DSET). Learning goals for this workshop type include:

- Improve teachers’ ability to apply common core math and/or ELA skills and knowledge in the context of a scientific investigation.
- Develop teachers’ science content knowledge through the use of scientific investigations, institutional resources provided by UA partners, and classroom activities that promote science practices.
- Strengthen teachers’ ability to implement UA tools and strategies that support common core math and/or ELA standards across the science curriculum.

In the Level 300 workshop, participants reflect on how research on learning can affect their teaching practice and students’ science investigations. Using research on teaching and learning and UA Partner exhibits, participants explore a given science topic, including:

- The development of science concepts across grade levels
- Common misconceptions
- Related science practices (inquiry)

Following the curriculum topic study format, the workshop utilizes the AAAS Atlas for Science Literacy and a variety of other resources, including exhibits, to explore these topics. Learning goals for this workshop type include the following:

- Strengthen teachers’ ability to teach middle school science content and/or practices in a way that is consistent with current research on teaching and learning by:
  - Providing opportunities for teachers to examine research findings on the teaching and learning of science content and/or practices.
  - Using research on teaching and learning to develop effective teaching strategies
and activities that integrate UA partner institutional resources.

The Level 400 workshops emphasize protocols for examining student work. Participants reflect together on key questions regarding teaching practice and student learning in science classes. Teachers engage in collaborative, critical, and supportive dialogue around focused examinations of student work. Learning goals for this workshop type include the following:

- With the support of protocols and community building exercises, participants examine and reflect on student work, with the goal of surfacing student thinking. Participants engage in a collegial and collaborative learning experience; teachers identify and develop opportunities to provide additional supports and scaffolds to their students.

A detailed description of each PD workshop is available on UA’s website.

**Professional development for administrators.**

Administrators are required to attend administrator’s breakfast events four times annually, as well as one administrator’s kickoff event. To date, breakfast events have addressed the following specific topics:

- Common Core ELA Standard 1 and UA investigations
- Common Core ELA Standard 2/3 and UA science investigations
- UA science leadership team schools
- UA investigations as a DOE-aligned common core literacy task
- Using field trips to support New York State science core curriculum
- Creating critical friends groups to explore teacher and student work
- Looking at UA science investigations to support literacy
- Linking science and literacy
• UA practices in the classroom (look for)
• Math common core connections
• How UA schools support class trips and connect science with literacy
• Integrating math with science with school panel
• Designing effective science fairs

**Professional development for parent coordinators**

Parent coordinators are required to attend one PD session. The workshops assist parent coordinators with using the resources offered by UA to further support family engagement at their school. Evaluation was:

• Conducted by a DOE approved evaluator.
• Purpose: To describe and understand the nature of teaching and research that is made possible by bringing together the formal educational setting of the schools and the science cultural institutions.
• Look at outcomes, including the number and quality of completed exit projects.

One of UA’s six research-based components is program assessment and student learning. As stated in the UA brochure,

“UA program goals are assessed by both internal and external evaluators. Each of the six components is evaluated for its impact and adherence to learning goals and outcomes. For example, evaluation measures focus on delivery systems such as voucher usage, classroom application of UA-providing teaching resources and equipment, and the impact of professional development on classroom instruction through site-based classroom observations. Each year, all participating teachers, principals, and parent coordinators receive a survey to share their UA experiences. UA’s impact on student learning is also measured through analysis of student achievement data provided by the NYC Department of Education.”

The UA brochure reports the following program impact: “Urban Advantage serves over 30 percent of New York City schools with eighth grade students. Program-wide assessments
reveal that the UA has had a tangible impact on the New York City Department of Education’s middle school science education program as measured by the following:

- Learning experiences in UA classrooms have become more inquiry-based.
- Exit projects are now designed around opportunities to conduct hands-on investigations.
- UA teachers report more mastery of science content and an increased capacity to support students’ investigations.
- Students have more confidence in their grasp of science content.
- An unprecedented number of school groups and families have visited the eight cultural institutions.”

During my research, I was not granted permission to photocopy or provided with copies of reports by a program evaluator who shared some negative feedback. In one such report, the evaluator discussed classroom observations of lead teachers. The evaluator indicated that inquiry teaching and learning was less than expected and that teachers scored themselves higher on lessons than the evaluator. In my rubrics review, I also reported similar findings. Furthermore, teachers evaluated student’s exit projects with higher scores than another independent researcher and I recommended. The program evaluator who submitted negative feedback evaluated aspects of the program that were in line with the original stated goals of UA: to support teachers and students in inquiry teaching and learning. Interestingly, this evaluator was not contracted for future assessments.

This clarification is not meant to undermine the positive impact of the UA program on teachers, students, and families; rather, it is intended to highlight a limitation of this study and, potentially, UA’s evaluation practices: Much of the data is self-reported by UA, which has a vested interest in showing the positive impact of its program in order to continue to receive
support and funding by both the NYCDOE and the NYC Council. In 2011, another evaluator was contracted to assess student achievement at the NYS Intermediate Level Science (ILS). This examination was not one of the original stated focuses of UA. The evaluator’s key findings included the following:

- Students at UA schools outperform students at non-UA schools. In 2005-06, the second year of the program, 44.2% of students at UA schools demonstrated proficiency on the Intermediate Level Science Test (ILS) exam, compared to 40.5% at non-UA schools. In 2008-09, 55.5% of students at UA schools demonstrated proficiency, compared to 46.2% of students at non-UA schools.

- Student achievement for UA students versus non-UA students has increased over time. Little change has been observed, however, in student performance on ELA or math for eighth-grade students. Thus, the effect does not merely reflect coincidence for overall school improvement.

In its 2011 publication, the stated primary goal of UA is “to improve student understanding of scientific inquiry as defined in the New York State Core Curriculum.” Weinstein, Whitesell, and Schwartz (2014) stated on the UA program’s progress, “Now in its tenth year, the program harnesses the resources and expertise of NYC’s ISEIs to (a) enhance the science content knowledge of middle school science teachers, (b) develop teachers’ skills at using inquiry-based approaches in their classrooms, and (c) improve the science achievement of middle school students.” The authors continued, “Our key outcome is performance on New York State’s eighth-grade intermediate-level science assessment; longer term outcomes include enrollment at specialized science, technology, engineering, and math high schools as well as taking and passing the high school (Regents) science exams.” Additionally, they reported, “We
find that attending a UA school increases student performance on the eighth-grade science exam by approximately 0.05 SD, and there is some evidence of small effects on Regents taking and passing rates.”

One of the authors of the publication commented, “Working with the first author, UA staff have developed a logic model to articulate inputs, activities, outcomes, and goals.” A simplified version of the logic model is presented in Table 6 below. Furthermore, the following disclosure statement included in the publication relates to program assessment funding: “The authors disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This research is supported by Urban Advantage; major public support for Urban Advantage is provided by the Speaker and the City Council of New York and the New York City Department of Education. The research reported here was also supported by the Institute of Education Sciences, U.S. Department of Education, through Grant R305B080019 to New York University.” Thus, research for program evaluation was funded in part by the program that was being evaluated. The most recent program evaluators are currently developing new program goals, which are supported by their research findings.

Table 6: UA program logic model (Weinstein et al., 2014)

<table>
<thead>
<tr>
<th>Activities</th>
<th>Outcomes</th>
<th>Goals</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Professional development for teachers, school administrators, and parent coordinators</td>
<td>Student Outcomes:</td>
<td>• Improve students’ middle school science achievement in order to increase participation and success in high school science courses that lead to greater college readiness</td>
</tr>
<tr>
<td>• Students completing long-term science investigations (exit projects)</td>
<td>• Improved quality of long-term student science investigations (exit projects)</td>
<td>• Increase participation of high-need students in inquiry-based science learning experiences that incorporate rigorous and</td>
</tr>
<tr>
<td>• Access to and resources provided by informal science education institutions for students and teachers</td>
<td>• Increased proficiency on New York State intermediate-level science assessment</td>
<td></td>
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<tr>
<td></td>
<td>• Increased enrollment in STEM high schools</td>
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<tr>
<td></td>
<td>• Greater success on high</td>
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</tbody>
</table>
• Leadership institutes for school-based science leadership teams and lead science teachers
• Outreach to families by informal science education institutions

<table>
<thead>
<tr>
<th>Teacher Outcomes</th>
<th>relevant project-based contextual learning opportunities</th>
</tr>
</thead>
<tbody>
<tr>
<td>school regents science exams</td>
<td>Improve teacher practice through the use of inquiry-based instructional strategies and performance-based formative assessments</td>
</tr>
<tr>
<td>Greater implementation fidelity of inquiry-based instructional practices</td>
<td>Inform new models of STEM-focused middle school designs</td>
</tr>
<tr>
<td>Ongoing use of formative assessments to inform students’ science learning</td>
<td></td>
</tr>
</tbody>
</table>

Program Stakeholders

Program administrators.

After examining numerous organizations around the world from diverse industries, Senge concluded that “healthy ‘leadership ecologies’ can only happen when there is effective leading by the executives, local line leaders, and ‘internal networkers,’ people who come from diverse formal roles to cross organizational boundaries and connect diverse innovators and emerging knowledge” (Senge, 1999). This assessment also applies to the program administration for UA, including the program director, school and teacher coordinator, and NYCDOE administrative liaison. All three administrators are dedicated professionals who are very effective at carrying out their job responsibilities, as illustrated by the fact that all three have remained in their positions since these positions were established. They are knowledgeable about the dynamic parts of UA and how they relate to each other. Thus, they are able to attend to the political, as well as educational aspects of the program.

Program recipients.

Program recipients include teachers, principals, parent coordinators, students, parents and families. Teachers, principals, and parent coordinators participate in professional development and are immersed in science inquiry learning and teaching. The Science Immersion Model for
Professional Development (SIMPL) is used throughout the UA’s professional development activities. In addition to completing components of long-term investigations, participants are introduced to how the common core standards in ELA and mathematics and the Next Generation Science Standards are integrated into UA and student activities. Through voucher usage, teachers, students, families, and parent coordinators can access the eight science cultural institutions of UA. Schools receive equipment and materials during the first year of participation, and teachers receive stipends to purchase materials during each subsequent year. During professional development activities, teachers receive books, model activities for classroom use, and materials for conducting science inquiry activities. The students receive improved science inquiry instruction, materials to conduct long-term science investigations, access to science institutions, and an invitation to attend the Science Expo event held at AMNH, in order to publicly celebrate their work.

**Stakeholder input on program implementation.**

The professional development and program activities for teachers and families have been developed and administered through the coordinated effort and collaboration of UA partners and lead teachers. At required monthly meetings UA partners and lead teachers address administrative issues. The majority of professional development planning occurs during the Annual Black Rock Retreat and during separate meetings organized by individual partners and lead teachers.

**Personal Mastery**

Personal mastery, according to Senge, is “the discipline of continually clarifying and deepening our personal vision, of focusing our energies, of developing patience, and of seeing reality objectively. As such, it is an essential cornerstone of the learning organization—the
learning organization’s spiritual foundation. An organization’s commitment to and capacity for learning can be no greater than that of its members. The roots of this discipline lie in both Eastern and Western spiritual traditions, and in secular traditions as well” (Senge, 1990). Although mastery can be seen as the achievement of a certain level of proficiency, personal mastery drives an individual to commit to ongoing self-improvement and lifelong learning.

**Partners and Managers for Professional Development**

As a participant and observer in the UA program, I conducted field study observations while simultaneously participating in professional development activities as a teacher. At the first kickoff event I attended at the New York Hall of Science, I met one of a representative from the Botanical Gardens, one of UA’s partner institutions, who had only recently taken on the task of partner representative. As was the case with many UA teachers, this marked the beginning of a professional relationship that deeply impacted my growth as a teacher with more than fifteen years of experience. We shared our experiences with UA over a four-year period, during which time I conducted interviews and attended professional development activities offered by the partner and her primary lead teacher. Both the partner and lead teacher with whom I interacted exemplified Senge’s personal mastery as a result of their involvement in UA.

As a result of her experiences with UA, the partner came to the realization that her previous role as a manager for teacher professional development at a reputable NYC based science institution did not really support science inquiry learning for either teachers or students. She made this assessment, even though she was pursuing a second masters degree in science education and presumably taking part in courses dedicated to improved pedagogy. Instead, her institution taught inquiry by asking questions that resulted in experiential learning, but did not encompass the rigor of science content or embrace the process of identifying and presenting
evidence and reasoning. She commented,

I was at Bronx Hill (pseudonym) for many, many years—eight and a half years—and later in my career there I was getting my second masters degree. So even at that stage I realized that what we were calling science education at Bronx Hill was more experiential education. And it was fine, it was lovely, but it wasn’t necessarily true scientific inquiry. I think inquiry is really thrown around a lot as a term and looking at what we do through the Urban Advantage project I know inquiry is also changing as the NGSS comes through. I know that all of these notions on how we talk about science and how we teach it is also going to shift slightly. But I think that idea of how you teach people about inquiry and how you use what we throw around as an inquiry based process, I think that that was not necessarily a scientific process at Bronx Hill whereas what we do here, both at the Botanical Garden and at the DOE through the Urban Advantage program is a much better model. A much stronger model. One of the strongest models I have seen in science education for kids at that age.

She repeatedly cited a strength of the UA program: its facilitation of collaboration between teachers, partner institutions, NYCTOE administrators, and UA administrators. She also highlighted the program’s connection to partners in other cities:

I think that it has increased my knowledge of what good science education is because of the collaborative nature of the project itself. And obviously the integration of the Department of Education gives you an eye-opening experience to see what teachers struggle with and what real, everyday students struggle with. So I do think that it has expanded my notion of how to teach science…UA is doing it right. There is total buy-in for everyone at the school. The principals are involved for example at the principal administrator’s breakfast. It allows for follow-through from others at the school. It actually is an amazing idea; genius to involve grades six through eight. The focus on both process and content is very effective. I see more process supporting content and content supporting process. I am also learning alongside with other PD developers, not just in NYC, but also with PD developers from Denver, Boston, Chicago, and Miami.

She acknowledged that the partners and lead teachers grow together and learn together:

There is something of a mentoring process when you work alongside a teacher over time, when you are obviously co-planning but they are also teaching. In my opinion, we can be the mentors and help them with the teaching, but the learning goes back and forth, because they are the eyes and ears of the Department of Education and keep us updated. Which is incredibly important when you are a partner with such a large institution, which is really a bureaucracy.

She commented that working with lead teachers was very positive, mutually beneficial,
and often led to future professional opportunities:

I find it invigorating. It is enjoyable. I have hired some of them for per diem work outside of UA. We enjoy teaching science together. I do see our relationship as a DOE representative and cultural institution representative. They know how to deal with the DOE, which is important. As a partner representative, however, I do oversee their paperwork and evaluate them.

Although she did not use the term “personal mastery,” her comments acknowledged that lead teachers are committed to this achievement and cited this commitment as one of the most common features that lead teachers share:

They are go-getters. They know their craft. They love being science teachers. They are innovative and always willing to learn and improve their practice. They tend to know more about the tools available. They are collaborators and are willing to be flexible within the system of the DOE, as well as UA.

She cited the specific features of the Urban Advantage Program that support partners to provide professional development to teachers for ongoing improvement:

The professional development model for staff actually has a large role in that we meet monthly for a full day at each of our partner organizations. So that involves updates very often, including us and helping everyone understand what is going on at an administrative level. Then we do a little bit of PD that is not very formal during those sessions. So there is a very good chunk of the year, usually in winter, where we look at student work from the prior Expo. We have designed a protocol for that so that we can really look at it in a targeted way. And actually what we were finding, year after year, we were always looking at that student work. We are always trying to find elements of that student work, which are weak. Then we try to work more and more formally on improving those elements. So I think it was the last couple of years, we have really, really focused on looking at how to not just help kids understand claims, evidence, reasoning but to think about how to integrate the literacy piece and now the math piece to help them basically with their scientific reasoning. And then there is a rubric that is sort of in process that is separate from the Urban Advantage general rubric. So again, that is somewhat informal. Then we have our formal, four formal professional development sessions with lead teachers throughout the year. Those sessions vary, depending upon what the focus is. Those decisions are made in some cases with staff input. Then, of course, we have the Black Rock Retreat, which is a two-day retreat. Part of that is professional development and a large chunk of that is planning time because over the last few years, I think it is going back about three years, partners have begun to collaborate. So for our Cycle 2, for example, the American Museum of Natural History and the New York Botanical Gardens, we have collaborated. Obviously AMNH is focusing on secondary research, and we focus on field investigations, and the two match very nicely. And we have just
started, a lit bit, to start collaborating on the continuing teacher professional
development sessions. And of course all institutions work together on the Cycle 1’s.
And then we have our new kick-offs for our administrators, which is four years old, and
of course our kick-offs for all teachers new and continuing in the program. So there is
just a lot of collaborative planning that always occurs, both in person and online,
basically using our free Google tool.

She mentioned the specific features of the Urban Advantage Program that help lead
teachers to grow in their roles as master science teachers, including their involvement in
providing professional development to other teachers:

We have either twenty or twenty-one lead teachers—some of whom have been in the
program for the entire ten years—and a lot of new ones. So the lead teachers are required
to attend a certain number of lead teacher meetings, occasionally that has a little bit of
informal professional development ingrained. They are required to attend four formal
professional development sessions throughout the year with partners. Those are full day.
And then Black Rock where they are also asked to attend obviously for planning
purposes and for whatever professional development is embedded in that.

When I asked her if any teachers have grown professionally or have improved in their
ability to provide inquiry teaching and learning opportunities to their students, she described two
teachers in particular:

I have seen so much growth. I will speak about Barbara (pseudonym) specifically
because she has been our lead teacher longest. One lead teacher retired, another left to
work at the high school level. We have had a few lead teachers who were with us for a
short period of time when they realized that being a lead teacher is such a huge
commitment and they would leave that position. But when Barbara entered the program,
she is in a good school. It is just a tough population. There are a lot of language issues.
I am going to quote her, although she should probably be speaking. Her first year her
projects were okay and she knew it. And she actually said this “but it is the first year that
any of my students finished a project.” So you could see the power in the project based
learning model. She has obviously incorporated the professional development more and
more, year after year of being in the program. She is involved in an external grant where
she is just getting an amazing amount of professional development in ELA, as well as
science education. And this year her projects were stronger than I have ever seen them.
And when I read it, I didn’t actually speak to the kids—I never actually saw her children
this year due to scheduling problems—when I read it, those products, I could just see that
those kids really understood what they were writing about. It was the first time that I had
seen that. So you could just see the growth. Each year I see growth in her. She puts a
lot of energy and effort into all of this. But you can just see the change over time…Our
lead teacher that started a month ago, she has been in the program for two years and she
got into the program and did her Cycle 2 with us, and it was a combo of Hudson River Ecology. So the secondary research, along with all of those tools, along with her field visits here. She teaches in the Bronx. So she was really inspired by the hands-on fieldwork. She is also a go-getter. So she thought, “this is an amazing way to engage my students.” And she launched into a yearlong study and came here every single month with her students. She worked with some of the volunteers who work closely with us, as well as myself, and my assistant. She didn’t actually know if she was going to do her long-term science investigation on what they did. She was looking at macro invertebrates and leaf pack of the Bronx River to access stream health. And she decided to do it. And she managed to do it with her kids. I haven’t looked at it with a rubric, but on the surface, it is one of the strongest projects based around the Bronx River I have seen in a while. And again she is a go-getter and has only been in the program for a couple of years. But her next step is that she is interested in becoming a lead teacher. And I honestly can see her improving her practice to an amazing extent over the years, just because of the ingrained professional development and the other opportunities that sometimes come along because of Urban Advantage.

**Interview with a lead teacher.**

In separate interviews, the lead teacher that the partner mentioned acknowledged similar experiences and professional improvements as a result of her involvement in UA. When I asked her how her participation in UA affected students’ exit projects and her teaching, she responded,

> Both have definitely improved. I have learned what really makes a good project. Compared to my first years it has definitely improved. I have gone away from “take your project and do it at home” to incorporating it into the classroom. Other teachers at my school now prefer to do it this way because they see the quality has improved. It also has allowed us to give students more support with their projects.

She also cited the collaborative nature of UA as a positive aspect of the program and the aspect she most appreciated:

> The ability to meet with other people and share ideas. I work better like that when I am able to talk through things, bounce ideas off of, and work with others doing the same thing and asking the same types of questions. Also people who are working with the same types of students I am.

When I asked her about the characteristics that lead teachers share, she responded:

> I think that the lead teachers are always trying to improve their own practices and like sharing their own successes with others to improve science practice throughout the whole city. We enjoy what we do…want others also [to do this]…Sharing…allow us to also
improve what we do.

As a result of her participation in UA, she mentioned that she is more likely to incorporate projects and lab activities in teaching. The program has made her more comfortable in facilitating these types of activities in the classroom and has allowed students the opportunity to focus on specific topics or projects that they may not have had the opportunity to explore previously. The skills she learned in UA were subsequently embedded in her science classroom, beyond the requisite exit projects. As evidence of this, when I asked her what type of inquiry activities she has conducted with her students over the past year, she responded,

We did a density lab where there were multiple objects to get density and then draw conclusions. It was a simple project but it incorporated the IDD. I use the IDD for all lab investigations now. We did a mini-CSI investigation that involved fingerprinting, hair fibers, and ink analysis. It was a 2-day lab...Then students did long-term investigations. Water testing once a week. Fridays is project day. My students are working on a Jamaica Bay project involving water testing. It is laying the foundation of understanding ecosystems, watersheds, and the interaction between abiotic and biotic factors. It is more of a research-based project. We tackled what does it mean to live in a watershed and how do we affect the watershed. It has morphed into a school-wide recycling program where we are reading articles about environmental issues surrounding the Bay, reading articles from local newspapers, hotly contested issues around the Floyd Bennett field auto mall pipeline. Students are putting their thoughts up on a school-wide website for science. It has become more of an environmental awareness project. I want to get back to the water testing.

Mental Models

Mental models “are deeply ingrained assumptions, generalizations, or even pictures or images that influence how we understand the world and how we take action.” Mental models are often seen as impediments to change in organizations because people are often not consciously aware of them and the effects that they have on their behavior. To counteract this, Senge states that “learningful conversations” are necessary to allow people the space to surface their thinking and offer it to others for feedback (Senge, 1990). Mental models that are relevant for implementing science inquiry teaching and learning by supporting the completion of long-term
science investigations include teachers’ assumptions, generalizations and thoughts on:

- Direct-instruction (teacher-directed), compared to inquiry instruction (student-centered)
- Science specific instructional practices (e.g., collecting and analyzing data; hands-on activities, including laboratory activities)
- The impact of state-wide standardized testing—especially ELA and math testing—on science instruction
- Administrative and non-UA teacher support
- Professional development and support provided by UA
- UA provided tools for implementing long term-investigations including the ID and DSET.

A series of survey and interview questions were presented in order to elucidate teacher’s mental models. Table 7 outlines teacher responses and resultant findings:

Table 7: Survey and Interview Questions

<table>
<thead>
<tr>
<th>Direct instruction (teacher-directed) compared to inquiry instruction (student-centered)</th>
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<tbody>
<tr>
<td><strong>Survey:</strong></td>
</tr>
<tr>
<td>Q10: Addressing content using inquiry instruction takes longer than direct-instruction.</td>
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<tr>
<td>Q11: More content can be addressed using direct-instruction than using inquiry activities.</td>
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<tr>
<td>Q12: My students learn more by direct-instruction than by inquiry activities.</td>
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<tr>
<td>Q13: My students learn more from inquiry activities than by direct instruction.</td>
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<tr>
<td>Q14: My students learn better from direct-instruction than from inquiry activities.</td>
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<tr>
<td>Q15: My students learn better from inquiry activities than from direct-instruction.</td>
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</tbody>
</table>

**Findings:**
Overall, teachers reported that inquiry instruction takes longer than direct-instruction (64.7%), but students learn more through inquiry instruction (64.7%).

**Interview:**
Q3: Compare an inquiry approach to teaching with direct-instruction, with regards to time required, amount of content addressed, and student learning outcomes.
Table 7 (Cont.)

Findings:
Overall, teachers reported that inquiry instruction takes longer than direct-instruction. However, students learn more through an inquiry instruction approach. Exemplary teacher comments include the following:

“Absolutely a lot more preparation for inquiry but once students dive in there is more individual instruction. Learning outcomes skyrocket. I am able to move forward both content and skills and students are able to transfer information to new situations.”

“I am incorporating more inquiry in my teaching from my 2nd year. Inquiry teaching sacrifices breadth for depth. My program focuses on curriculum and development using an inquiry approach. I am pursuing a Masters at Fordham in science teaching MST. I have anecdotal data and test scores that there are better outcomes for student learning with inquiry. Inquiry does take longer. However, the long-term is better. I am teaching 8th grade curriculum this year and had to cut out the Human Impact Unit in order to include more inquiry. I covered all other units. The Human Impact unit is last and has fewer questions on the state test.”

“To do proper inquiry takes time. It takes time to do it right. Direct-instruction is quicker – this is what you need to know. The amount of content addressed is more using direct-instruction but if inquiry is done properly you can get better comprehension. There needs to be a balance: proper inquiry cannot be done without foundational skills. There is a place for direct instruction to turn instruction into an inquiry-based project.”

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<tr>
<th>Science-specific instructional practices (collecting and analyzing data; utilizing hands-on activities including laboratory activities)</th>
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Survey:
Q16: My students collect data in my classroom on a regular basis.
Q17: Students graph and analyze data on a regular basis in my classroom.
Q18: My students have lab activities at least once per week.
Q19: I utilize hands-on activities on a regular basis.

Findings:
The majority of teachers reported that students are actively engaged in science activities, as illustrated by the following percentage breakdown of responses:

- My students collect data in my classroom on a regular basis. (76.5%)
- Students graph and analyze data on a regular basis in my classroom. (70.6%)
- My students have lab activities at least once per week. (82.4%)
- I utilize hands-on activities on a regular basis. (88.2%)

Interview:
Q6: How often do students collect, graph, and analyze data in your classroom?
Q7: How often do students have lab activities?
Table 7 (cont.)

Findings:
Teachers responses in interviews resembled survey responses; but they additionally discussed the effect of content on the amount and type of data collection. Exemplary teacher comments include the following:

“As often as I can. I love graphing and start it at the beginning of the year. I have a graph for every science investigation.”

“Depending on what they are doing. At least once a week we are looking at a graph, if not collecting data and graphing it themselves. At least twice a month, on average, students collect data to graph. I like to incorporate at least one time per topic to graph data and analyze it.”

“Depends on the marking period and content being covered. Some projects were daily collection of data.”

“At least once a week, sometimes more depending on the topic. I am at an advantage because my classroom is a lab.”

“At least twice a week, because we are doing inquiry activities and lab activities all the time.”

The impact of state-wide standardized testing, especially ELA and math on science instruction

Survey:
Q49: I limit the amount of time my students work on long-term investigations and/or exit projects in order to prepare students for science statewide tests.
Q50: I limit the amount of inquiry activities in my classroom in order to prepare students for science statewide tests.
Q51: Students lose science instructional time for state ELA exam preparation or testing.
Q52: Students lose science instructional time for state mathematics examination preparation or testing.

Findings:
A large number of teachers responded that students lose instructional time for ELA (76.5%) and mathematics (70.5%) exam preparation and testing. However, fewer reported that they limit the amount of time spent on long-term investigations (58.8%) or inquiry activities (58.8%) in order to prepare students for science statewide tests.

Interview:
Q1: Describe the effects, if any, of standardized testing and accountability on your teaching practices.
Q2: Does preparation for statewide testing, including ELA and mathematics, affect science
Table 7 (cont.)

instructional time in your school?

**Findings:**
Teacher responses varied widely, with regards to both the effects on their own teaching practices and the instructional time in school:

“I am more aware of the test and the baseline to meet. But in all honesty I ignore the test. I spend two days of preparation for the test. My students do well by doing science. I have all girls, roughly 40% Hispanic, 30% Middle Eastern and a small percentage—maybe 10% Asian. It is Astoria, Queens. A diverse neighborhood. Single sex education is the biggest factor. We are economically diverse.”

“It changes it. It doesn’t help it for sure. There is a definite focus on reading skills not necessarily the science content you are teaching.”

“Unfortunately, standardized testing is a reality. As much as I would like to not prepare for a specific test and covering material, I work within the boundaries and try to make the best out of a bad situation.”

“No, it doesn’t really affect it. The school doesn’t really teach to the test.”

“No affect at all. I teach to a higher standard than any test, way before standardized testing.”

“Makes it hard at certain times of the year to plan projects. The school is shut down.”

“No we actually have combined ELA and humanities classes. We actually have more time for science since we have included more literacy in the classroom—mostly Common Core. We have five periods a week for science. The issue is that it is a 90-minute block every other day.”

“Yes, unfortunately, constantly giving predictive tests throughout the year. We run a mock state test four times a year. The entire school does it at the same time.”

“Absolutely, they [ELA and math] take priority. We lost science periods to do small groups in both ELA and Math. ELA small groups were done twice a week. Practice tests, field tests, acuity…we lose a lot of science periods.”

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**Administrative support and non-UA teacher support**

**Survey:**
Q20: The administrators in the school where I work support my participation in the Urban Advantage Program
Q21: The non-Urban Advantage science teachers in the school I work support my participation in the Urban Advantage Program.
Table 7 (cont.)

Q53: Administrators limit the amount of time my students work on long-term investigations and/or exit projects.

Findings:
Administrators must sign off on the Memorandum of Understanding agreement between their institutions and UA. Therefore, it is not surprising that teachers overwhelmingly (94.1%) report support from their school administrators. However, a smaller number (76.5%) report that administrators impose no limit on the amount of time that students may dedicate to long-term investigations.

Interview:
Q8: How would you describe the support you receive from administrators and non-UA teachers in your school regarding your participation in UA?

Findings:
Interview responses align with survey results. Exemplary teacher responses include the following:

“Great support!”

“Was told by administrators to attend UA because the school is part of the program and all science teachers should participate in such a helpful program.”

“Full support. We are a demonstration school.”

“A 1000 percent. Administrators see it (UA) as PD helping students with Common Core standards. They love all the resources and the fact that students are in touch with the scientists. I get to take the students to the Zoo.”

“Allowed one class to take three class trips for their exit projects. Very supportive. They allowed me to go the National Science Teachers Association Conference.”

Survey:
Q22: My students’ projects (including long-term investigations, exit projects, or science fair projects) have improved as a result of my participation in the Urban Advantage program.
Q23: Participation in the Urban Advantage program has improved my ability to implement science inquiry activities in my classroom.
Q24: As a result of participation in the Urban Advantage program, I assign inquiry-based projects other than the exit project.
Q25: The professional development provided by the Urban Advantage program is higher quality than that of other New York City Department of Education professional development I have attended.
Table 7 (cont.)

Findings:
All teachers (100%) responded that participation in the UA program has improved their ability to implement science inquiry activities in their classrooms and improved their student’s projects (94.1%). Teachers also report assigning inquiry based projects other than the required exit project (94.1%) and that the professional development provided by UA was of higher quality (94.1%) than other NYCDOE professional development activities in which they have participated.

Interview:
Q9: How has your participation in UA affected your students’ exit projects and your teaching?
Q10: How does the quality of UA professional development compare to other professional development activities in which you have participated?

Findings:
All teachers responded positively regarding the effect of participation in UA on their students and their teaching. The following exemplary teacher comments support this conclusion:

“Over the course of four years, it has definitely allowed me to move toward inquiry learning. UA is a large part of my professional growth. Without UA I don’t know where I would be today.”

“It has definitely changed the way I look at things and deal with the kids. It is nice to have a community to talk about things with.”

“UA has actually helped me realize all of the important parts of an investigation. Every project we do now is done in UA style.”

“6th, 7th, and 8th grade students all do a long-term investigation now. It made them better. We are doing more investigations rather than demonstrations. We used to have students write large research papers, but have moved toward long-term investigations at all grade levels.”

“I love UA. The way I approach things because of it. It is basically teaching science as a way of thinking, not memorization. It has given me the tools to pass on to the students on how to do that.”

“I have definitely improved. I learned what really makes a good project. Compared to my first years, it has definitely improved. I have gone away from “take your project and do it at home” to incorporating it into the classroom. Other teachers now prefer to do it this way because they see the quality has improved. It also has allowed us to give students more support with their projects.”

“Made me better prepared. Gave me a lot more ideas.”
Teachers reported specific reasons why they think that UA PD is a higher quality PD than others they attended:

“I love the fact that it is well-structured with goals. UA PD keeps me going. It is teaching teachers to teach teachers to teach. It starts with those developing the program. They have become experts at doing professional development coupled with content knowledge. They create an entire learning activity. I also love being surrounded with people interested in their professional growth. In fact, people who are stagnant don’t continue.”

“It has been amazing, apart from helping with the exit projects. It is research-based. Through it I have learned about professional learning communities, analyzing instructional materials, and instructional graphics. They use the SIMPL model.”

“I like the UA PD because it is science based. I don’t have to translate it. Other PD is usually math or ELA, and I have to remember how to use it, whereas UA is about science and is more valuable to me.”

“UA PD is more hands-on and practical. They give materials and were very supportive. It teaches you how to teach and use materials in the classroom.”

“UA PD is the best ever. It is so useful. The next day I can go in and use it. A lot of the time PD we get from people that are not teachers and it would work for students at City College or is for really nice kids.”

“You have to be really invested in the process to do UA. Other PD is more passive. It is higher level in content and looking at student work. It doesn’t stay the same. I have relationships with the institutions which is very helpful.”

**UA tools for implementing long-term investigations including the ID and DSET**

**Survey:**
Q26: My students use the ID (Investigation Design diagram) only for exit projects.
Q27: My students use the DSET (Designing a Scientific Explanation Tool) provided by the Urban Advantage program for their exit projects.
Q28: The ID (Investigation Design Diagram) has been helpful to my students.
Q29: The DSET (Designing a Scientific Explanation Tool) has been helpful to my students.
Q30: Students can easily complete the ID (Investigation Design diagram).
Q31: The DSET (Designing a Scientific Explanation Tool) is easy for students to use.

**Findings:**
Not all teachers found the UA developed tools for implementing long term-investigations to be helpful (ID – 82.3% and DSET – 70.6%) or easy for students to use (ID 58.9% and DSET 64.7%).
Table 7 (cont.)

Interview:
Q11: What is the ID? Describe how and when you use the ID.
Q12: What is the DSET? Describe your students’ experiences using the DSET.

Findings:
Teachers described both tools as graphic organizers, but their use of the tools varied. Some teachers used both for all projects, while others used one or both only for long-term investigations. Some teachers did not use them at all. The following teacher comments exemplify the variety of responses:

“I use it with any experiment we are doing. So that the kids can identify the different parts of the experiment, especially the independent and dependent variable.”

“I don’t use the ID because it is an organizer and is less instructional. The concept of IV and DV is taught through examples and experimental design. I come back to IV and DV when doing exit projects.”

“Use it all the time with investigations, but once it is used the students don’t need the actual graphic organizer.”

“The ID is a graphic organizer to organize the variables in the experiment – to lay them out. I like to lay out the variables first, then have the students write the question, then form a hypothesis. I find it helpful to students. We explain to them, then give them the experiment. Sometimes we just give them the materials and let them by trial and error figure it out. What did you change? What did you measure?”

“That was the best thing. Was an eye-opener. I immediately took it back to students with a self-contained class and they GOT it! This tool is good to teach any kid, regardless of who they are. They get it.”

Overall findings on mental models.

Mental models that might impede the implementation of inquiry teaching and learning for long-term investigations were not found to be significant. Rather, teachers viewed inquiry teaching and learning positively and felt supported both by administrators and UA. This supports the UA program as a successful initiative and suggests that teachers who participate in the program remain committed to its overall goal and vision.
Team Learning

**Research based practices: What research informs UA?**

In 2009, I served on the leadership team for one of the thirteen Grade 6-12 NYCDOE schools that was selected to participate in the Middle School Science Leadership Institute held at the AMNH. The Middle School Science Leadership Institute was organized by the Gottesman Center for Science Teaching and Learning, in collaboration with the Biological Sciences Curriculum Study (BSCS) Center for Professional Development and the Urban Advantage Program. BSCS was founded in 1958. In 1987, under the direction of Roger Bybee, it developed the 5E Instructional Model for teaching inquiry science, based upon two theoretical principals for constructivist research: the Vygotsky and Ausubel and Karplus theories. BSCS also developed the Science Curriculum Improvement Study (SCIS). The Middle School Science Leadership Institute was funded through grants provided by the Carnegie Corporation of New York, Speaker and Council of the City of New York, and New York City Department of Education.

The institute exemplified the Urban Advantage Program’s best practices and made visible the research upon which it is based. It was held over six days on May 6 and 27; June 10, 29, and 30; and July 1. Each day addressed a research-based topic, including:

- research on how students learn science in formal and informal science environments;
- essential features of scientific inquiry;
- the nature of science and real scientists’ work;
- change process in school systems;
- using data-driven dialogue to analyze student assessment results; and
- developing an action plan focused on improving middle school science education.
The program goals were to:

- understand leadership knowledge bases that inform program design, including the topics outlined above;
- use student learning data to inform program-level decisions and classroom practice;
- understand the role of science-rich cultural institutions and their resources to support science curriculum in middle schools; and
- expand the capacity to sustain improvement efforts through the formation of a leadership team that seeds the development of professional learning at school.

Each school was assigned one or two representatives from a UA partner institution to improve their middle school science program by building a vision and plan for teaching and learning science. My school was assigned two members of the AMNH staff, both of whom have completed their PhDs in science education at Columbia University. Both have since moved on to new positions: One remains at AMNH in a new capacity, and the other is a superintendent of a school system in New York State. All partner institutions were represented, and among the fourteen schools, seven were current or future lead teachers. 2009 was the only year in which the leadership institute was held. In subsequent years, UA hosted an annual retreat at Black Rock over two consecutive days, following the end of the school term. All lead teachers, partner institutions, UA administrators, and the NYCDOE UA liaison were invited to attend.

The Leadership Institute (2009) and Black Rock Retreat (2011) were co-designed and co-facilitated by Jim B. Short, the Director of the Gottesman Center for Science Teaching and Learning who also served as the Director for the Science Curriculum Implementation (SCI) Center for BSCS from 2000-2005; and a science educator who has worked with BSCS since 2004 and who, in 2015, was promoted to the position of Senior Science Educator.
Day One: Learning and teaching science.

The first day’s agenda included the topics “Learning and Teaching in the Classroom,” “Research on How Students Learn Science,” “Learning and Teaching in Science-rich Cultural Institutions,” “Research on Learning Science in Informal Environments,” and “Research on Collaborative Work and Professional Learning Communities.” Participants received an executive summary of Bell, et al.’s Learning Science in Informal Environments: People, Places, and Pursuits (2009) in addition to the following reference list:


On the first day, the NYCDOE Middle School Science Instructional Supervisor—a position that was abolished the following year, but was re-established in 2014 under Chancellor Carmen Farina—provided a welcome address and led the introductory session. For almost five years, the UA program was the only science leadership and direction at the NYCDOE for middle schools.

The subsequent session “Research on How Students Learn Science in the Classroom” was based primarily based on the publication of the same name released by the National Research Council (2005). Participants learned that cumulative research has revealed three critical components for ensuring student learning: building upon student’s prior knowledge, emphasizing that doing science is important to learning science, and utilizing metacognition. By asking student’s to share their prior knowledge, educators can uncover their existing preconceptions, including any misconceptions. Educators must understand students’ misconceptions about how the world works in order to grasp new concepts and information. Misconceptions are often difficult to overcome: students may learn new, correct concepts for the purposes of testing, but then revert to their existing preconceptions that are void of scientific reasoning. Students also often exhibit misconceptions about the overall scientific process. In order for conceptual changes to occur, including the refinement or replacement of ideas, instruction must explicitly address students’ existing knowledge.

Three processes are involved in the development of competence in any given area of a science discipline. First, students must have a strong depth of usable knowledge, know facts and ideas within a context of conceptual understanding, and be able to organize their knowledge to improve accessibility and applicability. Inquiry experiences should not be limited to in-class
experiments to explore new content. Rather, inquiry experiences should be prioritized as students engage students in directly learning new content. By providing a metacognitive approach to instruction, students are allowed time to reflect on how they think so that they develop a sense of ownership over the learning process. This strategy also provides an instructional opportunity to address a common tendency for people to confirm what they already believe, rather than to rigorously test and possibly refute preconceived notions.

The “Research on Learning Science in Informal Environments” session was primarily based on the National Research Council’s *Learning Science in Informal Environments: People, Places, and Pursuits* (2009). According to the publication’s executive summary:

Informal science is a burgeoning field that operates across a broad range of venues and envisages learning outcomes for individuals, schools, families, and society. A range of disciplines and perspectives, including field-based research, visitor studies, and psychological and anthropological studies of learning, informs the evidence base that describes informal science, its promise, and effects. Learning Science in Informal Environments draws together disparate literatures, synthesizes the state of knowledge, and articulates a common framework for the next generation of research on learning science in informal environments across a life span. Contributors include recognized experts in a range of disciplines—research and evaluation, exhibit designers, program developers, and educators. They also have experience in a range of settings—museums, after-school programs, science and technology centers, media enterprises, aquariums, zoos, state parks, and botanical gardens. Learning Science in Informal Environments is an invaluable guide for program and exhibit designers, evaluators, staff of science-rich informal learning institutions and community-based organizations, scientists interested in educational outreach, federal science agency education staff, and K-12 science educators.

The study takes a blended approach to defining appropriate outcomes for science learning in order to avoid the errors of adopting the same tools and measures of achievement used in school settings or using only learner defined outcomes. A framework for “Strands of Science Learning” was created specifically for informal environments; it was built upon a framework that was originally developed for K-8 science learning in *Taking Science to School* (National
Research Council, 2007). A series of strands of learning in informal environments was formulated that is distinct from, but overlaps those of formal education institutions:

- **Strand 1:** Experience excitement, interest, and motivation to learn about phenomena in the natural and physical world.
- **Strand 2:** Come to generate, understand, remember, and use concepts, explanations, arguments, models, and facts related to science.
- **Strand 3:** Manipulate, test, explore, predict, question, observe, and make sense of the natural and physical world.
- **Strand 4:** Reflect on science as a way of knowing: on processes, concepts, and institutions of science; on their own process of learning about phenomena.
- **Strand 5:** Participate in scientific activities and learning practices with others using scientific language and tools.
- **Strand 6:** Think about themselves as science learners, and develop an identity as someone who knows about, uses, and sometimes contributes to science.

The session “Research on Collaborative Work,” was based on research by Garmston and Wellman (1999), who outlined seven norms of collaborative work: pausing, paraphrasing, probing, putting ideas on the table, paying attention to self and others, presuming positive intentions, and pursuing a balance between advocacy and inquiry. A checklist for the “Norms of Collaboration Inventory,” which outlined indicators for each of the seven norms, allowed participants to reflect on and whether these norms were rarely, occasionally, or frequently revealed when they met together to work as a team.

The session “Research on Professional Learning Communities” focused on two studies: Loucks-Horsley, et al.’s *Continuing to Learn: A Guidebook for Teacher Development* (1987) and
Louis and Kruse’s *Professionalism and Community: Perspectives on Reforming Urban Schools* (1995). The session outlined five characteristics of successful professional learning communities: shared norms and values, a focus on student learning, collaboration, de-privatized practice, and reflective dialogue. The session distinguished between groups and teams: Drawing on Garmston and Wellman (1999), teams were defined as working groups that employ conscious attention to the processes they use to develop as a group. Where a group is simply a collection of people that meets together, a team is a group of people that has a clear charter (or task), is interdependent, believes that working as a team equals more effective outcomes, and is self-accountable and rewarded as a unit (Harvey and Drolet, 1994). A quotation by Loucks-Horsley, et al. (1987) framed the conversation around team learning: “Community and leadership cannot occur if teachers remain isolated from each other. Developing this community requires the recognition that professional learning is a life-long process that is best nurtured within the norms and culture of the school.” Participants were additionally provided with the following 23 quotes, including three by Senge:

1. “The leadership we need is available in all of us. We have only to make it manifest” (Owen).

2. “This inherent capacity to choose, to develop a new vision for ourselves, to rescript our life, to begin a new habit or let go of an old one, to forgive someone, to apologize, to make a promise and then keep it, in any area of life, is, always has been, and always will be a moment of truth for every true leader” (Covey).

3. “The test of a vision is not in the statement, but in the directional force it gives the organization” (Senge, et al., 1994).
4. “We cannot hope to influence any situation without respect for the complex network of people who contribute to our organizations” (Wheatley).

5. “Example is leadership” (Schweitzer).

6. “A shared vision is not an idea…it is, rather a force in people’s hearts, a force of impressive power” (Senge).

7. “If we are to achieve a richer culture, rich in contrasting values, we must recognize the whole gamut of human potentialities and so weave a less arbitrary social fabric, one in which each diverse human gift will find a fitting place” (Mead).

8. “The only true insanity is doing the same thing over and over and expecting different results.” (Brown).

9. “Just like everything else in our society today, our understanding of leadership is changing. As conditions in our world have changed, our knowledge of the characteristics of effective leaders has evolved” (Burns).

10. “Leaders communicate more than other people in a group (DePree).

11. “Any organization that sets out to change its own culture remains powerfully influenced by that culture, even as it attempts the change” (Evans).

12. “Whether people perceive a change as positive or negative depends not only on the actual outcomes of the change, but also on the degree of influence they believe they exert in the situation” (Conner).

13. “There is only one way under high Heaven to get anybody to do anything. Did you ever stop to think of that? Yes, just one way. And that is by making the other person want to do it. Remember, there is no other way” (Carnegie).
14. “To affect true change, one must become a leader of leaders, one who inspires others to lead the transformation” (O’Toole).

15. “The very essence of leadership is [that] you have a vision. It’s got to be a vision you articulate clearly and forcefully on every occasion. You can’t blow an uncertain trumpet (Hesburgh).

16. “One cannot hope to implement change without persuading people that it is necessary. This is a task of daunting proportions that must often start by challenging people’s view of themselves, their performance and their clients (Evans).

17. “Character is the…personality of the…organization; it is the DNA of the organizational life form. It is the organization’s character that makes it feel and act like itself” (Bridges).

18. “Today’s successful…leaders will be those who are most flexible of mind. An ability to embrace new ideas, routinely challenge old ones, and live with paradox will be the effective leader’s premier trait. Further, the challenge is for a lifetime” (Peters).

19. “A bridge, like professional development, is a critical link between where one is and where one wants to be. A bridge that works in one place almost never works in another. Each bridge requires careful design that considers its purpose, who will use it, the conditions that exist at its anchor points…and the resources required to construct it. Similarly, each professional development program…requires a careful and unique design” (Loucks-Horsley).

20. “Learning does not occur in any enduring fashion unless it is sparked by people’s own ardent interest and curiosity” (Peter Senge, et al.).
21. “The whole is never the sum of its parts—it is greater or lesser, depending on how well the individuals work together” (Chuck Noll, former coach, Pittsburgh Steelers).

22. “The goal of all groups, if they are to carry out their mission effectively and efficiently, is to develop community” (Kaser, p. 203).

23. “Community is an outward and visible sign of an inward and invisible grace, the flowing of personal identity and integrity into the environment so that teams can do their work in a culture of respect and continuous improvement” (Kaser, p. 203).

**Day Two: Scientific inquiry.**

The agenda for Day Two included the topics, “An Experience in the Hayden Planetarium,” “Visualizing the Solar System and the Universe,” “An Experience with Scientific Inquiry,” “Investigating Termite Behavior,” “The Five Essential Features of Inquiry in the Classroom,” “An Experience with Experimental Design and Urban Advantage,” “Experimenting with Helicopters and Exit Projects” and a gallery walk for the observation and analysis of two students’ exit projects. During the latter activity, participants identified the investigation type, independent variable, dependent variable, number of trials performed, and whether or not a control was used. The UA Science Exit Project Evaluation Rubric and sections of the Science Exit Project Poster were presented prior to the gallery walk and used for the project analysis. Participants were expected to engage in science inquiry through activities and a research literature review on the “Five Essential Features of Inquiry in the Classroom” outlined by the National Research Council (2000):

1. Learners are engaged by scientifically oriented questions. Scientifically oriented questions center on objects, organisms, and events in the natural world; they connect to the science concepts described in the content standards. They are questions that lend
themselves to empirical investigation and lead to gathering and using data to develop explanations for scientific phenomena.

2. Learners give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions. Science distinguishes itself from other ways of knowing through the use of empirical evidence as the basis for explanations about how the natural world works.

3. Learners formulate explanations from evidence to address scientifically oriented questions. Scientific explanations are based on reason. They provide causes for effects and establish relationships based on evidence and logical argument.

4. Learners evaluate their explanations in light of alternative explanations, particularly those reflecting scientific understanding. Evaluation and the possible elimination or revision of explanations is one feature that distinguishes scientific from other forms of inquiry and subsequent explanations.

5. Learners communicate and justify their proposed explanations. Scientists communicate their explanations in such a way that their results can be reproduced. This requires a clear articulation of the question, procedures, evidence, proposed explanation, and review of alternative explanations. It provides for further skeptical review and the opportunity for other scientists to use the explanation in work for new questions.

Each of these essential features was accompanied by further explanations taken from the National Research Council (2000). Participants read, coded, reflected, and shared on each of the five essential features of inquiry.
Day Three: Nature of science.

Day Three’s agenda included the topics “Constructing Scientific Explanations,” “Roles and Expectations for Participating in the Leadership Institute,” “The Nature of Science,” and “The Work of Scientists: Case Discussion: Fish in the Lower Congo River.” The UA adapted the Developing a Scientific Explanation Tool (DSET) for the session, and a rubric for writing a scientific explanation, accompanied by research on scaffolding scientific explanations was also provided. According to the American Association for the Advancement of Science (AAAS) Benchmarks (1993), students should know about and be able to develop the following types of scientific inquiries at the respective grade levels provided in parentheses:

- Ask “How do you know?” in appropriate situations and attempt reasonable answers when others ask the same question (K-2).
- Offer reasons for findings and consider reasons suggested by others (3-5).
- Seek better reasons for believing something than “Everybody knows that…” or “I just know” and discount such reasons when given by others (3-5).
- Notice and criticize the reasoning in arguments in which fact and opinion are intermingled or the conclusions do not follow logically from the evidence given (6-8).
- Insist that the critical assumptions behind any line of reasoning be made explicit so that the validity of the position being taken—whether one’s own or that of others—can be judged (9-12).

Research on scaffolding scientific explanations conducted by McNeill, et al. was presented to synthesize the following problems compounding teaching scientific inquiry:

- Explanations are rarely a part of classroom practice (Kuhn, 1993; Newton, Driver & Osborne 1999).
• Students have difficulty using appropriate evidence (Sandoval & Reiser, 1997),
  including providing reasons for why they chose the evidence (Bell & Linn, 2000) in their
  written explanations.

• Students typically discount data if the data contradicts their current theory (Chinn &
  Brewer, 2001).

• During classroom discourse, discussions tend to be dominated by claims with little
  backing to support their claims (Jimenez-Aleixandre, Rodriguez, & Duschl, 2000).

During this session, participants were additionally provided with a copy of Chapter Seven
from Sutherland, et al.’s Supporting Middle School Students in Developing Scientific
Explanations and the NSTA’s Linking Science & Literacy in the K-8 Classroom. Participants
read, text coded, reflected, and shared their thoughts on the topic and resources provided. This
was followed by a case study presentation, “Tri-Lakes: The Investigation,” taken from BSCS
Biology: A Human Approach. The case study was intended to represent an exemplar for
developing better ways to present a data-rich body of scientific information to students for
analysis and writing scientific arguments. Participants were additionally provided with the
following list of references:

American Association for the Advancement of Science (1993). Benchmarks for science
literacy. New York, Oxford University Press.

Dubuque, IA: Kendall/Hunt.

developing scientific explanations. In R. Douglas, M. P. Klentschy, K. Worth, &
W. Binder, Linking science and literacy in the K-8 classroom (pp. 163-181).
Arlington, VA: NSTA.

construction of scientific explanations by fading scaffolds in instructional
**Day Four: Change process in schools.**

Day Four’s agenda included the topics “Understanding the Change Process as Leaders: Introduction to Change Strategies” and “Understanding the Change Process as a Team, with an Overview of the Concerns-Based Adoption Model.” Loucks-Horsley, et al.’s 2003 formed the basis of this session. For some reason, this particular session was not memorable to me. Neither my notes nor the materials provided served to jog my memory sufficiently to allow me to provide meaningful comments.

**Day 5 & 6: Using data.**

During Days Five and Six, each school leadership team was provided with a number of resources: They received a copy of Love, et al.’s *Understanding the Power of Collaborative Inquiry: The Data Coach’s Guide to Improving Learning for All Students* (2008), as well as *Contextual Factors That Affect Professional Development*. The contextual factors identified include students, standards, and learning results; teacher and teachers’ learning needs; curriculum, instruction, assessment practices and the learning environment; national, state, and local policies; available resources; organizational culture; organizational structure and leadership; history of professional development; and parents and community. Participants also received Wellman and Lipton’s (2004) *An Approach to Data-Driven Dialogue: 3 Phases*. Most relevant to the participants, each team then analyzed the data provided by its school, including six data packets composed of:

- a school profile (demographics data) for the years 2005-2006, 2006-2007, and 2007-2008;


- New York citywide “Grade 8 NYS Science Test Item Level Data) for the years 2005-2006, 2006-2007, and 2007-2008; and


Each team was responsible for analyzing the data and formulating a plan of action for improving student performance on the state assessments.

**Black Rock Forest Retreat.**

Like the Middle School Science Leadership Institute, the annual Black Rock Forest Retreat was co-designed and facilitated by Short and a BSCS representative. All lead teachers, partner representatives, UA Administrators and the NYCDOE UA liaison were invited to attend the 2011 retreat I attended as a participant and observer. Over the course of the two-day retreat, participants covered a range of topics, including an introduction to the newly designed Continuing Teacher Professional Development (CTPD) program and its vision statement and goals, as well as the topics, “Using Formative Assessments as Professional Development Strategies And Moves,” “Using the Science Immersion Model for Professional Learning (SIMPL) to Plan The New CTPD,” and “Curriculum Topic Study as a New PD strategy.” The modified professional development training narrowed its scope to three strategies: implementing curriculum, curriculum topic study, and focusing on student work. The PD facilitator’s sessions on curriculum development focused on the IDD and DSET tools developed by UA for
implementing long-term science investigations. Research literature was also further integrated into PD activities.

Research-based practices were evident throughout both days of the retreat. All five characteristics of a professional learning community outlined by Loucks-Horsley, et al. (1987)—shared norms and values, a focus on the student learner, collaboration, de-privatized practice, and reflective dialogue—were highlighted during the training, as were Garmston and Wellman’s seven norms of collaborative work (1999). The BSCS also embedded its “5 Es,” or five essential features of inquiry into the SIMPL model that was developed from a large-scale study on the effects of science immersion on teachers’ instructional practices and student achievement. The formative assessments and curriculum study topics were provided in a book by former president of the National Science Teachers Association Page Keeley. All publications by NSTA undergo a rigorous peer review process, and materials and strategies have been field-tested by large populations of teachers and students.

The morning of the first day of the retreat was dedicated to addressing the newly designed CTPD. Continuing teachers were assigned to sessions based on the number of years they had participated in the UA program and based upon a self-assessment of their level and interests. Partner institutions and lead teachers were assigned to session levels and topics according to the PD structure. This marked a major departure from group assignment in previous years, when each partner institution was given equal billing and involved in decision-making about participants in Cycle 2 and Cycle 3 PD workshops. In 2011, partner institutions were identified as playing either leading or supporting roles within UA. The UA administrators developed the new PD structure prior to the retreat, but participating partners and lead teachers were only informed about groups’ assignments when they arrived at the retreats. Some were not
happy about the changes. The partner with whom I spoke extensively about UA was particularly upset with her institution’s new assignment as a supporting, rather than a leading institution in the area in which she felt represented her institution’s strength. By the end of the retreat’s second day, however, her feelings about the decision had improved.

UA professional development was revised based on a data-driven dialogue on the increasing number of continuing teachers in the UA program. Participants called for differentiating the professional development to meet teachers at their respective experience levels, while continuing to educate beginning UA teachers with a standardized set of UA practices.

On Day One of the training, participants received the document *Toward a Shared Vision: The Urban Advantage Professional Development Model* for group discussion. They were encouraged to reflect on and speak freely about the stated goals outlined below:

- To improve teachers’ understandings about the components of long-term scientific investigations (science exit projects) and how to teach students how to successfully complete high quality projects.
- To increase teachers’ knowledge of and ability to use the resources available from New York City’s science-rich cultural institutions (UA partner institutions) to support students and their families engage in authentic inquiry-based science learning experiences.

*New teacher professional development program.*

**Cycle 1 Goals (two days)**

- Provide an introductory learning experience using specific UA tools and strategies for teaching science exit projects.
• Provide an overview of the four types of science exit projects and how UA partner institutions support the teaching of long-term science investigations.

Cycle 2 Goals (five days)
• As learners, teachers complete their own science exit project using specific UA tools and strategies designed to support students and the resources of a particular UA partner institution.
• Teachers reflect on their learning experience and develop plans for how to incorporate effective school group visits to a particular UA partner institution.
• Teachers develop lesson plans for their classrooms that apply the specific UA tools and strategies designed to support science exit projects with students and the resources of a particular UA partner institution.

Cycle 3 Goals (one day)
• Teachers learn how to design an effective school group visit to a second UA partner institution that is connected to the process of teaching students how to do successful exit projects.

Continuing teacher professional development program

Vision
• Integrate UA tools and strategies into core science curriculum.
• Embed inquiry (process of doing science) across science curriculum.
• Increase teachers’ and students’ abilities to successfully complete high quality science investigations.
• Develop teacher professional learning communities within the UA program.
• Increase collaborations among science teachers in UA schools.
• Blend learning outside of school in informal environments with formal learning inside school.

• Improve individual professionalism that includes knowledge of science, pedagogy, and students.

Goals

1. Improve teachers’ ability to integrate field trip learning experiences with learning specific science concepts in the core curriculum outside of the exit project work.

2. Deepen teachers’ knowledge and ability to teach students how to design investigations with applications to the four types of science exit projects and other parts of the core curriculum.

3. Deepen teachers’ knowledge and ability to teach students how to develop good scientific explanations based on claims, evidence, and reasoning and be able to apply these tools and strategies to other parts of the core curriculum.

4. Deepen teachers’ science content knowledge through the use of investigations and other inquiry-based activities.

5. Support teachers’ ability to use formative classroom assessments in science to improve the quality of students’ science exit projects.

6. Engage teachers in reflective practice through sharing student work and examining collaboratively student thinking.

7. Encourage and support school-based teams of science teachers to participate in UA professional development sessions together.
### Table 8: Curriculum Implementation: Years One and Two

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<thead>
<tr>
<th>Years 1-2 (2 days)</th>
<th>Host Partners</th>
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<tbody>
<tr>
<td><strong>Level 1 (Introductory)</strong></td>
<td></td>
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<tr>
<td>• Controlled Experiments (Goals 1 &amp; 2)</td>
<td>BBG and NYBG</td>
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<tr>
<td>• Field Studies (Goals 1 &amp; 2)</td>
<td>SIZ and NYAQ</td>
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<tr>
<td>• Design Projects (Goals 1 &amp; 2)</td>
<td>NYSci</td>
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<tr>
<td>• Secondary Research (Goals 1 &amp; 2)</td>
<td>AMNH</td>
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| **Level 2 (Advanced)** | |
| • Controlled Experiment/Design Projects (Goals 3, 4, & 5) | QBG |
| • Field Studies (Goals 3, 4, & 5) | Bronx Zoo |
| • Secondary Research (Goals 3, 4, & 5) | AMNH |

### Table 9: Curriculum Development: Years Three-Four; Five-Seven

<table>
<thead>
<tr>
<th>Years 3-4 &amp; 5-7 (2 days)</th>
<th>Host Partners</th>
<th>Supporting Partners</th>
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<tbody>
<tr>
<td>• Earth Science (Goals 1, 4, &amp; 7)</td>
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<td>• Life Science (Goals 1, 4, &amp; 7)</td>
<td>NYBG</td>
<td>Bronx Zoo</td>
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<tr>
<td>• Physical Science (Goals 1, 4, &amp; 7)</td>
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<td>BBG</td>
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**Examining Student Work**

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<tr>
<td>• IDD Focus (Goals 2, 6, &amp; 7)</td>
<td>NYAQ</td>
</tr>
<tr>
<td>• DSET Focus (Goals 2, 6, &amp; 7)</td>
<td>AMNH</td>
</tr>
</tbody>
</table>
### Table 10: New Teacher Professional Development

<table>
<thead>
<tr>
<th>Cycle 1: Lead Institutions</th>
<th>Cycle 2: Lead Partners</th>
<th>Cycle 3: Supporting Partners</th>
</tr>
</thead>
<tbody>
<tr>
<td>(2 Days)</td>
<td>(5 days)</td>
<td>(1 day)</td>
</tr>
<tr>
<td>AMNH</td>
<td>BBG</td>
<td>SIZ</td>
</tr>
<tr>
<td>NYSci</td>
<td>Bronx Zoo</td>
<td>QBG</td>
</tr>
<tr>
<td></td>
<td>NYSci</td>
<td>NYAQ</td>
</tr>
<tr>
<td>Additional support from:</td>
<td>AMNH</td>
<td>NYBG</td>
</tr>
<tr>
<td>QBG, NYAQ, NYBG</td>
<td>SIZ</td>
<td>BBG</td>
</tr>
</tbody>
</table>

### Table 11: New Teachers Cycle Focus

<table>
<thead>
<tr>
<th>Year 1 Cycle 2 focus</th>
<th>Lead Partner</th>
<th>Supporting Partner</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Controlled Experiments (Includes 6th)</td>
<td>BBG</td>
<td>SIZ</td>
</tr>
<tr>
<td>• Field Studies</td>
<td>Bronx Zoo</td>
<td>QBG</td>
</tr>
<tr>
<td>• Design Projects (includes 6th)</td>
<td>NYSci</td>
<td>NYAQ</td>
</tr>
<tr>
<td>• Secondary Research (Hudson River)</td>
<td>AMNH</td>
<td>NYBG</td>
</tr>
<tr>
<td>• Field Studies</td>
<td>SIZ</td>
<td>BBG</td>
</tr>
</tbody>
</table>
Table 12: Continuing Teacher Professional Development

<table>
<thead>
<tr>
<th>Years in UA</th>
<th>No. Continuing Teachers</th>
<th>PD Strategy (10 hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Curriculum Implementation using student work exemplars</td>
</tr>
<tr>
<td>1</td>
<td>87</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>131</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>28</td>
<td>Curriculum Topic Study Examining Student Work</td>
</tr>
<tr>
<td>4</td>
<td>57</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>25</td>
<td>Curriculum Topic Study Examining Student Work</td>
</tr>
<tr>
<td>7</td>
<td>8</td>
<td></td>
</tr>
</tbody>
</table>

The first few hours of the training were dedicated to discussion of the new CTPD vision and goals. The training utilized five PD strategies and actions outlined in Keeley’s *Science Formative Assessment: 75 Practical Strategies for Linking Assessment, Instruction, and Learning:* “Stand Up II,” “Popcorn Introduction,” “Public Notes,” “Norms of Collaboration,” and “Give Me Five.” Participants shared the following questions regarding the new CTPD, vision, and goals:

- “How do you push teachers to other partner institutions?”
- “Some teachers are not understanding UA or integrating UA in core curriculum, not just for exit projects. What is the reason for their hesitation?”
- “A community of learners does exist with lead teachers as well as the reflective process. How can we continue this with UA teachers?”
- “There is not enough collaboration between teachers at the same school and other schools in the UA program. Maybe teachers have their own teaching styles. How can we bridge
schools and teachers within the same school, teachers and other UA teachers, and
students from other schools?”

The PD facilitator addressed these concerns with the following responses:

- “We do have professional learning communities.”
- “A safe space, common language, common skill set.”
- “The strength is within the structure of the entire program.”
- “We need to encourage formative classroom assessments within the same school.”
- “The goals are skills and practices, whereas the vision is a loftier goal”
- The collaboration between teachers will take time. Looking at student work will take
time.”

The UA Administrator provided the following responses:

- “The scientific explanation part seems to be the most difficult part. It is a challenge.”
- “The team approach is important within the same school—Grades 6, 7, and 8.”
- “As far as One and Two of the vision, using tools makes teachers look beyond the exit
  project.”
- “Professional developers need more PD. For example: creating formative assessments.”
- “Goal Seven is really big and is the social service of our job.”
- “How many PDs do they need to have the skills to do this?”

Following this exchange, the PD facilitator redirected the discussion with the comment,
“The question is how do we implement/operationalize these vision/goals? They are good. Let’s
not question the goals/vision themselves. What strategies will be used for PD? You need to
broaden your ideas about formative assessments. Pair up—which is a formative assessment
strategy—with a partner. Talk about what your partner said, and not what you said.” The following outlines the ensuing discussion:

PD facilitator: “Moving into new teacher PD. Who from the design team wants to share?”

UA Administrator: “Cycle One is the same structure. Cycles Two and Three have changes. There are connections between them. It is more like a unit. AMNH and NYSci are the larger sites; however, additional support is necessary. In Cycle Two, we considered content areas as well as geographic areas: BBG (botany controlled experiments), Bronx Zoo (zoology field investigations), Hall of Science (physical science and design), AMNH (secondary research). Then we decided on Lead Partners versus Supporting Partners.”

PD facilitator: “Share with your group questions about where you fit in with this new design.”

After ten minutes of discussion, participants shared the following comments using the Number 7: Commit and Toss exercise:

- “There is more and stronger collaboration between partners.”
- “Teachers can learn more about plants.”
- “It is an opportunity to learn about other partner institutions.”
- “Allows for making deeper connections.”
- “Deeper understanding and ability to facilitate a specific type of exit project.”
- “It gives the chance to learn about other types of projects.”

The PD facilitator then closed this portion of the discussion with the following comments:
• "It provides opportunities to integrate and collaborate more than before. Let’s move to CTPD. Looking at 21 different PD strategies, we honed in on three different strategies: implementing curriculum, curriculum topic study, and focusing on student work using lead teacher exit projects because you are the classroom teachers and you don’t know who the teachers will be. The curriculum is the ID and the DSET and implementing these tools."

The UA Administrator added, "The curriculum implementation Levels One and Two: In the past, new teachers would be exposed to one type of exit project. The goal is to have teachers experience all four types of exit projects. In Level Two: We regrouped the design and controlled experiment into one workshop based on similarity. The second table for Years Three to Four and Five to Seven: There are more veteran continuing teachers. We needed PD beyond the tools in the content areas under the curriculum topic heading. It really is a modified curriculum topic study, because UA is through the lens of the exit project."

The PD facilitator then moved the discussion to a new topic with the following comment: "The PD needs to be aligned with the goals. Look at where your institutions are in terms of meeting those goals. All of the PD doesn’t have to be the same. Different strategies can be used to achieve the same goals. Brainstorm ideas about goals within your institution about Level 1 and Level 2.” After 10 minutes of discussion, and in reference to Number 36: Muddiest Point, participants responded to the question, “What part seems to be confusing to you?” The PD co-facilitator marked four of the strategies used on a poster with formative assessments from Keeley’s book:

• Number 2: Agreement Circles (p. 51)
• Number 7: Commit and Toss (p. 65)"
The PD co-facilitator commented and wrote on the whiteboard, “The challenge is to plan and design and evaluate the impact of lessons.” A participant then replied, “We do get time to plan and design but not to evaluate.”

The next portion of the training introduced the Science Immersion Model for Professional Learning (SIMPL). SIMPL developed out of a large-scale study by the Los Angeles Unified School District, in collaboration with the Wisconsin Center for Education Research at the University of Wisconsin, Madison, on science immersion’s effect on student achievement and teacher’s pedagogical practices, The study was published under the title *System-wide Change: An Experimental Study of Teacher Development and Student Achievement in Elementary Science*. The SIMPL model encourages teachers to participate as learners in immersion lessons designed for students and engages teachers in reflection about what content they teach their
students and what pedagogical practices they use to teach it. The lessons incorporate BSCS’s “5 E’s” of inquiry learning. While retreat participants had some experience with the SIMPL model, it had not yet been utilized for PD design.

The PD facilitator commented, “We will get back to that.” He then projected a slide titled USING SIMPL TO PLAN CTPD and commented, “The focus is setting the stage with clear goals—teacher goals and science learner goals and achieving the teacher goals. Then assessing the impact on teachers and students.” While pointing to the “Engage and Elicit Circle” diagram,
he commented, “How to engage teacher/learners into prior knowledge? Engage the teachers into the importance of PD—the buy-in.” He then pointed to the three inner circles (Engage and Elicit, Explore, and Explain and Reflect) and commented, “The focus is on the science learners, the teachers. It’s an immersion model that follows a research-based model of constructivism. Show me and I remember. Teach another results in a higher percentage of learning.” While pointing to the “Engage and Elicit” circle, he said, “[This] can change misconceptions by making thinking explicit.” In reference to the “Explain and Reflect” circle, he commented, “Reflection related to thinking is important. The two endpoints of teacher/learner experience. The suite of yellow circles [are] teacher/learner: explore.”

At this point, a participant interjected, “Teachers may think about using/applying it in the classroom.” The PD facilitator responded: “The application is to the classroom. What does the Explain and Reflect on the end look like? Teachers struggle with high-quality scientific explanations. What are the biggest challenges?” Participants responded to these questions with the following statements:

- “Depth of content knowledge.”
- “Misconceptions.”
- “Motivation to find context.”
- “Students struggle to draw conclusions because of struggling readers.”
- “Students identifying patterns.”
- “How do you get reasoning out?”

The PD facilitator then wrapped up this portion of the discussion and moved on to the next topic with the comment, “In a PD Scenario with teachers using the DSET: they, both students and teachers, still tend to make a claim and then use their evidence as reasoning or
restate their claim as reasoning. A participant responded. “The DSET has only been here for two years.” The PD co-facilitator said, “With elbow partners, what CTPD goals will guide your upcoming session?” Participant’s provided the following responses:

- “Goal three only applies to designing a scientific explanation.”
- “I disagree if a teacher is incapable due to lack of content knowledge.”
- “I agree that it is about content.”
- “It doesn’t apply directly to a specific exit project but 1.”

The PD facilitator then offered clarification: “The DSET is out front forgetting the supporting areas. The background may be an ‘and,’ not an ‘or.’” A participant then responded, “This needs to be embedded in a project to make it real. It goes back to the reasoning piece in the IDD. So is this assuming that the teacher and students can use the IDD well?” The PD facilitator replied, “I am going to pushback. The focus needs to be on the DSET. Yes, the context is important.” The PD co-facilitator added,

“If claims, evidence, and reasoning is the question, you need to clarify the program goal versus the session goal. With your elbow partner make a teacher learner goal for this. What teacher goal will guide your planning? To understand the difference between a claim, evidence, and reasoning but how do you support students in said goal. Identify what excellent, good, poor reasoning looks like. Recognize what it looks like. What science learner goal will guide your planning? Understand the differences between the claim, evidence, and reasoning. Be able to write them and do it within the context of the science content. Working with a partner—think of a CTPD teacher need. Choose one of the CTPD goals. Write a teacher goal and a science learner goal for a CTPD session that you might offer. Record a goal on a sentence strip, one goal per strip, and post it on the wall.”

Participants posted the following examples:

1. Teacher goal: Identify variables in a field study. Develop lesson plans to teach identifying variables (CTPD Goal 2).
• Science learner goal: SWBAT identify variables within a field study setting in order to plan/design a scientific investigation.

2. Teacher goal: To be able to use a field trip to provide an experience for students that can be built on to construct understanding of content.
   • Science learner goal: To integrate prior knowledge with direct experience through a field trip.

3. Teacher goal: Deepen teachers’ understanding of UA tools and exit projects through a new type of investigation (Goal 2).
   • Science learner goal: Understand the components of a design investigation within the context of the science content using UA tools (Goal 2).

4. Teacher goal: TWBAT Design learning activities that explore interactions between ecosystem variables and reasoning.
   • Science learner goal: SWBAT explain a variety of interactions between biotic and abiotic factors for several novel situations within the Hudson River freshwater ecosystem.

5. Teacher goal: Teachers understand how to use a field trip to the AMNH Hall of New York State to support student learning in populations and ecosystems (Life Science, Grade 6).
   • Science learner goal: Learner will understand predator/prey relationships affect the growth of populations. (6th grade, Unit 4)

6. Teacher goal: Teachers will be able to teach students to engage in a successful fishbowl think aloud (Two-hour PD session).
• Science learner goal: Students will be able to successfully complete a fishbowl think aloud regarding a given topic Number 5

7. Teacher goal: Identify the connections between animal behavior study and evolution.
• Science learner goal: Describe animal behavior studies.

8. Teacher goal: Be able to utilize science journals as an assessment tool.
• Science learner goal: Be able to formulate observations and questions through the use of science journals.

The PD facilitator asked the participants, “Which are the best examples?” One participant responded, “Four and five.” The PD facilitator responded, “NSES doesn’t have a process/skill standard. This is a content standard. Looking at Example One: Don’t put content in such a small box. Scientific inquiry is a content standard. It is cognitive, higher level thinking.”

Participants then completed a reflective activity, “What Did You Learn From This?” (Number 70: Two Stars and a Wish, p. 207) The PD co-facilitator said, “Write two good things about today and a wish about tomorrow.”

The agenda for Day Two of the retreat focused on a SIMPL review and feedback, CTPD planning time, and an introduction to the curriculum topic study (CTS). Poster papers were displayed in the classroom and featured participants’ comments or questions from the previous day, organized by the PD co-facilitator under topic headings:

1. Questions from yesterday about concerns about the vision/goals (Number 36: Muddiest point, p. 138)
• Is only one institution (QBG) the only partner who will offer Level 2: Controlled Investigation PD?
• Is there a “Kickoff” PD in addition to the PDs listed? If so, are there additional hours?

• What if a PD we want to do—we have expertise in delivering—does not fit into this plan?

• How do we determine when a teacher can attend “advanced” level?

• How do we advertise these to teachers? And help them self-access? Are we placing them? Do we push people to diversify their experiences?

• How will it be explained to CTs [Continuing Teachers] and/or monitored so that those registering as a Level 2 (for example) have more than Level 1 experience w/that particular Exit Project type. Not just “Oh that date works for me, I’ll go there.”

• How, when CTs register for Level 1, can we ensure they pick a new project type?

• What topics/parts of the core science curriculum are best for implementing UA inquiry tools?

• Are partners locked into the project types? Ex: NYBG and field studies?

• Place DSET in “level 1” PD?

2. Wishes

• Under the label “More Outside Time?,” which I don’t think was correctly labeled/classified:
  
  o More breaks.
  
  o Breaks on time.
  
  o Please honor our time with regard to breaks in the schedule. I love your sessions, but I get antsy if I’m expecting a break at a certain time and it doesn’t come.
• Teacher Engagement Options
  
  o I wish that the yellow “engage” for the teacher is more engaging or interesting then “How do you teach this?”

• Practice SIMPL
  
  o Need more practice on SIMPL model.
  
  o More detailed practice: make the SIMPL simple.
  
  o Time for real-world applications: Let’s start a SIMPL—or same such.
  
  o Start developing our next PD with even more complete SIMPL.
  
  o I wish I were clearer on what makes good teacher goals and science learner goals (simply need more time).
  
  o Writing goals to make continuing teachers interested in CTPD’s. Being specific so that CTs get what they signed up for.
  
  o Provide scenarios/models of SIMPL designed lessons that can be used as exemplars to “practice” our understanding.

• Time to plan
  
  o Provide time to develop the SIMPL (in groups of three) based upon specific teacher’s science learning goal.
  
  o I wish there were more time devoted to CTPD planning.
  
  o More time interacting with group to plan future CTPD

• Unclear of my role
  
  o Unclear if yellow/blue circles are over what period of time (whole, two-day goals or smaller goals).
o General outline/description of the role of lead teachers this year
(expectations).

• Team Co-planning
  o I wish my team were staying tomorrow.
  o More time for discussion with partners.
  o I wish I had more time with my team to reprocess our initial teacher learner
    goals and science learner goals after the discussion on the patio.

• Unlabeled/Miscellaneous
  o More assistance with SIMPL assessments.
  o I wish I could have lists of teachers’ needs as we know them now.
  o More opportunities to answer questions raised. This would clarify future
    planning needs.

3. Stars

  • UA Program
    o Knowledge of the new format that UA is following, as well as my upcoming
      role.
    o CTPD goals clearly written and listed.
    o Better understanding of the goals of UA PD.
    o Understanding the changes of the UA program and focus on CTPDs.
    o Familiarity with the goals for CTPD—it’s great to have a framework.
    o Learning more about the new revised UA Version 2.0.

  • Team
o Wonderful to work with whole team—mixing us up for pair/trios/small group activities.

o I got a book.

o Great working in my group.

o A chance to meet and to get to know the team.

o New collaborations with nice smart people.

o Getting opportunity to spend time with new lead teachers.

o Good company.

o Actual time for planning actual PD’s.

• Ready to plan

  o I feel confident having very specific steps we can take to begin planning SIMPL PDs.

  o Seems we will be prepared to prepare very thoughtful, engaging PDs using this model.

• Goals

  o Better understanding of yellow versus blue circles.

  o Benefit of creating focused goals.

  o Better understanding of teacher/student and goal writing.

  o More understanding around connectedness of the teacher goal and science learner goal.

  o Good practice of writing goals.

  o Thinking and reflecting on CT needs and planning CTPDs around needs.

  o The activity and questions/discussions helped for better understanding of the
teacher and student goals.

- **SIMPL**
  - Review and clarification of SIMPL.
  - Reinforced/refreshed SIMPL thoughts.
  - I liked the initial/final reflections to capture our thoughts and how they evolved with our understanding of SIMPL.
  - Now I know what SIMPL is!
  - Structured sequence with clear descriptions of tasks (written).
  - Starting to understand SIMPL.
  - Sentence and SIMPL model (sentence strips).
  - I learned the beginning stages of SIMPL elements and advanced/evolved thinking.
  - SIMPL conversations cemented understanding more.
  - I like learning about the SIMPL format (though I need to learn more).

- **Formative Assessment**
  - I like the Muddiest Point!
  - Nice use of various assessments to aid taking in the PD information.
  - Great modeling of strategies for informal evaluations.
  - Learned a new formative assessment method that could easily be applied in class.
  - Good feature…new ideas for formative assessment.

During the day’s first activity, participants reviewed and provided feedback on SIMPL using formative assessment Number 64: Three-two-one, with instructions to interview at least
three people not on their team, list two things they learned about SIMPL, and provide one question they have about SIMPL. The PD co-facilitator summarized the groups of “Stars” and groups of “Wishes,” as well as the importance of aligning goals and experiences when planning CTPD using the SIMPL model:

1. How will we access teachers PK?
2. What kind of science learner experience?
3. What kind of teacher learner experience?
4. How will we help teachers reflect on their learning?

The UA Administrator commented, “It is important to refer to science content and the curriculum,” and a participant suggested, “You should be able to translate this into classroom use of the 5Es—something that would successfully fit into 5Es, not just because it is cool.” The participants then dedicated forty minutes to discussing each of the circles in the SIMPL model. Participants, UA Administrators, and the two facilitators shared their thoughts and exchanged ideas. This was followed by two hours of teamwork on planning CTPD teacher goals and student goals for each partner institution. The PD co-facilitator concluded this portion of the training by using a formative assessment strategy, the Agreement Circle, to outline the following conclusions:

- SIMPL is easy.
- Effective PD is the result of deliberate design.
- Most of the time in PD session should be spent on teacher lens—explain and reflect.
- Student learning outcomes should be decided before activities are designed.
- Goal of all PD is about helping teachers improve student learning.
- All PD sessions should be designed using SIMPL.
The PD co-facilitator then transitioned to a presentation on CTS: The goal of this introductory session on CTS was to generate awareness rather than establish depth of knowledge on the topic. CTS was described as:

- the result of a NSF-funded PD Materials Project awarded to the Maine Mathematics and Science Alliance, headed by Page Keeley;
- a process that incorporates the systematic study of standards and research; and
- a set of tools and a collection of resources for improving curriculum instruction and assessment.

The presenter clarified that CTS is not:

- A remedy for weak content knowledge (CTS is used to enhance and support content learning);
- A collection of teaching activities (CTS describes considerations one must take into account when planning or selecting teaching activities);
- A description of “how to’s” (CTS help you think about effective teaching based on knowledge of learning goals and how students learn).
- A quick fix (CTS takes time and dedication to use it effectively).
- The end-all for professional development (CTS helps you identify additional experiences that will help you grow as a teacher and grow teachers).

A participant commented, “I am beginning to understand this. I used to think, why is UA tackling this big topic? Don’t teachers go to grad school and take P credits?” The co-facilitator responded, “I have yet to see teachers not just dig in,” and the primary facilitator added, “It is a way to deepen content knowledge. It provides a different way to get content
knowledge done in a way that is less threatening.” The presentation then continued with recommendations on why CTS should be used, including to:

- clarify and deepen knowledge of relevant curriculum topics;
- “stand on the shoulders of giants”: to have experts at your fingertips, 24/7;
- develop a common knowledge base and language about standards and research; and
- move beyond personal opinions and assumptions to consider key ideas used and practices developed through consensus by the science education community;

The facilitator further elaborated, “It allows us to use our resources from partner institutions such as AMNH and to deepen teacher content knowledge.” The co-facilitator then asked participants to refer to their CTS book and conduct the following exercise:

1. In a trio at your tables.
2. Open the CTS book at random. With your partners, do a quick scan of the page you opened to [sic]. What do you see that provides you with a “preview” of CTS?
3. Mark the page with a sticky note.
4. Repeat two to three times to get an initial sense of what is contained in the CTS book.
5. Share an example with the group that particularly interests you and tell why.

After ten minutes, the co-facilitator commented, “See Chapter Two of the CTS Study Guide, pages 19-22. Sections One and Three may be when you may be able to link resources from your institutions.” Participants were allocated fifteen minutes to complete the activity, “Getting to Know the CTS Resources.” Instructions were as follows:

- Assign one or two “experts” for each of the six CTS resource books.
- Read the description of your assigned resource from the CTS book, pages 24-26.
- Examine the resource, looking for notable features.
• Describe the resource to your table group, pointing out the notable features.

• On Page Nine are examples of scenarios. Read the six scenarios about CTS. Then turn to the Resources Scenarios for CTS Practice: Models, p. 269.

Then participants were then directed to work on the activity, “Resource Scenarios: How can we Add to What We Already Know?” They were given the following instructions:

• Focus on the scenario you have been assigned.

• Jot down a few ideas to contribute to the question posed by the scenario.

• Go to the chart paper representing your scenario and exchange ideas with others.

• Summarize your group’s ideas on the “Before Chart”.

Participants were allotted additional time to read the material on Models. Afterwards, they summarized their group’s ideas on the “After Chart.” There was a quick wrap-up after reviewing the group’s ideas. Then participants began to pack up and leave.

**Evaluation of Rubrics**

*Evolution of a rubric for long-term inquiry science investigations: Watch your science exit project “grow” rubric.*

The Watch Your Science Exit Project “Grow” student exit project rubric (New York City Department of Education, 2006; See Appendix H) was the first rubric to be created by UA. It was accompanied by a letter written by Science Instructional Specialists Gregory Borman and Frances Horne on letterhead from the office of the Teaching and Learning Chancellor Joel Klein and Deputy Chancellor Carmen Farina. Dr. Julia Rankin served as the Director of Science and Laura Kotch was the Executive Director of Curriculum and Professional Development. The letter and rubric were distributed to middle school teachers. The letter describes the rubric as a student performance checklist that should be used by students in planning and conducting their
exit projects. The rubric may also be used as a self-assessment and peer-assessment tool. It suggests that teachers employ the rubric as a formative assessment. A more enhanced version that may be used as a final assessment tool was still being developed at the conclusion of this research.

The authors, who were all UA lead teachers affiliated with the Department of Science at the NYC Department of Education, included Dr. Maritza McDonald, Jennifer Adams, Kristin Staffaroni, Lydia Sung, Barbara Kushner-Kurland, Christine Kola, Ramonita Torres, Jacqueline Rossy, Christine Zadrozny, Vanessa Petit-Phare, Dr. Mitch Goodkin, Lionel Callendar, Petal McPherson, Valhn Spears, Angela DeFillipis, Cristi Rau, Remo Velardo, Raji Menon, and Sabrina Ford. The rubric was designed as a formative assessment and includes a checklist for students to self-monitor their progress as they complete each of the four required sections. The students select from boxes marked “G” for “Great,” “R” for “Really well,” “O” for “On your way,” or “W” for “Keep working.” The four sections include Science Understanding, Scientific Process, The Written Report, and The Oral Presentation. The rubric’s written report includes an abstract, introduction, methods and materials, data and analysis, conclusion, reflection, glossary of terms and bibliography.

Analysis.

The UA program’s initial rubric was a collaborative effort between the science administrators in the central office of the New York City Department of Education and middle school science instructional specialists, who worked closely with the Director of Science under the umbrella support of the Executive Director of Curriculum and Professional Development and the Deputy Chancellor for Teaching and Learning. While the rubric initially included sections
dedicated to science understanding, a written report, and the oral presentation, subsequent versions that embraced scientific process revised these sections and prioritized the items included in the Science Understanding and Written Report sections. The Oral Presentation component was dropped altogether. The statement, “constructed a conclusion reporting on whether the hypothesis was correct or incorrect” is surprising. Later versions revised this to “the hypothesis was supported or unsupported.”

The Written Report section addresses several ELA skills, including the following:

- Supporting ideas with examples, definitions, and references to sources.
- Including footnotes if necessary.
- Checking for grammar, spelling, punctuation and sentence structure.
- Comparing concepts and demonstrating connections to other topics.

Sample science exit project rubric.

When the 2009 science exit project rubric was developed (NYC Department of Education Division of Teaching and Learning, Office of Curriculum, Standards and Academic Engagement, 2009; See Appendix I), the NYC Department of Education included Chancellor Joel Klein, Deputy Chancellor for Teaching and Learning Santiago Taveras, and Director of Mathematics and Science Linda Curtis-Bey, and. Contributing authors to Part Three of the rubric included David Erdil, Dr. Mitchel S. Goodkin, Christine Kola, Petal McPherson, and C. Rajeshwari Menon. In the rubric’s publication, the authors acknowledged the valuable insights provided by their participation in the UA initiative. Project facilitators included Middle School Science Instructional Specialist Sheldon Young and Science Instructional Specialist and Urban Advantage Liaison John Tom. All administrators and UA partners were listed in associated UA materials. These included Director of the Gottesman Center for Science Teaching and Learning
The Guidelines for creating the Science Exit Project poster included the following:

- Title: The effect of ……on
- Question: How will …….affect…..?
- Hypothesis: If……then……because…..
- Background Info:
- Experiment Design: Five components
  1. Independent Variable
  2. Dependent Variable
  3. Constant Variables
  4. Control Variables
  5. Number of Repeated Trials
- Procedure:
- Results (Data Tables and Graphs):
- Data Analysis/Discussion: Construct a scientific explanation including: Claim, evidence, and reasoning (The rubric also includes a reflection on possible sources of experimental error and suggestions for further experiments).
- Conclusion: A concised [sic] re-statement of the explanation already made in the (sic) Data Analysis/Discussion:
  - Whether the hypothesis was, or was not supported by the data
  - The evidence
  - The reasoning used to relate the claim and evidence
Analysis.

The science report guidelines were not produced by UA, nor was the sample exit project rubric. The guidelines for creating the science exit project poster and project examples that were developed by UA were adapted from: Cothron, Giese, and Rezba. The 4th edition (2006) of this publication was distributed to all UA teachers during professional development, and the book is recommended by the National Science Teachers Association and serves as a core teaching resource for science teachers carrying out science investigations and research in their classrooms. The sample exit project rubric included the sections The Project, Conceptual Understanding of Science, Scientific Process, Written Work, and Oral Presentation. Scoring was numerical, with a 4 awarded to projects that Exceed Standard, 3 for projects that Meet Standard, 2 for projects that are Approaching Standard, and 1 for projects that are Significantly Below Standard. The written work components were the same as the 2006 GROW rubric. The UA guidelines for the science exit project poster were intended to form the basis for the 2011 UA Exit Project Rubric and all subsequent rubrics developed by UA.

2011 UA science exit project poster and rubric.

The Science Exit Project Evaluation Rubric (See Appendix J) outlines the following instructions: “Please adapt the rubric to your own needs and your students’ needs.” The scoring table presented below is also intended to be modified to match teachers’ needs:

- Title
- Question
- Hypothesis
- Background Research
- Investigation Design (ID)
The Investigation Design, or the ID diagram used in UA professional development may be included as a graphic organizer in the hypothesis section. Rubric instructions are as follows:

Using the five components below, describe the design of the investigation:

1. Independent variable
2. Dependent variable
3. Constants
4. Levels of the independent variable
5. Number of repeated trials

The data reported in this section is the basis for students’ claims for whether or not a hypothesis has been supported. Exit projects are designed to give priority to evidence drawn from empirical observations. The data should be presented in a table, charts, or graphs and trends or patterns revealed in the data should be summarized. The student(s) make their own observations for projects involving controlled experiments, field studies, and design projects. The student(s) use observations or data reported by other investigators to conduct secondary research. When completing the rubric, each section(s) should be addressed by first identifying whether the hypothesis was or was not supported by the data. UA also emphasizes the importance of connecting the students’ results to the scientific knowledge already available on the topic by having students construct a scientific explanation. A student’s claim regarding his or her hypothesis, the data used to support this claim, and the reasoning employed to connect the claim to evidence (i.e., the connections to scientific knowledge) should all be included in a complete scientific explanation that forms the core of the Discussion/Conclusion section.

Reflections on possible sources of experimental error and suggestions for further investigations
are also important, as is literature cited and formatted according to the school’s expectations and ELA standards by grade level.

Rubric procedure involves listing all materials and writing the procedure so that another student can follow the directions and repeat the investigation. Students must provide a detailed and logical step-by-step description. Using the five components listed below, students describe the design of the investigation:

1. Independent variable: the variable that the student purposefully changes (In a field study, we describe the independent variable as the category(ies) that the student chooses. In a secondary research project, we describe the independent variable as the variable that the student lets change and does not keep constant).

2. Dependent variable: the variable that the student measures, which is affected (changed) as a result of changes purposely made in the independent variable.

3. Constants (also called constant variables): the variable(s) in an investigation that are kept the same and not allowed to change or vary.

4. Levels of the independent variable: the different levels of the IV at which the DV is measured, or the groupings of the IV for comparing DV observations.

5. Number of repeated trials: the number of times that a level of the independent variable is tested in an investigation, or the number of objects or organisms tested at each level of the independent variable.

A step-by-step procedure including materials is described in enough detail to repeat the investigation, and details should be consistent.

The hypothesis is intended to predict the effect that changing the independent variable will have on the dependent variable and presents scientific reasoning for the prediction, which is
supported by cited background research, as noted in the literature cited section. The hypothesis predicts the effect that changing the independent variable will have on the dependent variable. The “because…” reasoning is present, but incomplete or weak. The prediction is present, but does not frame a relationship between the variables, or the “because…” reasoning is missing from the hypothesis statement.

The data reported in this rubric are the basis on which the student will claim that his or her hypothesis is, or is not, supported. Exit projects should give priority to evidence in the form of empirical observations. The data should be shown in a table and in charts and graphs, and trends or patterns in the data should be summarized. Student(s) make their own observations for controlled experiments, field studies, and design projects. They use observations or data reported by other investigators to conduct secondary research. Background research that is relevant to the topic (and the DV and IV specifically), should support the “…because” portion of the hypothesis, and the “scientific reasoning” portion of the Discussion/Conclusion.

The final section, Discussion/Conclusion, should first state whether the hypothesis was, or was not supported by the data. Furthermore, UA emphasizes the importance of connecting students’ results to the scientific knowledge already available on the topic by having students construct a scientific explanation. Student’s claims about their hypothesis, the data they use to support their claim, and the reasoning they use to connect their claim and evidence (or the connections to scientific knowledge) should all be included in a complete scientific explanation that should form the core of the Discussion/Conclusion. Reflections on possible sources of experimental error and suggestions for further investigations are also included in this section.
Interestingly, unlike previous rubrics, this rubric makes no specific mention of the NYCDOE or contributing authors. There also is no suggestion to use the rubric as a teaching tool in ways other than as a formative or summative assessment. The scoring table rates each project section with a score of 0-3, where the Title, Question, and Literature Cited sections are weighted at x1; the Hypothesis, Background Research, Investigation Design (ID), and Procedure sections are weighted at x2; and the Data/Results and Discussion/Conclusion sections are weighted at x3. The scoring system reflects the emphasis UA places on each component of the exit project, with greater emphasis placed on the Data/Results and Discussion/Conclusion sections. The Experiment Design, as outlined in Cothron et al. (2006), was revised to an Investigation Design (ID). The original Experiment Design featured the five components of an Independent Variable, Dependent Variable, Constant Variables, Control Variables, and Number of Repeated Trials. This has been modified to the components of an Independent Variable, Dependent Variable, Constants, Levels of the Independent Variable, and Number of Repeated Trials.

After a review of existing literature I have not found any description of “levels of independent variable” in other sources. Based on observations during professional development activities and teachers in the classroom, I have concluded that this added component to UA’s rubric remains a difficult area for both teachers and students to interpret. Within the rubric, specific comments have been made with regards to UA’s emphasis and approach to writing a scientific explanation. Comments also reflect the “Got Data” initiative that was underway in the Urban Advantage program: In order to address the low quality of many exit projects presented at the annual Science Expo at AMNH—which some have assessed are nothing more than book
reports that lack empirical data,—UA launched the “Got Data” initiative. The initiative was highlighted in professional development and made visible when UA staff wore “Got Data” buttons at UA-related events. “Got Data” buttons were also distributed to UA teachers.

**2012 UA science exit project poster and rubric.**

The 2012 UA Science Exit Project Poster and Rubric (See Appendix K) is similar in format and content to the 2011 rubric, with the following relevant revisions: The 2012 rubric does not include the background information in the hypothesis section. The rubric describes students’ reasoning in defining their hypothesis in the following manner, “Why do they expect/predict this relationship between the variables and not a different relationship? The student should use this space to answer the question: ‘What did I read that makes me predict this outcome?’”

According to this rubric, students should be researching scientific concepts and knowledge related to their question both before and after they perform their investigation. Students should also provide relevant, well-chosen facts and scientific concepts, definitions, concrete details, quotations, and other information and examples related to the relationship between the IV and the DV. A scientific explanation begins with a claim that addresses or answers the original question asked. This claim should be supported by relevant, accurate data collected during the students’ investigation. Relevant science concepts and knowledge should be used to explain this data and relate it to the claim. Students should use words, phrases and clauses that connect and clarify the relationships between the claim, evidence (data), and reasoning using formal language. This background information provides the basis for the prediction. Students should also provide background information that answers the question, “What did I read that makes me predict this outcome?” Background information should also
support the scientific reasoning within the Discussion/Conclusion. This is designed to address the problem that students tend to present basic facts about their investigation, but fail to relate this information to the hypothesis or to scientific reasoning within the Discussion/Conclusion. A list of sources referenced should be provided. Sources should be varied (including books, articles, and websites), clearly related to the topic, and at the appropriate reading level. Citations should include the title, author, year, and URL, where appropriate.

Using the five components below, students are expected to describe the design of the investigation:

1. **Independent variable**: the variable that the student changes on purpose (In a field study, we describe the independent variable as the category(ies) that the student chooses. In a secondary research project, we describe the independent variable as the variable that the student lets change and does not keep constant).

2. **Dependent variable**: the variable that the student measures and which is affected (changes) as a result of changes purposely made in the independent variable.

3. **Constants (also called constant variables)**: the variable(s) in an investigation that are kept the same and not allowed to change or vary.

4. **Levels of the independent variable**: the values of the independent variable at which data is gathered. For example, when studying the effect of the time of day on sea lion behavior, the levels might be: 8:30 am, 12:30 am, 4:30 pm, etc. This refers to the time when the student observes the sea lion. When studying the effect of the mass of a ball on the distance it pushes something, the levels might be: 1g, 5g, and 10g.

5. **Number of repeated trials**: the number of times that a level of the independent variable is tested in the investigation, or the number of objects or organisms tested at each level of...
the independent variable. Typically, at least three trials are conducted at each level in a middle school investigation.

The procedure for this rubric involves a detailed, step-by-step description of the way in which the investigation was performed. The procedure should be written so that another student can replicate the investigation and should use precise language and scientific vocabulary. All materials and equipment used should be included in the appropriate portion of the procedure. In addition to being replicable, it is important that the procedure is appropriate for the investigation. The procedure should allow the student to answer the question posed and be consistent with the investigation design. The procedure is a step-by-step description of how the investigation was conducted, uses precise language and scientific vocabulary to describe both the sequence of actions taken and materials used, is sufficiently detailed to enable the reader to replicate the investigation, and is consistent with the Investigation Design Diagram (IDD) and is an appropriate test of the hypothesis.

According to this rubric, a strong hypothesis predicts the effect that changing the independent variable will have on the dependent variable and explains the reason for the prediction using scientific concepts (e.g., “because…”). A weaker hypothesis may predicts the effect that changing the independent variable will have on the dependent variable and explain the reasoning for the prediction using scientific concepts (e.g., “because…”), but it is incomplete or weak. Finally, a poor hypothesis may present a prediction that does not frame a relationship between the variables or does not explain the reasoning for the prediction using scientific concepts (e.g., “because…”).

Students use data reported in the Table and Graphs, Data Analysis section to determine whether or not their hypothesis was supported and to make a claim that answers the original
question. Data reported must be directly related to the question and hypothesis. Students make their own observations for controlled experiments, field studies and design projects and use observations or data reported by other investigators to conduct secondary research. Data should be shown in tables, charts, and/or graphs, where appropriate. All data tables and graphs should be accurate and include titles, axis labels, units of measure, etc. Overall trends and patterns in the data should be discussed, with reference to numeric or other data that demonstrates any trend or pattern.

The Discussion/Conclusion section is scored based on two primary items: the student’s the scientific explanation and reflections. Discussion/Conclusion should follow a format similar to the following: “In this investigation, the hypothesis (was/was not) supported.” Students should then make a claim and provide evidence and reasoning for that claim. In other words, students should present a scientific explanation). Finally, students should discuss sources of error and possible future investigations. Students should state whether or not their hypothesis was supported by the data. This statement is usually presented at the beginning of the discussion section. At the end of the discussion section, students should identify any possible causes of error, as well as explain how they might prevent these errors in the future. Students should also describe how they might use the data or ideas from this investigation in future investigations.

Analysis.

Like the 2011 rubric, the 2012 rubric indicates that the project should include a list of sources used. Sources should be varied (including books, articles, and websites), clearly related to the topic, and at the appropriate reading level. Citations should include the title, author, publisher, year and URL, where appropriate, and should be formatted according to school guidelines and ELA standards at this grade level. These sources should be cited in the text of the
hypothesis, background research, conclusion, and other sections, where appropriate. Background research should be presented throughout the project, particularly within the Hypothesis and Discussion/Conclusion sections. Background research should contain many relevant, well-chosen facts, concrete details, quotations, scientific concepts, or other information and examples that provide information on the IV and DV, including defining them and explaining the relationship between them; support the “because…” portion of the hypothesis; and support the “scientific reasoning” of the Discussion/Conclusion. According to this rubric, the project title should accurately state the independent variable and dependent variable and is worded as a statement, rather than a question. Scoring table for 2011 and 2012 rubrics.

The 2011 rubric weighted the Discussion/Conclusion section by 3, whereas the 2012 rubric broke the section down into two parts: Discussion/Conclusion: Scientific Explanation was weighted by 2 and Discussion/Conclusion: Reflections was weighted by 1. The literature section in the 2011 rubric was weighted by 1. This increased to 2 in the 2012 rubric.

Analytical comparison between the 2011 and 2012 rubrics.

This rubric underwent substantial revisions between 2011 and 2012. The 2012 rubric exhibits a greater emphasis on writing in all sections. Students’ claims are expected to form a direct link to evidence, in concurrence with the common core standards for science literacy. The language used in the Hypothesis section has also been revised: “Scientific reasoning” has been changed to “scientific concepts”. This reflects the new language used in the Next Generation Science Standards to address crosscutting concepts. The background section was greatly expanded, and there is a greater emphasis on students conducting research both before and after the investigation, as well as in providing relevant scientific concepts and ideas that directly link the independent and dependent variables. This also mirrors the common core standards, which
place strong emphasis on students’ inclusion of evidence and reasoning in their arguments or position. It also directly outlines the weaknesses found in many student projects. For example, the rubric states, “Often students will provide basic facts about things related to their investigation. However, information that is not clearly related to the hypothesis or to scientific reasoning within the discussion/conclusion should not be included.” During professional development sessions, teachers communicated difficulties in understanding the levels of the independent variable section. This section was not included in Cothron, et al. (2006). In order to address the difficulty that teachers and, consequently, students have had with this section, two examples were provided to model the concept and the statement, “Typically, at least three trials are conducted at each level in a middle school investigation” was added. The procedure section was greatly expanded in the 2012 rubric. The 2012 rubric places greater emphasis on student writing, as illustrated in the expectation that “precise language and scientific vocabulary” that is “appropriate for the investigation” is used.

The Data/Results (Table and Graphs, and Data Analysis) section included the language “make a claim answering or addressing the original question”. The rubric also states, “Data should be shown in tables, charts, and/or graphs as appropriate. All data tables and graphs should be accurate and include titles, axis labels, units of measure, etc. Overall trends and patterns in the data should be discussed (with numeric or other data being provided to demonstrate any trend or pattern” were added. This provides specific details regarding the information necessary to include accuracy in presenting data tables and graphs.” Additionally, the rubric states, “Overall trends and patterns in the data should be discussed (with numeric or other data being provided to demonstrate any trend or pattern)” was added which addresses the interpretation of data in a discussion.
The Discussion/Conclusion was expanded and divided into two sections: Discussion/Conclusion: Scientific Explanation and Discussion/Conclusion: Reflections. Both sections require that students write in more detail to address the “reasoning” component of scientific argumentation.

The Literature Cited section was expanded to instruct students to present citations “in a format that aligns with school expectations and ELA standards by grade level. These sources should be cited in the text of the hypothesis, background research, conclusion and other sections as appropriate.” This revision highlights an increased emphasis on ELA and Common Core standards. In addition, the section requires “a sufficient number of credible sources” which “are listed in the bibliography in an appropriate format that allows the reader to locate the resources…are cited in the text of the hypothesis, background research, conclusion, and other sections as appropriate…[and] include books, articles, scholarly websites, or personal communication with knowledgeable experts/scientists.” These specific criteria are in direct alignment with Common Core Literacy standards that emphasize students’ aptitude in reading informational text across multiple content areas and employing a variety of sources as evidence support their claims, hypothesis, argument, and position.

2013 Long-term science investigation poster and rubric.

The 2013 version of the Long-term Science Investigation Poster and Rubric (See Appendix L) is similar to the 2012 rubric, with the following revisions:

1. Title

   • 2012 Rubric: Sections of the Science Exit Project Poster and Rubric
   • 2013 Rubric: Sections of the Long-term Science Investigation Poster and Rubric

2. Evaluation Rubric
3. Background Research
   - 2012 Rubric: includes the language “relevant” for background research
   - 2013 Rubric: includes the language “accurate and complete”

4. Data/Results (Tables and Graphs, and Data Analysis)
   - 2012 Rubric:
     - Data table(s) and graph(s) should be accurate and include correct labels (titles, correct units of measure), address the hypothesis, and have been chosen to clearly address the original question
     - Data analysis identifies and summarizes trends or patterns in the data.
   - 2013 Rubric:
     - Data table(s) and graph(s) should be accurate and include labels (titles, axes with units of measure), address the hypothesis and have been chosen to clearly address the original question, and identify and accurately summarize trends or patterns in the data.

5. Discussion/Conclusion: The 2013 rubric has omitted the term “with reasoning” included in the 2012 rubric.

Analysis.

The most important change in the 2013 rubric has been the change to the title of the document to Long-term Science Investigation from Science Exit Project. The title change reflects the expansion of the program to include sixth and seventh graders who are not required to complete an eight grade Science Exit Project (Long-term Science Investigation). While the NYCDOE has discontinued the Social Studies Exit Project as a requirement for eighth grade graduation, the Science Exit Project remains in place. In my observations as a ninth grade
teacher, I have noted that some schools unofficially dropped the 8th Grade Science Exit Project (Long-term Science Investigation) requirement when the Social Studies Exit Project was officially dropped. It would not be surprising to find that these schools report lower scores on ELA and math State standardized exams and use this as an opportunity to focus more on those areas. Furthermore, I have not witnessed nor heard of an 8th grade Science Exit Project (Long-term Science Investigation) audit conducted by the NYCDOE.

**Grade 8 literacy in science: Straw rockets rubric.**

While the Urban Advantage Program did not produce the Grade 8 Literacy in Science: Straw Rockets Rubric, it is has adopted this rubric as part of its program. This rubric supports a Common Core-Aligned Task with Instructional Supports Literacy and was developed by a team of teachers from the PS 207 Fillmore Academy, led by Common Core Fellow, Diane Kelly (See Appendix M). Each section of the rubric aligns with Common Core Standards. Additionally, the task it evaluates, “Straw Rockets,” has been an activity featured during professional development activities offered at the New York Hall of Science, one of UA’s eight partners. This task and rubric are featured in the Common Core Library available on the NYCDOE website, a testament to the expanded influence of the UA program on teachers and students who are not part of the program.

**Overall Findings: Evolution of the Rubrics**

UA rubrics have undergone numerous revisions—a fact that illustrates the influence of team learning, one of the disciplines outlined in Senge’s organizational learning. These revisions also reflect the UA’s adherence to national standards, Common Core Standards and the Next Generation Science Standards. UA’s adaptation to evolving standards illustrates its supporters’ ability to “weather the dance of change”: a key component of a strong learning organization.
Overall, there was a statistically significant difference between teacher’s scores and the scores I reached during my research, as well as those reached by an additional independent evaluator. Teachers scored each component part higher, particularly in the areas of background, procedure, discussion, and the literature citation (See Table 8). Inter-rater reliability was established with a correlation of .879 between the researcher A and researcher B for each component part after each researcher scored all 112 projects and reflective rubrics submitted by teachers.

Table 13: Expo Reflective Rubric

<table>
<thead>
<tr>
<th>Component</th>
<th>Teacher Mean</th>
<th>Researcher Mean</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title</td>
<td>3.42</td>
<td>3.15</td>
<td>+0.27</td>
</tr>
<tr>
<td>Question</td>
<td>3.86</td>
<td>3.55</td>
<td>+0.31</td>
</tr>
<tr>
<td>Hypothesis</td>
<td>3.59</td>
<td>3.17</td>
<td>+0.42</td>
</tr>
<tr>
<td>Background</td>
<td>3.41</td>
<td>2.625</td>
<td>+0.785</td>
</tr>
<tr>
<td>Investigation Design</td>
<td>3.34</td>
<td>2.68</td>
<td>+0.66</td>
</tr>
<tr>
<td>Diagram (ID)</td>
<td>3.75</td>
<td>3.02</td>
<td>+0.73</td>
</tr>
<tr>
<td>Procedure</td>
<td>3.71</td>
<td>3.23</td>
<td>+0.48</td>
</tr>
<tr>
<td>Data/Analysis</td>
<td>3.42</td>
<td>2.645</td>
<td>+0.775</td>
</tr>
<tr>
<td>Discussion</td>
<td>3.39</td>
<td>2.605</td>
<td>+0.785</td>
</tr>
</tbody>
</table>

The discrepancies between the researcher and teacher ratings reveal a halo effect: For example, while 79.46% of teachers agreed that student projects should be featured at the Science Expo, only 43% of these projects were actually brought to the Expo because they were deemed to be exemplary. A total of 50% of student projects were at the Expo simply because the students wished to attend the event (See Table 14). Other reasons cited by teachers to include the projects include their performance at school science fairs, a desire to feature English language learners or special education students, because the topic covered was outside the scope of the curriculum, the student needed the success, or the student maintained a three month
dialogue with the partner institution regarding the project.

*Table 14: Reasons cited by teachers for bringing the project to the Expo event*

<table>
<thead>
<tr>
<th>Reason</th>
<th>Number of projects</th>
<th>Percentage of projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Great initiative</td>
<td>89</td>
<td>79.46%</td>
</tr>
<tr>
<td>Wanted to attend</td>
<td>56</td>
<td>50%</td>
</tr>
<tr>
<td>Exemplary project</td>
<td>43</td>
<td>38%</td>
</tr>
</tbody>
</table>

Students scored most poorly in areas related to writing—areas traditionally falling within the domain of ELA. These skills were most reflected in the background, discussion, and literature cited sections. Students scored highest in areas in which they employed the scientific method—areas that have been traditionally defined as science skills. These include the title, question, hypothesis, and data sections. External researchers assigned lower scores to the Investigation Design diagram (See Appendix C), with a mean of 2.68, whereas teachers reached a mean of 3.34. If the Investigation Design diagram (ID) is categorized as a component that develops science skills, then it represents an exception to students’ high scores in all categories that are traditionally categorized as science skills. However, one may also argue that a graphic organizer such as the ID is an interdisciplinary skill.
Chapter Five: Discussion

Unprecedented in size and scope, UA brings together the largest school system in the largest city in the United States in a partnership with eight large independent science cultural institutions toward supporting teachers and students in implementation of science inquiry. While UA has a national initiative for other cities to use their model for Middle School Science, the UA structure and approach can inform other disciplines. Prior to this research, UA has not been studied from a systems perspective with an analysis of each component in detail.

Using mixed methods to study UA, findings have shown UA to be a learning organization viewed through the lens of Senge’s Learning Organization Theory. All five disciplines or component technologies (systems thinking, personal mastery, mental models, building shared vision, and team learning) (Senge, 1990) were evident.

It appears from the outset that the Urban Advantage program was designed with systems thinking in mind. The program takes into consideration the concerns, needs, and logistical issues of all stakeholders involved in working with students to complete inquiry based long-term science investigations - students, parents, teachers, parent coordinators, NYCDOE building level administrators, NYCDOE central office administrators, lead teachers, and Partner Institutions. UA’s significant expansion since its commencement in 2004 is evidence of its ongoing success. When the program launched, 31 schools were identified as medium-needs schools. This has expanded to 177 schools representing a variety of institutions and communities, including District 75 special education schools. During the 2013-2014 school year, 177 public middle schools became UA schools, serving a total of 517 active middle school teachers and 51,351 middle school students. The program began by servicing only 8th grade students. It expanded to include 7th grade students in 2006 and 6th grade students in 2010. Today, teachers are
differentiated as beginning UA teachers (UA Year One teachers), continuing UA teachers (UA Year Two-Ten teachers), and lead teachers who have undergone a rigorous selection process. The program also added parent coordinators in 2006 and demonstration schools in 2007.

After examining numerous organizations around the world from diverse industries, Senge concluded that “healthy ‘leadership ecologies’ can only happen when there is effective leading by the executives, local line leaders, and ‘internal networkers,’ people who come from diverse formal roles to cross organizational boundaries and connect diverse innovators and emerging knowledge” (Senge, 1999). This assessment also applies to the program administration for UA, including the program director, school and teacher coordinator, and NYCDOE administrative liaison. All three administrators are dedicated professionals who are very effective at carrying out their job responsibilities; as illustrated by the fact that all three have remained in their positions since these positions were established. They are knowledgeable about the dynamic parts of UA and how they relate to each other. Thus, they are able to attend to the political, as well as educational aspects of the program.
The approaches that appear to support this structure are seen in the six research-based components that UA describes as the framework of the program: professional development for teachers, principals, and parent coordinators; educational materials, including science materials and equipment for schools, teachers and students; access to partner institutions through the allocation of vouchers for class field trips and family visits; outreach to families through public exhibitions featuring student work, family science events at institutions, and support for school-based family science nights; capacity building and sustainability through support for lead teachers and leadership institutes to develop science teams; and assessment of program goals, student learning, and systems of delivery.

However, at a Middle School Leadership Institute research that UA relies on was made visible as it was directly provided to participants. Research on how students learn science in
formal/informal science environments, essential features of scientific inquiry, nature of science and the work of real scientists, change process in school systems, and using data-driven dialogue to analyze student assessment results to develop a school-wide action plan.

Using one partner institution as a unit of analysis, personal mastery is evidenced via interviews and observations of a partner and lead teacher. Both repeatedly cited UA as being instrumental to their professional growth particularly in the area of inquiry teaching and learning. Mental models that might impede the implementation of inquiry teaching and learning toward long-term science investigations were not found to any great extent. To the contrary, teachers viewed inquiry teaching and learning in a positive light and felt supported both by administrators and UA. The mental models of UA teachers and lead teachers that surfaced through a survey and interviews included: teachers report that inquiry instruction takes longer than direct-instruction (64.7%) however, students learn more and better by it (64.7%); teachers were engaging students in some components of inquiry in the classroom outside of long-term investigations– collecting data (76.5%) and graphing and analyzing data (70.6%) however, only two reported being familiar with the 5E’s; a large number reported that students lose instructional time for ELA (76.5%) and Mathematics (70.5%) however, fewer reported limiting the amount of time spent on long-term investigations (58.8%) or inquiry activities (58.5%) in order to prepare students for science state-wide tests; not all teachers found the UA developed tools for implementing long-term investigations helpful (IDD -82.3% and DSET – 70.6%) or easy for students to use (IDD-58.9% and DSET- 64.7%); and teachers described both the IDD and DSET as graphic organizers. The UA IDD has been differentiated to address the different kinds of projects (See Appendices N through R) which may make it easier for teachers and students to use. In addition
a Teacher Investigation Design lesson plan for using the IDD has been created as well (see Appendix S).

Building shared vision was evidenced in a two day retreat of UA in 2011 as well as a Middle School Leadership Institute held at AMNH in the spring of 2009. Arguably, team learning is present throughout all of UA activities, however is markedly evident in the evolution of a UA designed tool, the Rubric for Long-Term Science Investigations. Analysis of the rubric changes over a ten year period demonstrated that UA incorporated the changes in the national standards including National Science Education Standards, Common Core Standards, and Next Generation Science Standards as they were published.

While a UA National initiative, using the UA model is already underway for Middle School Science in several cities, recommendations for further research include examining the UA model for use in NYC for high school students and for other disciplines including ELA, Social Studies and Art.
Appendix A

Urban Advantage Reflective Rubric

**Reflective Rubric** (for UA Science Exit Projects brought to EXPO)

**Teacher's name:**

**School name:**

**Title of project:**

Teachers have varied reasons for choosing which exit project(s) to bring to EXPO. Some base their decision on: which students worked the hardest; **AND/OR** which students wanted the most to attend EXPO, **AND/OR** which project is the best or strongest.

Please answer the question below “Why did this project come to EXPO?” to let us know YOUR reason for choosing the projects you selected.

**Why did this project come to Expo? (Check all that apply)**

- This (these) student(s) showed great initiative on this project.
- The (these) student(s) very much wanted to attend EXPO.
- This is an exemplary project.
- Other (explain):

Next, Please let us know the project’s “strengths” and “areas for improvement” by completing the rubric questions below. Check the appropriate box for each component, and provide longer responses as requested.

**Please check one box for each section:**

<table>
<thead>
<tr>
<th>A. Title (check box that best describes section)</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ The title correctly states the independent variable and the dependent variable and is worded as a statement.</td>
</tr>
<tr>
<td>☐ The title correctly states the independent variable and the dependent variable but is worded as a question.</td>
</tr>
<tr>
<td>☐ The title is present but does NOT correctly state the independent variable or the dependent variable.</td>
</tr>
<tr>
<td>☐ Not attempted</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B. Question (check box that best describes section)</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ The question states the independent variable and the dependent variable, and is testable.</td>
</tr>
<tr>
<td>☐ The question does not make the independent variable and the dependent variable clear, but is testable.</td>
</tr>
<tr>
<td>☐ The question is present but is NOT testable.</td>
</tr>
<tr>
<td>☐ Not attempted</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>C. Hypothesis (check box that best describes section)</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ The hypothesis predicts the effect that changing the independent variable will have on the dependent variable, and explains the reason for the prediction using scientific reasoning (“because...”) that is supported by cited background research as noted in the literature cited section.</td>
</tr>
<tr>
<td>☐ The hypothesis predicts the effect that changing the independent variable will have on the dependent variable. The “because...” reasoning is present but incomplete or weak.</td>
</tr>
<tr>
<td>☐ The prediction is present but does not frame a relationship between the variables, or the “because...” reasoning is missing from the hypothesis statement.</td>
</tr>
</tbody>
</table>
URBAN ADVANTAGE TO SUPPORT A CULTURE OF INQUIRY

What would you do to move section C of this student's project to the next level? (additional space on last page if needed)

D. Background Research  (check box that best describes section)

☐ Background Research is relevant to the topic (and the DV and IV specifically), supports the "...because...", portion of the hypothesis, and supports the "scientific reasoning" portion of the Discussion/Conclusion

☐ Background Research is relevant to the topic and is found to support either the "...because...", portion of the hypothesis, or the "scientific reasoning" portion of the Discussion

☐ Background Research is present, but irrelevant to the topic

☐ Not attempted

E. Investigation Design (ID)  (check box that best describes section)

☐ All 5 components of the investigation's design (or ID) are stated correctly and explicitly, AND only one independent variable (or IV) is allowed to change at a time, AND there are multiple trials

☐ All 5 components of the ID are stated correctly, BUT more than one IV is changing at a time or there are not multiple trials.

☐ Some of the components of the ID are not reported, and/or two or more components have issues as described above.

☐ Not attempted

What would you do to move section E of this student's project to the next level? (additional space on last page if needed)

F. Procedure  (check box that best describes section)

☐ A step-by-step procedure including materials is described in enough detail to repeat the investigation, and details seem consistent with the project overall.

☐ Materials are listed, and a step by step procedure is described, but some steps are missing or incomplete or not consistent with the ID.

☐ Materials are listed, and a procedure is described, but many steps are missing, incomplete or not consistent with the ID.

☐ Not attempted

G. Data/Results (Tables and Graphs, and Data Analysis)

☐ Data table(s) and graph(s) are accurate, include correct labels (titles, correct units of measure), and are relevant to the original question. Trends or patterns in the data are identified and summarized. Data address the hypothesis and the correct tables and/or graphs have been chosen to clearly answer the original question.

☐ Data table(s) and graph(s) include most of the characteristics listed above. Some trends or patterns in data are identified and summarized. Some data may be shown that are not relevant to the original question, or incorrect tables or graphs are used such that the original question is not clearly answered, or there are problems such as frequent incorrect or missing labeling.

☐ Data table(s), graph(s) do not directly answer the original question.

☐ Not attempted
### H. Discussion / Conclusion (check box that best describes section)

- Discussion/Conclusion makes a claim (i.e., the hypothesis is or is not supported...), supports the claim with evidence, and uses reasoning—in the form of connections to scientific concepts—to relate claim and evidence. The Discussion/Conclusion refers to relevant scientific concepts (content knowledge) to explain why the claim and evidence are related. Scientific sources supporting results are referred to and cited in the discussion. Reflections and “Next Steps” are included in the Discussion/Conclusion.
- Most parts of Discussion/Conclusion are complete and accurate.
- Some parts of Discussion/Conclusion are complete and accurate.
- Not attempted

What would you do to move section H of this student’s project to the next level? (additional space on last page if needed)

Additional comments from sections C, E and/or H (optional):

---

### I. Literature Cited (align citation format with school expectations and ELA standards by grade level)

- A sufficient number of sources are cited. Sources specifically address the project topic. Level of sources is appropriate.
- An insufficient number of sources is cited that specifically address the project topic.
- Only one source is cited and/or relation of source to the topic is unclear.
- Not attempted.
Appendix B

Interview Questions

1. Describe the effects, if any, standardized testing and accountability have on your teaching practices.

2. Does preparation for state-wide testing, including ELA and Mathematics, affect science instructional time in your school?

3. Compare using an inquiry approach to teaching to direct-instruction with regard to time required, amount of content addressed, and student learning outcomes.

4. Describe specific lessons you have done using an inquiry approach.

5. Describe any projects you have assigned to students in the past year.

6. How often do students collect, graph, and analyze data in your classroom?

7. How often do students have lab activities?

8. How would you describe the support you receive from the administrators and non-UA teachers in your school regarding your participation in UA?

9. How has your participation in UA affected your students exit projects and your teaching?

10. How does the quality of UA professional development compare to other professional development you have participated in?

11. What is the ID? Describe how and when you use of the ID.

12. What is the DSET? Describe your student’s experiences using the DSET.

13. Are you familiar with the 5E’s? If so, how do you incorporate them into your instructional practices?

14. Compare and contrast science teachers with scientists.
### Appendix C

Urban Advantage Continuing Teachers Survey

<table>
<thead>
<tr>
<th>Background Information</th>
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<tbody>
<tr>
<td><strong>1.</strong> Did you attend the Urban Advantage EXPO in June 2011?</td>
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<tr>
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<tr>
<td>* yes</td>
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<tr>
<td><strong>2.</strong> If you accompanied students with projects to UA EXPO 2011, did you complete and hand in a Reflective Rubric for your student’s projects?</td>
</tr>
<tr>
<td></td>
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<tr>
<td>* yes</td>
</tr>
<tr>
<td><strong>3.</strong> Check the science teacher professional organizations you are an active member in.</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>National Science Teacher's Association (NSTA)</td>
</tr>
<tr>
<td>Sciences Teachers Association of New York State (STANYS)</td>
</tr>
<tr>
<td>Science Council of New York City (SCONYC)</td>
</tr>
<tr>
<td>Other (please specify)</td>
</tr>
<tr>
<td><strong>4.</strong> How many years have you been teaching science?</td>
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<tr>
<td></td>
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<tr>
<td><strong>5.</strong> How many years have you been a science teacher for the New York City Department of Education?</td>
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<tr>
<td><strong>6.</strong> How many years have you participated in the Urban Advantage program?</td>
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<tr>
<td><strong>7.</strong> List any science conferences you have attended in the past year (2010-2011).</td>
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<tr>
<td><strong>8.</strong> List any professional development activities you have participated in during the past year (2010-2011) not including Urban Advantage professional development activities.</td>
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<tr>
<td><strong>9.</strong> List the degrees you have earned including the major concentration (for example B.S. in Biology, M.S. in Education).</td>
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</tbody>
</table>
### Urban Advantage Continuing Teachers

**INSTRUCTIONAL PRACTICES**

These questions are directed at how you view various instructional practices.

**1.** Addressing content using inquiry instruction takes longer than direct-instruction.

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**2.** More content can be addressed using direct-instruction than using inquiry activities.

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**3.** My students learn more by direct-instruction than by inquiry activities.

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**4.** My students learn more from inquiry activities than by direct-instruction.

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**5.** My students learn better from direct-instruction than from inquiry activities.

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**6.** My students learn better from inquiry activities than from direct-instruction.

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### Urban Advantage Continuing Teachers

#### CLASSROOM PRACTICES

These questions are directed at your individual classroom and teaching practices.

**1. Students collect data in my classroom on a regular basis.**

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**2. Students graph and analyze data on a regular basis in my classroom.**

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**3. My students have lab activities at least once a week.**

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**4. I utilize hands-on activities on a regular basis.**

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</tr>
<tr>
<td>1. The administrators in the school where I work support my participation in the Urban Advantage Program.</td>
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<tr>
<td>2. The non-Urban Advantage science teachers in the school I work in support my participation in the Urban Advantage program.</td>
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</table>
**Urban Advantage Continuing Teachers**

**Urban Advantage**

*1. My students’ projects (long term investigations, exit projects, or science fair projects) have improved as a result of my participation in the Urban Advantage program.*

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<thead>
<tr>
<th>strongly disagree</th>
<th>disagree</th>
<th>not sure</th>
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*2. Participation in the Urban Advantage program has improved my ability to implement science inquiry activities in my classroom.*

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<th>strongly disagree</th>
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*3. As a result of participation in the Urban Advantage program I assign inquiry based projects aside from the exit project.*

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*4. The professional development provided by the Urban Advantage program is a higher quality than other New York City Department of Education professional development I have attended.*

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<th>strongly disagree</th>
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*5. My students use the ID (Investigation Design diagram) only for exit projects.*

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*6. My students use the DSET (Developing a Scientific Explanation Tool) provided by the Urban Advantage program for their exit projects.*

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<th>strongly disagree</th>
<th>disagree</th>
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*7. The ID (Investigation Design diagram) has been helpful to my students.*

<table>
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<th>strongly disagree</th>
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<th>not sure</th>
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*8. The DSET (Developing a Scientific Explanation Tool) has been helpful to my students.*

<table>
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<th>strongly disagree</th>
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*9. Students can easily complete the ID (Investigation Design diagram).*

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**Urban Advantage Continuing Teachers**

*10. The DSET (Developing a Scientific Explanation Tool) is easy for students to use.*

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Urban Advantage Continuing Teachers

**LONG-TERM INVESTIGATIONS and/or EXIT PROJECTS**

These questions are directed at how you guide students in completing exit projects or long-term investigations.

**1. Students compose their own questions on topics that they choose.**

<table>
<thead>
<tr>
<th>strongly disagree</th>
<th>disagree</th>
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**2. Students compose their own questions based on a topic or topics provided by me.**

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<tr>
<th>strongly disagree</th>
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**3. Students select among questions on a topic provided by me.**

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<th>strongly disagree</th>
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**4. Students work on a question that was assigned to them by me.**

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<tr>
<th>strongly disagree</th>
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**5. Students independently determine what constitutes evidence and how to collect it.**

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<tr>
<th>strongly disagree</th>
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<th>agree</th>
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**6. Students are guided as to what constitutes evidence and how to collect it.**

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<tr>
<th>strongly disagree</th>
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<th>not sure</th>
<th>agree</th>
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**7. Students are provided with possible data sources to select from as evidence.**

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<tr>
<th>strongly disagree</th>
<th>disagree</th>
<th>not sure</th>
<th>agree</th>
<th>strongly agree</th>
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**8. Students are given data to use as evidence.**

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<tr>
<th>strongly disagree</th>
<th>disagree</th>
<th>not sure</th>
<th>agree</th>
<th>strongly agree</th>
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**9. Students determine how to analyze their data/evidence.**

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<tr>
<th>strongly disagree</th>
<th>disagree</th>
<th>not sure</th>
<th>agree</th>
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**10. Students are guided in analyzing their data/evidence.**

<table>
<thead>
<tr>
<th>strongly disagree</th>
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</table>
### Urban Advantage Continuing Teachers

**11. Students are given possible ways to analyze their data/evidence.**

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Not Sure</th>
<th>Agree</th>
<th>Strongly Agree</th>
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**12. Students are told how to analyze their data/evidence.**

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Not Sure</th>
<th>Agree</th>
<th>Strongly Agree</th>
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**13. Students formulate explanations based on evidence.**

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Not Sure</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
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</table>

**14. Students are guided in the process of formulating explanations from evidence.**

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Not Sure</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
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</table>

**15. Students are given possible ways to use evidence to formulate explanations.**

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Not Sure</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
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</table>

**16. Students are told how to use evidence to formulate explanations.**

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Not Sure</th>
<th>Agree</th>
<th>Strongly Agree</th>
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</table>

**17. Students are directed toward areas and sources of scientific knowledge to support the claims they make.**

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Not Sure</th>
<th>Agree</th>
<th>Strongly Agree</th>
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</table>
### Urban Advantage Continuing Teachers

#### STANDARDIZED TESTING

These questions are directed at how your instructional practices may or may not be affected by standardized testing.

**1.** I limit the amount of time my students work on long term investigations and/or exit projects in order to prepare students for science state-wide tests.

<table>
<thead>
<tr>
<th>strongly disagree</th>
<th>disagree</th>
<th>not sure</th>
<th>agree</th>
<th>strongly agree</th>
</tr>
</thead>
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<td></td>
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</tbody>
</table>

**2.** I limit the amount of inquiry activities in my classroom in order to prepare students for science state-wide tests.

<table>
<thead>
<tr>
<th>strongly disagree</th>
<th>disagree</th>
<th>not sure</th>
<th>agree</th>
<th>strongly agree</th>
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**3.** Students lose science instructional time for state ELA exam preparation or testing.

<table>
<thead>
<tr>
<th>strongly disagree</th>
<th>disagree</th>
<th>not sure</th>
<th>agree</th>
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</table>

**4.** Students lose science instructional time for state Mathematics examination preparation or testing.

<table>
<thead>
<tr>
<th>strongly disagree</th>
<th>disagree</th>
<th>not sure</th>
<th>agree</th>
<th>strongly agree</th>
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</table>

**5.** Administrators limit the amount of time my students work on long-term investigations and/or exit projects.

<table>
<thead>
<tr>
<th>strongly disagree</th>
<th>disagree</th>
<th>not sure</th>
<th>agree</th>
<th>strongly agree</th>
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</tbody>
</table>
Appendix D

Maritza McDonald Curriculum Vitae

American Museum of Natural History

Maritza MacDonald
1013 Hillcrest Road
Ridgewood, NJ 07450
(H) 201-317-9545 (W) 212-769-5182 maritza@amnh.org

EDUCATION
1995 Teachers College, Columbia University, New York, NY
Doctor in Education with Specialization in Teacher Education and Curriculum
Development, Department of Curriculum and Teaching.
1978 Bank Street College of Education, New York, NY
Master of Science in Education
1974 Fordham University, New York, NY, Bachelors of Science
1969 Institute of Modern Languages, Washington, DC
Simultaneous Translator and Interpreter (English - Spanish)

PROFESSIONAL FOCUS:
Direct, develop, research, create partnerships, and evaluate educational programs in formal and informal education settings focused on equity, achievement, and cross-cultural knowledge and understanding.

PROFESSIONAL EXPERIENCES

• RESEARCH AND EVALUATION, PROGRAM ADMINISTRATION, GRADUATE SCHOOL TEACHING

1997 - Present American Museum of Natural History, New York, NY
Senior Director of Education and Policy: Develop, implement, research and evaluate partnerships with higher education and with other ISEd organizations. Direct evaluation activities related to exhibitions and education. Represent the museum in policy related STEM activities such as the National Commission for 21 Century STEM Education and The New York State Regents Work Group to consider cultural institutions in policies related to teacher education. Member of two inquiry groups producing research reports for the Center for the Advancement of Informal Science Education (CAISE). Past evaluator of two Research Experiences for Teachers programs sponsored by NSE: Teachers Experiencing Antarctica and the Arctic (TEA) (2002-2005), and Research Experiences in Industry (REI) with Mississippi State University (2005-2007). Principal Investigator for NSF funded teacher enhancement program (2004-2008). Teacher Renewal for Urban Science Teaching (TRUST), now institutionalized at partner institutions. Researcher and Guest Editor for Journal Issue of The New Educator (2010) on partnerships between Science Cultural Institutions and Teacher Education Programs in the USA and the UK. Direct international development science and society programs between AMNH and Vietnam and South Africa. Adjunct professor at Columbia University Teachers College and Lehman College (CUNY) in NYC teaching courses on Science Teaching and Learning in Science Cultural Institutions. Dissertation advisor for doctoral students researching science learning in informal contexts at Columbia Teachers College and CUNY Graduate Center for Urban Education. Urban Advantage program partnership designer, and PI in AMNH study of visualization for science concept development in new English language learners of Spanish and Chinese home languages. A NOAA Project.

1992 - 1997 Teachers College, Columbia University, New York
Senior researcher at the National Center for Restructuring Education, Schools and Teaching (NCREST)
NCREST liaison with certification programs on the implementation of state and national teaching standards initiatives, such as the National Board of Professional Teaching Standards. Program Director, "Leading Edge," a national research project on Professional Development Schools and Teacher Preparation Institutions. Researcher and team coordinator for national study of exemplary teacher education programs funded by Carnegie Corporation and led by Linda Darling Hammond. Evaluator of CPB National Technology Summits. Graduate Course Instructor, Supervision and Administration for Curriculum Improvement.

Maritza MacDonald, Page 1 of 2
URBAN ADVANTAGE TO SUPPORT A CULTURE OF INQUIRY

American Museum of Natural History

Director, advisor, and instructor: Pre-Service Teacher Education Program. Administrative and academic role included supervising graduate professors, negotiating partnerships with schools, and leading curriculum committees. Teaching graduate level courses on Curriculum Design; Administration & Supervision of Curriculum Development; Evaluation of Curriculum for Bilingual Programs.

1997 - 2010  Graduate Level Teaching at AMNH for Public & Private Higher Education Programs
"Informal Science" a Museum-designed course for Teachers College, Columbia University, (1997-Present)
"Science Instruction Beyond the Classroom" a Museum-based course for Brooklyn College (1998-2000)
"Museum Resources for Teaching Science", AMNH required course for Lehman College (CUNY), 2002-present

1982 - 1986  Development Associates Inc., San Francisco, CA,

1975 - 1978  Bank Street College of Education New York, NY,
Associate Director of International Programs Served as cross-cultural advisor to teacher educators from Latin America. Developed and translated bilingual training films and evaluated teacher education curriculum for South American universities.

• CROSS CULTURAL SELF-STUDY EXPERIENCE
1978 - 1979  Sabbatical year in Europe and Northern Africa following personal interest in language loss and retention of minority languages affected by repressive government policies in Scotland, Wales, France, Spain and Morocco.

• PUBLICATIONS & RESEARCH STUDIES
2010  The New Educator Journal (Guest Editor) Special Issue on Teacher Education and Science Cultural Institutions: Widening the Scholarship for Preparing New Science Educators, City College, NYC.
2002  A Science Museum's Expedition into the World of Teacher Education. A three year action research study of museum and college partnerships on teacher education. With H. Sloan and E. Miele, Presented at AERA, 2002 in New Orleans, LA.
1997  Assessment for Equity and Inclusion: Embracing all our children, with L. A. Goodwin, Rutledge

• Professional Collaborators and Dissertation Advisor
Dr. Linda Darling Hammond, Stanford University Dissertation Advisor
Dr. Roger Anderson, Chair of Science Education at Columbia Teachers College, Collaborator in dissertations
Dr. John Snyder, Provost, Bank Street College of Education. Teacher for a New Era Collaboration
Dr. Bronwyn Bevan, The Exploratorium in San Francisco CILS Project presentations
Dr. Ed Mathe, AMNH Scientists on design of programs for science educators in South Africa
Dr. David Silvernail, University of Southern Maine. Partner in evaluation of NSF REI Program.

Maritza Macdonald, Page 2 of 2
Appendix E

James B. Short Curriculum Vitae

American Museum of Natural History

JAMES B. SHORT

American Museum of Natural History
Central Park West at 79th Street
New York, NY 10024-5192
212-769-5139 (phone)
212-769-5329 (fax)
jshort@amnh.org

EDUCATION

Ed.D. in Curriculum and Teaching with a concentration in Educational Leadership: Teacher Education/Supervision/Staff Development
Dissertation: Analyzing Standards-Based Science Instructional Materials: An Opportunity for Professional Development
Committee: Professors Frances Schoenmaker (Sponsor), A. Lin Goodwin, Ann Rivet, & Angela Calabrese Barton

M.Ed. in Science Education
George Peabody College for Teachers, Vanderbilt University, Nashville, TN, 1989.

B.S. in Biology

PROFESSIONAL EXPERIENCE

American Museum of Natural History, Education Department, New York, NY, 2007-present
Director, Gottesman Center for Science Teaching and Learning
• responsible for creating an education platform that has high visibility, influence, and presence in the science education and museum communities both locally and nationally
• integrate programs into the educational system in New York City, demonstrating that informal settings have a role in the city’s formal educational system
• develop partnership programs with public schools, non-profit organizations, and the New York Department of Education
• lead the development and planning of professional development programs for teachers and school administrators, Museum learning experiences for students, and educational outreach programs
• contribute to strategic planning, proposal development, annual reporting, and budget management
• supervise Center staff of 25 science educators and manage five million dollar annual Center budget

Denver Public Schools, Division of Teaching and Learning, Denver, CO, 2004-2007
Science Curriculum Coordinator
• plan and coordinate implementation of district-wide K-12 science programs and to orchestrate program improvement efforts
• design and facilitate professional development for science teachers and district/school administrators
• partner with community groups, professional organizations, and higher education institutions to support redesigned science curriculum in the district and coordinate special programs for schools
• collaborate with the Denver Museum of Nature and Science and the Denver Zoo to develop educational outreach programs that coordinate and extend the district’s K-12 science program
• develop district-wide support systems for K-12 science curriculum reform that include professional development opportunities, formative and summative assessments, materials management and kit refurbishment, and development of teacher leaders at schools
• observe and analyze science classes to identify ongoing professional development needs, monitor science assessment data, and utilize data to plan program improvements
• meet with parents and community groups to serve as a spokesperson for the district’s science program

Metropolitan State College of Denver, Department of Teacher Education, Denver, CO, 2005-2006
Instructor, Science Education
Science Education Course 3950: Teaching Science in Middle and Secondary Schools
Secondary science methods course designed for pre-service teachers preparing to teach in middle and high schools. The focus of the course is on inquiry-based learning and teaching using standards-based instructional materials and strategies aligned with the research on how students learn science.

Science Education Consultant, September 2005-present
Denver Museum of Nature and Science, Denver, CO
Served as a consultant for Project Curiosity focused on developing interactive questions and activities for various dioramas to support key concepts in science linked to national and state science standards

BSCS National Academy for Curriculum Leadership Program, Richland, WA
Senior staff member associated with the national expansion of the NAAC program into Washington State, a partnership between the BSCS Center for Professional Development and Washington State LASBRE, with major support from Agilent Technologies Foundation, Battelle, and the Pacific Northwest National Laboratory

Pacific Northwest National Laboratory, Richland, WA
Summer Institutes for Department of Energy Laboratory Science Teacher Professional Development program; sessions focused on science as inquiry and teaching experimental design

Space Science Institute, Boulder, CO
Institutes focused on designing professional development to support inquiry-based science for education and public outreach programs funded by NASA

(The Biological Sciences Curriculum Study (BSCS) is a leading non-profit educational research and development institution focusing on science education and offering products and services in K-12 curriculum development, professional development, and research and evaluation)

Director, SCI Center at BSCS and the National Academy for Curriculum Leadership
The Science Curriculum Implementation (SCI) Center at BSCS was funded by the National Science Foundation (five-year grant for $8 million) to develop resources and provide technical assistance to support the implementation of standards-based secondary science instructional materials. Responsibilities as project director included:
- led the development of professional development products and services that are focused on leadership development for systemic reform and curriculum implementation
- directed the design and implementation of the National Academy for Curriculum Leadership (a three-year professional development and technical assistance program for school districts implementing standards-based curricula) that involved 12 leadership teams representing 10 school districts from around the country (including San Diego, Boston, Cincinnati, and Pittsburgh Public Schools)
- managed the design, marketing and dissemination of center activities including presentations at conferences, workshops and seminars, contracts with school districts, and print- and web-based information
- supervised design and execution of project evaluation by external contractor
- planned and managed tasks, budgets and time lines of center activities

(Nation’s largest private manager of public schools from kindergarten through twelfth grade)

Director, Science Education K-12
Responsibilities involved all aspects of Edison’s K-12 science program including: program support, professional development, curriculum and instruction, and student achievement and assessment.
- revised Edison science standards to align with the National Science Education Standards
- designed and implemented new approaches to staff development for Edison’s K-12 science programs

(Co-od PreK-12 college preparatory day school)
Coordinator of Packer’s Science Research Program, 1994-1999
Program involving high school students working on independent research projects
• students conducted a literature review from scientific journal articles and used e-mail to get feedback from scientists; students located mentors and summer internships working in research laboratories
• students published their work using web pages and presented their findings each spring at the annual Science Research Symposium
• served on advisory board for Rockefeller University’s Science Outreach Program, one of the community partners in Packer’s Science Research Program

**Science Department Chair, 1993-1999**

• implemented a constructivist teaching and learning philosophy that was used by all science teachers
• developed and implemented a high school science curriculum that began with physics first in 9th grade, chemistry in 10th grade, and biology in 11th grade, with an emphasis on molecular genetics and biotechnology
• developed a High School Science Research Program that enabled students to conduct a sophisticated literature review and find a mentor using the Internet in order to design and conduct individual research projects and publish their work on the world-wide-web
• facilitated teachers in Grades 5-8 in development of an integrated approach to learning and teaching science using major themes that incorporate earth, life, and physical science
• implemented a K-4 constructivist science curriculum taught by both science specialist and classroom teachers based on active learning in cooperative groups focused on major concepts and skills in science

**Teaching Responsibilities** included Biology, AP Biology, and 12th Grade Advisor, member of Student-Faculty Judiciary Committee.

**Co-Chair, Professional Growth & Development Task Force, 1997-1999**

Purpose of task force was to formulate a policy and develop a new research-based professional development program for school that resulted in changing the professional culture of school and nurturing the development of an adult learning community.

• designed and implemented a two-year investigation of best practices in professional development
• served as the liaison with the administration during the formulation of the policy & programs
• directed Critical Friends Group (CFG) pilot program and provided ongoing support to CFG coaches

**Albany Academy for Girls, Albany, NY, 1991-1993.**

(Girls’ PreK-12 college preparatory day school)

**Science Department Chair, 1991-1993**

• developed a guided inquiry approach through a hands-on laboratory program that was implemented by all members of the science department
• developed and implemented a curriculum teaching experimental design to students in Grades 7 and 8 who demonstrated their understanding through independent research projects which were presented at the Annual Middle School Science Symposium
• implemented a hands-on K-6 science curriculum taught by Science Specialists based on constructivist learning theory and cooperative learning groups

**Teaching Responsibilities** included Biology, AP Biology, Seventh Grade Life Science, and an interdisciplinary science elective in Environmental Issues taught jointly with the History Department.

Other responsibilities included Ninth Grade Class Advisor and faculty sponsor for the Ecology Club

**Episcopal High School, Alexandria, VA, 1989-1991.**

(Boys’ 9-12 college preparatory boarding school)

**Teaching Responsibilities** included Biology and an elective in Environmental Science. Other responsibilities included dormitory master, assistant track coach, technical director for drama productions, and faculty sponsor for the Ecology Club and Youth in Philanthropy Club.

**PROFESSIONAL MEMBERSHIPS**

**National Science Teachers Association**

NSSTA Division XIV Director, 2006-2007
Member of NSTA Professional Development Committee, 2004-2006
URBAN ADVANTAGE TO SUPPORT A CULTURE OF INQUIRY

National Science Education Leadership Association
Chair of NSELA Professional Development Committee, 2005-2008

PUBLICATIONS


FEDERAL GRANTS
Principal Investigator (NSF Award No. DRL-0918560) with Co-PI Suzanne Wilson at Michigan State University and scientists from the Cuy Institute for Ecosystem Studies on project entitled Learning Science as Inquiry with the Urban Advantage: Formal-Informal Collaborations to Increase Science Literacy and Student Learning. The overarching research question is how can informal science education institutions best design resources to support teachers, school administrators, and families in the teaching and learning of students to conduct scientific investigations and better understand the nature of science? (2009-2013)

Principal Investigator (IMLS Award No. LG-26-09-0121-09) on project entitled Partnering for Results with Urban Advantage, a national leadership demonstration project to build and support outcome-based, sustained partnerships between museums and school districts in professional development. The two-year project focuses on establishing a partnership model for informal/formal science education initiatives centered around teacher professional development and student learning outcomes by creating a leadership institute for professional development providers.

Principal Investigator (NASA Grant No. NNX09AL93G) on project entitled Integrated Media and Teacher Professional Development Program: GRACE Mission Climate Change Science at AMNH to support teachers’ and students’ ability to engage with a global gravity data set visualization to understand how water distribution is affected by climate change. (2009-2010)

Co-Principal Investigator with Digital Learning Sciences and Denver Public Schools (NSF Award No. 0734872) with the American Geological Institute and It’s About Time/Hufff Jones Publishing as partners to develop an online curriculum customization service for the National Science Digital Library (NSDL) to support secondary Earth science teachers implementing standards-based curricula. (2008-2010)

Design Team member on a Teacher Professional Continuum Project (NSF-Award No. 0553174) entitled Building Systems for Quality Teaching and Learning in Science: A Simulation Game and Learning Modules with the Mathematics, Science, and Technology Program at WestEd. (2006-2009)
Former Project Director: BSCS Science Curriculum Implementation and Dissemination Center (NSF Award No. ESI-9911615) and former Director of the BSCS National Academy for Curriculum Leadership program in the BSCS Center for Professional Development, developed resources and provided technical assistance to support the implementation of standards-based secondary science instructional materials (2000-2005)

AWARDS

Recipient of the 2005 Susan Loucks-Horsley Award at BSCS for contributions and service in the field of professional development.

Recipient of the 2003 Executive Director’s Award at BSCS for providing vision and leadership in establishing the SCI Center at BSCS as a national leader in professional development for science education reform.

Recipient of the 1998 BSCS Teacher of the Year Award

BSCS is the nation’s leading biology-education organization developing innovative science curricula for grades kindergarten through college.

PRESENTATIONS

Numerous presentations and workshops at professional meetings and conferences (National Science Teachers Association, National Staff Development Council, National Science Education Leadership Association) over the last five years:

- Teaching Science as Inquiry and the National Science Education Standards
- Strategies and Tools for Teaching Experimental Design in the Science Classroom
- Linking research from How People Learn to Standards-Based Science Instructional Materials
- Analyzing Instructional Materials (AIM) Process and Tools
- Examining the Conceptual Flow of Science Content in Science Units
- Designing Transformative Professional Development
- Evaluating Professional Development
- Using the Concerns-Based Adoption Model (CBAM) for Monitoring Curriculum Implementation
**Appendix F**

**Investigation Design Diagram**

<table>
<thead>
<tr>
<th>Title: (\text{Sample format: The effect of (independent variable) on (dependent variable)})</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Research Question:</strong> (\text{Sample format: How will (independent variable) affect (dependent variable)?})</td>
</tr>
<tr>
<td><strong>Hypothesis:</strong> (\text{Sample format: I think (independent variable) will affect (dependent variable) because (explain why you expect/predict this relationship between the variables)})</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Independent Variable: (\text{(or the &quot;you change it&quot; or &quot;you choose it&quot; variable)})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in independent variable:</td>
</tr>
<tr>
<td>Number of repeated trials:</td>
</tr>
</tbody>
</table>

| Dependent Variable: \(\text{(or the "you measure it" variable)}\) |
| Constant Variables: |

<table>
<thead>
<tr>
<th>Definition of Terms</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Independent Variable:</strong> (\text{(manipulated variable) the variable that is changed on purpose by the experimenter.})</td>
</tr>
<tr>
<td><strong>Dependent Variable:</strong> (\text{(responding variable) the factor or variable that may change as a result of changes purposely made in the independent variable.})</td>
</tr>
<tr>
<td><strong>Control Group:</strong> (\text{the part of an experiment that serves as a standard of comparison. A control is used to detect the effects of factors that should be kept constant, but which vary. The control may be a &quot;no treatment&quot; group.})</td>
</tr>
<tr>
<td><strong>Constant Variable:</strong> (\text{factors in an experiment that are kept the same and not allowed to change or vary.})</td>
</tr>
<tr>
<td><strong>Repeated Trials:</strong> (\text{the number of times that a level of the independent variable is tested in an experiment or the number of objects or organisms tested at each level of the independent variable})</td>
</tr>
<tr>
<td><strong>Hypothesis:</strong> (\text{a prediction of the relationship of an independent and dependent variable to be tested in an experiment; it predicts the effect that the changes purposely made in the independent variable will have on the dependent variable.})</td>
</tr>
<tr>
<td><strong>Title:</strong> (\text{a statement describing an experiment. Titles are often written in the form, &quot;The Effect of the Changes in the Independent Variable on the Dependent Variable.&quot;})</td>
</tr>
</tbody>
</table>

### Investigation Design Diagram

**Title:**

**Question:**

**Hypothesis:**

<table>
<thead>
<tr>
<th>Independent Variable:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in independent variable:</td>
</tr>
<tr>
<td>Number of repeated trials:</td>
</tr>
</tbody>
</table>

**Dependent Variable:**

**Constant variables:**

---

Appendix G

Developing a Scientific Explanation Tool (DSET)

What is your question?

Support for your explanation

<table>
<thead>
<tr>
<th>Claim based on the evidence (What is the answer to your question based on your evidence?)</th>
<th>Evidence (Observations/data that answers your question)</th>
<th>Scientific Reasoning (Why you think this happened based on background research)</th>
</tr>
</thead>
<tbody>
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</table>

Scientific Explanation = Claim + Evidence + Science Reasoning

My claim is (fill in with above claim) because (evidence and science reasoning)
Appendix H

Student Exit Project Rubric

WATCH YOUR SCIENCE EXIT PROJECT “GROW”
Student Exit Project Rubric

Your Name ___________________________________________ Class _____

To see how you are doing, use this sheet as a guide. It is similar to the sheet your teacher will use when evaluating your work and calculating your grade.

How to Use This Guide: When you do one of the things listed, place a check mark ☑ in the box next to it, but only if you feel you’ve completed that task to the best of your ability.

Then, give yourself a “G,” “R,” “O,” or “W” based on the key at the end of each section.

You will be working on four sections.

SECTION 1: Science Understanding (as shown in the written report and the oral presentation)

☐ I used topics and ideas that we discussed in class or on field trips to come up with a question that I could investigate.

☐ I explained my observations and my results by using science terms and science ideas.

☐ I used more than one way of explaining my ideas, like words, pictures, diagrams, charts, or graphs.

☐ I was able to make connections between what I learned from the project and other areas of science.

How did I do in Section 1?
If you have all four boxes checked off, you did Great.
If you have three boxes checked off, you did Really well, but try to check off the remaining box.
If you have two boxes checked off, you’re On your way, keep up the good work!
If you only have one box checked off, keep Working!

Write a “G,” an “R,” an “O,” or a “W” based upon your results for this section here: __________

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SECTION 2: Scientific Process *(as shown in the written report and the oral presentation)*

☐ I identified a problem, and I asked a question that I could investigate (instead of a “yes or no” question).

☐ I did some background research.

☐ Using the background research, and before I actually did the project, I made a hypothesis that I could test. I did not already know for sure what the answer to my hypothesis would be. I also knew that my hypothesis did not have to be correct, because in science we can learn when we get results we expect or when we get results we do not expect.

☐ I designed a way to collect data to test my hypothesis.

☐ I conducted my research carefully and with scientific accuracy.

☐ I collected, recorded, and organized data from my work.

☐ I made graphs, charts, tables, or artwork that explained my data.

☐ I made a conclusion that says whether my hypothesis was correct or incorrect (either one is ok), according to my data; it explains my observations and why things came out the way they did.

☐ I explained what I would do differently next time, and I discussed any possible sources of error in my project.

☐ I looked back at my work and explained what I might have changed to make the project even better.

"If I were to do the project all over again, here is what I'd do differently this time....."

**How did I do in Section 2?**

If you have all ten boxes checked off, you did **Great**.

If you have nine boxes checked off, you did **Really well**, but try to check off the remaining box.

If you have eight boxes checked off, you’re **On your way**, keep up the good work!

If you only have less than eight boxes checked off, **keep Working!**

Write a “**G**,” an “**R**,” an “**O,**” or a “**W**” based upon your results for this section here: __________

© New York City Department of Education, 2006
SECTION 3: The Written Report

☐ I used at least three different sources to collect my background research information, which I have written down in my bibliography.

☐ The report is written in a manner that makes sense. I made sure my report has:
  ✓ An abstract.
  ✓ An introduction that includes the purpose and the reason I chose this topic.
  ✓ A section on methods and materials.
  ✓ My actual data and an analysis of it.
  ✓ A conclusion that refers back to my hypothesis with a discussion of the results and further questions I would like to investigate.
  ✓ A reflection on the quality of my entire project.
  ✓ A glossary of terms.
  ✓ A bibliography.

☐ I compared concepts and showed the reader that I understood MORE THAN just what I researched about. I compared it to other things not in my research (i.e. "this is similar to the idea of that").

☐ I supported my ideas with examples, definitions, and references back to other sources of information.

☐ I included footnotes for anything that I did not learn by myself. If I didn't learn it from doing this project, I showed where I got the information.

☐ I used graphics, charts, or artwork to enhance my report.

☐ I checked for grammar, spelling, punctuation, and sentence structure. I did not include any slang or computer abbreviations in my report.

☐ I used a typewriter or a computer to print my report. It is NOT handwritten.

How did I do in Section 3?
If you have all eight boxes checked off, you did Great.
If you have seven boxes checked off, you did Really well, but try to check off the remaining box.
If you have six boxes checked off, you’re On your way, keep up the good work!
If you only have less than six boxes checked off, keep Working!

Write a “G,” an “R,” an “O,” or a “W” based upon your results for this section here: __________
SECTION 4: The Oral Presentation

☐ I organized my presentation in a way that people can understand. I know that not everyone listening to the presentation is as much an expert on my topic as I have become.

☐ I used notes, index cards, or PowerPoint to make sure I followed my presentation in the correct manner and that I am giving accurate data. I did NOT read directly from my report, and I made eye contact with the audience.

☐ I gave examples and definitions, and I made direct references with quotes to support my ideas.

☐ I was able to answer questions about my topic; I am the expert!

☐ My audience was able to understand my concept.

☐ I used proper grammar and sentence structure. I did not use any slang. I spoke slowly, loudly, and clearly, so that I could be understood.

☐ I used some visual display such as: PowerPoint, trifold board, movie, or other multimedia to make my presentation more interesting.

How did I do in Section 4?

If you have all seven boxes checked off, you did Great.
If you have six boxes checked off, you did Really well, but try to check off the remaining box.
If you have five boxes checked off, you’re On your way, keep up the good work!
If you only have less than five boxes checked off, keep Working!

Write a “G,” an “R,” an “O,” or a “W” based upon your results for this section here: __________
So, how did my project GROW?

If you have four G’s, you did great on your project: give yourself a BIG “G” in the box below.
If you have three G’s, you did really well on your project: give yourself a BIG “R” in the box below.
If you have two G’s on your project, give yourself an “O.” You’re on your way.
If you have one G on your project, give yourself a “W,” and keep working.

As of _____ / _____ / ______, my project is rated a □ because:

---

WHEN YOU ARE FINALLY DONE, CONGRATULATE YOURSELF ON COMPLETING YOUR ADVANCED SCIENTIFIC RESEARCH PROJECT AND PRESENTATION !!!

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Appendix I

Sample Science Exit Project Rubric

Sections on the Science Exit Project Poster

Title: The title should state both the independent variable and the dependent variable. **Sample format:** “The effect of (the independent variable) on (the dependent variable).”

Question: The question describes the focus of the investigation. The question should ask how the independent variable will affect the dependent variable. The question should be written so that someone else can easily understand it. **Sample format:** “How will (the independent variable) affect (the dependent variable)?”

Hypothesis: An hypothesis predicts the effect that changing the independent variable will have on the dependent variable in the investigation. It predicts the effect that the change purposely made in the independent variable will have on the dependent variable. The hypothesis should make a statement about what the student thinks will happen and why (“because…”). **Sample format:** I think (independent variable) will affect (dependent variable) and I expect (predicted result) because (describe the scientific reasons of why you expect this relationship between the variables; include scientific concepts that relate to this prediction). **Sample format:** If (summarize investigation or action being planned, i.e., changing the independent variable) then (predict result, i.e., effect on dependent variable) because (describe the scientific reasons of why you expect this relationship between the variables. Include scientific concepts that relate to this prediction).

Background Information: Describes the student’s reasoning behind the hypothesis – why is this relationship between the variables expected/predicted and not a different relationship? Students should use this space to answer the question: “What did I read that makes me predict this outcome?”

Experimental Design: Using the five components below, describe the design of the investigation:

1. **Independent variable:** the variable that the student changes on purpose. (In a field study we describe the IV as the category(ies) that the student chooses. In a secondary research project, we describe the IV as the variable that the student lets change and does not keep constant.)
2. **Dependent variable:** the variable that may change as a result of changes purposely made in the independent variable.
3. **Constant variables:** the variable(s) in an investigation that are kept the same and not allowed to change or vary.
4. **Control group:** Controlled experiments are often the only type of exit project that have a control group. They are the part of an experiment that serves as a standard of comparison. A control is used to detect the effects of factors that should be kept constant, but which vary; the control may be a “no treatment” group.
5. **Number of repeated trials:** the number of times that a level of the independent variable is tested in an investigation, or the number of objects or organisms tested at each level of the independent variable.

Procedure: List materials and provide a detailed and logical step-by-step description of procedures.

Results (Data Table and Graphs): Got Data? The data in this section are the basis on which the student will claim that the hypothesis is or is not supported. The exit project gives priority to evidence in the form of empirical observations. The data should be shown in a table and in charts and graphs. The student(s) make their own observations for the following types of projects: controlled experiments, field studies and design projects. The student(s) use observations reported by other investigators when they do secondary research.

Data Analysis/Discussion: The priority of this section is for a student to summarize the trends or patterns in the data with the goal of determining whether the hypothesis was – or was not – supported by the data. In this section students communicate their finding or claim and back it up with their data. Further, Urban Advantage also emphasizes the importance of connecting the students’ results to the scientific knowledge already available on the topic.
The student’s claim, the data used to support the claim (evidence) and the reasoning used to relate claim and evidence (the connections to scientific knowledge) can be considered a complete scientific explanation that should form the core of a discussion/conclusion. Also important are reflections on possible sources of experimental error and suggestions for further investigations.

**Conclusion:** A concise re-statement of the explanation already proposed in the discussion – specifically, a statement including the student’s claim (whether the hypothesis was – or was not – supported by the data), the evidence, and the reasoning used to relate claim and evidence (the connections to scientific knowledge).

Appendix J

Urban Advantage Sections of the Science Exit Project Poster and Rubric

Sections of the Science Exit Project Poster and Rubric

Title
The title should state both the independent variable and the dependent variable.

Sample format: “The effect of (the independent variable) on (the dependent variable).”

Question
The question describes the focus of the investigation. The question should ask how the independent variable will affect the dependent variable. The question should be written so that someone else can easily understand it.

Sample format: “How will (the independent variable) affect (the dependent variable)?”

Hypothesis
A hypothesis predicts the effect that changing the independent variable will have on the dependent variable in the investigation. It predicts the effect that the change purposely made in the independent variable will have on the dependent variable. The hypothesis should make a statement about what the student thinks will happen. The hypothesis should state why the student thinks this will happen (“because…”).

Sample format: I think (independent variable) will affect (dependent variable) and I expect (predicted result) because (describe the scientific reasons of why you expect this relationship between the variables. Include scientific concepts that relate to this prediction).

Sample format: If (summarize investigation or action being planned, i.e., changing the independent variable) then (predict result, i.e., effect on dependent variable) because (describe the scientific reasons of why you expect this relationship between the variables. Include scientific concepts that relate to this prediction).

Background information (a part of the Hypothesis section)
Describes the student’s reasoning behind their hypothesis—why do they expect/predict this relationship between the variables and not a different relationship? The student should use this space to answer the question: “What did I read that makes me predict this outcome?”

1
Investigation Design (the ID diagram used in UA PD may be included as a graphic organizer here)

Using the five components below, describe the design of the investigation:

1. **Independent variable**: the variable that the student changes on purpose. (In a field study we describe the independent variable as the category(ies) that the student chooses. In a secondary research project, we describe the independent variable as the variable that the student lets change and does not keep constant.)

2. **Dependent variable**: the variable the student measures that is affected (changes) as a result of changes purposely made in the independent variable.

3. **Constants** (also called constant variables): the variable(s) in an investigation that are kept the same and not allowed to change or vary.

4. **Levels of the independent variable**: The different levels of the IV at which the DV is measured, or the groupings of the IV for comparing DV observations.

5. **Number of repeated trials**: the number of times that a level of the independent variable is tested in an investigation, or the number of objects or organisms tested at each level of the independent variable.

**Procedure**

List materials and write the procedure so that another student can follow the directions and repeat the investigation (provide a detailed and logical step-by-step description).

**Data/Results (Table and Graphs, and Data Analysis)**

Got Data? The data reported in this section are the basis on which the student will claim that their hypothesis is, or is not, supported. Exit projects should give priority to evidence in the form of empirical observations. The data should be shown in a table and in charts and graphs, and trends or patterns in the data should be summarized. The student(s) make their own observations for the following types of projects: controlled experiments, field studies and design projects. The student(s) use observations or data reported by other investigators when they do secondary research.

**Discussion/Conclusion**

This section(s) should first state whether the hypothesis was--or was not--supported by the data. Further, Urban Advantage also emphasizes the importance of connecting the students’ results to the scientific knowledge already available on the topic by having students construct a scientific explanation.

The student’s claim about their hypothesis, the data they use to support the claim and the reasoning they use to relate claim and evidence (the connections to scientific knowledge) should all be included in a complete scientific explanation that should form the core of the Discussion/Conclusion. Also important are reflections on possible sources of experimental error; and suggestions for further investigations.

**Literature Cited**

A list of sources used. Sources should be varied (books, articles, websites...), clearly related to the topic, and at the appropriate level. Citations should include title, author, year, and URL (if website).
Science Exit Project Evaluation Rubric:

Please adapt the rubric to your own needs and your students’ needs. The scoring table (below the rubric) should also be modified to match your needs.

<table>
<thead>
<tr>
<th>A. Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 The title correctly states the independent variable and the dependent variable and is worded as a statement.</td>
</tr>
<tr>
<td>2 The title correctly states the independent variable and the dependent variable but is worded as a question.</td>
</tr>
<tr>
<td>1 The title is present but does NOT correctly state the independent variable or the dependent variable.</td>
</tr>
<tr>
<td>0 Not attempted</td>
</tr>
<tr>
<td>Comments:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B. Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 The question states the independent variable and the dependent variable, and is testable.</td>
</tr>
<tr>
<td>2 The question does not make the independent variable and the dependent variable clear, but is testable.</td>
</tr>
<tr>
<td>1 The question is present but is NOT testable.</td>
</tr>
<tr>
<td>0 Not attempted</td>
</tr>
<tr>
<td>Comments:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>C. Hypothesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 The hypothesis predicts the effect that changing the independent variable will have on the dependent variable, and explains the reason for the prediction using scientific reasoning (&quot;because...&quot;) that is supported by cited background research as noted in the literature cited section.</td>
</tr>
<tr>
<td>2 The hypothesis predicts the effect that changing the independent variable will have on the dependent variable. The &quot;because...&quot; reasoning is present but incomplete or weak.</td>
</tr>
<tr>
<td>1 The prediction is present but does not frame a relationship between the variables, or the &quot;because...&quot; reasoning is missing from the hypothesis statement.</td>
</tr>
<tr>
<td>0 Not attempted</td>
</tr>
<tr>
<td>Comments:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>D. Background Research</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 Background Research is relevant to the topic (and the DV and IV specifically), supports the &quot;...because...&quot; portion of the hypothesis, and supports the &quot;scientific reasoning&quot; portion of the Discussion/Conclusion.</td>
</tr>
<tr>
<td>2 Background Research is relevant to the topic and in found to support either the &quot;...because...&quot; portion of the hypothesis, or the &quot;scientific reasoning&quot; portion of the Discussion.</td>
</tr>
<tr>
<td>1 Background Research is present, but irrelevant to the topic.</td>
</tr>
<tr>
<td>0 Not attempted</td>
</tr>
<tr>
<td>Comments:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>E. Investigation Design (ID)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 All 5 components of the investigation’s design (or ID) are stated correctly and explicitly. AND only one independent variable (or IV) is allowed to change at a time, AND there are multiple trials</td>
</tr>
<tr>
<td>2 All 5 components of the ID are stated correctly, BUT more than one IV is changing at a time or there are not multiple trials</td>
</tr>
<tr>
<td>1 Some of the components of the ID are not reported, and/or two or more components have issues as described above.</td>
</tr>
<tr>
<td>0 Not attempted</td>
</tr>
<tr>
<td>Comments:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>F. Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 A step-by-step procedure including materials is described in enough detail to repeat the investigation, and details seem consistent with the project overall.</td>
</tr>
<tr>
<td>2 Materials are listed, and a step by step procedure is described, but some steps are missing or incomplete or not consistent with the ID.</td>
</tr>
<tr>
<td>1 Materials are listed, and a procedure is described, but many steps are missing, incomplete or not consistent with the ID.</td>
</tr>
<tr>
<td>0 Not attempted</td>
</tr>
<tr>
<td>Comments:</td>
</tr>
</tbody>
</table>
G. Data/Results (Tables and Graphs, and Data Analysis)  
1. Data table(s) and graph(s) are accurate, include correct labels (titles, correct units of measure), and are relevant to the original question. Trends or patterns in the data are identified and summarized. Data address the hypothesis and the correct tables and/or graphs have been chosen to clearly answer the original question.  
2. Data table(s) and graph(s) include most of the characteristics listed above. Some trends or patterns in data are identified and summarized. Some data may be shown that are not relevant to the original question, or incorrect tables or graphs are used such that the original question is not clearly answered, or there are problems such as frequent incorrect or missing labeling.  
3. Data table(s), graph(s) do not directly answer the original question.  
0. Not attempted  
Comments:  

H. Discussion / Conclusion  
1. Discussion/Conclusion makes a claim (i.e., the hypothesis is or is not supported...), supports the claim with evidence, and uses reasoning—in the form of connections to scientific concepts—to relate claim and evidence. It is important that the Discussion/Conclusion refer to relevant scientific concepts (content knowledge) to explain why the claim and evidence are related. Scientific sources supporting results should be referred to and cited in the discussion. Reflections and “Next Steps” are included in the Discussion/Conclusion.  
2. Most parts of Discussion/Conclusion are complete and accurate.  
3. Some parts of Discussion/Conclusion are complete and accurate.  
4. Not attempted  
Comments:  

I. Literature Cited (citations formatted with school’s expectations and ELA standards by grade level)  
1. A sufficient number of sources are cited. Sources specifically address the project topic. Level of sources is appropriate.  
2. An insufficient number of sources is cited that specifically address the project topic.  
3. Only one source is cited and/or relation of source to the topic is unclear.  
4. Not attempted  
Comments:  

Please adapt the scoring section to your needs and your students’ needs.  

<table>
<thead>
<tr>
<th>Project Section</th>
<th>Score (0-3)</th>
<th>Weight</th>
<th>Weighted Score</th>
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</thead>
<tbody>
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<tr>
<td>B. Question</td>
<td>x 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. Hypothesis</td>
<td>x 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. Background Research</td>
<td>x 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E. Investigation Design (ID)</td>
<td>x 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F. Procedure</td>
<td>x 2</td>
<td></td>
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</tr>
<tr>
<td>G. Data/Results</td>
<td>x 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H. Discussion/Conclusion</td>
<td>x 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I. Literature cited</td>
<td>x 1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total weighted score = (51 max)  

Final Score (%) = Total weighted score/51 x 100 = %
Appendix K

Sections of the Science Exit Project Poster and Rubric

Title
The title should state both the independent variable and the dependent variable.

Sample format: “The effect of (the independent variable) on (the dependent variable).”

Question
The question describes the focus of the investigation. The question should ask how the independent variable will affect the dependent variable. The question should be written so that someone else can easily understand it.

Sample format: “How will (the independent variable) affect (the dependent variable)?”

Hypothesis
A hypothesis predicts the effect that a change purposely made in the independent variable will have on the dependent variable. The hypothesis should make a statement about what the student thinks will happen. The hypothesis should state why the student thinks this will happen (“because…”).

Sample format: I think (independent variable) will affect (dependent variable) and I expect (predicted result) because (describe the scientific reasons of why you expect this relationship between the variables. Include scientific concepts that relate to this prediction).

Sample format: If (summarize investigation or action being planned, i.e., changing the independent variable) then (predict result, i.e., effect on dependent variable) because (describe the scientific reasons of why you expect this relationship between the variables. Include scientific concepts that relate to this prediction).

Background Information (Background information should be found within the hypothesis section as well as the discussion/conclusion section)
Students should be researching scientific concepts and knowledge related to their question both before and after they perform their investigation. Students should provide relevant, well-chosen facts and scientific concepts, definitions, concrete details, quotations or other information and examples related to the relationship between the IV and the DV.
This background information provides the basis of the prediction. Students should consider the question: "What did I read that makes me predict this outcome?"

Background information should also be used to support the scientific reasoning within the Discussion/Conclusion. See the Discussion/Conclusion description for more information.

Often students will provide basic facts about things related to their investigation. However, information that is not clearly related to the hypothesis or to scientific reasoning within the discussion / conclusion should not be included.

Investigation Design (the ID diagram used in UA PD may be included as a graphic organizer here)
Using the five components below, describe the design of the investigation:

1. Independent variable: the variable that the student changes on purpose. (In a field study we describe the independent variable as the category(ies) that the student chooses. In a secondary research project, we describe the independent variable as the variable that the student lets change and does not keep constant.)

2. Dependent variable: the variable the student measures that is affected (changes) as a result of changes purposely made in the independent variable.

3. Constants (also called constant variables): the variable(s) in an investigation that are kept the same and not allowed to change or vary.

4. Levels of the independent variable: the values of the independent variable at which data is gathered. For example, when studying effect of the time of day on sea lion behavior, the levels might be: 8:30am, 12:30pm, 4:30pm, etc. as this is when the student is observing the sea lion. When studying the effect of the mass of a ball on the distance it pushes something, the levels might be: 1g, 5g, 10g.

5. Number of repeated trials: the number of times that a level of the independent variable is tested in an investigation, or the number of objects or organisms tested at each level of the independent variable. Typically, at least three trials are conducted at each level in a middle school investigation.

Procedure
The procedure is a detailed, step-by-step description of the way in which the investigation was performed. The procedure should be written so that another student can replicate the investigation and should use precise language and scientific vocabulary. All materials and equipment used should be included in the appropriate portion of the procedure. In addition to being replicable, it is important that the procedure be appropriate for the investigation. The procedure should be one that will allow the student to answer the question posed and should be consistent with the investigation design.

Data/Results (Table and Graphs, and Data Analysis)
Students use the data reported in this section to determine whether or not their hypothesis was supported and to make a claim answering or addressing the original question. Data reported in this section must be directly related to the question and the hypothesis.

Students make their own observations for the following types of projects: controlled experiments, field studies and design projects. Students use observations or data reported by other investigators when they do secondary research.
Data should be shown in tables, charts, and/or graphs as appropriate. All data tables and graphs should be accurate and include titles, axis labels, units of measure, etc. Overall trends and patterns in the data should be discussed (with numeric or other data being provided to demonstrate any trend or pattern).

Discussion/Conclusion

This is one section that is scored based on two different items: “the scientific explanation” and “reflections.”

The overall Discussion/Conclusion portion should follow a format similar to the one below:

“In this investigation, the hypothesis (was/was not) supported.” Students should then make their claim and provide evidence and reasoning for that claim (the scientific explanation - see below). Students should then discuss sources of error and possible future investigations.

Discussion/Conclusion: Scientific Explanation

The scientific explanation begins with a claim that addresses or answers the original question asked. This claim should then be supported by relevant, accurate data from the students’ investigation. Relevant science concepts and knowledge should be used to explain this data and relate it to the claim. Students should use words, phrases and clauses that connect and clarify the relationships between the claim, evidence (data) and reasoning in a formal style.

Discussion/Conclusion: Reflections

Students should state whether or not the hypothesis was supported by the data. This statement usually comes at the beginning of the discussion section. At the end of the discussion section, students should explain any possible causes of error as well as how they might prevent these possible errors in the future. Students should also explain how they might use the data or ideas from this investigation in future investigations.

Literature Cited

The project should include a list of sources used. Sources should be varied (books, articles, websites...), clearly related to the topic, and at the appropriate level. Citations should include title, author, publisher, year, and URL (if website) in a format that aligns with school expectations and ELA standards by grade level. These sources should be cited in the text of the hypothesis, background research, conclusion and other sections as appropriate.
### Science Exit Project Evaluation Rubric:

Please adapt the rubric to your own needs and your students’ needs. The scoring table (below the rubric) should also be modified to match your needs.

#### A. Title

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>The title correctly states the independent variable and the dependent variable and is NOT worded as a QUESTION.</td>
</tr>
<tr>
<td>2</td>
<td>The title correctly states the independent variable and the dependent variable but is worded as a question.</td>
</tr>
<tr>
<td>1</td>
<td>The title is present but does NOT correctly state the independent variable or the dependent variable.</td>
</tr>
<tr>
<td>0</td>
<td>Not attempted.</td>
</tr>
</tbody>
</table>

Comments:

#### B. Question

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>The question states the independent variable and the dependent variable, and is testable.</td>
</tr>
<tr>
<td>2</td>
<td>The question does not make the independent variable and the dependent variable clear, but is testable.</td>
</tr>
<tr>
<td>1</td>
<td>The question is present but is NOT testable.</td>
</tr>
<tr>
<td>0</td>
<td>Not attempted.</td>
</tr>
</tbody>
</table>

Comments:

#### C. Hypothesis

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>The hypothesis predicts the effect that changing the independent variable will have on the dependent variable, AND explains the reason for the prediction using scientific concepts (&quot;because...&quot;).</td>
</tr>
<tr>
<td>2</td>
<td>The hypothesis predicts the effect that changing the independent variable will have on the dependent variable AND explains the reasoning for the prediction using scientific concepts (&quot;because...&quot;) but is incomplete or weak.</td>
</tr>
<tr>
<td>1</td>
<td>The hypothesis is a prediction that does not frame a relationship between the variables OR DOES NOT explain the reasoning for the prediction using scientific concepts (&quot;because...&quot;).</td>
</tr>
<tr>
<td>0</td>
<td>Not attempted</td>
</tr>
</tbody>
</table>

Comments:
D. Background Research (found throughout the project especially within the hypothesis and discussion/conclusion sections)

3 Background research contains MANY relevant, well-chosen facts, definitions, concrete details, quotations, scientific concepts, or other information and examples that
   • provide information on the IV & DV; defining them and explaining the relationship between them AND
   • support the "because" portion of the hypothesis AND
   • support the "scientific reasoning" of the discussion/conclusion.

2 Background research contains SOME relevant, well-chosen facts, definitions, concrete details, quotations, scientific concepts, or other information and examples that
   • provide information on the IV & DV AND
   • attempts to support the "because" portion of the hypothesis OR
   • attempts to support the "scientific reasoning" of the discussion/conclusion.

1 Background research contains FEW relevant, well-chosen facts, definitions, concrete details, quotations, scientific concepts, or other information and examples that
   • provide information on the IV & DV OR
   • attempts to support the "because" portion of the hypothesis OR
   • attempts to support the "scientific reasoning" of the discussion/conclusion.

0 Not attempted.

Comments:

E. Investigation Design (ID)

3 All 5 components of the investigation’s design (or ID) are stated correctly and explicitly, AND only one independent variable (or IV) is allowed to change at a time, AND there are multiple trials

2 All 5 components of the ID are stated correctly, BUT more than one IV is changing at a time or there are not multiple trials.

1 Some of the components of the ID are not reported, and/or two or more components have issues as described above.

0 Not attempted.

Comments:

F. Procedure

3 The procedure
   • is a step-by-step description of how the investigation was done AND
   • uses precise language and scientific vocabulary to describe both the sequence of actions taken and materials used AND
   • is sufficiently detailed to enable the reader to replicate the investigation AND
   • is consistent with the Investigation Design Diagram (IDD) and is an appropriate test of the hypothesis.

2 Most parts of the Procedure are complete and accurate.

1 Few parts of the Procedure are complete and accurate.

0 Not attempted.

Comments:

9/6/12
## G. Data/Results (Tables and Graphs, and Data Analysis)

3. Data table(s) and graph(s)
   - are accurate and include correct labels (titles, correct units of measure) AND
   - address the hypothesis AND
   - have been chosen to clearly address the original question AND

   Data analysis identifies and summarizes trends or patterns in the data.

2. Most parts of the Data/Results are complete and accurate.
1. Few parts of the Data/Results are complete and accurate.
0. Not attempted.

Comments:

## IIa. Discussion/Conclusion: Scientific Explanation

3. A scientific explanation consisting of a statement that
   - makes an overall claim addressing the original investigation question AND
   - supports the claim with evidence and relevant, accurate data from the investigation AND
   - contains relevant scientific concepts with reasoning AND
   - uses words, phrases and clauses that clarify and connect the relationships between claim, evidence and reasoning AND
   - demonstrates an understanding of the topic.

2. Three or four parts of the Scientific Explanation are complete and accurate.
1. One or two parts of the Scientific Explanation are complete and accurate.
0. Not attempted.

Comments:

## IIb. Discussion/Conclusion: Reflections

3. Conclusion contains thoughtful, relevant, and reasonable reflections including
   - states whether the hypothesis was or was not supported AND
   - a description of possible sources of error AND
   - suggested solutions to these sources of error AND
   - “Next Steps” determined as a result of this investigation.

2. Two or Three parts of the Reflections are complete and accurate.
1. One part of the Reflection is complete and accurate.
0. Not attempted.

Comments:
### Literature Cited (applies throughout the project)
(align citation format with school’s expectations and ELA standards by grade level)

<table>
<thead>
<tr>
<th>3 A sufficient number of credible sources</th>
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<tr>
<td>• are listed in the bibliography in an appropriate format that allows the reader to locate the resource AND</td>
</tr>
<tr>
<td>• are cited in the text of the hypothesis, background research, conclusion, and other sections as appropriate AND</td>
</tr>
<tr>
<td>• include books, articles, scholarly websites, or personal communication with knowledgeable experts/scientists.</td>
</tr>
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</table>

| 5 Most parts of the Literature Cited are complete and accurate. Bibliography is present but references are not cited in the text of the investigation |
| 3 Few parts of the Literature Cited are complete and accurate. |
| 1 Not attempted. |

Comments:

---

Please adapt the scoring section to your needs and your students’ needs.

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<tr>
<td>C. Hypothesis</td>
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<td>=</td>
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<tr>
<td>D. Background Research</td>
<td>x 2</td>
<td>=</td>
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</tr>
<tr>
<td>E. Investigation Design (ID)</td>
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<td>=</td>
<td></td>
</tr>
<tr>
<td>F. Procedure</td>
<td>x 2</td>
<td>=</td>
<td></td>
</tr>
<tr>
<td>G. Data/Results</td>
<td>x 3</td>
<td>=</td>
<td></td>
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<tr>
<td>H.a. Discussion/Conclusion: Scientific Explanation</td>
<td>x 2</td>
<td>=</td>
<td></td>
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<tr>
<td>H.b. Discussion/Conclusion: Reflections</td>
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<tr>
<td>I. Literature Cited</td>
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Total weighted score = (54 max)

Final Score (%) = \[
\frac{\text{Total weighted score}}{54} \times 100
\%
\]

9/6/12
Appendix L

Urban Advantage Sections of the Long-term Science Investigation Poster and Rubric

Sections of the Long-term Science Investigation Poster and Rubric

Title
The title should state both the independent variable and the dependent variable.

*Sample format:* “The effect of (the independent variable) on (the dependent variable).”

Question
The question describes the focus of the investigation. The question should ask how the independent variable will affect the dependent variable. The question should be written so that someone else can easily understand it.

*Sample format:* “How will (the independent variable) affect (the dependent variable)?”

Hypothesis
A hypothesis predicts the effect that a change purposely made in the independent variable will have on the dependent variable. The hypothesis should make a statement about what the student thinks will happen. The hypothesis should state why the student thinks this will happen (“because…”).

*Sample format:* I think (independent variable) will affect (dependent variable) and I expect (predicted result) because (describe the scientific reasons of why you expect this relationship between the variables. Include scientific concepts that relate to this prediction).

*Sample format:* If (summarize investigation or action being planned, i.e., changing the independent variable) then (predict result, i.e., effect on dependent variable) because (describe the scientific reasons of why you expect this relationship between the variables. Include scientific concepts that relate to this prediction).

Background information (Background information should be found within the hypothesis section as well as the discussion / conclusion section)
Students should be researching scientific concepts and knowledge related to their question both before and after they perform their investigation. Students should provide relevant, well-chosen
facts and scientific concepts, definitions, concrete details, quotations or other information and examples related to the relationship between the IV and the DV.

This background information provides the basis of the prediction. Students should consider the question: "What did I read that makes me predict this outcome?"

Background information should also be used to support the scientific reasoning within the Discussion/Conclusion. See the Discussion/Conclusion description for more information.

Often students will provide basic facts about things related to their investigation. However, information that is not clearly related to the hypothesis or to scientific reasoning within the discussion/ conclusion should not be included.

Investigation Design (the ID diagram used in UA PD may be included as a graphic organizer here)

Using the five components below, describe the design of the investigation:

1. **Independent variable**: the variable that the student changes on purpose. (IN a field study we describe the independent variable as the category(ies) that the student chooses. In a secondary research project, we describe the independent variable as the variable that the student lets change and does not keep constant.)

2. **Dependent variable**: the variable the student measures that is affected (changes) as a result of changes purposely made in the independent variable.

3. **Constants** (also called constant variables): the variable(s) in an investigation that are kept the same and not allowed to change or vary.

4. **Levels of the independent variable**: the values of the independent variable at which data is gathered. For example, when studying effect of the time of day on sea lion behavior, the levels might be: 8:30am, 12:30pm, 4:30pm, etc. as this is when the student is observing the sea lion. When studying the effect of the mass of a ball on the distance it pushes something, the levels might be: 1g, 5g, 10g.

5. **Number of repeated trials**: the number of times that a level of the independent variable is tested in an investigation, or the number of objects or organisms tested at each level of the independent variable. Typically, at least three trials are conducted at each level in a middle school investigation.

**Procedure**

The procedure is a detailed, step-by-step description of the way in which the investigation was performed. The procedure should be written so that another student can replicate the investigation and should use precise language and scientific vocabulary. All materials and equipment used should be included in the appropriate portion of the procedure. In addition to being replicable, it is important that the procedure be appropriate for the investigation. The procedure should be one that will allow the student to answer the question posed and should be consistent with the investigation design.

**Data/Results (Table and Graphs, and Data Analysis)**
Students use the data reported in this section to determine whether or not their hypothesis was supported and to make a claim answering or addressing the original question. Data reported in this section must be directly related to the question and the hypothesis.

Students make their own observations for the following types of projects: controlled experiments, field studies and design projects. Students use observations or data reported by other investigators when they do secondary research.

Data should be shown in tables, charts, and/or graphs as appropriate. All data tables and graphs should be accurate and include titles, axis labels, units of measure, etc. Overall trends and patterns in the data should be discussed (with numeric or other data being provided to demonstrate any trend or pattern).

**Discussion/Conclusion**

This is one section that is scored based on two different items: “the scientific explanation” and “reflections.”

The overall Discussion/Conclusion portion should follow a format similar to the one below:

“In this investigation, the hypothesis (was/was not) supported.” Students should then make their claim and provide evidence and reasoning for that claim (the scientific explanation - see below). Students should then discuss sources of error and possible future investigations.

**Discussion/Conclusion: Scientific Explanation**

The scientific explanation begins with a claim that addresses or answers the original question asked. This claim should then be supported by relevant, accurate data from the students’ investigation. Relevant science concepts and knowledge should be used to explain this data and relate it to the claim. Students should use words, phrases and clauses that connect and clarify the relationships between the claim, evidence (data) and reasoning in a formal style.

**Discussion/Conclusion: Reflections**

Students should state whether or not the hypothesis was supported by the data. This statement usually comes at the beginning of the discussion section. At the end of the discussion section, students should explain any possible causes of error as well as how they might prevent these possible errors in the future. Students should also explain how they might use the data or ideas from this investigation in future investigations.

**Literature Cited**

The project should include a list of sources used. Sources should be varied (books, articles, websites, ...), clearly related to the topic, and at the appropriate level. Citations should include title, author, publisher, year, and URL (if website) in a format that aligns with school expectations and ELA standards by grade level. These sources should be cited in the text of the hypothesis, background research, conclusion and other sections as appropriate.
**Long-term Science Investigation Project Evaluation Rubric:**

Please adapt the rubric to your own needs and your students’ needs. The scoring table (below the rubric) should also be modified to match your needs.

### A. Title

<table>
<thead>
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<th>Score</th>
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</tr>
<tr>
<td>2</td>
<td>The title correctly states the independent variable and the dependent variable but is worded as a question.</td>
</tr>
<tr>
<td>1</td>
<td>The title is present but does NOT correctly state the independent variable or the dependent variable.</td>
</tr>
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<td>Not attempted.</td>
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Comments:

### B. Question

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<th>Score</th>
<th>Description</th>
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<td>The question states the independent variable and the dependent variable, and is testable.</td>
</tr>
<tr>
<td>2</td>
<td>The question does not make the independent variable and the dependent variable clear, but is testable.</td>
</tr>
<tr>
<td>1</td>
<td>The question is present but is NOT testable.</td>
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Comments:

### C. Hypothesis

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</tr>
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<td>2</td>
<td>The hypothesis predicts the effect that changing the independent variable will have on the dependent variable AND explains the reasoning for the prediction using scientific concepts (“because...”) but is incomplete or weak.</td>
</tr>
<tr>
<td>1</td>
<td>The hypothesis is a prediction that does not frame a relationship between the variables OR DOES NOT explain the reasoning for the prediction using scientific concepts (“because...”).</td>
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<th>D. Background Research (found throughout the project especially within the hypothesis and discussion/conclusion sections)</th>
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<td>5. Background research is accurate and complete, containing MANY relevant, well-chosen facts, definitions, concrete details, quotations, scientific concepts, or other information and examples that:</td>
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<tr>
<td>1. Support the 'because' portion of the hypothesis AND</td>
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<tr>
<td>2. Support the 'scientific reasoning' of the discussion/conclusion.</td>
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<tr>
<td>2. Background research is accurate, containing SOME relevant, well-chosen facts, definitions, concrete details, quotations, scientific concepts, or other information and examples that:</td>
</tr>
<tr>
<td>1. Support the 'because' portion of the hypothesis OR</td>
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<tr>
<td>2. Support the 'scientific reasoning' of the discussion/conclusion.</td>
</tr>
<tr>
<td>1. Background research contains inaccurate or FEW relevant, well-chosen facts, definitions, concrete details, quotations, scientific concepts, or other information and examples that:</td>
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<td>1. Provide information on the IV &amp; DV OR</td>
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</tr>
<tr>
<td>3. Support the 'scientific reasoning' of the discussion/conclusion.</td>
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Comments:

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<tr>
<td>3. All 5 components of the investigation's design (ID) are stated correctly and explicitly, AND only one independent variable (IV) is allowed to change at a time, AND there are multiple trials.</td>
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<tr>
<td>2. Four of the 5 components of the ID are stated correctly, OR more than one IV is changing at a time or there are not multiple trials.</td>
</tr>
<tr>
<td>1. Two or more of the components of the ID are not reported, and/or two or more components have issues as described above.</td>
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<tr>
<td>0. Not attempted.</td>
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Comments:

<table>
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<th>F. Procedure</th>
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<td>3. The procedure:</td>
</tr>
<tr>
<td>1. Is a step-by-step description of how the investigation was done AND</td>
</tr>
<tr>
<td>2. Uses precise language and scientific vocabulary to describe both the sequence of actions taken and materials used AND</td>
</tr>
<tr>
<td>3. Is sufficiently detailed to enable the reader to replicate the investigation AND</td>
</tr>
<tr>
<td>4. Is consistent with the Investigation Design Diagram (IDD) and an appropriate test of the hypothesis.</td>
</tr>
<tr>
<td>2. The Procedure accurately and completely satisfies two or three of the above.</td>
</tr>
<tr>
<td>1. The Procedure accurately and completely satisfies one of the above.</td>
</tr>
<tr>
<td>0. Not attempted.</td>
</tr>
</tbody>
</table>

8/2/13
### G. Data/Results (Tables and Graphs, and Data Analysis)

3. Data table(s) and graph(s)
   - are accurate and include labels (titles, axes with units of measure) AND
   - address the hypothesis and have been chosen to clearly address the original question AND
   - data analysis identifies and accurately summarizes trends or patterns in the data.

2. Most parts of the data graphs and tables are present, complete and accurate. Data analysis is attempted but may not be accurate.

1. Few parts of the Data/Results section are complete and accurate or data analysis is not attempted.

0. Not attempted.

### H a. Discussion/Conclusion: Scientific Explanation

3. A scientific explanation consisting of a statement that
   - makes an overall claim addressing the original investigation question AND
   - supports the claim with evidence and relevant, accurate data from the investigation AND
   - contains relevant scientific concepts AND
   - uses words, phrases and clauses that clarify and connect the relationships between claim, evidence and science concepts AND
   - demonstrates an understanding of the topic.

2. Three or four parts of the Scientific Explanation are complete and accurate.

1. One or two parts of the Scientific Explanation are complete and accurate.

0. Not attempted.

### H b. Discussion/Conclusion: Reflections

3. Conclusion contains thoughtful, relevant, and reasonable reflections including
   - states whether the hypothesis was or was not supported AND
   - a description of possible sources of error AND
   - suggested solutions to these sources of error AND
   - "Next Steps" determined as a result of this investigation.

2. Two or Three parts of the Reflections are complete and accurate.

1. One part of the Reflection is complete and accurate.

0. Not attempted.

Comments:
1. Literature Cited (applies throughout the project)
(align citation format with school's expectations and ELA standards by grade level)

3 A sufficient number of credible sources
- are listed in the bibliography in an appropriate format that allows the reader to locate the resource AND
- are cited in the text of the hypothesis, background research, conclusion, and other sections as appropriate AND
- include books, articles, scholarly websites, or personal communication with knowledgeable experts/scientists.

5 Most parts of the Literature Cited are complete and accurate. Bibliography in present but references are not cited in the text of the investigation.
1 Few parts of the Literature Cited are complete and accurate.
0 Not attempted.

Comments:

Please adapt the scoring section to your needs and your students' needs.

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Total weighted score = (54 max)

| Final Score (%) = | Total weighted score (54) x 100 | %          |

8/2/13
Appendix M

NYDOE Grade 8 Literacy in Science

GRADE 8 LITERACY IN SCIENCE: STRAW ROCKETS

Unit Overview
Applying Newton’s three laws of motion, students design an investigation involving straw rockets. The five tasks have students develop their writing skills by having them practice formulating a question, paraphrasing text, developing a hypothesis, constructing a procedure, and analyzing data to draw a conclusion. The final performance task requires them to aggregate these portions of a lab report as well as make real-world connections from what they learned. [See below for the NY State Intermediate Science content standards addressed.]

TASK DETAILS
Task Name: Controlled Experiment: Straw Rockets
Grade: 8
Subject: Physical science, Newton’s laws of motion
Depth of Knowledge: 4
Task Description: The task requires students to write a lab report that demonstrates their knowledge of science content (laws of motion) as well as literacy skills, in which support their hypothesis, conclusion and application using evidence from informational texts. This content is usually taught towards the end of the year, so students should already have a basic understanding of the scientific method and lab procedures. This task can be used as a year-end exit project.

Standards Assessed:
WHST.6-8.2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.
a. Introduce a topic clearly, previewing what is to follow; organize ideas, concepts, and information into broader categories as appropriate to achieving purpose; include formatting (e.g., headings), graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension.
b. Develop the topic with relevant, well-chosen facts, definitions, concrete details, quotations, or other information and examples.
c. Use appropriate and varied transitions to create cohesion and clarify the relationships among ideas and concepts.
d. Use precise language and domain-specific vocabulary to inform about or explain the topic.
e. Establish and maintain a formal style and objective tone.
f. Provide a concluding statement or section that follows from and supports the information or explanation presented.

WHST.6-8.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

WHST.6-8.9. Draw evidence from informational texts to support analysis, reflection, and research.

RST.6-8.1. Cite specific textual evidence to support analysis of science and technical texts.

NYS Intermediate Science 5–8
Standard 1: Analysis, Inquiry, and Design: Scientific Inquiry
COMMON CORE-ALIGNED TASK WITH INSTRUCTIONAL SUPPORTS

Key Idea 2: Beyond the use of reasoning and consensus, scientific inquiry involves the testing of proposed explanations involving the use of conventional techniques and procedures and usually requiring considerable ingenuity.

Key Idea 3: The observations made while testing proposed explanations, when analyzed using conventional and invented methods, provide new insights into phenomena.

Standard 4: The Physical Setting

Key Idea 5: Energy and matter interact through forces that result in changes in motion.

5.1 Describe different patterns of motion of objects.

5.2 Observe, describe, and compare effects of forces (gravity, electric current, and magnetism) on the motion of objects.

Materials Needed:

While this performance task and unit uses instructional material from Pitsco Education, it can easily be applied to anything that students can make fly: paper planes, balloon rockets, etc.

Pitsco Straw Rockets
http://www.pitsco.com/store/default.aspx?CategoryId=85&searchtype=0&c=2-1117-2185-3&t=&l=&loc=mm1

Texts:

Article: “What is a Rocket?”
http://www.nasa.gov/audience/foreducators/rocketry/home/what-is-a-rocket-k4.html (Lexile 980)

Article: “Special Delivery”

Website: “How Rocket Engines Work”
http://www.howstuffworks.com/rocket.htm (Lexile 1090)

Article: “NASA Launches New ‘Black Hole Hunter’”

Article: “Water Rocket Stability”
http://www.specs2learn.com/rocketSoftware.html (Lexile 1600)

Article: “Mechanics and Motion”
http://www.physics4kids.com/files/motion_intro.html (Lexile 940)

Article: “What a Drag: The Effect of Friction/Drag on Rocket Performance”

Article: “What is Drag? Factors That Affect Aerodynamics”
http://www.grc.nasa.gov/WWW/K-12/airplane/crash1.html (Lexile 1140)

http://www.grc.nasa.gov/WWW/K-12/BSP/Askie/BalloonRocketCar_easy.html (Lexile 1260)

Article: “What is Aerodynamics?”
http://www.nasa.gov/audience/forstudents/5-8/features/what-is-aerodynamics-58.html (Lexile 690)

TABLE OF CONTENTS

The task and instructional supports in the following pages are designed to help educators understand and implement Common Core–aligned tasks that are embedded in a unit of instruction. We have learned through our pilot work that focusing instruction on units anchored in rigorous Common Core–aligned assessments drives significant shifts in curriculum and pedagogy. Callout boxes and Universal Design for Learning (UDL) support are included to provide ideas around how to include multiple entry points for diverse learners.

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<td>UNIT OUTLINE</td>
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<tr>
<td>ACTIVITIES AND GRAPHIC ORGANIZERS</td>
<td>28</td>
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Acknowledgments: This bundle was developed by a team of teachers from PS 207 The Fillmore Academy that was led by Common Core Fellow, Diane Kely.
### Longterm Science Investigation Project Evaluation Rubric:
Please adapt the rubric to your own needs and your students’ needs. The scoring table (below the rubric) should also be modified to match your needs.

#### A. Title

<table>
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<th>The title correctly states the independent variable and the dependent variable and is NOT worded as a QUESTION.</th>
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<td>The title correctly states the independent variable and the dependent variable but is worded as a question.</td>
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Comments:

#### B. Question

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<td>The question does not make the independent variable and the dependent variable clear, but is testable.</td>
</tr>
<tr>
<td>1</td>
<td>The question is present but is NOT testable.</td>
</tr>
<tr>
<td>0</td>
<td>Not attempted.</td>
</tr>
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</table>

Comments:

#### C. Hypothesis

| 3 | The hypothesis
- predicts the effect that changing the independent variable will have on the dependent variable, AND
- explains the reasoning for the prediction using scientific concepts (“because...”). |
|---|--------------------------------------------------------------------------------------------------|
| 2 | The hypothesis
- predicts the effect that changing the independent variable will have on the dependent variable AND
- explains the reasoning for the prediction using scientific concepts (“because...”) but is incomplete or weak. |
| 1 | The hypothesis
- is a prediction that does not frame a relationship between the variables OR
- DOES NOT explain the reasoning for the prediction using scientific concepts (“because...”). |
| 0 | Not attempted |

Comments:
Controlled Experiment: Building a Straw Rocket

Content: Newton's three laws of motion

Performance Task Description:

Develop your own controlled experiment to see how a variable (e.g., fin size, shape, cone size, etc.) affects the way a rocket flies (e.g., distance, speed, vertical height, etc.). Using Microsoft Word or PowerPoint to create a report or presentation, you will communicate your full investigation, maintaining a formal and appropriate style and tone for peers, teachers, and parents.

Your report or presentation should include an organized development of all the steps of the scientific method:

- Question to investigate
- Hypothesis
- All variables and constants
- Procedure
- Data tables and graphs
- Discussion and conclusion

To demonstrate your understanding of Newton's laws and other physical science principles you have learned, it is vital that you incorporate appropriate content-specific vocabulary in your report. Your hypothesis must be an educated guess that answers your specific experiment question and must cite reliable resources to support relevant scientific reasoning for your prediction. Your conclusion must include evidence (data) you gathered during your investigation to support your claim as well as any possible sources of error that may have influenced your results. Your discussion should include an application of your findings to the real world, which must also cite reliable relevant resources. Use MLA formatting for all citations. When appropriate, use transitional words or phrases (e.g., furthermore, at first, as a result) to help create clarity and relationship among ideas presented in the report.
URBAN ADVANTAGE TO SUPPORT A CULTURE OF INQUIRY

Additional Support Strategy:
While most students should be familiar with the scientific method at this point in the school year, some students who struggle with organization may benefit from the following handout. While this sheet gives descriptions of the different sections required in the report and can be used as a checklist, it does not significantly diminish the rigor of the assignment, as it does not tell students how to complete each section of the report.

Helpful Information for Completing Your Report

Question
The question describes the focus of the investigation. The question should ask how the independent variable will affect the dependent variable. The question should be written so that someone unfamiliar with your experiment can easily understand it.

Sample format: "How will (the independent variable) affect (the dependent variable)?"

Hypothesis
A hypothesis is an educated prediction. It should explain the effect that changing the independent variable will have on the dependent variable in the investigation. The hypothesis should state why you think this will happen ("because . . ."). You must have a reference (evidence from an outside source) to support why you think something is going to happen.

Sample format: "I think (independent variable) will cause (dependent variable to . . .), and I expect this to happen because (describe the scientific reasons of why you expect this relationship between the variables)."

Include cited scientific concepts that relate to this prediction.

Investigation Design
Using the five components below, describe the design of the investigation:

1. Independent variable: the variable that is changed on purpose
2. Dependent variable: the variable that is measured as a result of changes purposely made in the independent variable
3. Constant variables (also called "constants"): the variable(s) in an investigation that are kept the same and not allowed to change or vary
4. Number of repeated trials: the number of times that a level of the independent variable is tested in an investigation, or the number of objects or organisms tested at each level of the independent variable

Procedure
List materials and provide a detailed and logical step-by-step description of procedures.

Data Results (Table and Graphs) and Data Analysis
The data reported in this section are the basis on which the student will claim that their hypothesis is or is not supported. The data should be shown in appropriate table and graph formats to be sure trends or patterns in the data are summarized.

Discussion/Conclusion
Conclusion: State whether the hypothesis was—or was not—supported by the data, and be sure to refer to and explain the data you collected. Also, you must use the scientific knowledge you learned in class to explain your interpretation of your results.

Discussion: Also important are reflections on possible sources of experimental error and suggestions for further investigations, as well as how your experiment and results relate to real-world applications. Here again you should be citing information to help explain results and real-world applications.

Works Cited
List the sources you used in your project. Sources should be varied (books, articles, websites, and so on), clearly related to the topic, reliable, and at the appropriate grade level. Citations should be written in MLA style.
GRADE 8 LITERACY IN SCIENCE: STRAW ROCKETS

RUBRIC

This task was scored using a task-specific rubric that assesses the target Common Core standards.
URBAN ADVANTAGE TO SUPPORT A CULTURE OF INQUIRY

RUBRIC

<table>
<thead>
<tr>
<th>Question (WHST.6-8.2.a)</th>
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<tbody>
<tr>
<td>4</td>
</tr>
<tr>
<td>3</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Hypothesis (WHST.6-8.2.b.d, WHST.6-8.9, RST.6-8.1)</th>
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<tbody>
<tr>
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<table>
<thead>
<tr>
<th>Experimental Design/Procedure (Counted Double) (WHST.6-8.2.a,b,c,d)</th>
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<tr>
<td>4</td>
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<table>
<thead>
<tr>
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</tr>
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<tbody>
<tr>
<td>4</td>
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<tr>
<td>3</td>
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<tr>
<td>2</td>
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<table>
<thead>
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<th>Conclusion (Counted Double) (WHST.6-8.2.d.f)</th>
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</thead>
<tbody>
<tr>
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<tr>
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<td>2</td>
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<tr>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Discussion (Counted Double) (WHST.6-8.2.b,f, WHST.6-8.9, RST.6-8.1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
</tr>
<tr>
<td>3</td>
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<tr>
<td>2</td>
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<tr>
<td>1</td>
</tr>
</tbody>
</table>

Adapted from:
http://www.urbanadvantagenyc.org/www/urbanadvantage/site/hosting/UA_exit_project_rubric.pdf
## RUBRIC

<table>
<thead>
<tr>
<th>Literature Cited (WIST.6-8.9, RST.6-8.1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>2</td>
</tr>
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<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Quality of Writing (WIST.6-8.2.c.d.e, WIST.6-8.4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>1</td>
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</tbody>
</table>

Adapted from: http://www.urbanadvantagenyc.org/www/urbanadvantage/site/hosting/UA_exit_project_rubric.pdf
GRADE **8** LITERACY IN SCIENCE:

STRAW ROCKETS

ANNOTATED STUDENT WORK

This section contains annotated student work at a range of score points and suggested next steps for students. The student work shows examples of student understandings and misunderstandings of the task.
Grade 8 Literacy in Science: Straw Rockets
Annotated Student Work

Student Work Level 3

Question: How does the shape of the fins affect the speed of the rocket?

Hypothesis: I think that the shape of the fin will affect the speed of the rockets. I have three different types of fins, I have curved, triangle, rectangle. I think that the fin that will fly the fastest is the triangle shaped fin. The reason I think this is because the more air hits the surface, the more drag the air will give you. Drag is a force that opposes motion, like friction. So the triangle shaped fin will have less surface area hitting the air, less drag and fly at the fastest speed. My hypothesis is based off of Aerodynamics. “What is drag?”

Variables

Independent Variable: shape of the fins
Dependent Variable: speed of the rocket

Constants:

length of the rocket, mass of the rocket, mass of the cone, size of the cone, degree of the launch angle, air pressure (force put on rocket), length of the straw, shape of the cone, and the amount of tape, size, fin material

Materials

5 straws, tape, triple beam balance scale, ruler, clay, index cards, rocket launcher, meter sticks, stopwatch

Procedure

1. Tape the openings of the straw shut (both sides of each straw)
2. Measured out a piece of clay 45 grams
3. Form a triangular shaped cone out of clay (height 1.5cm)
4. Cut different shaped fins out of index cards. Three fins each; triangle, curved, rectangle. All with a height of 3cm and width 1.5cm
5. Tape 3 fins of same shape on the bottom of each straw
6. Measure the mass of the rocket after everything was put together, make sure they are all equal
7. Launch rocket at a 45 degree angle and 2 meters of pressure
8. Record time and distance the rocket travels
9. Repeat launch at same angle and pressure three times each for the three different fin types.
Grade 8 Literacy in Science: Straw Rockets
Annotated Student Work

Data Table: Speed of Different Shaped Fins on a Rocket

<table>
<thead>
<tr>
<th>FIN (ID)</th>
<th>TRIAL 1</th>
<th>TRIAL 2</th>
<th>TRIAL 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curved</td>
<td>648 cm</td>
<td>625 cm</td>
<td>618 cm</td>
</tr>
<tr>
<td></td>
<td>1.28 sec</td>
<td>1.26 sec</td>
<td>1.79 sec</td>
</tr>
<tr>
<td>Rectangle</td>
<td>480 cm</td>
<td>326 cm</td>
<td>502 cm</td>
</tr>
<tr>
<td></td>
<td>1.81 sec</td>
<td>1.81 sec</td>
<td>1.26 sec</td>
</tr>
<tr>
<td>Triangle</td>
<td>386 cm</td>
<td>506 cm</td>
<td>207 cm</td>
</tr>
<tr>
<td></td>
<td>1.13 sec</td>
<td>1.26 sec</td>
<td>1.18 cm</td>
</tr>
</tbody>
</table>

Average Speed

Comment [Text]: Unit conversion data table, rectangle and triangle results removed to show comparisons and averages. (WDO 6/8/24)
Grade 8 Literacy in Science: Straw Rockets
Annotated Student Work

Conclusion and Application

I can conclude that the shape of the rocket’s fin does affect the speed the rocket travels. My hypothesis that the rocket with the triangle fin will fly the fastest is supported by the data. It flew an average of 45 cm per second, the rectangle flew on an average of 30 cm per second, and curved flew on an average of 20 cm per second. This is because the triangular shaped fin has less surface area creating less drag on the rocket so it will fly the fastest. (NASA “What is drag?”)

Some rockets that NASA uses today do have very small and triangular shaped fins that are active! This means they move. According to Newton’s 3rd Law every action has an equal and opposite reaction. Having fins can both help a rocket, when it is flying straight it stays straight, but when it “fishtails” or wobbles then the fins can make it worse. Rockets that have fins that can move can help the rockets straighten out. (NASA: Rockets Applying Newton’s Laws)

Today rockets are used for many purposes. They are used to carry payloads for commercials or scientific purposes into space. One of the most important commercial payloads are satellites, which we use in our daily communication. (Rockets.com)

Bibliography


4. Rockets.com
# Grade 8 Literacy in Science: Straw Rockets

**Annotated Student Work**

**Level 3**

<table>
<thead>
<tr>
<th>Evidence for Meeting the Standard</th>
<th>Evidence for Not Meeting the Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question (WHST 6-8.2.a)</td>
<td>Score: 4</td>
</tr>
<tr>
<td>Question is testable and asks how the independent variable would affect the dependent variable.</td>
<td>None</td>
</tr>
<tr>
<td>Hypothesis (WHST 6-8.2.b,d, 6-8.9 RST 6-8.1)</td>
<td>Score: 3</td>
</tr>
<tr>
<td>Hypothesis is stated and is supported by some details given in the text.</td>
<td>The concept of drag is defined but more details are needed to clearly support the prediction.</td>
</tr>
<tr>
<td>Experimental Design/Procedure (Counted Double) (WHST 6-8.2.a,c)</td>
<td>Score: 3</td>
</tr>
<tr>
<td>The concept of drag is defined but more details are needed to clearly support the prediction.</td>
<td>Construction of the rockets is missing</td>
</tr>
<tr>
<td>Data Results (Tables and Graphs) and Data Analysis (WHST 6-8.2.a)</td>
<td>Score: 3</td>
</tr>
<tr>
<td>Data table and graph are accurate and appropriate, easily understood and complete; includes title, labels, appropriate placement of variables, and correct units of measure.</td>
<td>Although data is discussed in the conclusion, trends are not identified and summarized directly below the graph. Also data table should have average of the three trials for each fin type.</td>
</tr>
<tr>
<td>Conclusion (Counted Double) (WHST 6-8.2.d,f)</td>
<td>Score: 3</td>
</tr>
<tr>
<td>The conclusion makes a claim (shape of the rocket affects the speed), supports the claim with data gathered from the experiment as well as uses principle from Newton’s 3rd law to explain results.</td>
<td>Sources of error that may have influenced the results is missing.</td>
</tr>
<tr>
<td>Discussion (Counted Double) (WHST 6-8.2.b,f, 6-8.9 RST 6-8.8)</td>
<td>Score: 2</td>
</tr>
<tr>
<td>A real world situation is explained and supported with relevant details and inferences drawn about the importance of fins on a rocket flight path. The importance and use of rocket are also given and supported by research.</td>
<td>The relationship of the real world application and this experiment is unclear. The experiment is regarding fin shape, but the real-world application is regarding weather fins move or not.</td>
</tr>
<tr>
<td>Literature Cited (WHST 6-8.9 RST 6-8.8)</td>
<td>Score: 3</td>
</tr>
<tr>
<td>A variety of sources are cited, they are clearly related to the topic, analysis of text helps support hypothesis, conclusion and real-world application. Most sources are reliable and at the appropriate grade level.</td>
<td>“Rockets.com” needs more information to access for grade level and relevancy.</td>
</tr>
<tr>
<td>Quality of Writing (WHST 6-8.2.c,d,e 6-8.8)</td>
<td>Score: 3</td>
</tr>
<tr>
<td>Writing is well organized and style is appropriate to task, purpose. Uses domain-specific vocabulary (drag, friction surface area, motion, speed, Newton’s 3rd Law) to develop the topic.</td>
<td>Sentence structure is simple, one thought sentences. Details and examples can be given for deeper understanding.</td>
</tr>
</tbody>
</table>

**Next Steps:** Student’s sentence structure is simple. Each sentence contains one idea with no connecting clause. This makes the text appear “choppy” and unsophisticated. One next step could to underline each claim in the student paper and have the student add at least one more detail and example for each claim. Then have the student build on sentence complexity by stringing sentences that support/connect with each other together. See [http://mrscull.org/combiningsentences/](http://mrscull.org/combiningsentences/) for further instruction.
Grade 8 Literacy in Science: Straw Rockets
Annotated Student Work

Student Work Level 2
How will the placement of the rocket affect where the rocket lands?

Hypothesis: I think the placement of the fin will not affect the distance. I think it will not affect the distance due to Newton's second law of motion which states F=MA. This means force is equal to the mass of the object and its acceleration. In other words if you move the same object with the same force the acceleration will stay the same. In the experiment we will not change the net force so the rocket should remain at a constant speed.

Resource Glencoe 8th grade science text book pg 470

Independent Variable: Placement of the fin
Dependent: Distance rocket flies

Materials: Fins made out of index cards. Straw also known as rocket. Clay also known as cone. Launcher

Procedure
1. Gather materials
2. Record what angle you launch at
3. Place rocket on its launch pad
4. Launch rocket
5. Record where your rocket lands
6. Repeat these steps 3 different times for each rocket in total you should have 9 measurement
7. Conclude your data
<table>
<thead>
<tr>
<th>Placement of the fin</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
<th>Avg.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 bottom: weight 5.8 grams distance from cone 14 cm</td>
<td>1,020 cm</td>
<td>1,002 cm</td>
<td>645 cm</td>
<td>919 cm</td>
</tr>
<tr>
<td>2 middle distance from cone 8.5 cm</td>
<td>928 cm</td>
<td>1,007 cm</td>
<td>846 cm</td>
<td>957 cm</td>
</tr>
<tr>
<td>3 top: weight 5.8 grams distance from cone 0 cm</td>
<td>864 cm</td>
<td>587 cm</td>
<td>640 cm</td>
<td>634 cm</td>
</tr>
</tbody>
</table>

**Conclusion**

My hypothesis was incorrect because looking back at the data we found out the placing the fin in different positions does change the distance. The average distance rocket placement 1 was 819 cm. rocket placement 2 average distance was 957 cm and rocket placement 3 average distance was 634 cm. So the rocket placement 2 which had the fins in the middle went the longest average distance and the rocket placement 3 which had the fins at the top of the rocket went the shortest average distance. The rocket with the fins at the bottom went the 2nd longest distance. The difference average distance between the rocket with the fins in the middle and at the bottom is not a big amount (36 cm). In conclusion I can say there was an effect of distance due to the placements of fin. This is why most rockets you see have the fins at the bottom of the rocket. (Glencoe 8th grade science text book pg 468)
Grade 8 Literacy in Science: Straw Rockets
Annotated Student Work

Sources of Error:
The cones may have been damaged during the trials of the rocket launches. For instance, after the first launch when it hit the ground it got smashed. The fins were not stable in one of our rockets. The fin may have been damaged after each trial, like the cone. The rocket may not have been at the same launching angle each trial. The amount of force applied may have not been same.
Grade 8 Literacy in Science: Straw Rockets
Annotated Student Work

Level 2

<table>
<thead>
<tr>
<th>Evidence for Meeting Standard</th>
<th>Evidence for Standard Not Met</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question (WHIST 6-8.2.a)</td>
<td></td>
</tr>
<tr>
<td>The question asks how the independent variable (placement of fin) affects the “where the rocket lands”</td>
<td>“Where the rocket lands” is vague, should use specific quantity being measured, distance.</td>
</tr>
<tr>
<td>Hypothesis (WHIST 6-8.2.b, 6-8.9 RST 6-8.1)</td>
<td></td>
</tr>
<tr>
<td>The hypothesis predicts that “the placement of the fin will not affect the distance.” Explanation of Newton’s 2nd law is paraphrased (developing level) from cited text.</td>
<td>The explanation given does not directly relate to prediction, rather it refers to force of rocket and does not address the placement of the fin.</td>
</tr>
<tr>
<td>Experimental Design/Procedure (Counted Double) (WHIST 6-8.2.a,c)</td>
<td></td>
</tr>
<tr>
<td>Independent and dependent variables are identified. Most materials are listed and procedure is vaguely described.</td>
<td>Constants not identified (i.e., force, mass of rocket, fin size...) Construction of rocket not stated.</td>
</tr>
<tr>
<td>Data Results (Tables and Graphs) and Data Analysis (WHIST 6-8.2.a)</td>
<td></td>
</tr>
<tr>
<td>Data table neat organized and properly labeled.</td>
<td>Graph is not included.</td>
</tr>
<tr>
<td>Conclusion (Counted Double) (WHIST 6-8.2.d,f)</td>
<td></td>
</tr>
<tr>
<td>Hypothesis is evaluated and is supported by data, from the experiment.</td>
<td>Scientific reasoning is not used to support findings.</td>
</tr>
<tr>
<td>Discussion (Counted Double) (WHIST 6-8.2.b, 6-8.9 RST 6-8.8)</td>
<td></td>
</tr>
<tr>
<td>Includes reflection of experiment by including sources of error.</td>
<td>Relationship of this particular experiment (placement of fin) is not directly made to real-world rockets or missiles.</td>
</tr>
<tr>
<td>Literature Cited (WHIST 6-8.9 RST 6-8.8)</td>
<td></td>
</tr>
<tr>
<td>Glencoe Text is cited.</td>
<td>Only one resource is cited.</td>
</tr>
<tr>
<td>Literature Cited (WHIST 6-8.9 RST 6-8.8)</td>
<td></td>
</tr>
<tr>
<td>Writing is clear and logical.</td>
<td>Lacks details, examples and direct relationships to scientific reasoning and real world applications.</td>
</tr>
</tbody>
</table>

Score: 3

Next Steps: This student is struggling to make clear direct relationships between their experiment and scientific concepts as well as between their results and real-world applications. It might be helpful for student to perform simple activities that apply Newton’s laws and have student practice writing what happened and how these laws of motion explain the outcomes. Once they have mastered using scientific concepts to explain the outcomes in the activity, have them write a scenario for how they can be applied to real life situations. For example: Have student put a coin on a toy car and push the car towards a wood block. Have them repeat this but now tape the coin to the car. Student should write explaining how Newton’s 1st law explains the motion of the coin in both scenarios and then the teacher could prompt them to make the real life application to using a seat belt in a car.
Grade 8 Literacy in Science: Straw Rockets
Annotated Student Work
Student Work Level 1

How will the density of the cone affect the distance the rocket travels?

If the density decreases the rocket will travel at a longer distance because the weight on the rocket is less.

Independent Variable: The density of the cone

Dependent Variable: The distance the rocket travels.

Constants: The length of the rocket, the size of the fins, the mass of the fins, the placement of the fins, the volume of the cone, the shape of the cone, the position of the cone, the position of the rocket launcher, the angle of the rocket launcher, location, force used to launch the rocket, meter stick used to measure distance

Materials
Straw
Tape
2 index cards
Ruler
Rocket launcher
Clay
Tin foil
Scissors
Triple beam balance

Procedure
1. Measure the straw and record length.
2. Make fins out of index cards, by measuring the size to keep them constant.
3. Attach the fins to both straws (rods) in the same spot with tape.
4. Form cones out of both tin foil and clay.
5. Measure the volume and mass of each cone.
6. Attach the cones to each rocket.
7. Measure the mass of each rocket.
8. We did a practice run to see if the rockets would launch.
9. Create data table
10. Place rocket on rocket launcher at a 45 degree angle.
11. Launch rocket with clay cone with a force of 30m, repeat for three trials, measure and record data.
12. Repeat steps 10 and 11 with rocket with foil cone.
Conclusion
The foil has less density than the clay so the clay didn’t go that far. If the rocket average of the tin foil had a better average distance because it was lighter than the clay. The rocket with the clay went 200.7 and the tin foil went 255 so it went further.

Application
Our experiment can be applied to a real rocket or airplane. A rocket or plane built out of less dense material will travel further with the same amount of force than the rocket made from a more dense material.

Citation: Chapter 16 New York, NY: Glencoe/ McGraw Hill 2008
# Grade 8 Literacy in Science: Straw Rockets

## Annotated Student Work

### Level 1

<table>
<thead>
<tr>
<th>Evidence for Meeting the Standard</th>
<th>Evidence for Not Meeting the Standard</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question (WHST 6-8.2.a)</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>The question asks how the independent variable affects the dependent variable and is testable.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypothesis (WHST 6-8.2.b,d, 6-8.9 RST 6-8.1)</td>
<td>Score: 1</td>
<td></td>
</tr>
<tr>
<td>The hypothesis predicts the effect of changing the independent variable (density) on the dependent variable (distance).</td>
<td>A hypothesis does not explain the reason for the prediction using scientific reasoning (“because…”) that is supported by relevant research</td>
<td></td>
</tr>
<tr>
<td>Experimental Design/Procedure (Counted Double) (WHST 6-8.2.a,c)</td>
<td>Score: 2</td>
<td></td>
</tr>
<tr>
<td>Variable and constants are identified. Materials are listed and procedure is listed in numbered order.</td>
<td>While the procedure attempts to include details, it lacks pertinent information such as how density was determined, specific rocket part measurements and how distance was measured.</td>
<td></td>
</tr>
<tr>
<td>Data Results (Tables and Graphs) and Data Analysis (WHST 6-8.2.a)</td>
<td>Score: 1</td>
<td></td>
</tr>
<tr>
<td>Graph is included with legend,</td>
<td>Graph needs to have a title, X and Y axis needs to be labeled as well as summary of trends the graph shows needs to be included. Need to include data table so graph can be accurately assessed.</td>
<td></td>
</tr>
<tr>
<td>Conclusion (Counted Double) (WHST 6-8.2.d,f)</td>
<td>Score: 1</td>
<td></td>
</tr>
<tr>
<td>Conclusion answers the experimental question with limited data to support it.</td>
<td>The conclusion needs to reflect as to whether the hypothesis is supported or not and needs to include data with measured units to support it. Also, there is scientific reasoning to explain results.</td>
<td></td>
</tr>
<tr>
<td>Discussion (Counted Double) (WHST 6-8.2.b,f, 6-8.9 RST 6-8.8)</td>
<td>Score: 1</td>
<td></td>
</tr>
<tr>
<td>Limited real-world application is given with a reliable .</td>
<td>Discussion is not directly relevant to the experiment.</td>
<td></td>
</tr>
<tr>
<td>Literature Cited (WHST 6-8.9 RST 6-8.8)</td>
<td>Score: 1</td>
<td></td>
</tr>
<tr>
<td>Only one source is cited.</td>
<td>More research and scientific reasoning is needed to be cited to support you hypothesis, conclusion and real-world applications.</td>
<td></td>
</tr>
<tr>
<td>Quality of Writing (WHST 6-8.2.c,d,e 6-8.4)</td>
<td>Score 2</td>
<td></td>
</tr>
<tr>
<td>A formal lab report format is used and is presented in a logical order.</td>
<td>Domain specific vocabulary, like Newton’s Laws, gravity, aerodynamics etc. should be used to explain hypothesis, conclusion and real world application</td>
<td></td>
</tr>
</tbody>
</table>

**Next Steps:** While the student seems to understand most of the steps to scientific method, it is unclear they grasp the physical science content of the unit, or whether they are struggling with the writing process. Consider conferencing with the student verbally and discuss each section separately. Have student take notes on “post-its” to add content they are able to express verbally or questions that need to be clarified with more research.
GRADE 8 LITERACY IN SCIENCE:
STRAW ROCKETS

INSTRUCTIONAL SUPPORTS

The instructional supports on the following pages include a unit outline with formative assessments and suggested learning activities. Teachers may use this unit outline as it is described, integrate parts of it into a currently existing curriculum unit, or use it as a model or checklist for a currently existing unit on a different topic.
### Unit Outline

**INTRODUCTION:** This unit outline provides an example of how to integrate performance tasks into a unit. Teachers may (a) use this unit outline as it is described below; (b) integrate parts of it into a currently existing curriculum unit; or (c) use it as a model or checklist for a currently existing unit on a different topic. The length of the unit includes suggested time spent on the classroom instruction of lessons and administration of assessments. Please note that this framework does not include individual lessons.

#### Grade 8 Literacy in Science: Straw Rockets

<table>
<thead>
<tr>
<th><strong>UNIT TOPIC AND LENGTH</strong></th>
<th><strong>CONTROLLED EXPERIMENT 5–6 WEEKS</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>➢ About 1–2 weeks should be spent covering Newton’s three laws of motion. Students then spend approximately 3–4 weeks designing and implementing a controlled experiment testing a variable on a straw rocket. The final assessment requires students to write a lab report describing their experiment, draw a conclusion based on the data and relate their findings to real world applications. Please note that this framework does not include individual lessons.</td>
</tr>
</tbody>
</table>

#### COMMON CORE LEARNING STANDARDS:

**WHST.6-8**

- ➢ 2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
- ➢ 4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
- ➢ 9. Draw evidence from informational texts to support analysis, reflection, and research.

**RST.6-8**

- ➢ 1. Cite specific textual evidence to support analysis of science and technical texts.

#### BIG IDEAS/ENDURING UNDERSTANDINGS:

- ➢ To develop a scientific hypothesis one must use prior knowledge and background research.
- ➢ A series of calculated steps, the scientific method, must be used to test a specific variable’s effect on the motion of a rocket.
- ➢ A scientific conclusion must be supported by evidence (data) and explained using established scientific reasoning.
- ➢ Valid controlled experiments can be applied to different scaled real-world applications.

#### ESSENTIAL QUESTIONS:

- ➢ How can one predict, test, and explain the interactions between a rocket’s motion and the forces acted upon it?
- ➢ How do scientists develop experiments that produce reliable results that can be applied to the real world?
Newton's laws of motion can be used to explain the motion or stability of an object.

<table>
<thead>
<tr>
<th>CONTENT:</th>
<th>SKILLS:</th>
</tr>
</thead>
<tbody>
<tr>
<td>➢ Newton's three laws of motion</td>
<td>➢ Develop a scientific hypothesis</td>
</tr>
<tr>
<td>➢ Forces: unbalanced, gravity, friction</td>
<td>➢ Design a controlled experiment</td>
</tr>
<tr>
<td>➢ All steps to a valid controlled experiment</td>
<td>➢ Identify cause-and-effect relationships</td>
</tr>
<tr>
<td></td>
<td>➢ Analyze data</td>
</tr>
<tr>
<td></td>
<td>➢ Reason to support a conclusion</td>
</tr>
</tbody>
</table>

**VOCABULARY/KEY TERMS:**
Newton's three laws of motion
Drag
Aerodynamics
Friction
Force
Gravity
Inertia
Speed
Independent and dependent variables
Constants
Hypothesis
Conclusion

**ASSESSMENT EVIDENCE AND ACTIVITIES:**

**INITIAL ASSESSMENT:**
Using the four-question strategy, elicit student's prior knowledge about rockets and their design. This will also help students identify independent and dependent variables as well as constants, which will enable them to formulate an investigable question.

**FORMATIVE ASSESSMENT:**
➢ Investigative Design Diagram (IDD): Use this graphic organizer to assess students' ability to formulate their question, develop their hypothesis, and identify their variables and constants.
➢ Procedural Outline: Students should write an initial procedure, be given an opportunity to do a "trial run," and then revise their procedure.
➢ Developing Scientific Explanation Tool (DSET): Use this organizer to assess students' ability to develop a scientific conclusion.

**FINAL PERFORMANCE TASK:**
➢ Lab Report: Students write a clear coherent report that includes all steps of the scientific method and includes works cited in their hypothesis, conclusion, and discussion.
**Learning Plan & Activities:**

- The focus of this task is for students to design an investigation that demonstrates Newton’s laws of motion. Pitsco straw rocket are used as an example, but can be substituted by balloon/straw rockets, models cars, etc.

- Prior to starting this task, be sure students have a good understanding of Newton’s laws through reading and activities. (Glencoe Grade 8 Science Chapter 16)

- Formative assessments: Students should be given feedback once each task is completed so they can make revisions. Posting their work, revisions, and progress on classroom bulletin boards with constructive comments is one way you might consider guiding students.

- Focus on writing strong scientific hypotheses; conclusions and discussions should be stressed. These portions of the report are where students should cite research about scientific principles that help explain their hypothesis and results as well real-world applications.

- The five tasks that are outlined give specific lesson plans to accomplish each formative assessment.

**Additional Support Strategies:** Since this topic is content-heavy with lots of new vocabulary, additional support and assistance should be provided for English Language Learners and students with disabilities through the use of ESL and Special Education methodologies, such as explicit vocabulary instruction and reinforcement of high-frequency academic words and content-specific terminology. Students should be provided with examples of the target words within the context of the lesson; they should review the connection with cognates; and also have access to bilingual glossaries for native-language support. Teachers should model the correct use of words and provide lists with sentence starters to use during discussion of the unit material. The use of visuals (video, photos, and diagrams) can also help students to understand the content.

In this bundle the following are addressed:

- Students are encouraged to actively engage in hands-on activities to promote scientific thinking and writing.

- Students create their own investigation based on ability and interest.

- Technology is infused throughout, with the use of videos, internet, and publishing programs to engage all learning styles.

- Graphic organizers, checklists, and other techniques are used to help students keep clear records and stay on task.

- Students are encouraged to verbalize their thinking with multiple opportunities for shared discussion.

- Students are given ample opportunities to practice new skills.
URBAN ADVANTAGE TO SUPPORT A CULTURE OF INQUIRY

RESOURCES:
- Various video clips regarding Newton's laws can be found at [http://vitalthirteen.org](http://vitalthirteen.org)
- This task suggests using Pitsco straw rockets, but could be adapted for most objects that can move, for example, toy cars, balloon rockets, or paper planes. [http://www.pitsco.com/store/default.aspx?CategoryID=85&searchtype=0&c=2-117-2|85-3&t=16&loc=mm1](http://www.pitsco.com/store/default.aspx?CategoryID=85&searchtype=0&c=2-117-2|85-3&t=16&loc=mm1)

For tools and strategies that help guide the investigation process (for example, the four-question strategy):
- Graphic organizers such as the IDD and DSET as well as many other resources can be found at [http://www.urbanadvantagenyc.org/](http://www.urbanadvantagenyc.org/) under Teachers/Investigation Design and Developing a Scientific Explanation.

Texts:
- Article: "What is a Rocket?" [http://www.nasa.gov/audience/foreducators/rocketry/home/what-is-a-rocket-k4.html](http://www.nasa.gov/audience/foreducators/rocketry/home/what-is-a-rocket-k4.html) (Lexile 980)
➢ Article: “Water Rocket Stability”
  http://www.seed2lrn.com/rocketSoftware.html (Lexile 1600)

➢ Article: “Mechanics and Motion”
  http://www.physics4kids.com/files/motion_intro.html (Lexile 940)

➢ Article: “What a Drag: The Effect of Friction/Drag on Rocket Performance”

➢ Article: “What is Drag? Factors That Affect Aerodynamics”
  http://www.grc.nasa.gov/WWW/K-12/airplane/drag1.html (Lexile 1140)

  http://www.grc.nasa.gov/WWW/K-12/RPG/RPG-BalloonRocketCar_easy.html (Lexile 1260)

➢ Article: “What is Aerodynamics?”
  http://www.nasa.gov/audience/forstudents/5-8/features/what-is-aerodynamics-58.html (Lexile 690)
Task 1: Four-Question Strategy

Objective: How can we develop a question that can be investigated using a controlled experiment?

Time Frame: 2 or 3 class periods

NOTE: While this task bundle specifically uses Pitsco straw rockets, it can easily be applied to anything that students can make fly: paper planes, balloon rockets, etc.

Introduction:

Have students read the following article, "What Is a Rocket," and answer the following text-based questions:

http://www.nasa.gov/audience/foreducators/rocketry/home/what-is-a-rocket-k4.html (Lexile 980)

- What are the two definitions of a rocket?
- How are rocket engines different from jet engines? How does this difference help rockets fly in outer space?
- How does Newton's third law help explain how a rocket moves? (Be sure to use your own words!)
- The text uses an example of how rockets work with a person on a skateboard and a bowling ball. Sketch an illustration of what is being explained, using arrows and key words to label and explain your illustration.

Motivation:

Show Pitsco Straw Rocket Video: This five-minute video gives an over view of how a rocket can be designed and things that can be measured.

And/or

Launch a pre-made rocket and demonstrate a few times how it can be launched, using different amounts of force and different angles.

Development: Activity/Hands-on

In this activity, encourage students to follow brainstorming guidelines—no suggestion is a bad suggestion, there should be no critical analysis at this point, be creative, no negative feedback.

For each group, place several materials that could be used for building a rocket: straws, several types of paper, tin foil, foam sheets, clay, etc. Have students examine materials to see how they might be used with a straw to build a rocket.

- Each group should have a copy of the four-question strategy handout (preferably enlarged or written on chart paper).
- Have groups generate a list of materials that could be used for the cone. Remember: no critiques—be creative!
• Have groups share their list and write on the board.
• Continue filling out the graphic organizer in this manner until all four questions have been completed.
• Now, go back and have a class discussion about the limitations of some of the items listed for each, such as using food items (not sanitary, too messy) or measuring the stability of a rocket (how do you quantify "wobble").

Post-Assessment:

With materials in front of them and the graphic organizer filled out, have the group members discuss and decide on which independent variable they will use and which dependent variable they will measure, and have them generate their question in the following format:

“How does the (Independent Variable) affect the (Dependent Variable)?”

Ex: How does the size of the fin affect how far the rocket travels?

Hint: Students can choose from Box 3 for independent variables, and Box 4 for dependent variables.

Have them also list the constants—many will be listed in Box 3, so there should be an extensive list.

Differentiation:

For more tactile learners, it might be useful to allow them to experiment with the materials and rocket launcher throughout the task. This will help them eliminate impractical variables and identify constants.

Measuring speed requires collecting two sets of data (time and distance) and more calculations. You might want to consider encouraging advanced students or students with strong math skills to use this as their dependent variable.

Resources:


Pitsco Straw Rockets


Projects Involving Flight


http://www.sciencekids.co.nz/lessonplans/flight.html

http://www.easy-science-fair-projects.net/science-fair-projects.html
### Four-Question Strategy

**Topic:** Straw Rockets

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What materials can be used to build a straw rocket?</td>
<td>Cone</td>
</tr>
<tr>
<td></td>
<td>Fins</td>
</tr>
<tr>
<td></td>
<td>Body</td>
</tr>
<tr>
<td>2. How do rockets act? What do they do?</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>3. What can we change about the materials a rocket is made out of?</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>4. What can we measure about how a rocket acts?</td>
<td></td>
</tr>
</tbody>
</table>
Task 2: Paraphrasing

Objective: How can I demonstrate understanding of scientific texts using paraphrasing skills?

Time Frame: 2 or 3 class periods

Activity/Hands-on
"Paraphrasing Telephone"
In the same small groups, students will play a game of “Telephone” using a short text. In a line, the first student will read the excerpt, and then tell the next person what the text is about. The last person will write down what has been passed along as the “gist” of the text. Students will share out and compare the accuracy of each explanation and paraphrase.

Sample short text:
At 9:47 a.m. on February 20, 1962, John Herschel Glenn Jr. lifted off from Cape Canaveral, Florida, in Friendship 7. He was ready to do something that no American had done before—fly a spacecraft around the Earth. After nearly five hours in space, orbiting the Earth three times, Glenn landed the spacecraft safely in the Atlantic Ocean. He was an instant hero. 2012 marks the fiftieth anniversary of the historic flight.

Questions:
- What did you observe in this activity?
- What happened to the explanation as it was passed along?
- How accurate do you think the paraphrase was? How can you improve it?
  What were the difficulties for the first reader? The middle listeners? The writer?

Motivation/Pre-Assessment:
In groups, students will do a jigsaw reading of a National Geographic or other scientific publication article related to rockeby or aviation. Using sticky notes, students will write down two important facts that they read. In a share-out, students will state the facts from their part of the reading, and explain why they feel this is important. A group reporter will take notes for the large group share-out.

Sample Articles:


http://www.howstuffworks.com/rocket.htm (Lexile 1090)
URBAN ADVANTAGE TO SUPPORT A CULTURE OF INQUIRY


Large Group Discussion Questions:
- Why were the facts that you found important? How did you know?
- What words were difficult for you?
- What does paraphrasing mean?

Development/Model:
Using the SMART board, the teacher will review the definition of paraphrasing, highlight key points to remember, and point out common pitfalls when trying to paraphrase in writing.

Definition:
**par-a-phrase**

*n.* 1. A restatement of a text or passage in another form or other words, often to clarify meaning.
2. The restatement of texts in other words as a studying or teaching device.

**v.** par-a-phrased, par-a-phras-ing, par-a-phras-es

**v.tr.** To restate in a paraphrase

**v.intr.** To compose a paraphrase

Key Points:

1. The purpose of paraphrasing is

   - **to present a writer's ideas, keeping as close as possible to their original meaning**
   - **to repeat much of the original material, but without quoting directly**
   - **to re-present a relatively short piece of written work**
   - **to be sure to avoid plagiarism**

2. In essence, paraphrasing in writing involves

   - **putting another writer's text into our own words**
   - **adhering as closely as possible to the original**
   - **keeping the same meaning**
   - **making use of different words or phrases to capture the same idea**
   - **re-phrasing a shorter text, and**
   - **sometimes producing a longer rather than a shorter version of the original text**

Having identified the purpose and essence of paraphrasing, we now need to consider how paraphrasing is actually done.
The most useful tools for paraphrasing the text of another author are synonyms, changes in voice or perhaps in word form, and the packing or unpacking of word groups. These strategies enable us to acknowledge that the intellectual content of a text is someone else's, but the information is in our own words. Let's therefore consider what each of those involves.

Plagiarism Pitfalls and Errors:

Paraphrasing

Paraphrase, according to Merriam Webster, is “a restatement of a text, passage, or work giving the meaning in another form.” So to paraphrase is to put someone else's words into your own words. In many ways paraphrasing is a good thing and something faculty loves to see. It becomes a problem and act of plagiarism, though, when you paraphrase but fail to cite the original author and do not give credit where the words came from.

Purdue University's Online Writing Lab (OWL) is a great resource on academic writing. They have identified some steps to follow to effectively paraphrase.

6 Steps to Effective Paraphrasing

1. Reread the original passage until you understand its full meaning.
2. Set the original aside, and write your paraphrase on a note card.
3. Jot down a few words below your paraphrase to remind you later how you envision using this material. At the top of the note card, write a key word or phrase to indicate the subject of your paraphrase.
4. Check your rendition with the original to make sure that your version accurately expresses all the essential information in a new form.
5. Use quotation marks to identify any unique term or phraseology you have borrowed exactly from the source.
6. Record the source (including the page) on your note card so that you can credit it easily if you decide to incorporate the material into your paper.

(Purdue University's Online Writing Lab (OWL))
Here is an example of how a student could correctly use a source without plagiarizing.

<table>
<thead>
<tr>
<th>Poor Practice</th>
<th>Better</th>
<th>Best</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;The name 'Auraria'&quot; (Stone, 1918, p. 140) means &quot;Gold Town&quot; (p. 140). It &quot;was one of two suggested by Dr. L. J. Russell and appears for the first time in the...&quot; (p. 140). Stone explains that the name Auraria &quot;appears for the first time in the title of the constitution&quot; (p. 140). He later points out that Auraria &quot;was established at the mouth of the Cherry Creek and was the... center of the present City of Denver&quot; (p. 140). &quot;Many of the first features of Colorado&quot; (p. 140) such as the first newspaper, church, and school were started in Auraria (p. 140).</td>
<td>&quot;According to Stone (1918), &quot;the name 'Auraria,' meaning 'Gold Town,' was one of two...&quot; (p. 140). Stone explains that the area's first newspaper, church and school were all in Auraria (p. 140).</td>
<td>&quot;Although long forgotten Denver in many respects.&quot;</td>
</tr>
</tbody>
</table>

While the first example isn’t plagiarizing, it’s awkward and considered poor academic writing. The second example is much better because everything is appropriately quoted and cited. But nearly every sentence includes a direct quote. There is little evidence of the student’s own thinking or writing. The third example is better and clearly the best out of the three because it paraphrases the original source.

http://www.ucdenver.edu/academics/CUOnline/FacultyResources/AcademicHonesty/Documents/student/IPlialrism/PlagiarismPitfallsParaphrase.htm

**Model:** Using the article "Special Delivery," read the first paragraph as whole class. Then, sentence by sentence, use paraphrasing strategies to re-write paragraph, and display on SMART board. Do this for as many paragraphs as needed.

**Practice:** Students will work first in pairs, then independently, paraphrasing the paragraphs set up in the text-paraphrasing worksheet, "What Is Aerodynamics?" (This text may be used in the next task to help support their hypotheses.)
Additional samples:

Differentiation:

Teaching Strategies/Graphic Organizers:

- Own the Word vocabulary worksheets for struggling students and/or ELLs:
  wvde.state.wv.us/Strategybank/documents/OwntheWord.doc

This worksheet/graphics organizer will help students better understand new vocabulary as well as to develop strategies to assist them with future vocabulary acquisition and paraphrasing.

Final Assessment: Hypothesis/Analysis portions of the final lab report for the straw rocket investigation.

Note: In the next task, students incorporate paraphrasing to cite text to help support their hypothesis in the straw rocket experiment.

Resources:
www.thefreedictionary.com/paraphrase
http://writingworkshop.edtec.unsw.edu.au/ownwords.html

http://www.ucdenver.edu/academics/CUOnline/FacultyResources/AcademicHonesty/Documents/student/1Plagiarism/PlagiarismPitfallsParaphrase.htm

wvde.state.wv.us/Strategybank/documents/OwntheWord.doc

http://www.education.com/worksheets/writing
Task 3: Hypothesis

Objective: To develop a hypothesis that uses scientific principles to support the student’s prediction.

Time Frame: 4 or 5 class periods

Pre-assessment

Examine these statements. Could they be hypotheses? Could they be predictions? Could they be conclusions?

Examples of hypotheses:
1. Ultraviolet light may cause skin cancer.
2. Temperature may cause leaves to change color.
3. The diameter of a rocket may affect its altitude performance.
4. Angled fins may affect the straightness of a rocket’s boost.
5. Fins that have airfoil streamlining may affect the altitude the rocket reaches.
6. The thrust of a rocket may affect the duration of its flight.
7. The number of rocket fins may increase a rocket’s stability.

Distinguish between predictive and concluding statements vs. hypothesis statements:

- Ultraviolet light causes skin cancer. (Conclusion)
- Tree leaves will change color when it gets cold. (Prediction)

Today we will focus on one of the required elements.

For example: If skin cancer is related to ultraviolet light, then people with a high exposure to UV light will have a higher frequency of skin cancer.

If leaf color change is related to temperature, then exposing plants to low temperatures will result in changes in leaf color.

Notice that these statements contain the words, if and then. They are necessary in a hypothesis. Remember: if one thing is related to another, then you should be able to test it.

Development:

A hypothesis contains two variables. One is "independent" and the other is "dependent." The independent variable is the one you, the "scientist," control, and the dependent variable is the one that you observe and/or measure to determine the results. In the statements above, the dependent variable is italicized and the independent variable is underlined.
1. Rewrite hypotheses examples #3-7 using the style shown above. Circle the dependent variable and underline the independent variable in the if clause of each hypothesis.¹

2. In small groups, complete the Hypothesis Worksheet. Each group should be assigned one question to present to the class.

_PRACTICE:_

Students read two short scenarios of experiments and identify the key components of the scientific method (including correct phrasing of the hypothesis and identification of the independent variable and the dependent variable)

Handout: _Scientific Method in Action_ (see _Scientific Method in Action Planner_ for additional support)

_More Practice (if needed):_

1. Give pairs of students the following problem and have them evaluate it as a hypothesis statement.

   Will Brand A plastic wrap keep air away from the bean seed?

   (It’s not in the correct format)

2. Have students re-write the problem in the accepted format for a hypothesis. Allow a few minutes for their conversations and then ask what difficulties they are having.

   One problem is how will they KNOW if the plastic wrap kept air away from the seed?

   Another concern might be WHY someone might think that plastic wrap would block air.

3. a) Elicit the use of plastic wrap (It helps preserve food) and explain that it blocks air (including oxygen) from combining with the food and causing it to decay.

   b) Explain that bean seeds will not sprout (germinate) if they are not exposed to the air.

4. Allow the students to again attempt to re-write the hypothesis. Emphasize that research is essential for conducting a credible experiment.

5. Have students complete their hypothesis by including a “because” phrase.

6. Write the completed hypothesis and show other examples:

   If bean plants are watered two times a week, then their growth will increase because plants need water for photosynthesis and each plant has a maximum capacity for water.
If acid rain is in the water, then the fish population will increase because a pH between 5.6 and 6.2 supports successful fertilization.

**Activity**

Put students in small groups and assign one of the hypothesis statements from the Hypothesis worksheet and the appropriate research text (see websites for texts):

1. **What effect does rocket fin size have on the stability of the rocket?**  
   **Article:** Water Rocket Stability  
   [http://www.seeds2lrn.com/rocketSoftware.html](http://www.seeds2lrn.com/rocketSoftware.html) (Lexile 1600)

2. **What effect does the mass of a rocket have on its acceleration?**  
   **Article:** Mechanics and Motion  

3. **What effect does the surface finish (smooth or rough) of a rocket have on its altitude performance?**  
   **Articles:** Rockets: The Effect of Friction/Drag on Rocket Performance and Factors That Affect Aerodynamics  
   *Note this requires two articles; might consider using this for advanced students.*

4. **What effect does the nozzle size have on the distance the rocket travels?**  
   **Article:** Beginner's Guide to Propulsion: Balloon Rocket Car  
   [http://www.grc.nasa.gov/WWW/K-12/FOP/Ashtle/BalloonRocketCar_easy.html](http://www.grc.nasa.gov/WWW/K-12/FOP/Ashtle/BalloonRocketCar_easy.html) (Lexile 1260)

5. **What effect does the distance between the rocket's center of mass and its fins have on the direction of the rocket's flight?**  
   **Article:** Water Rocket Stability  
   [http://www.seeds2lrn.com/rocketSoftware.html](http://www.seeds2lrn.com/rocketSoftware.html) (Lexile 1600)
Formal Assessment: Rocket Experiment

Have students write a formal hypothesis in the form of “If... then... because...”. Their hypothesis must include a citation from the text that supports their prediction. Note: require format used by ELA teacher (usually MLA at this grade level).

Individually have students complete the Investigative Design Diagram IDD graphic organizer. (Handout)

Differentiation:

Have students write their initial hypothesis on three sentence strips, one labeled “If”, second “Then”, and third “Because”. Have students fill in strips using prompt questions like:

“if” we change what? What are you changing on purpose in your experiment? (IV)

“Then” what do you think will happen? What are you going to measure about the rocket? (DV)

“Because” why do you think this will happen? What scientific laws, theories, or principles make you think that these changes will take place? Where did you read that information?

For advanced students, use hypothesis #3. Students are required to synthesize information from two sources to formulate a hypothesis.

Resources:

Chapter 16 New York Science Grade 8, New York, NY: Glencoe/McGraw-Hill 2008 Print

http://www.seeds2lrn.com/rocketSoftware.html (Hypothesis 1 and 5)

http://www.physics4kids.com/files/motion_intro.html (Hypothesis 2)


http://www.grc.nasa.gov/WWW/K-12/airplane/drag1.html (Hypothesis 3)

http://www.grc.nasa.gov/WWW/K-12/BASP/Ashlie/BalloonRocketCar_easy.html (Hypothesis 4)
HYPOTHESIS WORKSHEET
Write a hypothesis for each of the following research problems. Identify the independent and dependent variable for each.

1. What effect does rocket fin size have on the stability of the rocket?

   ____________________________

   Independent variable:
   ____________________________

   Dependent variable:

2. What effect does the mass of a rocket have on its acceleration?

   ____________________________

   Independent variable:
   ____________________________

   Dependent variable:

3. What effect does the surface finish (smooth or rough) have on its altitude performance?

   ____________________________

   Independent variable:
   ____________________________

   Dependent variable:

4. What effect does the nozzle size have on the distance the rocket travels?

   ____________________________

   Independent variable:
   ____________________________

   Dependent variable:

5. What effect does the distance between the rocket’s center of mass and its fins have on the direction of the rocket’s flight?

   ____________________________

   Independent variable:
   ____________________________

   Dependent variable:
Scientific Method in Action

Galileo’s Discovery of Acceleration

Galileo was fascinated by objects in motion and conducted many experiments to refine his ideas. He took a board that measured 20 feet by 10 inches and cut a groove, as straight and smooth as possible, down the center. He inclined the plane and rolled brass balls down it, timing their descent with a water clock—a large vessel that emptied through a thin tube into a glass. After each run he would weigh the water that had flowed out—his measurement of elapsed time—and compare it with the distance the ball had traveled.

Aristotle would have predicted that the velocity of a rolling ball was constant: double its time in transit and you would double the distance it traversed. Galileo was able to show that the distance is actually proportional to the square of the time: double it and the ball would go four times as far. The reason is that it is being constantly accelerated by gravity.

1. State the problem.

2. What was the hypothesis?

3. How was the hypothesis tested?

4. Should the hypothesis be supported or rejected based on the experiment?

5. What could be a new hypothesis and how would you test it?

The Effect of Drag on a Car’s Gas Mileage

A couple of students wanted to find out if cars actually used more gas when the drag on the car was increased. They occasionally went on family trips with bicycles on the roof of the car. They realized that the additional rack and the bicycles would increase the drag. They decided to test the gas mileage with and without a roof rack and bicycles on the car.

6. Identify the problem.

7. What was the hypothesis?

8. How was the hypothesis tested?

9. How would they know if their hypothesis should be supported or rejected?

10. What could be a new hypothesis and how might you test it?
URBAN ADVANTAGE TO SUPPORT A CULTURE OF INQUIRY

Investigation Design Diagram (IDD)

**Question:** (hint) How will the Independent Variable affect the Dependent Variable.

**Hypothesis:** (hint) If (describe how you will change the independent variable) then (describe the way you think the dependent variable will change) because (explain why you expect this result using prior knowledge and scientific reasoning).

**Citation:**

**IV:** (Independent Variable/"You Change It Variable")

**DV:** (Dependent Variable/"You Measure It Variable")

**Constants:** (hint) factors in an experiment that are kept the same and not allowed to change or vary.

Task 4: Procedure/Data Table

Objective: How can we create a procedure that demonstrates a step-by-step set of instructions that will elicit reliable data?

Time Frame: 4 class periods

Pre-Assessment/Motivation:
Have pairs of students write directions as to how to make a peanut butter and jelly sandwich that includes all materials and is in the correct sequence.

Ask a group to demonstrate their directions by having one student read the group’s instructions exactly as written and have the other follow exactly as written. Have class give constructive criticism as each step is demonstrated. Have groups revise their directions and have another group demonstrate their directions. Continue having groups share their set of instructions until a fully detailed step-by-step of instructions is modeled.

Development: Activity/Hands-on
Note: Refer to “Cone Fly with Me” Lab as to basic guidelines for testing paper planes.

As a whole class, discuss the variables and constants that should be considered when investigating the following question: “How does the type of paper affect how far a paper airplane flies?”

Independent Variable: type of paper
Dependent Variable: distance paper airplane travels
Constants: same size plane and construction, force applied to plane, starting point, angle of plane, height the plane flies, etc.

Materials: several different types of paper (construction, computer, cardstock, etc.)

Have groups of two or three students create a step-by-step procedure that would answer the question above. Have them construct at least two different paper planes made of different paper. Be sure that procedure includes specific construction directions to make each airplane as well as how to conduct each trial.

Have groups share their constructions and procedures by having groups conduct a “gallery walk.”

As a collective group discuss how many trials would be appropriate for each airplane type. This can lead into a discussion about the greater number of trials gives more accurate results, and how data collection after a trial is crucial. A data table should be constructed prior to carrying out experiment so that data is collected in an organized fashion.
Data Table:
While there are no specific rules in designing a data table, in general the following can be used as a guideline:

- Independent variable is generally recorded in the left column.
- Dependent variable is generally recorded in the columns directly to the right of the independent variable, usually with multiple columns for multiple trials.
- Average is generally calculated to the far right column.
- Title should represent the purpose of the experiment.

Example:

<table>
<thead>
<tr>
<th>Paper Type</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
<th>Trial 4</th>
<th>Average</th>
</tr>
</thead>
</table>

Differentiation:

Have struggling students choose from a set of blueprints for construction the airplane.

Use a graphic organizer (see Resources).

Give student a checklist to keep them on track (see Resources).

If students are struggling with developing a detailed set of instructions, have them simulate a trial and have one student describe exactly what they are doing while the other records each action. Prompt students with questions like “How high above the floor?” “How will you know how much force is applied?” “How will you keep this constant?”

Post-Assessment
Students will create their procedure and data table for the rocket experiment.

Resources:
Come Fly with Me Lab:
http://sciencespot.net/Media/comefly_1.pdf
Airplane Blueprints:
http://www.10paperairplanes.com/
Graphic Organizer:
Checklist:
Task 5: Conclusion/Analysis

Objective: How can we graph results to formulate a conclusion and analyze what can be concluded from our results?

Time Frame: 3 or 4 class periods

Pre-assessment:

Use page 3 in the following document to assess student’s ability to read and analyze graphs:


Development: Using the paper airplane data from previous task to develop good graphing skills with students

Ask students if they know when to use a bar graph or a line graph. Discuss when each would be appropriate:

Bar Graph: Appropriate when Independent Variable is discrete data. This means when they are categorical, like days of the week, kind of animal, or brand of paper towel.

Line Graph: Appropriate when Independent Variable is continuous. This means they are equal intervals or a scale like height of a plant or number of days.

Generally, then, if Independent Variable is best described using words choose a bar graph; if the description uses numbers then choose a line graph.

Use graph from Pre-Assessment to reinforce this idea, as well as discuss other graphing skills, like labeling x-axis and y-axis. Elicit from students that the X-axis is labeled with the independent variable and since this is continuous data (time) a line graph is used.

Activity: Use data from Paper Airplane experiment and have students:

Determine whether a line or bar graph is appropriate.

Determine what should be labeled on x-axis and y-axis.

Determine appropriate name for the graph.

Graph results.

Have students write a summary of what the graph shows (trends) under the graph itself.

Use the Developing Scientific Explanation Tool (DSET) to help formulate a conclusion that incorporates both data and the scientific reasoning to support it.
Post-Assessment: Students will graph the data for their rocket experiment as well as complete the DSET organizer to formulate a conclusion.

Differentiation:

Some students may require additional graphing practice. (See Resources)

Use larger-scaled boxed graph paper for students that have visual/writing difficulties. (See Resources)

Use spreadsheet program like Excel for data tables and graphs. (See Resources)

Resources:

Pre-Assessment:


Graphing Examples

http://staff.tusd.k12.az.us/gfoster/standard/bgraph2.htm

Graph Paper

http://www.printfreedownload.com/

Graphing Using Excel

http://staff.tusd.k12.az.us/gfoster/standard/excelgra.htm
Developing a Scientific Explanation Tool (DSET)

What is your question?

Support for your explanation

<table>
<thead>
<tr>
<th>Claim based on the evidence (What is the answer to your question based on your evidence?)</th>
<th>Evidence (Observations/data that answer your question)</th>
<th>Scientific Reasoning (Why you think this happened based on background research)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Scientific Explanation = Claim + Evidence + Science Reasoning
My claim is (fill in with above claim) because (evidence and science reasoning)
Appendix N

Investigation Design Diagram

**Investigation Design Diagram (ID)**

<table>
<thead>
<tr>
<th>Title: The effect of (IV) on (DV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question: How will (IV) affect (DV)?</td>
</tr>
</tbody>
</table>
| Hypothesis: IF (describe how you will change the I.V.)  
THEN (describe the way that you think the D.V. will change as a result of the change in the I.V.)  
BECAUSE (explain why you expect this result referring to related scientific concepts that you know from your background research) |

**I.V. (Independent variable)**

<table>
<thead>
<tr>
<th>L.E.V.E.L. (Control Group if you have one)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T.R.I.A.L.S. (Control Group if you have one)</td>
</tr>
</tbody>
</table>

**D.V. (Dependent variable)**

**Constants:** All of the other things that you will try to keep the same for each of your trials.

* Levels of Independent Variable such as time of day, sites being compared or individuals being compared. Use as many boxes as needed.
** Number of repeated trials at each level of the I.V. or at each site.

Appendix O

Investigation Design Diagram for Animal Behavior Projects

<table>
<thead>
<tr>
<th>Title:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample format: The effect of (independent variable) on (dependent variable)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Research Question:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample format: How will (independent variable) affect (dependent variable)?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hypothesis:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample format: I think (independent variable) will affect (dependent variable) because (explain why you expect/predict this relationship between the variables)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Independent Variable: “you choose it” variable (i.e. an event, inter-species, intra-species…)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Independent Variable</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Change in independent variable:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Differences of the Independent Variable</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of Observations:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of times observations were made</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dependent Variable: “you measure it” variable (what are you measuring/observing?)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent Variable</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Constant Variables:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factors in an experiment that are kept the same</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Definition of Terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Independent Variable: (“you choose it” variable) the variable that is chosen by the experimenter to observe.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dependent Variable:</th>
</tr>
</thead>
<tbody>
<tr>
<td>(responding variable) the factor or variable that is being observed as a result of naturally changing or natural difference chosen in the independent variable.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Control Group:</th>
</tr>
</thead>
<tbody>
<tr>
<td>There is no control group in Animal Behavior Investigations.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Constant Variable:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factors in an experiment that are kept the same and not allowed to change or vary.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Repeated Trials:</th>
</tr>
</thead>
<tbody>
<tr>
<td>The number of times that observations were made</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hypothesis:</th>
</tr>
</thead>
<tbody>
<tr>
<td>A prediction of the relationship of an independent and dependent variable to be observed and recorded in an experiment; it predicts the effect that the changes occurring naturally in the independent variable will have on the dependent variable.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Title:</th>
</tr>
</thead>
<tbody>
<tr>
<td>A statement describing an experiment. Titles are often written in the form, “The Effect of the Changes in the Independent Variable on the Dependent Variable.”</td>
</tr>
</tbody>
</table>

### Investigation Design Diagram for Animal Behavior Projects

**Title:**

**Question:**

**Hypothesis:**

<table>
<thead>
<tr>
<th>Independent Variable:</th>
<th>Change in independent variable:</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Number of Observations:</th>
</tr>
</thead>
</table>

**Dependent Variable:**

**Constant variables:**

Investigation Design Diagram: Design Experiment

<table>
<thead>
<tr>
<th>Title: The Effect of _______ and _______ on _______.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(independent variable #1)</td>
</tr>
</tbody>
</table>

**Question #1:** How does _______ affect _______?  
(Independent variable #1)  (Dependent variable)

**Hypothesis #1 (If...then...because):**

**Question #2:** How does _______ affect _______?  
(Independent variable #2)  (Dependent variable)

**Hypothesis #2 (If...then...because):**

<table>
<thead>
<tr>
<th>Independent Variable #1 (what you change):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Levels (how you change the IV)</td>
</tr>
<tr>
<td># of Trials for this experiment</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Independent Variable #2 (what you change):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Levels (how you change the IV)</td>
</tr>
<tr>
<td># of Trials for this experiment</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dependent Variable (what you measure):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constants (what stays the same):</td>
</tr>
</tbody>
</table>

Appendix Q

Design Experiment: Best Design

Design Experiment: Best Design
(This part of the design experiment is completed after the data for IV#1 and IV#2 has been collected and analyzed, and a scientific explanation for IV#1 and IV#2 has been written.)

Name: _______________________

1. For this investigation, the two independent variables you tested (what you changed), each during its own controlled experiment, were...
   a. __________________________
      (Independent variable #1)
   b. __________________________
      (Independent variable #2)

And the dependent variable (what you measured) throughout the investigation was...
   __________________________
      (Dependent variable)

2. Based on the data collected during these experiments, the Best Design should have...
   (Include specific characteristics)
   __________________________
   __________________________
   __________________________
   __________________________
   __________________________
   __________________________

3. Results of Best Design Test:

<table>
<thead>
<tr>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Best</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. When compared to the two previous experiments, did the Best Design perform as expected? Was it really the Best Design? Explain your reasoning.

   __________________________
   __________________________
   __________________________
   __________________________
   __________________________
   __________________________
Appendix R

Investigation Design Diagram (IDD) for Continuous Data Sets

**Investigation Design Diagram (IDD)**

*For Continuous Data Sets*

Title:

Question:

Hypothesis:

<table>
<thead>
<tr>
<th>I.V. (Independent variable name and units)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source of Data for your IV: ________________________________</td>
</tr>
<tr>
<td>Range of readings of the IV: Lowest value: ________ (units: )  Highest value: ________ (units: )</td>
</tr>
<tr>
<td>Number of data points: ___________________________ (Trials)</td>
</tr>
<tr>
<td>Time span over which the data was collected (if appropriate): From: ________ To: ________</td>
</tr>
<tr>
<td>Data analysis strategy:*</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>D.V. (Dependent variable name and units)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source of Data for your DV: ________________________________</td>
</tr>
</tbody>
</table>

Constants:

* How will you graph or mathematically analyze your data? 3/15/13

Appendix S

Teaching Investigation Design using the Investigation Design Diagram (IDD)
Investigating with Helicopters
Making a Helicopter

- Cut along the dotted lines
- Fold A behind B
- Fold C behind B
- Fold D behind B
- Fold blade X in one direction
- Fold blade Y in the opposite direction
Flying your Helicopter

- Hold your helicopter high and drop it. Observe the results. Compare with your neighbor…

- Do all helicopters behave the same?

- Do they all spin in the same direction?

- TRY THIS: What can you do to the helicopter to change the spin direction?
Introducing “Variable”

- **Variable**: anything that can be changed in an investigation.
- **Independent variable**: Something YOU CHANGE in an investigation. (cause)
- **Dependent variable**: Something that changes AS A RESULT of what you changed. (effect)
- **Constant variable**: Something that could be changed but is not.
Helicopter investigation Record Page - Directions

1. What did you do to the helicopter?

2. What variable was affected by your change in the helicopter?

3. What variable did you observe to see a difference in your change to the helicopter?

4. What variable(s) did you keep the same about your helicopter?
Helicopter investigation Record Page - Directions

1. What did you do to the helicopter?
2. What variable was affected by your change in the helicopter?
3. What variable did you observe to see a difference in your change to the helicopter?
4. What variable(s) did you keep the same about your helicopter?
## Helicopter Investigation Record Page

<table>
<thead>
<tr>
<th>Question 1</th>
<th>Question 2</th>
<th>Question 3</th>
<th>Question 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Action</strong></td>
<td>You purposely changed</td>
<td>Result of your change</td>
<td>Could have changed, but remained the same</td>
</tr>
<tr>
<td>What did you do to the helicopter?</td>
<td>What variable was affected by your change in the helicopter?</td>
<td>What variable did you observe to see a difference in your change to the helicopter?</td>
<td>What variables did you keep the same?</td>
</tr>
</tbody>
</table>
# Helicopter Investigation Record Page

<table>
<thead>
<tr>
<th>Question 1</th>
<th>Question 2</th>
<th>Question 3</th>
<th>Question 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Action</td>
<td>You purposely changed</td>
<td>Result of your change</td>
<td>Could have changed, but remained the same</td>
</tr>
<tr>
<td>What did you do to the helicopter?</td>
<td>What variable was affected by your change in the helicopter?</td>
<td>What variable did you observe to see a difference in your change to the helicopter?</td>
<td>What variables did you keep the same?</td>
</tr>
</tbody>
</table>
# Helicopter Investigation Record Page

<table>
<thead>
<tr>
<th>Question 1</th>
<th>Question 2</th>
<th>Question 3</th>
<th>Question 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Action</strong></td>
<td><strong>You purposely changed</strong></td>
<td><strong>Result of your change</strong></td>
<td><strong>Could have changed, but remained the same</strong></td>
</tr>
<tr>
<td>What did you do to the helicopter?</td>
<td>What variable was affected by your change in the helicopter?</td>
<td>What variable did you observe to see a difference in your change to the helicopter?</td>
<td>What variables did you keep the same?</td>
</tr>
<tr>
<td>• Refold the blades in the opposite direction</td>
<td>• Direction of blades</td>
<td>• Direction of spin</td>
<td>• Drop height</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Release position</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Climate in room</td>
</tr>
</tbody>
</table>


Try Another Helicopter Investigation

- What do you think will happen to the helicopter if you increase its weight by adding a paperclip? Try it several times, and observe how the helicopter behaves.

- Repeat your investigation, increasing the number of paperclips. What happens as you increase the weight?

- As you conduct your investigation, complete the Helicopter Investigation Record Page.
## Helicopter Investigation Record Page

<table>
<thead>
<tr>
<th>Question 1</th>
<th>Question 2</th>
<th>Question 3</th>
<th>Question 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Action</strong></td>
<td>You purposely changed</td>
<td>Result of your change</td>
<td>Could have changed, but remained the same</td>
</tr>
<tr>
<td>What did you do to the helicopter?</td>
<td>What variable was affected by your change in the helicopter?</td>
<td>What variable did you observe to see a difference in your change to the helicopter?</td>
<td>What variables did you keep the same?</td>
</tr>
</tbody>
</table>
### Helicopter Investigation Record Page

<table>
<thead>
<tr>
<th>Question 1</th>
<th>Question 2</th>
<th>Question 3</th>
<th>Question 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Action</strong></td>
<td><strong>You purposely changed</strong></td>
<td><strong>Result of your change</strong></td>
<td><strong>Could have changed, but remained the same</strong></td>
</tr>
<tr>
<td>What did you do to the helicopter?</td>
<td>What variable was affected by your change in the helicopter?</td>
<td>What variable did you observe to see a difference in your change to the helicopter?</td>
<td>What variables did you keep the same?</td>
</tr>
</tbody>
</table>
| • Add 1 paperclip | • Increase the weight | • Rate of descent | • Drop height  
*Release position  
Climate in room  
Direction of blades* |
| • Add 2 paperclips | • Increase the weight | • Rate of descent | • Drop height  
*Release position  
Climate in room  
Direction of blades* |
What is the Investigation Design?

- What is the IV?
- How was the IV changed?
- What is the DV?
- What variables were held constant?
- What was the control group?
- How many repeated trials were conducted?
- What are the different levels of Independent Variable used?
- State the hypothesis of this investigation
- What was the question being investigated?
- What would be an appropriate title for this investigation?
Investigation Design Diagram

Title:
Question:
Hypothesis:

<table>
<thead>
<tr>
<th>IV:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(control group)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DV:</th>
<th></th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Constants:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Definition of Terms</td>
<td></td>
</tr>
<tr>
<td>Independent Variable</td>
<td>(manipulated variable) the variable that is changed on purpose by the investigator.</td>
</tr>
<tr>
<td>Levels of IV:</td>
<td>the specific values (kinds, sizes or amounts) of the IV that are tested in an investigation.</td>
</tr>
<tr>
<td>Dependent Variable:</td>
<td>(responding variable) the factor or variable that may change as a result of changes purposely made in the independent variable.</td>
</tr>
<tr>
<td>Control Group:</td>
<td>the part of an investigation that serves as a standard of comparison. A control is used to detect the effects of factors that should be kept constant, but which vary. The control may be a &quot;no treatment&quot; group or an &quot;investigator selected&quot; control.</td>
</tr>
<tr>
<td>Constants:</td>
<td>factors in an investigation that are kept the same and not allowed to change or vary.</td>
</tr>
<tr>
<td>Repeated Trials:</td>
<td>the number of times that a level of the independent variable is tested in an investigation or the number of objects or organisms tested at each level of the independent variable</td>
</tr>
<tr>
<td>Hypothesis:</td>
<td>a prediction of the relationship between an independent and dependent variable to be tested in an investigation; it predicts the effect that the changes purposely made in the independent variable will have on the dependent variable.</td>
</tr>
<tr>
<td>Title:</td>
<td>a statement describing an investigation. Titles are often written in the form, &quot;The Effect of the Changes in the Independent Variable on the Dependent Variable.&quot;</td>
</tr>
</tbody>
</table>
Investigation Design Diagram

**Title:** The Effect of Weight on the Rate of Descent of a Helicopter

**Question:** What is the effect of weight on the rate of descent of a helicopter?

**Hypothesis:** If the weight is increased then the helicopter will descend at a faster rate, while keeping all other variables constant.

<table>
<thead>
<tr>
<th>IV: Weight of helicopter</th>
<th>Independent Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>(control group) 0 paperclips</td>
<td>Levels of Independent Variable including the Control Group</td>
</tr>
<tr>
<td>1 paperclip</td>
<td>Repeated Trials Number of times each of the levels of IV was tested</td>
</tr>
<tr>
<td>2 paperclips</td>
<td>Dependent Variable</td>
</tr>
<tr>
<td>3 paperclips</td>
<td>Constants</td>
</tr>
<tr>
<td>4 paperclips</td>
<td></td>
</tr>
</tbody>
</table>

| 3 trials | 3 trials | 3 trials | 3 trials | 3 trials |

**DV:** Rate of descent of helicopter

**Constants:** Drop height, release position, climate in room, position of blades

**Definition of Terms**

- **Independent Variable:** (manipulated variable) the variable that is changed on purpose by the investigator.
- **Levels of IV:** the specific values (kinds, sizes or amounts) of the IV that are tested in an investigation.
- **Dependent Variable:** (responding variable) the factor or variable that may change as a result of changes purposely made in the independent variable.
- **Control Group:** the part of an investigation that serves as a standard of comparison. A control is used to detect the effects of factors that should be kept constant, but which vary. The control may be a "no treatment" group or an "investigator selected" control.
- **Constants:** factors in an investigation that are kept the same and not allowed to change or vary.
- **Repeated Trials:** the number of times that a level of the independent variable is tested in an investigation or the number of objects or organisms tested at each level of the independent variable.
- **Hypothesis:** a prediction of the relationship of an independent and dependent variable to be tested in an investigation; it predicts the effect that the changes purposely made in the Independent variable will have on the dependent variable.
- **Title:** a statement describing an investigation. Titles are often written in the form, “The Effect of the Changes in the Independent Variable on the Dependent Variable.”
Debrief

- How does using the ID help the teacher guide students to an understanding of the process of scientific investigation?

- How does the investigational design diagram support student understanding of the process of scientific investigation?
PRACTICE

- In the “Sunflower investigation” scenario that we will provide for you, identify the following components of an investigation:

1) Independent Variable
2) Dependent Variable
3) Constants
4) Repeated Trials
5) Levels of Independent Variable

- Use the scenario to write a title and a hypothesis using the following formats:

6) Title: The Effect of the (changes in the independent variable) on the (dependent variable)

7) Hypothesis: If (independent variable – describe how it will be changed), then (dependent variable – describe the effect)
Practice Using the ID Controlled investigation Model

Scenario:
In the course of her background reading on sunflowers, Becky read about organic farming and she became interested in the use of compost and other organic fertilizers for growing crops. She decided she wanted to test the effect of compost on the germination and growth of sunflowers. Becky decided to make her own soil mixes so that she could control the amount of organic compost very closely. She used a compost made by worms ("vermicompost") and mixed this with perlite (an inorganic rock material) to make her own soil types. Becky hypothesized that if the soil contained more compost, the seeds would germinate sooner, plants would grow taller, and the plants would make flowers earlier. She decided to plant some seeds in compost alone, some in the perlite alone, and some in mixtures of the two that contained different ratios of compost and perlite. The 3 mixtures she created were: 75% compost / 25% perlite; 50% compost / 50% perlite; and 25% compost / 75% perlite. This resulted in her planning for 5 different sets of pots. Becky used 3 pots for each soil media/soil media mixture. In each of these 15 pots she planted 3 seeds. The plants were observed and measured for 30 days.
Investigation Design Diagram

**Title:**
**Question:**
**Hypothesis:**

<table>
<thead>
<tr>
<th>IV:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(control group)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DV:</th>
<th></th>
</tr>
</thead>
</table>

**Constants:**

**Definitions of Terms**

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Investigation Design Diagram

**Title:** The Effect of Compost on Sunflower Seed Germination and Plant Growth

**Question:** How does the amount of compost (organic material) in a soil mixture affect the germination and growth of sunflowers planted from seed?

**Hypothesis:** If sunflower seeds have a soil mix that contains more compost then they will germinate faster, grow taller, and flower sooner.

<table>
<thead>
<tr>
<th>IV: Amount of compost added to soil mixture</th>
<th>Independent Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% compost</td>
<td>Levels of Independent Variable</td>
</tr>
<tr>
<td>25% perlite</td>
<td>Including the Control Group</td>
</tr>
<tr>
<td>75% compost</td>
<td>Repeated Trials Number of times each of the levels of IV was tested</td>
</tr>
<tr>
<td>50% perlite</td>
<td></td>
</tr>
<tr>
<td>25% compost</td>
<td></td>
</tr>
<tr>
<td>75% perlite</td>
<td></td>
</tr>
<tr>
<td>100% perlite</td>
<td></td>
</tr>
<tr>
<td>3 pots, 3 seeds per pot</td>
<td>Dependent Variable</td>
</tr>
<tr>
<td>3 pots, 3 seeds per pot</td>
<td>Constants</td>
</tr>
</tbody>
</table>

**DV:** Number of days until seeds germinate; Height of Stem; Number of days until plants flower

**Constants:** Volume of soil mix or ingredient added to each pot, number of hours of light, amount of water and frequency of watering, type of pots, type of sunflower seeds, temperature, humidity

**Definition of Terms**

**Independent Variable:** (manipulated variable) the variable that is changed on purpose by the investigator.

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investigational Design Diagram

Title:

Question:

Hypothesis:

<table>
<thead>
<tr>
<th>IV:</th>
<th>(Independent Variable/&quot;You Change It Variable&quot;)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DV:</th>
<th>(Dependent Variable/&quot;You Measure It Variable&quot;)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Constants:
investigational Design Diagram

**Title:** The Effect of Compost on Sunflower Seed Germination and Plant Growth

**Question:** How does the amount of compost (organic material) in a soil mixture affect the germination and growth of sunflowers planted from seed?

**Hypothesis:** If sunflower seeds have a soil mix that contains more compost then they will germinate faster, grow taller, and flower sooner

<table>
<thead>
<tr>
<th>IV: (Independent Variable/&quot;You Change It Variable&quot;)</th>
<th>Amount of compost added to soil mixture</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 % Compost</td>
<td>75 % Compost 25 % Perlite</td>
</tr>
<tr>
<td>3 pots 3 seeds per pot</td>
<td>3 pots 3 seeds per pot</td>
</tr>
<tr>
<td></td>
<td>50 % Compost 50 % Perlite</td>
</tr>
<tr>
<td></td>
<td>3 pots 3 seeds per pot</td>
</tr>
<tr>
<td></td>
<td>25 % Compost 75 % Perlite</td>
</tr>
<tr>
<td></td>
<td>3 pots 3 seeds per pot</td>
</tr>
<tr>
<td></td>
<td>100% Perlite</td>
</tr>
<tr>
<td></td>
<td>3 pots 3 seeds per pot</td>
</tr>
</tbody>
</table>

**DV:** (Independent Variable/"You Measure It Variable") Volume of soil mix or ingredient added to each pot, number of days until seeds germinate; Height of stem; Number of days until plants flower

**Constants:** Number of hours of light, amount of water and frequency of watering, type of pots, type of sunflower seeds, temperature, humidity
## Summary Data Table

<table>
<thead>
<tr>
<th>Levels of Soil Media</th>
<th>Final Average Height (cm) of Pot 1 after 30 days</th>
<th>Final Average Height (cm) of Pot 2 after 30 days</th>
<th>Final Average Height (cm) of Pot 3 after 30 days</th>
<th>Average Height (cm) of all Plants in all 3 Pots of 1 Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% vermicompost</td>
<td>9.0 cm</td>
<td>8.0 cm</td>
<td>8.5 cm</td>
<td>8.5 cm</td>
</tr>
<tr>
<td>75% compost 25% perlite</td>
<td>11.0 cm</td>
<td>10.0 cm</td>
<td>12.0 cm</td>
<td>11.0 cm</td>
</tr>
<tr>
<td>50% compost 50% perlite</td>
<td>13.0 cm</td>
<td>12.0 cm</td>
<td>11.0 cm</td>
<td>12.0 cm</td>
</tr>
<tr>
<td>25% compost 75% perlite</td>
<td>7.0 cm</td>
<td>8.0 cm</td>
<td>7.5 cm</td>
<td>7.5 cm</td>
</tr>
<tr>
<td>100% perlite</td>
<td>3.0 cm</td>
<td>2.5 cm</td>
<td>2.0 cm</td>
<td>2.5 cm</td>
</tr>
</tbody>
</table>
References


