School-museum partnership: Bridging formal and informal science learning in the elementary school
A Master's Thesis

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SCHOOL-MUSEUM PARTNERSHIP:

BRIDGING FORMAL AND INFORMAL SCIENCE LEARNING

IN THE ELEMENTARY SCHOOL

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ABSTRACT

The purpose of this study was to investigate the effect of school-museum partnership activities on the cognitive and affective learning gains of students involved in the program. A relatively small amount of research has been conducted on the impact of sustained partnerships between schools and museums. In this study a large state science museum in the U.S. Pacific Northwest worked with a large urban elementary school located nearby to collaboratively leverage, integrate and focus resources with the intention of impacting student outcomes. Pre- and post-test, mixed-method assessments were conducted on a sample first-grade classroom engaged in the program. At the end of the partnership, both cognitive and affective learning gains were realized, some gains were related to museum activities and other gains were not. Findings suggest a family homework assignment may have influenced deeper affective and cognitive connections to science related to partnership activities in the home environment.

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SCHOOL-MUSEUM PARTNERSHIP: BRIDGING FORMAL AND INFORMAL SCIENCE LEARNING IN THE ELEMETARY SCHOOL

The need for quality science education for young people in the United States has grown rapidly in response to the demands created by today's fast paced global economy (West Ed 2004b). Many studies have indicated that the United States is lagging behind other developed nations in science education (West Ed 2004a). It is widely acknowledged that a decline in enthusiasm for science through the high school years and fewer students choosing to study science as a career after high school are primary contributors to the growing lack of adequate science literacy (Braund and Reiss 2006a; Braund and Reiss 2006b). Science literacy is important not only for the need to supply future scientists but also important for tomorrow's adults to understand and engage in the scientific issues of the day, whether it be on an individual level or broader political level (Braund and Reiss 2006a; National Research Council 1996).

Attitudes towards science and of scientists has been found to develop in children as young as kindergarten and primary school age (Eshach 2007). Thus, it is important that young people are exposed to accurate, engaging experiences with science, especially considering that early scientific attitudes of children have been linked to future choices and performance related to science later in school and life (Melber 2003). The United States Department of Education revised the National Science Standards in 1996 in an effort to more effectively engage all students in gaining necessary accurate scientific literacy, but it is noted that teacher practice related to these standards continues to lag way behind these changes (West Ed 2004a).

Museums and science centers have been highlighted as one potentially effective way to "contribute to the understanding of science and encourage students to further their interest [of science] outside of schools," (National Research Council 1996, 22). Museums are seen to be exciting, challenging, and uplifting, and museum learning is seen as more in line with the type of work real scientists do than that of most classroom science (Braund and Reiss 2006a; Eshach 2007; Guisasola, Morentin, and Zuza 2005). Bridging school science with the science offered outside of the classroom, such as that which can be experienced in a science museum, in a focused and purposeful way offers the potential to allow children to experience authentic practical work, access rare material, stimulate further learning, and work collaboratively with peers to significantly improve scientific literacy and enthusiasm for science (Anderson, Kisiel, and Storksdieck 2006; Braund and Reiss 2006a; DeWitt and Storksdieck 2008; Melber 2003).

Background Information

This school-museum partnership involves a large science museum in the United States' Pacific Northwest and a nearby public, urban, kindergarten to fifth grade, arts-focused, elementary school. The school and museum agreed upon a partnership program in the 2007–2008 academic year to commence in the 2008–2009 academic year. The objective of the partnership program was to provide the school a way to customize museum programming such that pre-planning and pre-payment could ease a time-intensive process for teachers. In addition, pre-payment would ensure equitable program access to all classes and students in the school. If the school-museum partnership objectives were met, teachers would presumably have more time to meaningfully integrate museum resources with the formal curriculum and deepen student science learning.

The school's administrator first proposed the school-museum partnership to the parent community in January 2008 as a way to increase science learning for students at the art-focused school. The partnership would help students make natural connections between science and art, thereby improving science literacy and enthusiasm for science. It was thought that this partnership could potentially positively influence student test scores in science over the long term. Parents raised $7,300 to fund the partnership during the school's annual fundraising auction in February 2008.

In April 2008, a partnership design was drafted by the school's administrator and the museum partnership managers, with liaison assistance from the researcher who is a volunteer at both the school and the museum. It was during this time that the researcher chose to engage in the process of formally evaluating both the cognitive and affective student learning outcomes of the partnership in partial fulfillment of the requirement of her masters of science degree in Curriculum and Instruction.

Partnership Design

This partnership included four key learning experiences: (1) staff training in inquiry-based learning, (2) an all-school assembly highlighting the link between art and science, (3) two additional learning experiences to be determined by the teacher grade-teams based on planned curriculum for the year. This range of activities was expected to inform teachers at the school of the resources available at the museum, introduce the students to the links between science and the arts, and ensure equitable access to partnership activities for all students.

Staff training in inquiry-based learning

The partnership began with school educators attending a two-hour training at the museum. Prior research has indicated the importance of such training to the success of school-museum learning (Anderson, Kisiel, and Storksdieck 2006; Price and Hein 1991; Eshach 2007). The purpose of this particular training was to introduce teachers to the partnership, the informal learning environment at the museum, the museum educators, and the programming opportunities, as well as to provide a refresher on inquiry-based learning. The training occurred in May 2008 based on the assumption that grade-teams would then have time to conceptualize and plan how to incorporate the partnership opportunities into the curriculum. During the training, school educators were provided with examples of the integration of art and science concepts as the arts are the lens through which much is taught and learned at the school.

All-school assembly

At the beginning of the partnership year, September 2008, a kick-off assembly occurred with the theme, “physics of juggling.” This assembly was chosen because the content integrated the theatrics of juggling with the science of physics. In their fifteen-year study of school-museum science programs, Price and Hein (1991) found that very rarely is the science area of physics addressed with younger children. Additionally Beck’s study (2008) highlights how juggling makes learning physics concepts engaging, fun, and exciting for elementary students.

Two additional learning experiences

The specifics of the remaining two experiences varied by grade-team based on the needs of the classroom, the planned curriculum, and students’ needs. A menu of options was available to teachers including: (1) museum outreach educators visiting student classrooms to teach on a selected science topic, (2) class visits to the museum including private instruction in a lab, or (3) class visits to the museum including a visit to the planetarium or a tour of the museum's submarine. Increased effectiveness of school museum programs have been noted when teachers have choice and influence in the content delivery (DeWitt and Storksdieck 2008; Price and Hien 1991). All teachers chose a combination of school visits and/or museum visits.

Purpose of the Study

The goal of this partnership was to collaboratively leverage, integrate, and focus resources to improve cognitive and affective student science learning. The purpose of this study was to investigate the effect of school-museum partnership activities on the cognitive and affective learning gains of students involved in the program. The researcher sought to answer the questions:

(1) How does adding focused scientific learning in the form of an elementary school science museum partnership affect students' scientific literacy and enthusiasm for science?

(2) In what ways does this experience influence the out-of-school scientific interests of students?

Definition of Terms

School-museum partnerships by nature vary greatly in terms of what is offered (Melber 2003; Price and Hein 1991). In this paper, the term school-museum partnership refers to the unique characteristics of this particular partnership as described in the background section of this paper.

Formal learning refers to the formal learning in the classroom taught and evaluated by the teacher, such as an inquiry-based classroom activity of a science concept. This definition is based on the Commission of the European Communities (2000) definition.

Non-formal learning refers to purposeful teacher-planned learning activities that support the formal learning in the classroom but are not taught by the teacher or evaluated, such as learning on field trips at a science museum. This definition is based on the Commission of the European Communities (2000) definition.

Informal learning refers to learning that is not directed, taught, or evaluated by the teacher, such as free-choice activities at school, home, or museum. This definition is based on the Commission of the European Communities (2000) definition.

Bridging of formal, non-formal, and informal learning in the context of this research study is conceptualized on a continuum where non-formal learning sits somewhere between formal and informal learning to varying degrees (Colley, Hidkinson, and Malcome 2002).

Scientific literacy is the ability of an individual "to ask, find, or determine answers to questions derived from curiosity about everyday experiences," (National Research Council 1996, 22). In the context of this research study, scientific literacy relates to cognitive learning about science.

Cognitive learning refers to the conceptual learning goals [content knowledge] related to the formal [science] curriculum (DeWitt and Osborne 2007). This includes learning about what science is, the work of scientists, as well as specific subject knowledge, for example understanding of simple machines.

Enthusiasm for science, where enthusiasm is defined as intense and eager enjoyment (Merriam Webster 2009). In the context of this research study enthusiasm relates to affective learning related to science.

Affective learning is the enjoyment, interest (DeWitt and Osborne 2007), self-concept, and motivation (Delcourt, Cornell, Goldberg 2007) of students doing science.

Out-of-school scientific interest refers to the informal interest of students doing or learning in scientific ways in day-to-day life, outside of formal or non-formal learning environments such as at home.

Review of Related Literature

The differences between school and museum learning environments are first reviewed in order to demonstrate how they can be combined or bridged and to clarify terms for the purpose of this paper. Literature exploring the different ways students learn science are then reviewed to gauge various aspects of cognitive and affective learning gains within the non-formal learning environment. Finally, the broad array of factors that can affect school learning in non-formal learning environments, such as museums, and the benefits and challenges associated with school-community collaborations are explored to identify broad factors that can play a role in influencing student learning gains.

Bridging school and museum learning

Schools and museums have different broad approaches to learning that are somewhat juxtaposed. Understanding these different perspectives reveals some of the complexities encountered when bridging learning between schools and museums. The three broad approaches to learning are referred to as formal learning, informal learning, and non-formal learning. It should be noted that there is some disagreement in the literature regarding the definition of these terms that is not fully explored in this paper (Colley, Hodkinson, and Malcom 2002; Eshach 2007).

Schools, historically, are seen as formal learning institutions. Reasonable agreement can be found for the definition of formal learning as that which is a structured learning experience in the classroom, led by the teacher, evaluated, sequential, and compulsory (Colley, Hodkinson, and Malcome 2002; Eshach 2007). Completing an assigned science investigation in the school classroom would be an example of formal science learning.

Science museums, on the other hand, are informal learning institutions. Informal learning is commonly defined as unstructured, voluntary, non-sequential, and usually learner led (Eshach 2007). Often in the literature, out-of-school learning is used interchangeably with informal learning, yet definitions of informal learning can include everything from "all learning out-of-school" (which by this definition would include school field trips) to "all things learned in free time in day-to-day life" (which arguably could take place at school) (Eshach 2007). Spontaneously choosing to go to and explore a museum engaging in whatever activity or exhibit that seems interesting, such as experimenting with a bottle rocket installation, would be an example of informal learning.

Non-formal learning is a term that is, at times, used to describe the bridging between formal and informal learning, taking an intermediary position between the two with varying degrees of factors from both approaches. Eshach (2007) describes non-formal learning as that which occurs in a "planned or prearranged manner in institutions, organizations, and situations beyond the spheres of formal or informal education. It shares the characteristic of being mediated with formal education, but the motivation for learning may be wholly intrinsic to the learner" (Eshach 2007, 173). Non-formal learning can occur at an institution out-of-school, or can occur in school led by a community institution or individual, and is not usually evaluated (Eshach 2007). Using this definition, a school field trip to a science museum would be an example of non-formal science learning, as would a program led by an outreach science educator in the classroom.

When reviewing the literature on bridging informal and formal science learning, much of the terminology seems to come down to perspective, context, and purpose. The term non-formal learning is used only rarely in the literature when referring to science museums, yet there is clearly an understanding of the complexities involved with bridging between formal school and informal science museum learning. For example, The National Science Foundation funded the Center of Informal Learning and Schools (CILS) in 2002 to support research and build leadership to address the challenges involved with effectively bridging informal learning and schools (CILS n.d.). For the purpose of this paper the term non-formal learning is used to describe the bridging of informal and formal learning.

Different ways students learn in non-formal learning environments

From the teacher perspective it is generally important that students have cognitive gains (gains in understanding specific scientific concepts and ideas) in learning when engaging in non-formal learning activities, whether it is to extend on ideas already learned in the formal environment or to explore and learn about new concepts all together

(DeWitt and Storksdieck 2008; Guisasola, Morentin, and Zuza 2005; Melber 2003). There is much contradiction in the research about whether or not field trips are effective in bringing about cognitive learning gains in students, most identify that the potential for learning is there, if conditions are right (DeWitt and Osborne 2007; DeWitt and Storksdieck 2008; Eshach 2007).

There is an emerging set of research that points to the need to broaden the definition of what constitutes valid cognitive outcomes in non-formal school-museum interactions (DeWitt and Storksdieck 2008; Guisasola, Morentin, and Zuza 2005). Cognitive outcomes can be linked to the broader scope of scientific literacy, which is the ability of an individual "to ask, find, or determine answers to questions derived from curiosity about every day experiences" (National Research Council 1996, 22). When these broader ideas of scientific literacy are applied to cognitive learning objectives, such as the process of learning about science, and the awareness of life-long learning community infrastructure (museums), there is a greater likelihood that cognitive learning goals will be attained during non-formal, school-museum interactions (DeWitt and Storksdieck 2008).

Affective learning is measured far less frequently during non-formal learning experiences (DeWitt and Storksdieck 2008). Affective learning can take the form of a sense of wonder, interest, enthusiasm, motivation, and eagerness to learn (Eshach 2007). "It is necessary to realize that science museums do not have objectives that are centered exclusively on improving knowledge of scientific concepts, but that they usually push objectives which are more widely related to culture, personal development, attitudes, and socialization (Guisasola, Mornin, and Zuza 2005; Tran 2006)." The importance of promoting positive attitudes should not be underestimated. Positive attitudes have been reflected in improved performance in related formal learning settings (DeWitt and Osborne 2007). Additionally, many scientists report making a positive connection with science in the early grade-school years (Eshach 2007).

Factors affecting learning potential in non-formal learning environments

Over 20 years of research has resulted in a common set of recommendations for teachers to implement in order to increase the learning potential on school trips to informal learning environments (Anderson, Kieisel, and Storksdieck 2006; DeWitt and Storksdieck 2008; DeWitt and Osborne 2007; Eshach 2007). Some of the variables that teachers can influence include orienting the students to the setting to reduce the novelty factor, clarifying learning objectives, aligning activities with curricular goals, taking advantage of the uniqueness of the setting, and ensuring quality preparation and follow-up experiences for students.

More recently it has been noted that the extent to which museums are able to support teachers in addressing these variables can play an important role in positively affecting student learning outcomes (Anderson, Kisiel, and Storksdieck 2006; DeWitt and Osborne 2007; DeWitt and Storksdieck 2008). A gap often exists between teacher aspirations and teacher practice during non-formal learning experiences, due in part to lack of time created by an overcrowded curriculum (Anderson, Kisiel, and Storksdieck 2006).

The alignment of teacher and science museum learning goals is an area that is often in disequilibrium, meaning that schools and museums do not always share similarities in learning objectives (DeWitt and Starksdieck 2008; Price and Hein 1991).

For example, museum educators might align with informal learning objectives to entertain and inspire ongoing interest and inquiry on a broad array of scientific knowledge, in contrast with teachers' learning objectives to have students engage in direct learning on a specific curricular understanding, such as being able to describe insect habitats, as is common in formal learning contexts. Rarely is there opportunity for teachers and museum education staff to dialogue prior to the field trip visit to reconcile these differing planned outcomes (DeWitt and Storksdieck 2008; Anderson Kisiel and Storksdieck 2006).

School-community partnerships: Challenges and benefits

Literature regarding school-community partnerships underlines long-term benefits of such collaborations as contributing to building and maintaining healthy communities (Sanders 2003). While community partnerships have great benefits, there are also potential barriers. Sanders (2006) emphasizes that successful partnerships require leadership from those who are experienced in collaboration. Sanders' studies (2003, 2006) highlight pragmatic barriers such as lack of time, attitudinal barriers, and professional barriers that contribute to less than successful partnerships. Other issues that have commonly been noted to occur in school-community partnerships include individuals neglecting the process to get the job done, trying to do too much with too little, and failing to follow through (Sanders 2006). Time for reflection and evaluation are most critical in working to create successful school-community partnerships (Sanders 2003).

In summary, there are potential benefits and challenges when engaging students in non-formal learning experiences such as partnerships between schools and museums.

Non-formal learning experiences have the potential to create a more rich and vibrant learning environment for students that is closer to the real work of scientists. Other potential benefits include increasing scientific literacy through a broader definition of cognitive learning goals, as well as increasing student enthusiasm for science through a conscious focus on affective learning goals. Learning outcomes are more likely to be realized when schools and museums communicate and synchronize learning objectives and then work together to realize them. This requires clear consistent communication, reflection, and evaluation among all stakeholders involved including: students, teachers, parent volunteers, administrators, museum educators, and museum partnership coordinators.

Methodology

This study employs a mixed method design to answer the research questions: How does adding focused, science learning in the form of an elementary school-science museum partnership effect students' scientific literacy and enthusiasm for science? In what ways does this experience influence the out-of-school science interests of students?

A quantitative pre-experimental design of a one-group pre-test, post-test was combined with a qualitative grounded-theory design. The grounded-theory design was chosen in part for the iterative process in working to answer the research question primarily through coding and recoding double-entry field notes, informal interview notes, and research journal pages to identify themes in relation to the research question. It was also chosen, in part, because of its similarity to action research design that would be used by a practitioner in a classroom.

The pre-experimental, single group pre-test, post-test was chosen because of the challenges of access to a random sample of students in the school. Also, no control group was available as the whole school was involved in the partnership. The dependent *t* test scores provided a different lens to view the research questions and data were triangulated with the qualitative results in relation to the research questions.

Participants

Of the 18 classes in the school, one first grade class of 29 students, age six and seven, and their parents were selected as the sample of the population. The class was a representative subset of the diversity of the school population consisting of approximately 79 percent White, five percent Hispanic, five percent Asian, five percent African American, and six percent Multiple Ethnicities.

This single group selection was chosen, in part, because of the teacher's enthusiasm towards engaging in the project, the teacher's 14 years of teaching experience, the researcher's knowledge of the teacher's program having been a parent of a child in the class the previous year, and the confirmed flexible access to the class and research participants. In essence, the class was selected much as an action teacher-researcher would select their own class.

Materials

Four worksheets were created by the researcher, along with three scoring guides. The worksheets and scoring guides are described below. Additional materials used included pencils, crayons, and a field notebook.

Science is… feelings worksheet. A "Science is…" feelings concept map worksheet was created with the intention that, before and after partnership activities, students would use pictures and words to create an image of how science makes them feel (Appendix A). This worksheet was created to measure changes in enthusiasm for science and affective learning gains using a dependent *t* test. The "Science is…" scoring guide (Appendix B) was created by the researcher based on identified indicators of enthusiasm and affective gains in learning (Eshach 2007).

Draw a scientist worksheet. A "Draw a Scientist" worksheet was adapted from the work of Chambers (1983) with the intention that before and after partnership activities, students would draw their perception of a scientist (Appendix C). This worksheet was created to measure enthusiasm for science and affective learning gains by measuring student attitudes about the work of scientists using a dependent *t* test. This same test was also intended to measure participants' scientific literacy and cognitive learning gains through understanding of the work of a scientist. The "Draw a Scientist" scoring guide (Appendix D) was adapted by the researcher from the work of Chambers (1983) in order to score participants' responses.

Science concept worksheet. A "Simple Machines" concept map worksheet (Appendix E), along with a "Paleontology" worksheet, were created with the intention that before and after partnership activities students would use pictures and words to explain the described set of science concepts. Worksheets were created to measure scientific literacy and cognitive learning gains through understanding of a specific scientific concept using a dependent *t* test. The "Simple Machines" scoring guide (Appendix G) was created by the researcher based on field notes from the trip to the museum reserve lab to score participants' responses. A paleontology scoring guide was never created because it was not used. See procedure for explanation.

Family homework assignment worksheet. A “Family Homework” worksheet (Appendix H) was created with the intention that after the partnership activities, students would work with those at home to identify four things[*] that were scientific around their house and then answer four additional questions including: What is science? What are your favorite things about science? Why? What are your least favorite things about science? Why? Are you a scientist? Why or why not? Parents were then invited to add any additional notes about their child’s interest in science. This worksheet was created to measure out-of-school scientific interest of students. The worksheet was qualitatively coded by question.

Procedure

In late October 2008, after consent forms were collected from parents, students were to complete the three pre-test worksheets on separate days. The cooperating teacher taught a short mini-lesson in a whole-group setting, where she explained the “Science is…” feelings worksheet and how to complete it. Students then returned to their seat to map their feelings.

During the initial data collection stage of the research project, the cooperating teacher had a family tragedy and she took an extended leave of absence. This halted the data collection process and, thus, only feelings maps data were collected prior to the juggling assembly and paleontology partnership activity, both of which occurred in early November. The researcher continued to take field notes on partnership activities and volunteered in the classroom, building relationships with the students. It was during this time that the researcher worked out a more effective way to collect worksheet data from

[*] The word “things” was chosen because of its common use and understanding among first grade students to reference “anything.”

students. After much discussion, the researcher chose to focus data collection on the third partnership activity, a simple machines partnership activity, which occurred at the museum in early March 2009. The revised data collection procedures are described below.

In January 2009 student data collection resumed starting with the "Draw a Scientist" activity. The researcher sat with small groups of two to four, asking students to "Draw a picture of what you think a scientist looks like. Draw whatever you think, don't worry about what your neighbor is drawing." Students were provided with pencils and crayons. While students completed the sheets, the researcher simultaneously took field notes about what students were discussing while drawing, asking occasional questions for clarification.

In February 2009 students completed a similar activity with the simple machines worksheet about balls, ramps, and levers.[*] Upon completion of the worksheet students were asked to review the "Science is…" feeling sheets to see if they agreed with what they initially completed. The researcher took field notes about what the participants discussed.

In early March 2009 the researcher shadowed the class in the reserved lab at the science museum, taking double-entry field notes and then stationed herself at a hands-on da Vinci exhibit involving simple machines that students attended after the reserved lab. The researcher recorded observations of students' interaction with these simple machines.

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[*] The terms "Balls, Ramps, and Levers" were chosen because these were the names the cooperating teacher gave to the unit on simple machines and how the teacher referred to the names of the simple machines.

These field notes were used to identify specific activities that students experienced during the partnership program.

Post-test data collection commenced in late March 2009 and was completed in April 2009 in the same fashion as the pre-test with the additional prompt: "Now that you have been studying science, what do you think about…."

The family homework assignment was handed out in late March 2009 and participants were asked to return it in two weeks. Reminder notices were sent home via the teacher's newsletter.

Pre- and post-data were numerically coded according to scoring sheets and dependant *t* tests were conducted. Field notes were transferred to a word processing document and coded into emergent themes. Family homework responses were transferred to a word processing document and questions were coded according to emergent themes.

Results

"Science is…" feelings activity quantitative data results from pre- and post-tests

A dependent samples *t* test was performed comparing the mean feelings about science score before (M = 2.37, SD = 1.74) and after (M = 3.42, SD= 0.96) the partnership program. The alpha level was .05. This test was found to be statistically significant, $t(18) = -2.97$, $p < .05$. This test indicates that the partnership program did significantly increase positive feelings about science.

"Science is…" feelings activity qualitative data results from pre- and post-tests

Nineteen students completed both pre- and post-tests regarding their feelings about science. Eighty-four percent of pre-test respondents made positive, yet simple, comments about science (e.g., "It is fun;" "I like it;" "I love it") while 16 percent made comments suggesting they were not positive about science (e.g., “It’s boring;” “It’s too tiring”). In comparison, post-test responses were more contextualized. Sixty-eight percent of respondents made positive comments about science, all in greater frequency (more than two comments) than in the pre-test (e.g., “It’s good;” “magnificent;” “perfection;” “exciting”). Fifty-four percent of these responses contained justification for positive response (e.g., “I like it [science] because you discover things;” “science activities and experiments make me feel good;”;“It [science] is interesting and fun because I like working with simple machines and making electrical stuff”).

Other themes that emerged in both pre- and post-tests include 79 percent of students identifying science topics when asked to draw and write about their feelings towards science in the pre-test (e.g., “Dinosaurs;” “Robots”) versus 21 percent in the post-test. Science skills (e.g., “thinking;” “exploring;” “listening”) emerged in pre-test at 21 percent and post-test at 26 percent. Five percent in both pre- and post-tests discussed the social aspects of science (e.g., “working with others;” “making friends while working on school”). No reference to the museum was made in the post-test of feelings about science. Table 1 summarizes themes from student discussions.

Table 1. "Science is…" feelings activity qualitative coding result summary

Responses (N=19)	Pre-test (no.)	Post-test (no.)
positive comments (simple*)	16	6
positive comments (contextualized**)	0	7
negative comments	3	3
science topics	15	4
science skills	5	6
social aspects of science	1	1
museum references	0	0

*Positive comments (simple) refers to responses such as "I like science."
**Positive comments (contextualized) refers to responses in context such as "I like science because I discover things."

Draw a Scientist quantitative results from pre- and post-activities

A dependent samples *t* test was performed comparing the mean image of scientist score before (M = 18.90, SD = 2.73) and after (M = 19.45, SD= 2.30) the partnership program. The alpha level was .05. This test was not found to be statistically significant, $t(19) = -0.91$, $p > .05$. This test indicates that the partnership program did not significantly improve student images of scientists.

"Draw a scientist" qualitative results from pre- and post-activities

Twenty students completed both the pre- and post-test activities about their attitudes and perceptions of scientists. Twenty-five percent of students in the pre-test indicated that they did not know what a scientist looked like and drew various images. In the post-test 80 percent of these students described an image of a scientist in a lab while the remaining one student indicated he was still unsure of what a scientist looked like. Fifteen percent described a person not related to a scientist or a mad scientist in the pre-test and in the post-test two describe a laboratory scientist while the third remains a person not related to a scientist. Twenty percent of students described images of a scientist in a laboratory environment in the pre-test. Of these students, 50 percent described scientists in the lab in the post-test, 25 percent described a mad scientist, the other 25 percent described a scientist in an outdoor environment. Thirty-five percent of students drew scientists in a scientific environment outside of a lab in the pre-test. Of these students 57 percent described their scientist in a similar or different setting outside of the lab and 43 percent personalized their description indicating they were drawing themselves (see Figure 2) or their teacher. Additionally, 16 percent contained influences from popular culture including Tinker Bell (see Figure 1), Captain Underpants, and Indiana Jones.

Table 2. Descriptions of scientists during "Draw a Scientist" activity

Change pre- to post-activity	Number of students n=20
remained the same positive	5
remained the same stereotypical*	2
remained the same unknown**	2
changed to a more positive image of a scientist	4
changed from unknown to image of a scientist	6
changed to a less positive image of a scientist	1

*Stereotypical represents a scientist in a lab coat working in a lab.
**Unknown represents students who indicated that they were not sure what a scientist was and drew a person anyhow as well as those images that did not represent the work of a scientist.

Figure 1. Student 18 pre-test "Draw a Scientist" test

Figure 2. Student 12 post-test “Draw a Scientist” test

Simple Machines quantitative results from pre- and post-activities

A dependent samples *t* test was performed comparing the mean simple machine understanding score before (M = 4.05, SD = 1.61) and after (M = 4.80, SD= 1.64) the partnership program. The alpha level was .05. This test was found to be statistically significant, $t(19) = -2.26$, $p < .05$. This test indicates that the partnership program did significantly increase understanding about simple machines.

Simple Machines qualitative results from pre- and post-activities

Nineteen students completed both the pre- and post-test activities on balls, ramps, and levers. In the pre-test 79 percent of respondents described ramps as “things that go down” in comparison to 100 percent of respondents in the post-test. The remaining 21 percent in the pre-test indicated that they did not know what ramps were. Fifty-three percent of students in the pre-test described ramps in relation to balls (e.g., “ Balls roll down ramps”) while 26 percent described ramps with no relation to balls (e.g., “Balls bounce and skateboards go down ramps”). No respondents in the pre-test indicated that ramps could be used to go up, while in the post-test five percent described ramps for this purpose.

Thirty-two percent of students gave a description of levers in the pre-test in comparison to 47 percent in the post-test. In the pre-test 83 percent of the six descriptions were misconceptions, (e.g., “Levers are on springs and lift things up,” Figures 3 and 4) in comparison to 78 percent of the nine descriptions (e.g., “Levers make things fly”). Eleven percent of students made direct references to their museum experience when describing levers in the post-test.

Table 3. Descriptions of Ramps* and Levers

Number of students n=19	pre-test	post-test
no description of a ramp	4	0
description of ramp with misconceptions**	0	0
basic*** description of a ramp	15	18
complex description of ramp	0	1
no description of lever	13	10
description of lever with misconceptions	5	0
basic description of lever	1	7
complex description of lever	0	2

*Ramps is the term used for incline plane by the teacher.
**Misconception refers to an incorrect description of the simple machine.
***Basic refers to a description of only one aspect of the simple machine.

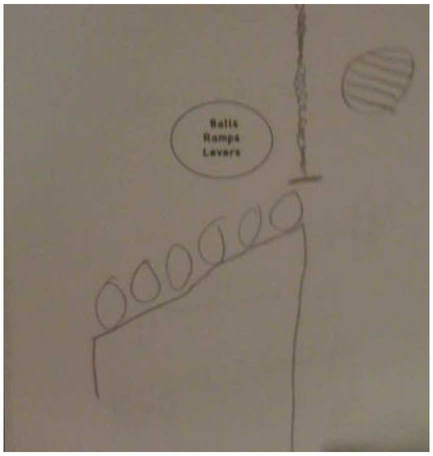

Figure 3. Student 6 Pre-Test Simple Machines

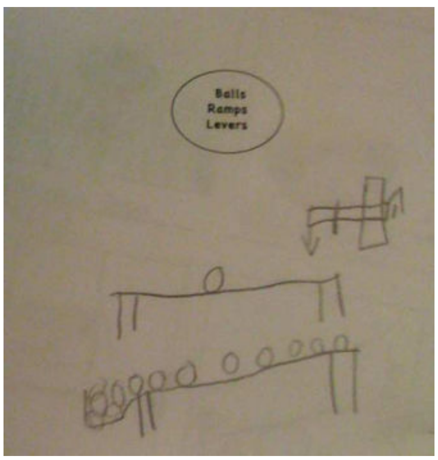

Figure 4. Student 6 Post-Test Simple Machines

Family Homework results on out-of-school learning

Ten family homework assignments were returned. The first question asked students to draw four pictures of science around the home. Of the 40 images, 48 percent were life sciences (e.g., "plants;" "dogs;" "germs"), 30 percent were of physical sciences including technology (e.g., "computer;" "electricity;" "car"), 18 percent were of chemical sciences (e.g., "spa science kit;" "ice cubes melting;" "cooking bread"), and 5 percent were of Earth sciences (e.g., "rocks").

In response to the question "What is science?" 60 percent of the students indicated science was an active process (e.g., "discovering stuff;" "figuring things out;" "experimenting") and 40 percent related science to learning about specific topics (e.g., "learning about chemicals and machines;" "learning about the world;" "volcanoes;" "rocks"). All of the students who referred to science topics had a connection to topics learned at the museum (e.g., "levers").

Nine responses were completed for the questions "What is your favorite thing about science? Why? What is your least favorite thing about science? Why?" Sixty-seven percent of the students indicated that the process of doing science was their favorite thing (e.g., "testing to see if it works") and 33 percent indicated that science topics were their favorite (e.g., "fossils;" "chemicals"). Forty-four percent of the students indicated that they didn't have any least favorite things about science. Twenty-two percent indicated that their least favorite part about science was when it gets confusing, and 11 percent each indicated that social aspect (e.g., "frustrated with partner"), process (e.g., "frustrated when it doesn't work"), or controls (e.g., "when we have to be careful") was their least favorite part.

Of the nine responses to the question, "Are you a scientist? Why or why not?" 100 percent indicated "yes." Sixty-seven percent indicated yes because they could do the process of science (e.g., "I discover things;" "I figure things out;" "I use scientific tools"). Twenty-two percent indicated that they are a scientist because "everyone is." Eleven percent related being a scientist to liking a science topic (e.g., "Yes, because I like volcanoes").

Table 4. Summary of Family Homework responses

Questions	Number of students n=9 *n=10
What is science?*	
an active process	6
learning about a topic	4
Like best about science?	
doing the process of science	6
learning about a specific topic	3
Like least about science?	
nothing	4
confusing	2
frustration (social or process)	3
Are you a scientist?	
yes	9

Seven parents made additional comments on the family homework sheet about their child's interest in science at home. Fifty-seven percent of the parent responses included a note about the connection between science learning at the museum and how it has increased their child's interest at home. Eighty-six percent of parent responses included notes about scientific play at home.

Discussion

How does adding focused scientific learning in the form of a science based elementary school-museum partnership affect students' scientific literacy?

The results point to two areas of improved scientific literacy: (1) increased understanding of how simple machines (specifically how balls, ramps, and levers) work together, and (2) increased understanding of who a scientist is and the work of scientists. There is strong evidence that the museum partnership activities played a role in increasing the former, however there is little evidence to suggest that museum partnership activities played a role in increasing the latter.

The results of the dependant *t* test measuring the student understanding of simple machine concepts indicates that student understanding of simple machines did increase. The field notes from the students agreed with this. Twenty-six percent of students deepened their explanation of ramps, and 53 percent deepened their explanation of levers. This happened despite the fact that there was a disconnect between the terms used in class and the museum when referring to incline planes. Incline planes were described and referred to by the teacher as ramps, while the museum educators used the more scientific term of incline planes. Also, the teacher had intended to teach the students about levers when the program was set up at the beginning of the year, however, due to time constraints, the topic of levers was not addressed in the formal class. Students were introduced to this concept only during the museum visit. In the post-test discussions with students about levers, students gave descriptions of museum activities to explain their basic understanding of levers as simple machines. It is with reasonable confidence that the addition of the partnership program activities did increase students' scientific literacy in understanding simple machines, particularly that of levers.

Students gained an increased understanding of who a scientist is and the work of scientists, though no link was found to say that the museum partnership activities were the reason for this increase. The Draw a Scientist Test (DAST) created by Chambers (1983) was intended to measure student attitudes towards scientists. Chambers' test makes the assumption that students know what a scientist is. When recording field notes with students, it was noted that 35 percent of children explained that they did not know what a scientist looked like and could not describe what scientists did. During the post-activities all students but one explained that they knew who a scientist was. Of those who explained they knew who a scientist was, only one student explained someone who was in no way related to scientist. Some students explained their final picture of a scientist as themselves. Only one student referred to those at the museum as being scientists. While this result showed an improvement in understanding who scientists are and the work of scientists, there is little evidence that experiences at the museum had any influence on this new understanding.

How does adding focused science learning in the form of an elementary school science museum partnership effect students' enthusiasm for science?

The results point to two areas of improved enthusiasm for science. The first is students' feelings about science and doing science. The second is in reference to student attitudes towards scientists. There is some evidence that the museum partnership activities played a role in increasing the former, however there is little evidence to suggest that museum partnership activities played a role in increasing the latter.

The results of the dependant *t* test measuring the student feelings toward science indicate that students' positive attitudes toward science did increase. The field notes indicate that 16 percent fewer students had positive comments about science at the end of the partnership; however 37 percent of students who responded positively included justifications as to what it is about science that made them feel positive. There was no increase in comments that were not positive, instead students made comments about science skills or topics when referring to their feelings. No comments were made linking the museum to students' feelings about science. Field notes were recorded during museum visits and all but one note indicates the positive affect of students while engaged in the scientific activities. Additionally, 57 percent of the parents of students who returned the family homework assignment wrote a note about the connections between the museum visits and the increase in their child's interest in science noticed at home. Overall, students' positive attitudes towards science did increase. While there is an indication in field notes during partnership activities and the family homework assignment that partnership activities did play a role in increasing the students' positive attitudes towards science, it is not possible to say to what extent.

The dependent *t* test did not show significant improvement in student images of scientists. This is likely because, as noted earlier, the test makes the assumption that students know who a scientist is. In the pre-test 40 percent of the students did not know what a scientist was, which affected the scores negatively based on the initial drawings. Field note data, on the other hand, indicated that 50 percent of students changed their description of a scientist to a more personally relevant one. Fifteen percent of students described themselves or their teacher as a scientist while only one student discussed a museum staff member in relation to scientists. In the family homework assignment question, Are you a scientist? Why or why not?, completed by nine students, all students responded "yes." The overall data point to students' increased positive attitudes towards scientists however there is little evidence to say that the museum partnership activities played a role in change.

In what ways does adding focused scientific learning in the form of an elementary school science museum partnership influence the out-of-school scientific interests of students?

The 10 responses collected (one-third of the students in the classroom) all indicated scientific interests out of school. Of the respondents, 57 percent of their parents specifically pointed to museum partnership activities as contributing to this interest.

Limitations

The design of this partnership is unique to this school, which makes the results difficult to apply to other school museum partnership designs. Also, within the school, each grade level experienced different partnership activities. Within the first grade, all three of the teachers did not necessarily integrate the museum experiences into classroom learning in the same way. Thus the results are unique to this class during this school museum partnership experience.

The students in this school were mostly from middle-income families. Most of the students had been to the museum on previous occasions and many of the students' families had a membership to the museum. These results may not have been the case with a group of students in a lower socio-economic status and/or who had no previous experience with the museum.

Limitations also exist in the nature of working with students in classrooms, as the researcher must adapt to classroom changes including absent students and teachers. Approximately two-thirds of students in the class completed both pre- and post-tests related to scientific literacy and enthusiasm towards science and only one-third of students and families responded to the inquiry into out-of-school learning connections. In addition, extenuating circumstances limited the researcher's pre- and post-data collection to a single museum experience instead of the planned two museum experiences.

Finally, the researcher's use of created and adapted tests and scoring methods that had not been tested for validity also has implications for the interpretation of results.

Conclusions and recommendations for further study

Adding focused scientific learning in the form of an elementary school-museum partnership increased students' scientific literacy of scientific content knowledge (simple machines) and enthusiasm for doing science. There is some limited evidence that out-of-school scientific interest is also increased because of student involvement in the school-museum partnership. There is little evidence however, that the museum partnership activities played a role in increasing student understanding of who scientists are, or what scientists do, or in increasing student positive attitudes towards scientists.

Recommendations for further study

Research is needed on the effects of making more explicit the connection of museum educators as scientists during interactions with school children. Research is also needed on the affects of sharing learning objectives between the classroom teacher and the museum educators *before* the museum visit.

A better understanding is needed of how teachers go through the process of integrating science museum activities into their class curriculum. How do teachers select science museum activities for their classes? What effect does the added museum experience have on influencing student learning? As well, research studies that focus on the classroom perspective of this process are particularly rare.

The family homework assignment used in this study, while limited in response, seemed to offer rich, detailed information about students' at-home, out-of-school connections with science as a result of museum visits. The use of similar tools to understand the nature of the longer-term effects on science interest resulting from museum activities seems promising. It is possible that this homework assignment stimulated scientific discussion at-home, engaging parents in their children's learning about science. Research on the effectiveness of an at home extension after class visits to the science museum could be useful in increasing out-of-school scientific interest.

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Appendix A

Name: ____________________________

How does science make you feel? Do you like doing science? Draw and write out your feelings about science below. Draw lines to connect your ideas.

Science is…

Feeling Pre/Post-Assessment Student Identification Code: ____________________________

Appendix B

Science is Feelings Checklist

Author # Pre Test Post Test

Drawing/Writing

One dislike comment	=1
Two or more dislike comments	=2
One like comment	=3
Two or more like comments	=4

Appendix C

13

Name: ___________________________

Draw a picture of a scientist in the box below. What does a scientist look like? What do they wear? What do they do? Where do they work?

D.A.S.T. Pre/Post Assessment Student Identification Code__________________

Appendix D

Draw-A-Scientist Test Checklist Revised

Author # Pre Test Post Test

Drawing

Lab coat	Yes=1	No=2		
Eyeglasses	Yes=1	No=2		
Facial hair	Yes=1	No=2		
Pens/pencils in pocket	Yes=1	No=2		
Unkempt appearance	Yes=1	No=2		
Symbols of science	Yes=1	No=2		
Gender	Male=1	Female=2	Neutral=3	Both=4
Ethnicity	Caucasian=1	Diverse=2	Neutral=3	Both=4
Setting	Neutral=1	Laboratory=2	Other=3	
Overall image	Eccentric=1	Sinister=2	Neutral=3	Natural=4

Appendix E

15

Name: ___________________________

What do you know about Balls, Ramps and Levers? What are they? How are they the same? How are they different? Use words and pictures to show what you know. Draw lines to connect your ideas.

Balls
Ramps
Levers

Simple Machine Pre/post-Assessment Student Identification Code: ______________________

Appendix F

Simple Machines Concepts Checklist

Author # Pre Test Post Test

Drawing/Writing

Balls	Not present=0	Present=1		
Ramps	Not present=0	Present=1	Present with =2 objects going up OR down	Present with =3 objects going up AND down
Levers	Not present=0	Present=1	Present with =3 fulcrum OR with object	Present with =3 fulcrum AND with object
Overall	Not present=0	Working =1 independently	Working =2 together OR additional simple machine	working =3 together AND additional simple machine

Appendix G

Name

Family Homework Activity

In the squares below, draw pictures of science around your house.
Below write something to describe you picture.

Family Homework Activity

Discuss the following questions with your child and then write response:

What is science? ____

____

What are your favorite things about science? Why?______________________

____

What are your least favorite things about science? Why? ________________

____

Are you a scientist? Why or why not?_____________________________

____

Add any additional notes about your child's interest in science.