FOSTERING SCIENCE LITERACY, ENVIRONMENTAL STEWARDSHIP, AND COLLABORATION: ASSESSING A GARDEN-BASED APPROACH TO TEACHING LIFE SCIENCE

By

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ABSTRACT OF THE DISSERTATION

Fostering Science Literacy, Environmental Stewardship, and Collaboration: Assessing a Garden-Based Approach to Teaching Life Science

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Recently, schools nationwide have expressed a renewed interest in school gardens (California School Garden Network, 2010), viewing them as innovative educational tools. Most of the scant studies on these settings investigate the health/nutritional impacts, environmental attitudes, or emotional dispositions of students. However, few studies examine the science learning potential of a school garden from an informal learning perspective. Those studies that do examine learning emphasize individual learning of traditional school content (math, science, etc.) (Blaire, 2009; Dirks & Orvis, 2005; Klemmer, Waliczek & Zajicek, 2005a & b; Smith & Mostenbocker, 2005). My study sought to demonstrate the value of school garden learning through a focus on measures of learning typically associated with traditional learning environments, as well as informal learning environments. Grounded in situated, experiential, and contextual model of learning theories, the purpose of this case study was to examine the impacts of a school garden program at a K-3 elementary school. Results from pre/post tests, pre/post surveys, interviews, recorded student conversations, and student work reveal a number of affordances, including science learning, cross-curricular lessons in an authentic setting, a sense of school community, and positive shifts in attitude toward nature and working collaboratively with other students. I also analyzed this garden-based unit as a type curriculum reform in one school in an effort to explore issues of implementing effective practices in schools. Facilitators and barriers to implementing a garden-based science curriculum at a K-3 elementary school are discussed. Participants reported a number of implementation processes necessary for success: leadership, vision, and material, human, and social resources. However, in spite of facilitators, teachers reported barriers to implementing the garden-based curriculum, specifically lack of time and content knowledge.

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To my sisters and parents who were there to listen and taught me that anything is possible if you put your mind to it. And, to my alternate hands and arms, Cate and Jana, who were there to hug and care for my boys when I was working.

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CHAPTER 1

INTRODUCTION

Recently, schools nationwide have expressed a renewed interest in school gardens (California School Garden Network, 2006), viewing them as innovative educational tools. Most of the studies on these settings investigate the health/nutritional impacts, environmental attitudes, or emotional dispositions of students. However, few studies examine the science learning potential of a school garden from an informal learning perspective. The purpose of this case study was to examine the impacts of a school garden program at a K-3 elementary school. Results from pre/post tests, pre/post environmental and collaboration attitudes surveys, interviews, and recorded student conversations reveal a number of affordances. Affordances include student motivation, real-world experiences, science learning, an opportunity to teach about healthy eating, a sense of school community that was fostered, and shifts in attitude toward the environment and collaboration. I also analyzed this garden-based unit as a type curriculum reform in one school in an effort to explore issues of implementing effective practices in schools. Facilitators and barriers to implementing a garden-based science curriculum at a K-3 elementary school are discussed. Participants reported a number of implementation processes necessary for success: leadership, vision, and material, human, and social resources. However, in spite of facilitators, teachers reported barriers to implementing the garden-based curriculum, specifically lack of time and content knowledge.

My dissertation explores the value of school garden learning through a focus on measures of learning typically associated with the informal learning environment (Fisher-

Maltese & Zimmerman, in review). From the informal learning research literature, I developed a framework for what I am calling an informal learning lens (see Table 1) (Fisher-Maltese & Zimmerman, in review). This framework guides my analysis of learning that occurs in a school garden.

Table 1

Informal Learning Lens

NARST Description of Learning in Informal Environment (Dierking et al., 2003)	Additional Research on Learning in Informal Environments
Socially Mediated	Bell, et al., 2009; Ash, 2003; Ash, Crain, Brandt, Loomis, Wheaton, & Bennett, 2007; Borun, Chambers, & Cleghorn, 1996; Rowe, 2002; Eberbach & Crowley, 2005
Derived from Real-world Experiences in an Authentic Context	Bell, et al., 2009; Kisiel, 2003; Rennie, 2007
Self Motivated and Guided by Learner's Needs and Interests	Bell, et al., 2009; Informal Learning Environments Newsletter, May/June, 1998; Falk, 1999, 2001; Falk & Dierking, 2002
Voluntary	Bell, et al., 2009; Informal Learning Environments Newsletter, May/June, 1998; Falk, 1999, 2001, 2005; Falk & Dierking,

	2002; Rahm, 2002; Bamberger & Tal, 2007
Life-long	Bell, et al., 2009; Informal Learning Environments Newsletter, May/June, 1998; Falk, 1999, 2001; Falk & Dierking, 2002; Rahm, 2002

These measures of learning also tend to take into account shifts in attitude which can be important factors in learning. I argue that this broad view of learning and knowing can lead to the development of curricula and pedagogical approaches that maximize the use of these spaces for learning (Fisher-Maltese & Zimmerman, in review). In contrast, existing studies on school gardens that do examine learning emphasize individual learning of traditional school content (math, science, etc.) (Blaire, 2009; Dirks & Orvis, 2005; Klemmer, Waliczek & Zajicek, 2005a & b; Smith & Mostenbocker, 2005).This analysis provides a new and important contribution to the small but growing body of research on garden-based learning and provides further evidence for science learning and shifts in attitude toward the environment and collaboration in out-of-school contexts.

Summary of Research Questions

My dissertation attempts to answer three questions. Each of the three chapters comprising this dissertation focuses on one of the following questions: 1) How is student learning impacted when in the context of a school garden? (Chapter 2); 2) Does involvement in a garden-based curriculum lead to shifts in students’ attitudes toward the environment or collaboration? (Chapter 3); and 3) What factors are necessary for successful implementation of a garden-based science curriculum? (Chapter 4)

Theoretical and Historical Background

One exploration that is lacking from the literature is which learning theory can best be sued to understand learning in garden-based environments. I argue that garden-based learning can be understood using the following learning theories: experiential learning and situated learning.

Experiential learning. In 1977, James Coleman set forth his work on the experiential learning process, which is different than the assimilation process, the common mode of learning in the traditional classroom (Coleman, 1977). Kraft (1990) summarizes, "In the traditional classroom assimilation model, the student generally receives the information through a symbolic medium such as a lecture or book, and then assimilates and organizes the information so that the general principle is understood" (p. 184) In contrast, Coleman suggests that the experiential learning process is actually the reverse. There is no symbolic medium, at least initially, which transmits information. Instead, the learner engages in an action and sees the results of that action. The learner moves toward a new understanding by understanding the consequences of the action and applying it to new situations (Kraft, 1990). Coleman suggests that the assimilation model is used predominantly in schools because it requires less time to learn something new, while the experiential learning process is more time consuming. In spite of being less time efficient, Kraft (1990) summarizes why the experiential learning mode is preferential, "Motivation is intrinsic as actions with real consequences occur as the first step in the learning process. Finally, experiential learning seems to be more deeply etched into the brain of the learner, as all learning can be associated with concrete actions and events, not just abstract symbols or general principles" (p. 185).

Historically, experiential learning theory, and the use of nature and gardens in education, can be traced back to the writings of John Dewey and Maria Montessori 100 years ago, and even Jean-Jacques Rousseau 200 years ago. In the 1700s at the birth of the Enlightenment Period, Jean-Jacques Rousseau (1762) was one of the first to discuss the importance of nature and learning through experience in the growth and development of children. He puts forth his educational ideals in *Emile*, a semi-fictitious novel about the growth of a young boy. In *Emile*, Rousseau makes the conscious decision of rearing Emile in the countryside as opposed to the city to help him develop righteous ideals. Both the importance of returning to nature to get back to an original state and the presence of new experiences on which to reflect are poignant themes of his work. According to Barbara Beatty (1995), his criticism of education led to new teaching practices, “In place of formal instruction in reading or book learning, he prescribed informal learning experiences in which children explored the physical environment, observed objects in nature, and played games designed to enhance their sensory abilities” (p. 9).

At the turn of the century, Maria Montessori, an Italian educator, again emphasized the importance of nature and experience in education and recommended gardening as an activity for all students. Referring to the psycho-social benefits of gardening, she states, “Gardening leads children to the intellectual contemplation of nature, as well as an awareness of an appreciation for their environment” (Alexander, North, & Hendren, 1995, p. 260). She saw the value of students learning from real experiences in real settings. For example in reference to studying plants, she writes, “Children love flowers, but they need to do something more than remain among them and contemplate their colored blossoms. They find their greatest pleasure in acting, in knowing, and in exploring, even apart from the attraction of external beauty" (Montessori, 1967). Instead of learning about botany by reading textbooks or through lecture, she asserts that students should observe, inquire, and investigate for themselves.

Concurrent with Maria Montessori's impact on early childhood education in Europe, school gardens reached their height of prominence in the United States (Dewey, 1915). During the earliest days of Progressive education, school gardens were seen by reformers as one means to change teaching and learning in schools so that it was more experiential and applicable to real life. Historically, "the progressive period had a wide agenda, but one priority was an explicit attempt to change the core of schooling from a teacher-centered, fact-centered, recitation-based pedagogy to a pedagogy based on an understanding of children's thought processes and their capacities to learn and use ideas in the context of real-life problems" (Elmore, 2004, p. 15). An ideal setting for children to observe and explore these real-life problems was a school garden. In the late 1800s, the United States was predominantly an agrarian society with farming accounting for 37.5% of the gross domestic product (GDP); this share declined over the next 150 years as the United States' economy expanded with the growth of industry, but, at the time, gardening was certainly relevant (Alston, Anderson, & Pardey, 2010). One of the Progressive Period's central figures, John Dewey, saw the utility of gardening in education. In *Democracy and Education* (1916/66), he explains:

> There is nothing in the elementary study of botany which cannot be introduced in a vital way in connection with caring for the growth of seeds. Instead of the subject matter belonging to a peculiar study called botany, it will then belong to life, and will find, moreover, its natural correlations with the facts of soil, animal life, and human relations. (p. 200).

In *Schools of Tomorrow*, John Dewey and his daughter, Evelyn (1915), detail several experimental schools that incorporate active learning through nature study and working school gardens. They warn that public schools have become too indirect, abstract, and bookish and suggest schools be reorganized (Dewey, 1916). They recommend school gardens as a type of remedy since they incorporate best practice pedagogy into instructional practice through participation in real-life activities.

Situated learning. Another more recent learning theory is situated learning. Situated learning accounts for the important role context play in learning (Quay, 2003). Situated learning theory came out of Soviet psychologist, Lev Vygotsky's work, but was further developed by Jean Lave and Etienne Wenger (1991). Situated learning shifts the focus, "From the individual as learner to learning as participation in the social world" (Lave & Wenger, 1991, p. 43). Situated learning involves motivating students by engaging them in activities that have real life applications. "It emphasizes the context and application of knowledge rather than memorizing facts" (Gee, 2007, p. 362). Situated learning theorists posit that students learn best through authentic activities and in environments that provide opportunities to use the knowledge as it would be used in real life. Whereas, both experiential learning theory and situated learning theory posit that learning comes from real-life experiences, situated learning diverges as it privileges the social process as an integral factor in learning. In Lave and Wenger's (1991) seminal work, they describe learning as a process of "legitimate peripheral participation." In contrast to the abstract and out-of-context learning that typically occurs in schools, legitimate peripheral participation involves learning that is situated, or embedded in the given context, culture, and activity. According to this theory, learning is participation, not experience (Quay, 2003).Although increasingly uncommon, this type of learning is common in apprenticeship models (Lave & Wenger, 1991). Social interaction and collaboration are essential components as learners engage in a community of practice and transition from peripheral members of a community to full participation (Lave & Wenger, 1991).

Rationale and Need for This Research

Children's current disconnect with nature. According to a national poll from the Pew Research Center, protecting the environment is still on the list of top twenty priorities for 2010 (Cohen, 2009). In February 2010, President Obama included environmental literacy in the U.S. Department of Education budget for the first time (NCLI Coalition, 2010). Ironically, in spite of concerns about environmental issues, children are growing up with less contact and direct exposure to nature than ever before (Louv, 2006). Several factors seem to be the cause, such as parental concerns about safety, the prevalence of electronic forms of entertainment (i.e., televisions, computers, and video games), and outdoor recess being eliminated from the school day for many children. The sedentary life style of youth has led to increased rates of childhood obesity, learning and/or developmental disabilities, and overall poor physical and psychological health (Whelan, 2008; Lopez et al, 2008; Crowhurst-Lennard & Lennard, 1995). One response to children's present disconnect with nature and less healthy lifestyles has been several *No Child Left Inside* initiatives throughout the country with individual states (e.g., Vermont, Connecticut, Tennessee, Michigan) developing programs to get children outside to learn and play. The *No Child Left Inside Act* was passed in 2008 and is being included in the reauthorization of NCLB. Experiences in a school garden are just the kind of activity that is promoted in the *No Child Left Inside Act*.

Importance of informal learning environments. Another response to children's disconnect with nature as well as the shortcomings of traditional formal learning settings (i.e., schools) is a growing number of out-of-school science and nature programs. A school garden falls under the broad definition of an informal learning environment (Bell, et al., 2009), although museums are more commonly described in the literature. Learning experiences in these informal contexts are characterized as learner-motivated, interest-based, voluntary, open-ended, non-evaluative, and collaborative (Falk & Dierking, 2000; Griffin, 1998; Rennie, 2007). Bell et al. (2009) summarize the importance of these settings, "Informal environments can be powerful environments for learning. They can be organized to allow people to create and follow their own learning agenda and can provide opportunities for rich, social interaction. While this potential is often only partially fulfilled, research that illustrates experience in informal environments can lead to gains in science knowledge or increased interest in science" (p. 311). Major national organizations have shown support for informal science learning opportunities as a means to improving science literacy. In order for future generations to address serious environmental issues, such as climate change and the need for alternative fuels, both in-school and out-of-school resources must be tapped (American Association for the Advancement of Science, 1993; National Research Council, 1996).

Instructional gardens: A growing phenomenon not fully understood. As mentioned above, school gardens are a growing phenomenon. School gardens are not merely a plot of land with plants growing, but a type of pedagogy. Garden-based learning is an instructional strategy that uses a garden of some kind as a teaching tool. Evidence suggests that a school garden can be used to improve nutritional habits (Graham & Zidenberg-Cherr, 2005; Lineberger & Zajiceck, 2000; McAleese & Rankin, 2007), academic achievement (Brynjegard, 2001; Dirks & Orvis, 2005; Faddegon, 2005; Klemmer, Waliczek & Zajicek, 2005a; Klemmer, Waliczek & Zajicek, 2005b), environmental attitudes (Alexander, North, & Hendren, 1995; Brunotts, 1998; Brynjegard, 2001; Faddegon, 2005), and social and emotional growth in children (Alexander, North, & Hendren, 1995; Thorp & Townsend, 2001; Waliczek, Bradley, Lineberger, & Zajicek, 2000).

REFERENCES

Alexander, J., North, M.W., & Hendren, D.K. (1995). Master gardener classroom garden project: An evaluation of the benefits to children. *Child Environments,* 12(2), 124-133.

Alston, J.M., Anderson, M.A., James, J.S., & Pardey, P.G. (2010). Persistence pays: U.S. agricultural productivity growth and the benefits from R&D spending. New York: Springer.

American Association for the Advancement of Science. (1993). *Benchmarks on-line.* Retrieved November 6, 2007, from http://www.project2061.org/publications/bsl/online/bolintro.htm

Ash, D. (2003). Dialogic inquiry in life science conversations of family groups in a museum. Journal of Research in Science Teaching, 40(2), 138-162.

Ash, D., Crain, R., Brandt, C., Loomis, M., Wheaton, M., & Bennett, C. (2007). Talk, tools, and tensions: Observing biological talk over time. International Journal of Science Education, 29(12), 1581-1602.

Bamberger, Y., & Tal, T. (2007). Learning in a personal context: Levels of choice in a free choice learning environment in science and natural history museums. Science Education, 91(1), 75-95.

Beatty, B. (1995). *Preschool education in America: The culture of young children from the colonial era to the present*. New Haven: Yale University Press.

Bell, P., Lewenstein, B., Shouse, A.W., & Feder, M.A. (Eds.). (2009). Learning science in informal environments: People, places, and pursuits. Washington, D.C.: National Academies Press.

Blair, D. (2009). The child in the garden: An evaluative review of the benefits of school gardening. *Journal of Environmental Education*, 40(2), 15-38.

Borun, M., Chambers, M., & Cleghorn, A. (1996). Families are learning in science

museums. Curator: The Museum Journal, 39(2), 123-138.
Brunotts, C.M. (1998). School gardening: A multi-faceted learning tool. An evaluation of the Pittsburgh civic garden center's Neighbors and Schools Gardening Together. Unpublished masters thesis, Duquesne University, Pittsburgh, PA.
Brynjegard, S. (2001). School gardens: Raising environmental awareness in children. San Rafael, CA: School of Education, Dominican University of California. (ERIC Documentation Reproduction Service No. ED452085). Retrieved October 25, 2010, from http://edres.org/eric/ED452085.htm.
California School Garden Network. (2006). Gardens for learning: Creating and sustaining your school garden. Irvine, CA: California School Garden Network.
Coleman, J.A. (1977). Differences between experiential and classroom learning. In M.T. Keeton (Ed.), *Experiential learning: Rationale, characteristics, and assessment* (pp. 49-61). San Francisco, CA: Jossey-Bass Publishers.
Crowhhurst-Lennard, S.H., & Lennard, H.L. (1995). *Livable cities observed*. Gondolier Press: Carmel, CA.
Dewey, J. (1915). *Schools of tomorrow*. New York: E.P. Dutton.
Dierking, L.D., Falk, J.H., Rennie, L., Anderson, D., & Ellenbogen, K. (2003). Policy statement of the "Informal Science Education" Ad Hoc Committee. Journal of Research in Science Teaching, 40, 108-111.
Dirks, A.E., & Orvis, K. (2005). An evaluation of the junior master gardener program in third grade classrooms. *HortTechnology*, 15, 443-447.
Eberbach, C., & Crowley, K. (2005). From living to virtual: Learning from museum objects. Curator: The Museum Journal, 48(3), 317-338.
Elmore, R. F. (2004). *School reform from the inside out*. Cambridge: Harvard Education Press.
Faddegon, P.A. (2005). *The kids growing food school gardening program: Agricultural literacy and other educational outcomes.* Doctoral dissertation, Cornell University, Ithaca, NJ.
Falk, J.H. (1999). Museums as institutions for personal learning. Daedalus, 128, 259-275.
Falk, J.H. (2001). Free-choice science learning: Framing the issues. In: Falk, J., (Ed.), Free-choice science education: How people learn science outside of school (pp. 2-9). New York: Teacher's College Press.
Falk, J.H. & Dierking, L.D. (1998, May/June). Free-choice learning: An alternative term to informal learning? Informal Learning Environments Research Newsletter (p. 2). Washington, DC: American Educational Research Association.
Falk, J.H. & Dierking, L.D. (2002). Lessons without a limit: How free-choice learning is transforming education. Walnut Creek, CA: AltaMira.
Fisher-Maltese, C., & Zimmerman, T.D. (in review). Teaching science in a "living laboratory:" How an informal learning lens reveals new insights into the use of a school garden
Gee, J.G. (2007). Reflections on assessment from a sociocultural-situated perspective. *Yearbook of the National Society for the Study of Education*, 106(1), 362-375.
Graham, H. & Zidenberg-Cherr, S. (2005). California teachers perceive school gardens as an effective nutritional tool to promote healthful eating habits. *Journal of the American Dietetic Association*, 105 (11), 1797-1800.
Griffin, J., & Symington, D. (1997). Moving from task-oriented to learning oriented

strategies on school excursions to museums. *Science Education*, 881, 763-779.
Kisiel, J. (2003). Teachers, museums, and worksheets: A closer look at a learning experience. *Journal of Science Teacher Education*, 14(1), 3-21.
Klemmer, C.D., Waliczek, T.M., & Zajicek, J.M. (2005a). Development of a science achievement evaluation instrument of a school garden program. *HortTechnology*, 15, 433-438.
Klemmer, C.D., Waliczek, T.M., & Zajicek, J.M. (2005b). The effect of a school gardening program on the science achievement of elementary students. *HortTechnology*, 15, 448-452.
Kraft, R. J. (1990). Experiential learning. *Adventure Education*, 175-183.
Lave, J. & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge, England: Cambridge University Press.
Lineberger, S.E. & Zajicek, J.M. (2000). School gardens: Can a hands-on teaching tool affect students' attitudes and behaviors regarding fruits and vegetables? Hortechnology, 10(3), 593-597.
Lopez, Russ, Campbell, Richard, & Jennings. (2008). The Boston schoolyard initiative: A public-private partnership for rebuilding urban play spaces. *Journal of Health Politics, Policy and Law*. 33, 617-638.
Louv, R. (2005). L*ast child in the woods: Saving our children from nature-deficit disorder*. Chapel Hill, NC: Algonquin Books of Chapel Hill.
McAleese, J. & Rankin, L. (2007). Garden-enhanced nutrition education affects fruit and vegetable consumption in sixth-grade adolescents. *Journal of the American Dietetic Association*, 107 (4), 662-665.
Montessori, M. (1967). *The discovery of the child*. New York: Ballantine Books.
National Research Council. (1996). *National Science Education Council.* Washington, DC: National Academy Press.
No Child Left Inside (NCLI) Coalition. (2008). *The problem*. Retrieved on December 1, 2008 from http://www.cbf.org/site/PageServer?pagename=act_sub_actioncenter_federal_nclb_problem
Quay, J. (2003). Experience and participation: Relating theories of learning. *Journal of Experiential Education*, 26(2), 105-112.
Rahm, J. (2002). Emergent learning opportunities in an inner-city youth gardening program. Journal of Research in Science Teaching, 39(2), 164-184.
Rennie, L.J. (2007). Learning science outside of school. In: S.K. Abell & N.G. Lederman (Eds.), Handbook of research on science education (pp. 125-167). Mahwah, NJ: Lawrence Erlbaum Assoc., Inc.
Rousseau, J. (1762). *Emile or on education* (introduction, translation, and notes by Allan Bloom, 1979). New York: Basic Books.
Rowe, S. (2002). The role of objects in active, distributed meaning-making. Perspectives on Object-Centered Learning in Museums, , 19-35.
Smith, L.L., & Mostenbocker, C.E., (2005). Impact of hands-on science through school gardening in Louisiana public elementary schools. *HortTechnology*, 15, 439-443.
Thorp, L., & Townsend, C. (2001, December 12). Agricultural education in an elementary school: An ethnographic study of a school garden. *Proceedings of the 28th Annual National Agricultural Education Research Conference in New*

Orleans, LA (pp. 347-360). Retrieved from http://www.aaaeonline.org/conference_files/758901.

Waliczek, T.M., Bradley, J.C., Lineberger, R.D., & Zajicek, J.M. (2000). Using a web-based survey to research the benefits of children gardening. Hortechnology, 10(1), 71-76.

Whelan, D. L. (2008). Let them eat kale: With America's kids in danger of becoming obese, a growing number of schools are thinking outside the lunchbox. *School Library Journal*. 54(6), 44-49.

CHAPTER 2

TEACHING SCIENCE IN AN INFORMAL LEARNING SETTING: ASSESSING A GARDEN-BASED APPROACH TO TEACHING THE LIFE CYCLE OF INSECTS

Abstract

Recently, schools nationwide have expressed a renewed interest in school gardens (California School Garden Network, 2006), viewing them as innovative educational tools. Most of the scant studies on these settings investigate the health/nutritional impacts, environmental attitudes, or emotional dispositions of students. However, few studies examine the science learning potential of a school garden from an informal learning perspective. Those studies that do examine learning emphasize individual learning of traditional school content (math, science, etc.) (Blaire, 2009; Dirks & Orvis, 2005; Klemmer, Waliczek & Zajicek, 2005a & b; Smith & Mostenbocker, 2005). Grounded in situated and experiential learning theories, the purpose of this case study was to examine the impacts of a school garden program at a K-3 elementary school. Results from pre/post tests, interviews, recorded student conversations, and student work reveal a number of affordances. Affordances include student motivation, real-world experiences, and science learning.

My study sought to demonstrate the value of school garden learning through a focus on measures of learning typically associated with traditional learning environments, as well as informal learning environments. I argue that this broad view of learning and knowing can lead to the development of curricula and pedagogical approaches that maximize the use of these spaces for learning. This analysis provides a new and

important contribution to the small but growing body of research on garden-based learning and provides further evidence for science learning in out-of-school contexts.

Objectives

Over 3,000 school gardens are being used across the country for educational purposes (National Gardening Association, 2010). This renewed interest, not seen since the Progressive Period, spawned from the environmental movement of the 1970s. Indicative of the general public's current interest in gardens as educational settings is First Lady Michelle Obama's White House Kitchen Garden. Although the primary aim of the First Garden is targeting childhood obesity through nutrition education and growing your own food, Mrs. Obama says, "I also knew that I wanted this new White House garden to be a 'learning garden,' a place where people could have a hands-on experience of working the soil and children who have never seen a plant sprout could put down seeds and seedlings that would take root" (Obama, 2012, p. 10).

School-based instructional strategies that use a garden of some kind as a teaching tool are often referred to as garden-based learning. Beginning in the mid-1990s, a number of researchers started to explore the effects of school garden programs. Most of the studies that have been conducted have been in the area of nutrition education and have been small-scale and quantitative in methodology. Evidence shows that school gardens can be used to improve nutritional habits by encouraging children to eat more vegetables (Lineburger & Zajiceck, 2000; Nanney, Johnson, Elliot, & Haire-Joshu, 2006). A small number of studies have explored how school gardens affect students' environmental attitudes (Desmond, Grieshop, & Subramaniam, 2002; Skelly & Zajicek, 1998) and social and emotional growth (Desmond et al., 2002; Waliczek, Bradley, Lineberger, & Zajicek, 2000). Some studies have focused on the impacts of outdoor learning opportunities. These impacts include learning academic content, providing an opportunity for exercise, and improving students' attitudes about the environment (Dillon, et al., 2006). In addition, and particularly relevant to this study, a small number of studies have looked at learning by evaluating specific garden-based curricula and academic achievement by students in science (Blaire, 2009; Dirks & Orvis, 2005; Klemmer, Waliczek & Zajicek, 2005a & b; Smith & Mostenbocker, 2005). National policy has been responsive to such research. For example, the *No Child Left Inside Act*, passed in 2008, encourages access to outdoor learning opportunities, such as learning in a school garden, by supporting states to develop programs to get children outside to learn and play.

However, in spite of interest in exploring school garden programs, the learning that takes place in them is still poorly understood. As I discuss in Fisher-Maltese and Zimmerman (in review), I believe these studies approach garden-based learning too narrowly, in that they focus mainly on content learning. My objective is to make a case for the use of an informal learning perspective when studying a garden-based learning experience. This paper is grounded in situated learning theory and experiential learning theory. Situated learning theory emphasizes the importance of context, the learning setting, and engagement in activities with real-life application (Quay, 2003). Similarly, experiential learning theorists posit that the learner moves towards new understanding by engaging in an action or experience, in this case his/her experience in the school garden (Kraft, 1990). I draw upon existing research on learning in informal settings, situated and experiential learning theory, and data from a K-3 elementary school garden program to present the utility of framing learning as "informal" when studying garden-based learning experiences. In sum, using an informal learning lens to examine the learning that occurs in a school garden affords a broader view of learning and potential affordances than what is typical in a traditional school setting.

This paper is part of a larger case study of an elementary garden-based, science curriculum on insects, which used a school garden as an informal learning setting. It focuses on the following research question: 1) How is student learning impacted when in the context of a school garden? This paper will focus on data surrounding how teachers use an informal learning context to promote the understanding of insect life cycles.

Background

In the last 25 years, the research community has learned a lot about students' understanding of science (Driver, 1996). One important finding is that students often interpret lessons in the classroom differently than they are intended by teachers and curriculum writers (Driver, 1996). Pertinent to this study are students' misconceptions about life cycles. Nguyen and Rosengren (2004) found through parental reports that children tend to outgrow misconceptions about life cycles. Specifically, older 5- to 6-year-old children have fewer misconceptions about life cycles than 3- to 4-year-olds. The younger children in the study commonly thought that babies grew from seeds, like plants, whereas older children knew that babies grew inside their mothers. Similarly, Hickling and Gelman (1995) found that 5-year-old children had already gained the understanding that plants grew from seeds. Pertinent to student misconceptions about insect life cycles, Pine, Messer, and St. John (2010) found through a teacher survey that first-grade students did not think insects were animals because they were not furry, four-legged creatures. This study explores teaching the concept that the stages of the insect life cycle are predictable, discrete phases through which all insects go. Difficulty in understanding insect life cycles may be attributable to the fact that the insect usually, but not always, changes appearance during the different stages. This examination of student learning provides a new and important contribution to the small, but growing, body of research on garden-based learning and provides further evidence for science learning outside of schools that takes place in a non-museum setting (Dierking et al., 2003).

My study comes at a time when there is growing interest in understanding how people learn science in informal settings. In the spring of 1999, the Board of the National Association of Research in Science Teaching (NARST) established an Ad Hoc committee focused on out-of-school science education. The consensus policy statement, issued after two years of collaboration, outlined several aspects of learning that directly connect to the categories of learning I documented in a school garden. More recently, the NRC released *Learning science in informal environments: People, places, and pursuits* (Bell, Lewenstein, Shouse, & Fedder, 2009) in which learning in informal science contexts is described as “learner-motivated, guided by learner interests, voluntary, personal, ongoing, contextually relevant, collaborative, nonlinear, and open-ended” (p. 11). In Fisher-Maltese and Zimmerman (in review) I argue that in order to understand learning in school gardens, researchers should approach these contexts from an informal learning perspective, a perspective that adopts a broad view of learning. This paper further refines the argument set out in Fisher-Maltese and Zimmerman (in review) and expands upon the work by analyzing a different school garden program. From these documents, and the associated research literature, I developed a framework for what I call an informal learning lens (see Table 2) (Fisher-Maltese & Zimmerman, in review). This framework guides my analysis of learning that occurs in a school garden.

Table 2

Informal Learning Lens

NARST Description of Learning in Informal Environment (Dierking et al., 2003)	Additional Research on Learning in Informal Environments
Socially Mediated	Bell, et al., 2009; Ash, 2003; Ash, Crain, Brandt, Loomis, Wheaton, & Bennett, 2007; Borun, Chambers, & Cleghorn, 1996; Rowe, 2002; Eberbach & Crowley, 2005
Derived from Real-world Experiences in an Authentic Context	Bell, et al., 2009; Kisiel, 2003; Rennie, 2007
Self Motivated and Guided by Learner's Needs and Interests	Bell, et al., 2009; Informal Learning Environments Newsletter, May/June, 1998; Falk, 1999, 2001; Falk & Dierking, 2002
Voluntary	Bell, et al., 2009; Informal Learning Environments Newsletter, May/June, 1998; Falk, 1999, 2001, 2005; Falk & Dierking, 2002; Rahm, 2002; Bamberger & Tal, 2007

Life-long	Bell, et al., 2009; Informal Learning Environments Newsletter, May/June, 1998; Falk, 1999, 2001; Falk & Dierking, 2002; Rahm, 2002

In addition, I have created a conceptual framework that guides this study (see Figure 1). It is a conjecture map (Sandoval, in press). The map is read from left to right. It begins with a *high level conjecture* which describes the kind of learning I am interested in supporting. The conjecture becomes treated within the *Embodiment* of the design. *Embodiment* includes necessary tools and materials and task and participant structures. *Embodiment* generates certain *Mediating Processes* which lead to desired *Outcomes (Sandoval, in press)*.

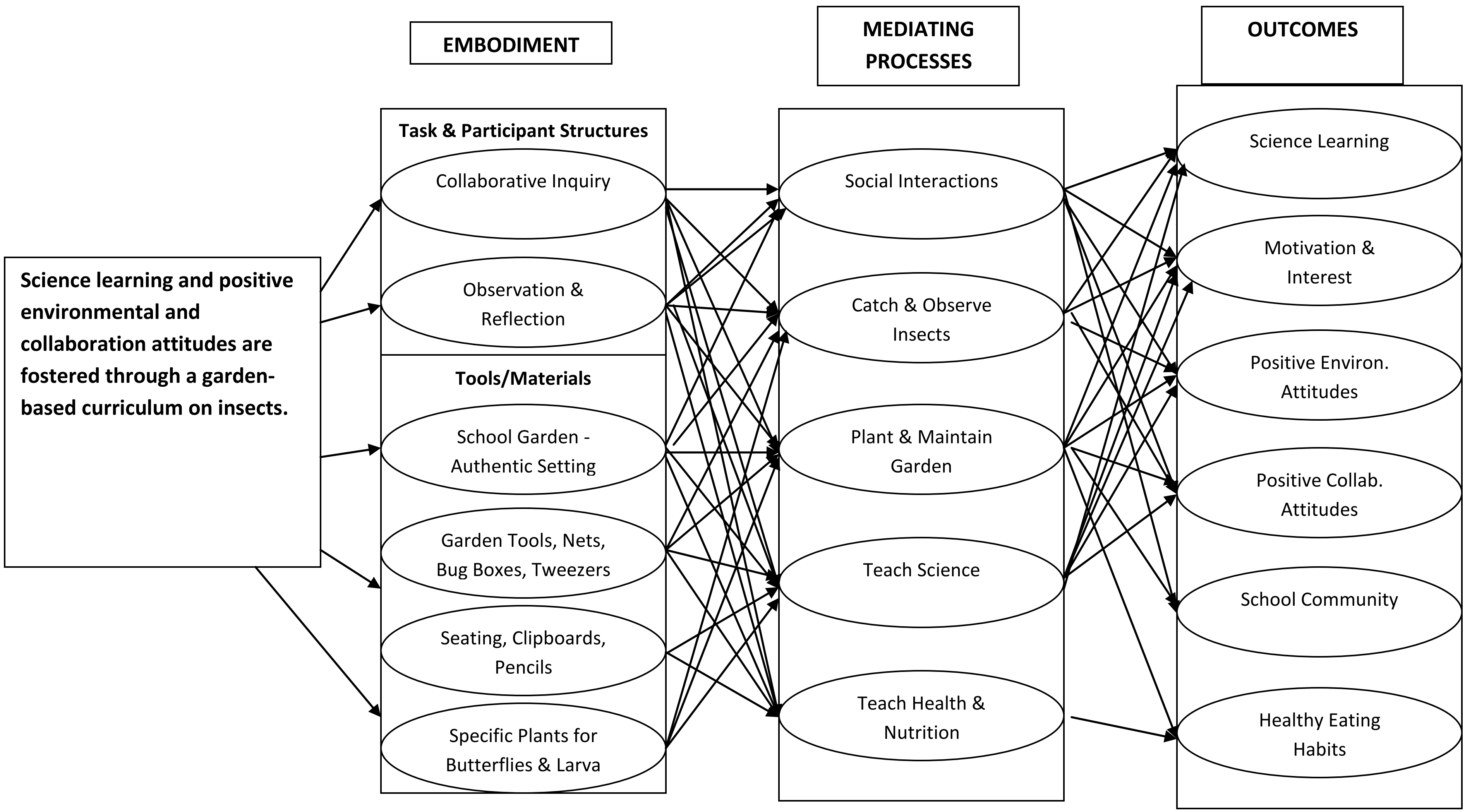

Figure 1. Conceptual Framework (Sandoval, in press)

Methods

This paper is part of a larger case study of a garden-based, science curriculum on insects, which uses a school garden as an informal learning setting. There are advantages to both qualitative and quantitative methods being used to explore this curricular approach; dual methodologies add to the richness of data analysis (Firestone, 1987; Fraser & Tobin, 1993; Orion & Hoftstein, 1994; Sieber, 1973). Fraser and Tobin (1992) explain the rationale for a combined method:

> …the complexity of qualitative observational data and quantitative data added to the richness of the data base as a whole…Through triangulation of quantitative data and qualitative information, greater credibility could be placed in findings because they emerged consistently from data obtained using a range of different data collection methods (p. 290)

Study Context

This study took place in four second-grade classrooms within a K-3 elementary school, located in an affluent, predominantly White (60%) and Asian (40%) school district in central New Jersey. Sixty-six second graders participated in the study, along with four teachers, and one principal (n = 71).

Garden-based Curriculum and Framework

The second-grade science curriculum at Penn's Neck Elementary School (a pseudonym) includes a unit on insects. Typically specimens are ordered from a science supply company and raised in the classroom to demonstrate their life cycle changes. Painted Lady butterflies are the most common insect observed in classrooms at the school. In an effort to connect the insect curriculum to the school garden, teachers from

Penn's Neck chose ladybugs and praying mantises, in addition to Painted Lady butterflies, to study since they are beneficial to the garden and served as a practical means to connect the insect curriculum to the school garden. However, ladybugs pose a unique challenge to observing the different phases of the life cycle since most science supply companies will only ship adults, as larva are fragile and tend to die during transport.

Following a co-design approach (Penuel, Roschelle, & Shechtman, 2007), a four-week standards-based science curriculum on insects, which uses the school garden, was developed collaboratively with the four participating second-grade teachers. Each week, the students participated in insect lessons in the classroom and in the garden. I facilitated lessons by supporting the teachers and co-teaching the lessons. The weeks' lessons had a given focus, including anatomy, life cycles, helpful and harmful insects, butterfly and larva identification, and designing a butterfly garden (see Table 3).

Table 3

Curriculum Overview

Lesson 1: Using the 5 senses to observe and explore the school garden	
Day 1:	What's a garden? How do I use my 5 senses to observe and explore?
Day 2:	Exploration in the school garden

Lesson 2: Arthropods and insects – Basic anatomy and life cycle	
Day 1:	What's an insect? What's an arthropod? Conduct an observation of a praying mantis Using a rubric in the classroom
Day 2:	Catch and conduct an observation of an insect in the school garden
Day 3:	Helpful and harmful insects
Lesson 3: Butterflies – A type of insect	
Day 1:	How to identify butterflies
Day 2:	Conduct an observation of butterflies in the school garden
Day 3:	Identifying butterflies by their larva; Conduct an observation of caterpillars in the classroom
Lesson 4: Designing a butterfly garden	

Day 1:	What attracts butterflies to a specific habitat?
Day 2:	Butterfly life cycle
Day 3:	Plant nectar and host plants in the school garden

Role of the Researcher. Over the course of the study, my role as observer varied as direct observer and participant observer. (Creswell, 2007). I had been a second-grade teacher at this school and led the initiative to plant the school garden described in the study six years ago. Due to my close connections to the teachers, school garden, and garden-based curriculum the teachers were implementing, I had to be aware of how my biases would affect this research. I took certain precautions to limit bias by asking peers and professors at the university to review the curriculum, instruments, and data. I also made a conscious effort to look for contradictory evidence. While bias is a limitation of my work, my positive relationship with the participants lent themselves to certain affordances, namely access to the school, teachers, and students. Also, my background knowledge of the teachers and principal helped me to know where the participants were coming from and what was going on at the school (Patton, 1990). The teachers were willing to try the garden-based curriculum I created and entrusted me with co-teaching the lessons with them. Throughout the study, I was cognizant about remaining objective and encouraged the teachers to take the lead so I could remain in the role of observer.

The curriculum was designed using a framework called Learning Across Contexts (LAC) (Zimmerman, 2005, 2009). LAC is a curriculum design framework that addresses the need to capture evidence of learning across the gaps between informal and formal science learning settings (Zimmerman, 2005, 2009). A goal of the curriculum was to provide evidence that students are learning concepts in the garden that are connected to and reinforced in the classroom. LAC involves a three-phase pedagogical model: (a) pre-visit preparatory activities including learning important terminology and content information, (b) activities and tasks during the field trip (or visit to the school garden), such as going out to the garden, seeing real-life examples of what students are studying in the classroom and recording observations, and (c) post-visit reflection activities, including writing in a science journal or completing a written assignments (e.g., making an insect life cycle timeline) (Zimmerman, 2005, in review). According to this framework, the informal learning experience, in this case lessons in the school garden, is viewed as an integral part of the curriculum, instead of a supplementary or disconnected activity (Zimmerman, 2005, 2009).

Data Sources

Over the course of the curriculum, several data sources allowed for the assessment of both the effectiveness of the curriculum and the knowledge gains by students. The research design and assessment protocols included comparisons within the student population. Data collection involved multiple forms of complementary data: (a) field notes from curricular planning meetings, (b) pre-curriculum and post-curriculum semi-structured student interviews (audio recorded), (c) observations of the school garden in use: lessons in the garden and preliminary and follow-up lessons in the classroom (video recorded), (d) digital audio-recorded conversations of students during lessons in the school garden, (e) pre/post tests to assess science content knowledge, and (f) relevant documents (e.g., student work produced before, during, and after the curriculum). I conducted observations at the school garden site, as well as in the classrooms. Almost all of the curricular lessons were observed in all four classrooms. Field notes recorded in a research journal during the observations captured contextual information, such as teacher, setting, date and time, activity, dialogue, and included preliminary analysis. With students from three of the four classes, pre/post interviews were conducted with individual students (n = 16). With Mrs. Captree's class, due to scheduling constraints, pre-curriculum interviews were conducted with individual students, but post interviews were conducted with one of the students individually, and the other three students as a group. Interviews were videotaped for accuracy. Pre/post tests included multiple choice and open-ended questions designed to elicit students' understanding of insect anatomy, life cycles, behavior, habitats, as well as attitudes toward the environment and collaboration.

Data analysis followed a multi-step process as quantitative and qualitative data were analyzed separately and then examined for triangulation (Patton, 2002). Pre/post test data were analyzed using a rubric I developed. For example, question 7 reads, "Can you describe how a butterfly becomes a butterfly? Please label and draw the different stages in the space below." It is a four-part question (a-d). For Parts a-d, the correct answers, "egg," "larva," "pupa," and "adult," respectively, were coded a "1." An accurate drawing was coded a "2." Other responses were coded a "5" and not counted as correct. Not answered questions were coded as an "88" and not counted as correct. Inter-rater reliability was conducted and yielded 94% reliability. Paired sample t-tests were conducted using the statistical software, SPSS, on the total number of questions on the pre/post tests and on a question specifically addressing insect life cycles. Interview and observational data (e.g., student conversations during lessons in the garden and classroom) were first transcribed and organized by data source and then examined and organized by research question. The final step involved describing the data set with several rounds of coding using a coding scheme developed to highlight examples of student learning (see Table 4).

Table 4

Coding Table

	Code	Criteria	Example
Science Content Knowledge	Anatomy	Demonstrates knowledge of the body parts.	"Look! You can see its proboscis!" "It only has 6 legs so it can't be a spider!"
	Identification/Nomenclature	Demonstrates knowledge of different types of insects and larva.	"It's a Black Swallowtail!" "Look at the beautiful Cabbage White!"
	Life Cycle	Demonstrates knowledge of the different phases of an insect's life cycle.	"Remember the Ladybug eggs? Now they're on the leaf being larva!"
	Survival Needs	Demonstrates	"Look! It's

		knowledge of what insects need to survive.	drinking!”
	Habitat	Demonstrates knowledge of where insects live.	“I found the red ant over there in the dirt.” “They’re putting bug spray…and then they’re well, they’re searching for the habitat and [people are] building cities there.”
	Beneficial/Harmful	Demonstrates a knowledge of what insects are helpful and harmful to people and/or the garden.	“Yeah, because then like bees, if you ruin their home, they’ll chase after you. But beware of killer bees because they might like, I think they might kill you because they’re called killer bees.”
	Specificity	Demonstrates knowledge of what plants different butterflies and their larva eat.	“The Monarch caterpillar eats Milkweed.”
	Defenses	Demonstrates knowledge of what defenses insects have/use that help them survive.	“This aphid is green, just like the leaf. It really blends in.”
School Garden	Affordances	Demonstrates a learning affordance for students that garden provides.	“That they get to see out in the actual real world what the insects

			need to live.”
	Barriers	Demonstrates a barrier to using the garden.	“But I just, I only had so much time.”
	Garden versus Classroom	Demonstrates perceived differences between learning/teaching in the garden versus the classroom.	“I think to be able to see the insects out in nature really helps. It’s just so isolated here in the classroom.”
Informal Learning Setting Affordance	Socially Mediated Learning	Demonstrates learning through social interactions.	“Guys! I think you caught a Mayfly. They only live for like 30 minutes.”
	Learning Derived from Real-World Experience in Authentic Context	Demonstrates learning from experiences and their consequences that occur in real life.	“I mean obviously it’s more real life and authentic for kids to go through those experiences.”
	Learning Guided by Interests and Needs	Demonstrates learning that happens as a result of student interest and needs.	“I’m going to see if those ladybug eggs are still there.”
	Motivation/Voluntary/Interest	Demonstrates motivation or interest in garden or curriculum	“Mrs. F-M can you come next week and we can try to catch more butterflies? YAY!!!”

Results

Research on learning in school garden settings has approached learning in these settings from a school-centered perspective. That is, measures of learning in this literature center around content knowledge. Similar to existing studies, my study collected important data on content knowledge through the administration of a researcher-created pre/post test, interviews, observations of lessons, and digital audio recordings of student conversations during lessons in the garden. In contrast to other studies, I also explored the data set to address other learning affordances, such as social mediation, real-world experiences, and motivation/interest, affordances typically associated with learning in informal settings. In the following sections, I first review evidence of student learning gains in science content knowledge and then illustrate how an informal learning lens can be applied to this setting by providing evidence of the types of learning outlined by the NARST committee. In sum, I found examples of learning that are socially mediated, derived from real-world experiences in an authentic context, self motivated and guided by the learner's needs and interests, and voluntary.

Traditional Measure of Learning: Science Content Knowledge

Pre/post tests, which were administered to all participating students ($n = 66$), showed student learning gains. A paired t-test yielded a positive significant pre/post gain for the total test score (total possible score = 47) (pre-test: $M = 18.61$, $SD = 5.18$; post-test: $M = 23.41$, $SD = 5.24$; $t(66) = -8.39$, $p = 0.00$ (two-tailed), $d = 65$) (see Figure 2).

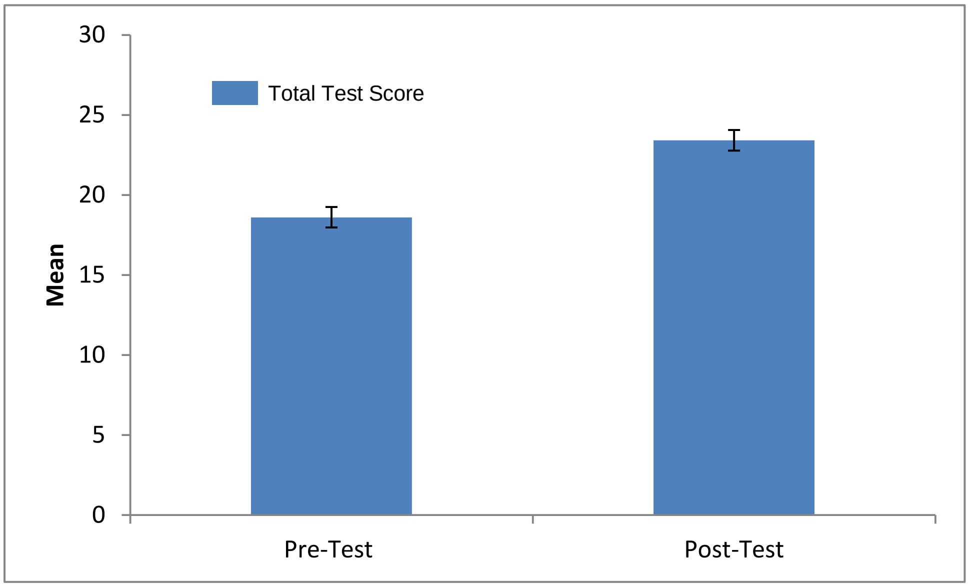

Figure 2. Pre/Post Test Response Comparison

Question 7 on the pre/post test, a short-answer question, was designed to assess student understanding of insect life cycles. Students are required to know by the end of the insect unit the different stages of the life cycle during complete metamorphoses and incomplete metamorphoses. They are expected to know the terminology used for each stage (i.e., what it is called) and what happens during the stage. Question 7 read: "Insects develop and change as they grow. Can you describe how a butterfly becomes a butterfly? Please label and draw the different stages in the space below." This question measured student knowledge about complete metamorphosis. Each stage of the life cycle was a separate part of the question: Part a (egg), Part b (larva), Part c (pupa), and Part d (adult) (see Figure 3).

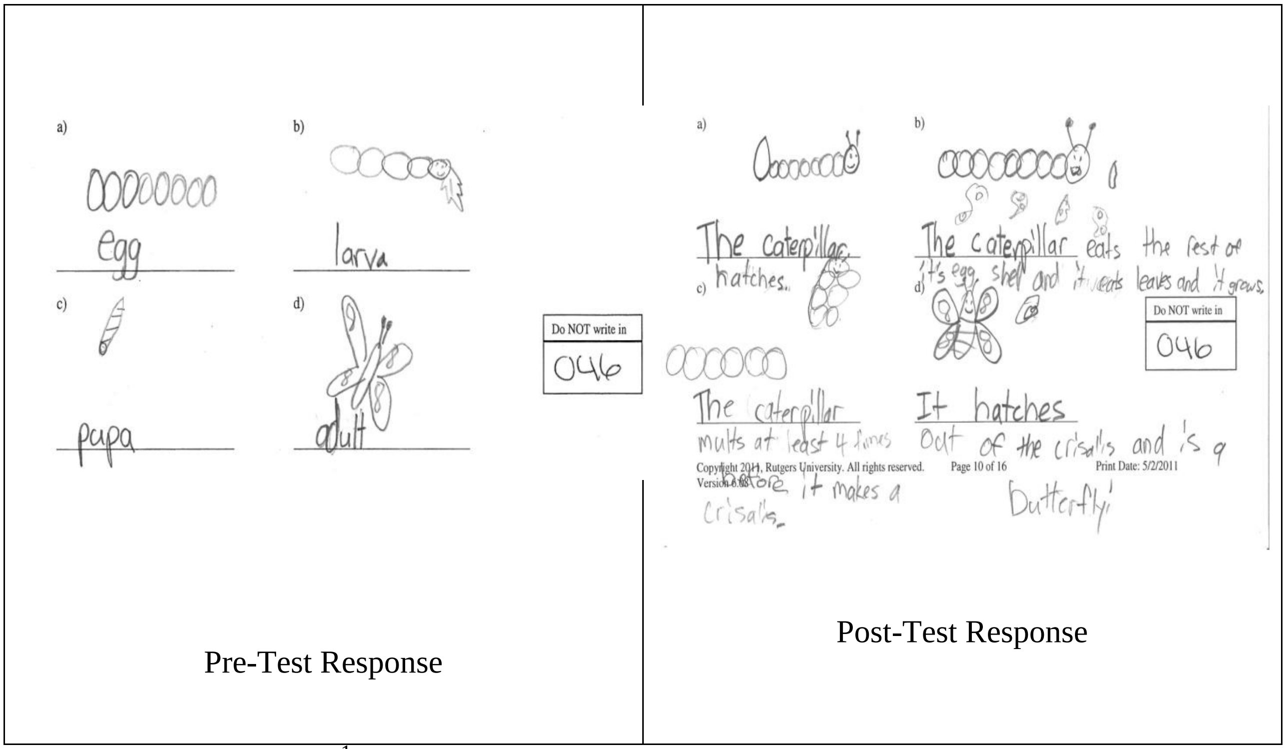

Figure 3. Shreya Singh's[1] Responses to Insect Life Cycle Question on Pre/Post Test

[1] All names are pseudonyms.

Shreya (see Figure 3) demonstrates in her pictures and labels on the pre-test that she knows the different stages of the insect life cycle for a butterfly. However, in the post-test, she is able to tell a much more detailed story of how a butterfly transforms from an egg to an adult. She has added that the larva's (in part b) primary job is eating and growing, that the caterpillar molts at least four times before it makes its chrysalis in the pupa stage (in part c), and actually hatches out of the chrysalis as an adult butterfly (in part d). Pre/post gains for student answers to parts a and b of this question were statically significant (pre-test part 7a: M = 0.74, SD = 0.44; post-test part 7a M = 0.89, SD = 0.42; t(66) = -2.44, p = 0.02 (two-tailed), d = 65; pre-test part 7b: M = 0.77, SD = 0.42; post-test part 7b: M = 0.89, SD = 0.31; t(66) = -2.05, p = 0.04 (two-tailed), d = 65). Student answers to Parts c and d of question 7 were not statistically significant (pre-test part 7c:

M = 0.82, *SD* = 0.39; post-test part 7c *M* = 0.92, *SD* = 0.27.; *t*(66) = -1.84, *p* = 0.07 (two-tailed), *d* = 65; pre-test part 7d: *M* = 0.94, *SD* = 0.24; post-test part 7d: *M* = 0.92, *SD* = 0.28; *t*(66) = 0.33, *p* = 0.74 (two-tailed), *d* = 65). I believe I saw no change from pre- to post-test for parts c and d of question 7 because students knew the information (pupa and adult) already. When coding the responses to the pre/post test, chrysalis and pupa were both coded as correct for part c. Pupa is technically the correct term for the third stage of the life cycle, but the caterpillar does form a chrysalis during this stage, which conveys conceptual understanding. Comparing pre to post, only 9 students used the correct terminology, “pupa” in the pre-test; whereas, 27 students did in the post-test. Also, significantly more students used the term “chrysalis” (n = 29) instead of “cocoon” (n = 9) for the sac the larva forms in the pupa stage in the post-test. Although “chrysalis” is not the correct term for this stage of the life cycle, the students are demonstrating that they have learned the correct terminology. Students had the opportunity to observe caterpillars (larva), pupas, and adult butterflies in both the classroom and the garden. In the classroom, they observed the Painted Lady Butterflies that their teachers had ordered from the science supply company. In the garden, they observed naturally occurring Gypsy Moth (larva) and Cabbage White (larva and adult), Monarch, Tiger Swallowtail, and Black Swallowtail Butterflies (adults).

In addition, pre/post curriculum student interviews showed evidence of student learning gains of insect life cycles. For example, one pre-curriculum question asked, “How would you describe how insects develop or change as they grow?” Whereas all of the students interviewed were familiar with the stages of the butterfly life cycle, post-curriculum interview responses were more detailed and nuanced and sometimes corrected prior misconceptions. In the following example, second-grader, Kristin Barton, response to the post curriculum interview question, “Before when you were asked how insects develop or change as they grow, you said *(researcher provides student's former answer)*. How would you describe how insects develop or change now, given all that you have learned?” demonstrates clarification of a prior misconception and new content knowledge.

Researcher: So last time I asked you how insects develop or change as they grow, and you told me:

> *From pre-curriculum interview:*
> Kristin: They change from babies to larva to adults.
> Researcher: Okay.
> Kristin: Such as these ones (picks up a plastic butterfly from sorting activity). They start as baby caterpillars. Then go on to the larva and come out as butterflies.
> Researcher: Yeah. And what do the larva look like?
> Kristin: The larva is like a thing in a crescent shape. The thing, the insect in the crescent shape is growing. And while, it develops somehow, which it, in a weird way, and it hangs upside down.
> Researcher: Okay. So when it comes out of the egg, what does it look like? Does it look like a butterfly?
> Kristin: Yes.
> Researcher: Yeah? When it comes out of the egg? Not the chrysalis, but when it’s first born.
> Kristin: Oh it looks like a caterpillar.

Researcher: So do you want to add anything or change anything?
Kristin: Well the crescent shape, that’s the pupa. Also, that was the complete metamorphosis, but not all insects go through that. Some insects, such as the Praying Mantis, come out of an egg and they come out basically a miniature version of the adult. And then as they grow, they don’t really change that much, other than growing bigger, until they end up fully grown at the adult stage. And then the adult also lays its eggs, even though with Praying Mantises it doesn’t exactly fly over to a leaf to do it.

From the pre- to the post-curriculum interview, Kristin seems to have clarified her understanding of the larval and pupa stages of the insect life cycle. In the pre-interview, she seems confused that larva *are* actually caterpillars during the larval stage, which transform into a hanging upside-down “J” during the pupa stage. In the post-interview, she demonstrates that she not only has clarified this misconception, but she understands the concepts of complete and incomplete metamorphosis. She knows that a butterfly is an example of compete metamorphosis, while the Praying Mantis is an example of incomplete. As she explains, the Praying Mantis hatches out of its egg as a miniature version of itself (a nymph) and merely grows bigger until it reaches adulthood. A butterfly changes its appearance as it goes through the different stages (e.g., larva, pupa, adult). A post-curriculum group interview with three students, Melissa, Carson, and Eliza, in Mrs. Captree’s class revealed similar student learning gains in the area of complete and incomplete metamorphosis:

Melissa:	In the butterfly it goes like this: egg, larva, pupa, adult.
Researcher:	Okay. Carson, do you want to add something to that?
Carson:	In the butterfly I think it goes like egg, larva, pupa, cocoon, adult.
Researcher:	Okay.
Melissa:	Pupa and cocoon are the same thing.
Carson:	Oh.
Melissa:	Butterflies have a chrysalis. They don't have cocoons. Cocoons are just for moths.
Researcher:	Mm-hmm. What do you think, Eliza? Do you want to add on to how they change as they grow?
Eliza:	They change in different stages and they grow as they change. And then they get to an adult because the caterpillar eats and eats and eats and then it's really fat and it goes into the chrysalis. And then it becomes this big butterfly.
Researcher:	Okay. Do you want to add something here, Carson?
Carson:	Yes. Praying mantises don't have pupas. They just...here's the stages: egg, big kid, bigger kid, bigger kid, teen, adult.
Researcher:	Do you know what the stages, big kid, bigger kid, bigger kid, are called?
Carson:	No.
Researcher:	They’re called nymphs.
Carson:	So here’s what I drew. So egg, nymph, nymph, nymph, adult.
Researcher:	Did you draw that? A nymph? Okay good. So, as Carson said, the praying mantis doesn't have a pupa phase.
Carson:	Yeah.

Researcher: Okay. So do you guys remember the name of this type of metamorphoses for the Praying Mantis?
Eliza: Incomplete metamorphosis.
Researcher: Incomplete metamorphosis. Right. And, for the butterfly?
Eliza: Complete metamorphosis.
Researcher: Great. So those life cycles are different.

Carson demonstrates an understanding of incomplete metamorphoses when he explains that Praying Mantises do not go through a pupa stage. Although he does not know the terminology, nymph, he demonstrates a conceptual understanding when he describes his drawing and compares their growth to children in that they grow larger and larger, instead of changing appearance entirely. Eliza remembers that this type of metamorphosis is called incomplete. In addition, Melissa demonstrates a detailed understand of the butterfly life cycle when she corrects Carson for using the term, cocoon. She has learned that a cocoon and chrysalis are the same thing and that cocoon is a term that is used for moths, while chrysalis is used for butterflies. The following examples from post-interview data represent what I would classify as a simple, mediocre, and advanced understanding of the insect life cycle.

Simple:

Researcher: So before when I asked you about how insects change as they grow, you told me about the butterfly. You said, 'They shed their skin. It goes into a cocoon and comes out in about a week or two as a butterfly. It starts as an egg on a leaf. And then a caterpillar.' Do you want to add anything about how insects grow or change?

Justin: It starts as an egg. Then to a caterpillar. And then it goes into a cocoon. Then a few days later you'll see the wing wrapped around the cocoon. Then it'll come out. It gives you a little hint the next day it'll come out.

Mediocre:

Researcher: So before when I asked you about how insects change as they grow, you told me about the butterfly. You told me, ‘First the egg opens and it’s a caterpillar. The caterpillar keeps eating and grows fatter. Then the caterpillar turns into a chrysalis, then the butterfly comes out. Then they die, or if they’re a Monarch, they migrate to Texas and lay their eggs.’ So given all that you’ve learned, do you want to add or change anything?

Katie: Yeah. Well, the caterpillars after they come out of their eggs, they first eat their eggs and then they start eating the leaf and stuff like that. The caterpillar grows and it forms a chrysalis out of silk. Then the chrysalis takes a few weeks, I think. And then the butterfly comes out, dries its wings off, and takes off.

Advanced:

Researcher: So before when I asked you about how insects change as they grow, you told me about the butterfly. You said, ‘It starts off as an egg, like most animals do, and then it goes into another stage, larva, but this one has a special name, caterpillar. Then it grows into a chrysalis, not a cocoon, and then it metamorphosizes into a butterfly and grows wings. Then it breaks out of the chrysalis and is an adult butterfly and flies over to a plant and lays its eggs.’ So do you want to add or change anything?

Isaac: Well, that was complete metamorphosis, but not all insects go through that. Some insects, such as the Praying Mantis, come out of the egg and they are nymphs, which is basically a miniature version of the adult. And then as they grow they change. They don’t really change that much, other than grow bigger, until they end up fully grown at the adult stage. And then the adult lays its eggs, even though the Praying Mantis doesn’t exactly fly over to a leaf to do it.

Learning that Is Socially Mediated

As above-mentioned, traditional measures of learning, specifically content knowledge, have been explored in existing garden-based learning research. My study explores additional measures of learning which are common in informal learning research, specifically learning that is: socially mediated, derived from real-world experiences, self-motivated, voluntary, and guided by learner's needs and interests. In interviews, students seemed to focus on the garden as an opportunity to socialize and work with their friends. They described different ways that they worked together, such as catching insects and butterflies and planting flowers. Second-grade student, Penelope Luther, in Mrs. Briarwood's class described,

> My partner and I helped each other out to catch that red ant. So whenever I'd find it, I'd tell her so she would be the one picking it up. I've got the good eyes so I'd always find it.

Carson Miller in Mrs. Captree's class described working with his group to catch butterflies,

> Well, we learned from the last time my group was doing the butterfly catching. We, like, decided to split up into two pairs and each cover one part of the garden. We finally caught it, but then it escaped. Then I saw that if we just be quiet and work together and just let one person get it.

When asked during student interviews if they preferred working as a team or working alone, 8 out of 15 students preferred working as a team. They cited reasons such as "I can work with my friends and I won't feel left out," "Because it's funner to talk to your friends. You get an opportunity to listen to what your friends say and you can actually help them if they need help. If you work single, you don't have anyone to help you," "Because it's fun to share your observations. If I don't notice something, maybe my partner will," and "Because you get more work done quickly and it's fun getting to be with different students." Three students preferred working alone for the following reasons: "Because I don't have to help anyone so I get my work done faster," "Because I can make my own decisions and there's no fighting going on," and "When I work by myself, I can do all the work so I can see kind of how smart I am." Four students felt it depended on the project or with whom they would be working.

Audio-recorded conversations of students in the garden revealed students working together and talking about what they were seeing and doing, as seen in this example of Miranda and Diana in Mrs. Captree's class trying to catch a butterfly with butterfly nets and put it into a net house:

Miranda: C'mon I see one let's go! It's fast! (Running, out of breath) Diana, c'mon let's find another one.

Diana: A Cabbage White is hiding in there. Let's wait for it. There it is! (Runs) I got it! (Screams) I see it in the trees. That's where it likes to be.

Miranda: Let's go this way! Diana, I'll look down here. You go over there. It went in the garden!!! Over there! There it is! Careful, that's Poison Ivy over there.

Diana: It keeps flying away. Butterflies have compound eyes.

Miranda: (To a parent volunteer) I caught one, but it got away. I see one! It's over there! Go to the front!

Diana: Got it?

Miranda: I think…We got it! We got it! (shrieking) Go get the net house!

Diana: We got a Cabbage White! You have to put it in here and close it.

Miranda: It's under my net. Get ready to zip it closed. (Screams)

Diana: We got it, but it flew away! Did you see the eggs?

Miranda: Yes, I saw them. I know a better way to catch them. We put the nets in (the net house) and then quickly pull it out and zip it.

Diana: We have to find another one in 10 minutes! (Running)

In another example, Archie and Kevin in Ms. Emilio's class catch an insect they do not recognize and go to show their friend, John.

Archie: It's in! We got something! (goes to show John)

Kevin: Me and Archie caught it (to John).

John: Guys! I think you caught a Mayfly. They only live for like 30 minutes.

Archie: We caught something! (to other students) I just went like this and it flew into my met! You okay little fella (to the insect)? Ms. Emilio, look we caught something!

Kevin: What is it?

Ms. Emilio: I don't know, but it looks cool.

Researcher: You caught a Lace Wing. Those are really beneficial for the garden. They eat aphids!

Archie: Should I let it go?

Researcher: Yeah, I would let it go.

Archie: There you go little buddy. He won't go out.

Researcher: Just put it upside down and shake it.

Archie: I don't want to hurt it!

Kevin: (To others pointing to Lace Wing) That can eat aphids!

Archie: Yeah, like the famous Ladybug!

Learning that Is Derived from Real-World Experiences

One of the main benefits of the garden, as expressed by all four of the teachers and the principal and many of the students during interviews, is that the garden is as an authentic setting where students can observe real-life examples of what they are studying in the classroom. Mrs. Captree summarized the benefits she sees of the garden as,

> That they get to see out in the actual real world what the insects need to live. And which insects are harmful and helpful, which is part of the curriculum. I think it's so beneficial for them to be able to go out there and, you know, see how the whole process works with the planting and how the insects correlate with the planting…I think to be able to see the insects out in nature really helps. It’s just so isolated here in the classroom.

Similarly, Ms. Emilio described how the teachers have been replacing the science kits they typically order from a science supply company with a teacher-created curriculum that uses the garden for some of their science units in order to teach science outside in an authentic setting:

> We’ve been working to supplement our science kits. So we’ve been trying to weed out the science kits more so now and try and do a lot of science lessons out there (in the school garden). Like the insect unit, we only get the bugs anymore. We don’t get the whole kit. I know when I taught first grade, we opted out of the rock, sand, and soil kit so that we could work more in the garden, as well. So I think we’re moving away from that and using the garden as a bigger resource.

The principal at the school, Mr. Agnosto, explained that he is supportive of the garden because of the academic benefits it provides, specifically that it is “authentic” and “real life”:

> There’s the academic benefits because certainly we could tie a lot of the uses of the garden into our curriculum and make it, and it’s actually, I mean obviously more real life and authentic for kids to go through those experiences. To understand when they’re studying insects to go out in the garden and find the type of insects that are important to the garden…So I think it’s the fact that it’s something that is connected to the curriculum. It’s authentic. It’s real life. It’s something we can just go out right to the backyard and walk to and learn about right here at the school.

Students echoed similar sentiments about why the garden is a helpful learning tool (see Table 5).

Table 5

What students say about why they think their teachers take them to the school garden

I think that [teachers] need to take [students] out to the school garden because it helps them learn when they actually see the real thing.
To actually see some butterflies outside and not just see them in the classroom.
Well, instead of just, instead of looking at pictures of insects and plants and stuff, we could actually see them for real.
The garden has lots of bugs so that's the way to *really* study them.

One student voiced that she likes that learning in the garden because it is more hands-on with less worksheets, "Because, well, I think you can, well, it's nearly impossible to give out worksheets because where are they going to write them. So it kind of lets you be more creative."

Learning that Is Self-Motivated, Voluntary, and Guided by Learner's Needs and Interests

Recorded conversations of students during lessons in the school garden revealed students using self-motivation and choice to guide their learning. For example, students found small, orange ladybug eggs (the first stage of the insect's life cycle) on the underside of the leaves of a milkweed plant in the garden in all four classes. During the next week's lesson in which students were planting butterfly-specific plants, or plants which attract specific kinds of local butterflies, and catching butterflies and insects to observe, students returned to the milkweed plants without prompting and discovered the eggs were in the process of hatching into larva. The students identified ladybug larva, as well as adults. In the following example, Jason and Victoria from Ms. Emilio's class decide to check on the ladybug eggs that they found on the milkweed plants the week before.

Jason:	I'm going to see if those ladybug eggs are still there (walking). Oh! Oh my G-d! Victoria, the larva ladybugs are here on this leaf! Remember these were eggs? The larva!
Victoria:	Oh my Gosh!
Jason:	I'm going to tell Mrs. M. Mrs. M, remember the ladybugs eggs (shouting)? Now, they're on the plant being larva!
Mrs. M:	I'm going to get my camera. Show me.
Jason:	It looks like it has spots and it's blackish. Right there! They're moving. The egg shell looks broken.

This example is significant for several reasons. First, students had the opportunity to see ladybug eggs and larva, two stages of the life cycle that they would be unable to see in the classroom. As mentioned previously, science supply companies will only ship ladybugs in the adult stage since the other two stages tend to be too fragile and perishable. Second, the students found examples of the insect in its different stages based on their own motivation and choice. Looking for the eggs was voluntary so they took ownership of it. And, third, the students found the insect in its authentic setting, which was unexpected and exciting for the students.

In another example, two students in Mrs. Briarcliff's class found a Black Swallowtail caterpillar, which they had never seen before, on a parsley plant in the school garden. As part of the curriculum, the students had learned how to identify Tiger Swallowtail larva and butterflies, but not Black Swallowtails.

Alexis: Lisa, come here! Look, on this plant! It's a caterpillar!

Lisa: Wow! What kind of caterpillar is it? C'm here boy! (to the caterpillar)

Alexis: I don't know. I bet it's a Monarch. Look at the stripes!

Lisa: Let's go show Mrs. M!

Alexis and Lisa: Mrs. M! Come quick! Look what we found!

Mrs. M: Well, look at that. Do you girls know what kind of larva this is?

Lisa: Alexis thinks it's a Monarch.

Mrs. M: What do you think?

Lisa: Well, didn't the Monarch caterpillar have yellow and black stripes? This guy is green with black and yellow stripes…

Mrs. M: Hmmm…did we study any larva that kind of look like this one? Maybe a green one?

Alexis: The Tiger Swallowtail larva! It was green and fat!

Mrs. M: Okay, maybe. Can we find out any clues from what plant you found it on? What plant was it eating?

Lisa: We found it on this plant. The sign says it's parsley!

Mrs. M: Okay, so it's green with black and yellow stripes and it likes to eat parsley. What kind of plant does the Monarch larva eat?

Alexis: Milkweed! It only eats Milkweed.

Mrs. M: Yes! So could this be a Monarch caterpillar?

Lisa: No.

Mrs. M: Let's get one of my field guides and see if you can find a picture of it. (Girls run to get a field guide from the basket. They sit on a railroad tie and flip through the book.)

Alexis: We found it! We found it! Look on this page!

Lisa: It's a Black Swallowtail! And, look! It says it eats parsley!

Mrs. M: Great! There it is. Good detective work!

In this example, Alexis and Lisa found the Black Swallowtail larva through their own motivation and interest, and a little luck. With some scaffolding, they are able to use deductive reasoning to identify the larva. They deduce what kind of larva it is based on its appearance and what plant they found it eating. They also learn to use a field guide as a resource to find out the name of the unfamiliar larva. The school garden setting lends itself to such impromptu learning experiences.

As evident in the previous examples, students demonstrate motivation and interest through expressions of happiness and excitement associated with garden-based learning. In addition to recorded conversations of students out in the garden, student and teacher interviews produced similar findings. For example, all 15 students interviewed reported enjoying going out to the garden for science lessons. In a post-curriculum interview, when Kristin Barton was asked what her favorite part of the garden-based science unit was, she replied, "I can't decide. There were so many good things about it!" When asked, "So you liked going out to the school garden?" She responded, "I loved it! (grinning)." What did she like about it? She explained: "Well, it was nice to get fresh air and see all these insects and how they behave. And look at the plants and look at all the different kind of plants, maybe try to identify them." Another student expressed that he liked the opportunity to "enjoy nature" and "have some fresh air." And, another student, articulated that going out to the garden met his needs, "Basically I like going out there because it got me out of the classroom and it was a lot easier to pay attention and everything was a lot nicer."

Teachers also reported that their students expressed excitement about learning in the school garden and, in some cases, their own surprise at how much their students got out of the garden-based curriculum (see Table 6).

Table 6

Teachers' comments about students' experience with garden-based curriculum

Teacher	Comment
Mrs. Briarcliff	The way you taught them about the different types of caterpillars was great. They actually took a lot away from that, that they could identify caterpillars when they see them out there. Also I've watched them when they're outside. They're really more interested in looking in the ground instead of just aimlessly walking. They're looking for things.
Mrs. Captree	They really enjoyed it!
Ms. Emilio	I thought it might be over their heads. Especially classifying the butterflies. I just…because it was hard for me to grasp. But then seeing the results like when you came in here with that caterpillar and they were just rattling things off and they remembered it. And when they were out in the garden identifying the different types of butterflies. It was really cool to see. So I think they got a lot out of it. And I learned a lot. So it's been neat to see them. And they've been bringing in all types of caterpillars and insects. And talking about their markings and everything. So they're excited about it!
Mrs. Martin	But the kids learned so much. I was amazed at what they remembered from the lessons and, as far as I know, I don't think any other second grade teachers go too much in depth. With the naming of the butterflies and different families of butterflies. But kids can do it. They learn it. Because I saw it! So I think overall it was really fun from start to finish. Finishing with the fourth lesson where you got to plant those

> specific flowers for the certain butterflies that they learned about and the caterpillars. So I really liked it.

Principal Agnosto explained that he thinks that it is not only that the students are excited about learning in the garden, but the teachers and parents, which makes it so successful at the school.

> I think any initiative that really builds from within is going to be the most successful. And what I mean by that is when you have a small group of teachers that start a project and then you have other teachers who are excited about it. Kids are excited. Parents are excited…then it's sort of contagious and other people want to find out about it, especially if it's something that appears to be successful. With this (the garden), people saw the long-term benefits of it and got excited about it. So that's how I think it grew and grew. A lot of people believed in it obviously.

He also shared positive feedback he got from the participant teachers: "Teachers were really excited. Like I'd see a teacher and she'd say, 'Oh my G-d! It was so great today! [The researcher] came in. We did a great lesson and the kids were excited!'"

Discussion

Research on learning in school garden settings relies on measures of learning centered around content knowledge and do not attend to other learning affordances, such as social mediation, real-world experiences and motivation/interest, affordances typically associated with learning in informal settings. My study is unique in that I not only examine learning around content knowledge, but also attend to these other areas. This is important because such a view of learning and knowing can lead to the development of curricula and pedagogical approaches that maximize the use of these spaces for science learning (Fisher-Maltese and Zimmerman, in review). My data fit the model of informal learning as outlined by Dierking, et al., (2003) (see Table 7). This mapping reveals benefits to learning science in school gardens that are not apparent when learning in a school garden is approached solely from a school-based learning perspective.

Table 7

Informal Learning Lens and Data

NARST Description of Learning in Informal Environment (Dierking et al., 2003)	Fisher-Maltese & Zimmerman Study Data	Additional Research on Learning in Informal Environments
Socially Mediated	-Students discuss insects and plants in the school garden, which mediates science learning. - Majority of students report that they like opportunity to work as a team with other students in garden.	Bell, et al., 2009; Ash, 2003; Ash Crain, Brandt, Loomis, Wheaton, & Bennett, 2007; Borun, Chambers, & Cleghorn, 1996; Rowe, 2002; Eberbach & Crowley, 2005
Derived from Real-world Experiences in an Authentic Context	-Teachers say that they use school garden to teach science units due to authenticity of setting. -Teachers and students say garden provides “real-life examples” of what students are studying.	Bell, et al., 2009; Kisiel, 2003; Rennie, 2007;

Self Motivated and Guided by Learner's Needs and Interests	-Students look for examples of what they are learning in science in garden guided by their own motivation and interest (e.g., ladybug eggs, butterflies, other insects). -Students express enjoyment and interest in lessons related to the garden. - Students express that lessons in the garden meet their needs (e.g., easier to focus and pay attention)	Bell, et al., 2009; Informal Learning Environments Newsletter, May/June, 1998; Falk, 1999, 2001; Falk & Dierking, 2002;
Voluntary	-Students are able to express choice in garden (e.g., choose which insect or butterfly to catch, choose to look for ladybug eggs).	Bell, et al., 2009; Informal Learning Environments Newsletter, May/June, 1998; Falk, 1999, 2001, 2005; Falk & Dierking, 2002; Rahm, 2002; Bamberger & Tal, 2007

Student Learning Gains Revealed through Measures of Content Knowledge

The limited research that does exist on the academic effects of school gardens focuses on measures of student learning in science content knowledge (Dirks & Orvis, 2005; Klemmer, Waliczek & Zajicek, 2005a; Klemmer, Waliczek & Zajicek, 2005b; Smith & Mostenbocker, 2005). Many of these studies evaluate the handful of school gardening curricula that have been written in the past ten years (Blair, 2009; California Department of Education, 2005; Dirks & Orvis, 2005; Faddegon, 2005; Life Lab, 2006;

National Gardening Association, 2012). My study provides further evidence of science learning in out-of-school settings. Pre/post test data, student interviews, and conversations of students in the garden during lessons support existing research that students learn science content knowledge in a school garden.

Additional Benefits of Garden-learning Programs Only Revealed through an Informal Learning Lens

Social Learning. An important aspect of science learning is that it is socially-culturally mediated (Dierking et al., 2003). Additionally, situated learning theory posits that socialization and collaboration are integral factors in learning (Lave & Wenger, 1991). Not surprisingly then, a setting that provides opportunities for students to work with partners and small groups is fertile ground for science learning. During data collection, I heard repeatedly from student participants that they enjoyed the opportunity to work as a team and help each other when out in the school garden. When Penelope describes how she worked with her partner to catch an ant or Diana and Miranda excitedly talk back and forth as they struggle to catch a butterfly, they speak directly to this point. Indeed, many of their classmates expressed the same sentiment. This is not to say that simply because they want to work with their friends that the learning is socially-mediated per se, but it provides greater opportunities for discourse which may mediate learning (Fisher-Maltese & Zimmerman, in review). Several researchers have reported on the mediating role of discourse in informal settings. Though the discourse may not always be on topic, conversations in museums and other informal settings mediate the learning experience (Ash, 2003; Ash, Crain, Brandt, Loomis, Wheaton, & Bennett, 2007; Borun, Chambers, & Cleghorn, 1996). Therefore, if students enjoy using the garden because it allows them an opportunity to socialize, discourse in this setting may lead to science learning in unexpected ways (Zimmerman, 2010). For example, Zimmerman (2010) found students engaging in science-related talk during a visit to an aquarium. Though this talk was not the focus of the field trip exercise, the students, who were clearly friends, began a science-related conversation that led both students to verbalize science ideas. Often omitted in a school learning perspective, an informal learning context highlights the social learning opportunities that the school garden provides. Capitalizing on these opportunities through timely scaffolding may lead to deeper learning (Dierking et al., 2003).

Garden as a Real-World Experience. Situated learning theorists posit that students learn best through authentic activities and in environments that provide opportunities to use the knowledge as it would be used in real life (Quay, 2003). Dierking et al. (2003) similarly point out, “The physical setting in which such learning takes place is extremely important, so this learning needs to be investigated in *authentic* [emphasis added] contexts” (2003). Lasting learning is often derived from real-world experiences that children, and adults, are able to apply to their own lives. “This broad view of learning recognizes that much of what people come to know about the world, including the world of science content and process, derives from real-world experiences within a diversity of appropriate physical and social contexts, motivated by an intrinsic desire to learn” (Dierking et al., 2003, p. 109). According to experiential learning theory and the work of James Coleman (1977), “Motivation is intrinsic as actions with real consequences occur as the first step in the learning process. Finally, experiential learning seems to be more deeply etched into the brain of the learner, as all learning can be associated with concrete actions and events, not just abstract symbols or general principles" (Kraft, 1990, p. 185).

The real-world objects in the garden can also mediate learning conversations. Rowe (2002) demonstrates how museum visitors discuss different objects in a museum exhibit. The objects serve as tools for a discussion about science concepts and scientific practices. Eberbach and Crowley (2005) specifically extend the definition of objects to include "real living plants and animals" (p. 318). In similar ways, data from my study include students discussing insects, butterflies, and plants that mediate science learning during their garden-based experiences. For example, when Archie and Kevin catch an insect and do not know what it is, they go ask their friend, John, and eventually the researcher who helps them look it up in a field guide. They come to learn that they have caught a lace wing, which is a beneficial insect to the garden. If the students had been working alone, it is conceivable that only one of the boys would have learned to identify this unknown insect, but in a setting that encourages social interactions and is mediated by real-world objects, all three students benefited from this experience.

Additionally, all of the teachers and the principal interviewed recognized the importance of learning from real-world objects. For example, all teachers said that they used the school garden to teach lessons from their science units and most cited the authenticity of the garden setting as a reason for doing so. Indeed, the second grade teachers integrate the garden into lessons from their insect unit, just as the third grade teachers utilize the garden during their plant unit. These teachers could have recreated some of these garden experiences in the classroom, using a science kit, for example, but instead they saw the garden as an authentic, real-world setting for studying science. Four students in the study describe how the garden provides an opportunity to see "real-life examples" of what they are studying. Second-grader, Helena, hits the nail on the head when she says, "Well, instead of just, instead of looking at pictures of insects and plants and stuff, we could actually see them for real." Abundant in the school garden setting, an informal learning lens acknowledges the important role real world experiences play in learning.

Motivation, Interest, and Emotion. Dierking et al. (2003) note, "The importance of motivation, interest, and emotion in the learning process itself, suggesting that when people are interested and curious about something, there is a high possibility that they will follow up on that feeling with action, resulting in meaningful learning" (p. 110). According to the teachers and students interviewed and recordings of student conversation in the garden, the school garden encourages learning that is self-motivated or guided by learner's needs or interests. My data from the garden-based learning curriculum reveal instances of the connection between motivation to learning in the school garden and emotional states. For example, second grader, Kristen, could not contain her excitement when asked whether she liked going out to the school garden. "I loved it!" was her reply. Similarly, Jason and Victoria in Mrs. Emilio's class, nearly jumped out of their skins when they independently, driven by their own interest and motivation, found ladybug eggs on the underside of a leaf in the garden and then discovered that they had hatched into larva one week later. All four of the teachers and the principal also reported that students felt excited, and/or enjoyed, learning in the school garden. In post-curriculum interviews, all of the teachers conveyed that they were pleased that their students seemed excited about learning over the course of the unit and three out of four were even surprised that they learned as much as they did. Overall, student and teacher interview and student conversation data suggest student motivation, enjoyment, and interest seems to have played a big role.

Opportunities for Voluntary Learning. The school garden at Penns Neck Elementary School provides opportunities for spontaneous learning, which is defined as learning that occurs when children are permitted to explore, discover, and observe in an unstructured environment (Center for Ecoliteracy, 1999). The idea of spontaneous learning shares many similarities with free-choice learning experiences defined as, “Learning experiences where the learner exercises a large degree of choice and control over the what, when, and why of learning” (Falk, 2005, p. 265). The activities I observed in the school garden can be characterized as “free-choice” learning experiences. For example, children being set loose to catch an insect and observe it (Lesson 2) or exploring the garden using their five senses and recording what they notice (Lesson 1). Jason and Victoria finding ladybug eggs on the underside of a leaf in the garden, and later larva, guided by their own volition is another example of voluntary learning, or a free-choice learning experience. Rare in the traditional classroom for practical reasons and time constraints, a major contributing factor to the positive feelings reported by students associated with the school garden seems to be the degree of choice that students experience and a perception that participation is voluntary (Fisher-Maltese & Zimmerman, in review). Research in this area suggests that choice is associated with not only enjoyment, but meaningful learning (Falk, 2005; Bamberger & Tal, 2007). Bamberger and Tal (2007) examined how choice opportunities contribute to student learning. Findings from their large-scale study of students visiting four museums provide evidence that providing some level of choice, in fact, leads to students' deep engagement in learning, as well as connecting the experience, the museum visit in this case, to their lives and previous experiences. By taking into account this notion of "free-choice" or voluntary learning, an informal learning perspective helps to explain how meaningful learning occurs in the school garden setting.

Conclusion

In this paper, I analyze a garden-based learning instance through traditional measures, as well as an informal learning lens revealing new insights into the use of school gardens. My findings indicate that students learn science content knowledge in a school garden. Moreover, I conclude that learning in school gardens is characteristic of informal learning settings where learning is driven by real-world experience, is socially mediated, self-motivated, voluntary, and has implications for life-long learning. Most importantly, using an informal learning lens leads me to conclude that a shift from the "typical" use of gardens as simply a tool for teaching content to a view of gardens as an informal learning context can mediate broader leaning goals.

This work draws from a small sample of teachers, administrators, and students. Though limited in scope, this study provides a rich example of the ways an informal learning framework can shed light on the affordances of a garden-based learning curriculum that can frame larger garden-based learning studies. In particular, I see opportunities for research on the social, motivational and real-world aspects of garden-based learning. It is my hope that researchers will utilize this work on garden-based learning using an informal learning lens to conduct studies on the effects of school gardens on student learning generally, and science learning specifically.

References

Alexander, J., North, M.W., & Hendren, D.K. (1995). Master gardener classroom garden project: An evaluation of the benefits to children. *Child Environments,* 12(2), 124-133.

Anderson, D., Lucas, K. B., Ginns, I. S., & Dierking, L. D. (2000). Development of knowledge about electricity and magnetism during a visit to a science museum and related post-visit activities. Science Education, 84(5), 658-679.

Ash, D. (2003). Dialogic inquiry in life science conversations of family groups in a museum. Journal of Research in Science Teaching, 40(2), 138-162.

Ash, D., Crain, R., Brandt, C., Loomis, M., Wheaton, M., & Bennett, C. (2007). Talk, tools, and tensions: Observing biological talk over time. International Journal of Science Education, 29(12), 1581-1602.

Bamberger, Y., & Tal, T. (2007). Learning in a personal context: Levels of choice in a free choice learning environment in science and natural history museums. Science Education, 91(1), 75-95.

Bell, P., Lewenstein, B., Shouse, A.W., & Feder, M.A. (Eds.). (2009). Learning science in informal environments: People, places, and pursuits. Washington, D.C.: National Academies Press.

Blair, D. (2009). The child in the garden: An evaluative review of the benefits of school gardening. *Journal of Environmental Education*, 40(2), 15-38.

Borun, M., Chambers, M., & Cleghorn, A. (1996). Families are learning in science museums. Curator: The Museum Journal, 39(2), 123-138.

Brown, A. (1992). Design experiments: Theoretical and methodological challenges in creating complex interventions in classroom settings. *The Journal of the Learning Sciences,* 2(2), 141-178.

California Department of Education. (2010). *Catalogue listing of publications*. Retrieved October 25, 2010, from http://www.cde.ca.gov./re/pn/rc/ap/pubdisplay.aspx?ID=001512.

California School Garden Network. (2006). Gardens for learning: Creating and sustaining your school garden. Irvine, CA: California School Garden Network.

Canaris, I. (1995). Growing foods for growing minds: Integrating gardening into the total curriculum. Children's Environments, 12(2), 134-142.

Center for Ecoliteracy. (1999). The edible schoolyard. Berkeley, California: Learning in the real world.

Coleman, J.A. (1977). Differences between experiential and classroom learning. In M.T. Keeton (Ed.), *Experiential learning: Rationale, characteristics, and assessment* (pp. 49-61). San Francisco, CA: Jossey-Bass Publishers.

Creswell, J.W. (2007). Qualitative inquiry & research design: Choosing among five approaches. London, England: Sage Publications.

Desmond, D., Grieshop, J., & Subramaniam, A. (2002). Revisiting garden based learning in basic education: Philosophical roots, historical foundations, best practices and products, impacts, outcomes, and future directions. Prepared for IIEP/FAO, SDRE Food and Agricultural Organization/United Nations, Rome, Italy, UNESCO International Institute for Educational Planning, Paris, France.

Dierking, L.D., Falk, J.H., Rennie, L., Anderson, D., & Ellenbogen, K. (2003). Policy statement of the "Informal Science Education" Ad Hoc Committee. Journal of Research in Science Teaching, 40, 108-111.

Dillon, J., Rickinson, M., Teamey, K., Morris, M., Choi, M.Y., Sanders, D., Benefield, P. (2006). The value of outdoor learning: Evidence from research in the U.K. and elsewhere. *School Science Review,* 87(320), 107-111.

Dirks, A.E., & Orvis, K. (2005). An evaluation of the junior master gardener program in third grade classrooms. *HortTechnology,* 15, 443-447.

Driver, R., Leach, J., Milllar, R., & Scott, P. (1996). *Young people's images of science*. Buckingham, England: Open University Press.

Eberbach, C., & Crowley, K. (2005). From living to virtual: Learning from museum objects. Curator: The Museum Journal, 48(3), 317-338.

Faddegon, P.A. (2005). *The kids growing food school gardening program: Agricultural literacy and other educational outcomes.* Doctoral dissertation, Cornell University, Ithaca, NJ.

Falk, J.H. (1999). Museums as institutions for personal learning. Daedalus, 128, 259-275.

Falk, J.H. (2001). Free-choice science learning: Framing the issues. In: Falk, J., (Ed.), Free-choice science education: How people learn science outside of school (pp. 2-9). New York: Teacher's College Press.

Falk, J. H. (2005). Free-choice environmental learning: Framing the discussion. Environmental Education Research, 11(3), 265-280.

Falk, J.H., & Dierking, L.D. (1992). The museum experience. Walnut Creek, CA: AltaMira Press.

Falk, J.H. & Dierking, L.D. (1998, May/June). Free-choice learning: An alternative term to informal learning? Informal Learning Environments Research Newsletter (p. 2). Washington, DC: American Educational Research Association.

Falk, J.H. & Dierking, L.D. (2000). Learning from museums: Visitor experiences and the making of meaning. Lanham, MD: AltaMira Press.

Falk, J.H. & Dierking, L.D. (2002). Lessons without a limit: How free-choice learning is transforming education. Walnut Creek, CA: AltaMira.

Firestone, W.A. (1987). Meaning in method: The rhetoric of qualitative and quantitative methods in classroom environment research. *Educational Researcher,* 16, 16-21.

Fisher-Maltese, C., & Zimmerman, T.D. (in review). Teaching science in a "living laboratory:" How an informal learning lens reveals new insights into the use of a school garden

Fraser, B. J., & Tobin, K. (1992). Combining qualitative and quantitative methods in classroom environment research. In B. J. Fraser & H. J. Walberg (Eds.), *Educational environments: Antecedents, consequences, and evaluation* (pp. 271-292). London: Pergamon Press.

Griffin, J., & Symington, D. (1997). Moving from task-oriented to learning oriented strategies on school excursions to museums. *Science Education*, 881, 763-779.

Hein, G. (1998). Learning in the museum. New York, NY: Routledge.

Hickling, A. K., & Gelman, S. A. (1995). How does your garden grow? Early conceptualization of seeds and their place in plant growth cycle. *Child Development*, 66, 856-876.

Kisiel, J. (2003). Teachers, museums, and worksheets: A closer look at a learning experience. *Journal of Science Teacher Education*, 14(1), 3-21.

Klemmer, C.D., Waliczek, T.M., & Zajicek, J.M. (2005a). Development of a science achievement evaluation instrument of a school garden program. *HortTechnology*, 15, 433-438.

Klemmer, C.D., Waliczek, T.M., & Zajicek, J.M. (2005b). The effect of a school gardening program on the science achievement of elementary students. *HortTechnology*, 15, 448-452.

Kraft, R. J. (1990). Experiential learning. *Adventure Education*, 175-183.

Lave, J. & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge, England: Cambridge University Press.

LifeLab. (2006). *Garden based learning that promotes a sustainable future.* Retrieved July 31, 2008, from http://www.lifelab.org/about/index.html.

Lineberger, S.E. & Zajicek, J.M. (2000). School gardens: Can a hands-on teaching tool affect students' attitudes and behaviors regarding fruits and vegetables? Hortechnology, 10(3), 593-597.

Moore, R. (1995). Growing foods for growing minds: Integrating gardening and nutrition education into the total curriculum. *Children's Environments*, 12(2), 134-142.

Morris, J., & Zidenberg-Cherr, S. (2002). Garden-enhanced nutrition curriculum improves fourth grade school children's knowledge of nutrition and preference for some vegetables. *Journal of the American Dietetic Association*, 102 (1), 91-93.

Nanney, M., Johnson, S., Elliot, M., & Haire-Joshu, D. (2006). Frequency of eating home-grown produce is associated with higher intake among parents and their pre-school aged children in rural Missouri. Journal of the American Dietetic Association, 107(4), 577-584.

National Gardening Association. (2012). *GrowLab Curricula*. Retrieved November 29, 2012, from www.gardeningwithkids.org

National Gardening Association. (2010). Garden in every school registry. Retrieved April 23, 2010, from http://kidsgardening.com

Nguyen, S.P., & Rosengarten K.S. (2004). Parental reports of children's biological knowledge and misconceptions. *International Journal of Behavioral Development*, 28, 411-420.

Obama, M. (2012). *American grown: The story of the White House kitchen garden and gardens across America.* New York, NY: National Parks Foundation.

Orion, N., & Hoffstein, A. (1994). Factors that influence learning during a scientific fieldtrip in a natural environment. *Journal of Research in Science Teaching*, 33(10), 1097-1119.

Patton, M.Q. (1990). *Qualitative evaluation & research methods*. Thousand Oaks, California: Sage Publications.

Penuel, W. R., Roschelle, J., & Shechtman, N. (2007). Designing formative assessment software with teachers: An analysis of the co-design process. *Research and Practice in Technology Enhanced Learning*, 2(1), 51-74.).

Pine, K., Messer, D., & St. John, K. (2010). Children's misconceptions in primary science: A survey of teachers' views. *Research in Science & Technological Education*, 19, 79-96.

Quay, J. (2003). Experience and participation: Relating theories of learning. *Journal of Experiential Education*, 26(2), 105-112.

Rahm, J. (2002). Emergent learning opportunities in an inner-city youth gardening program. Journal of Research in Science Teaching, 39(2), 164-184.

Rennie, L.J. (2007). Learning science outside of school. In: S.K. Abell & N.G. Lederman (Eds.), Handbook of research on science education (pp. 125-167). Mahwah, NJ: Lawrence Erlbaum Assoc., Inc.

Rowe, S. (2002). The role of objects in active, distributed meaning-making. Perspectives on Object-Centered Learning in Museums, , 19-35.

Sieber, S. D. (1973). The integration of fieldwork and survey methods. *The American Journal of Sociology*, 78(6), 1335-1359.

Skelly, S.M. & Zajiceck, J.M. (1998). The effect of an interdisciplinary garden program in the environmental attitudes of elementary school students. Hortechnology, 8(4). 579-583.

Smith, L.L., & Mostenbocker, C.E., (2005). Impact of hands-on science through school gardening in Louisiana public elementary schools. *HortTechnology*, 15, 439-443.

Waliczek, T.M., Bradley, J.C., Lineberger, R.D., & Zajicek, J.M. (2000). Using a web-based survey to research the benefits of children gardening. Hortechnology, 10(1), 71-76.

Zimmerman, T.D. (2005). Unpublished doctoral thesis, University of California, Berkeley.

Zimmerman, T.D. (March, 2010). Paper presented at the National Association for Research on Science Teaching Annual Conference. Philadelphia, PA.

Zimmerman, T.D. (2011). In J.E. Katz. W. LeBrar & E. Lynch (Eds.), Creativity and Technology: Social Media, Mobiles and Museums. Museumsetc., Edinburgh.

CHAPTER 3

HOW A GARDEN-BASED APPROACH TO TEACHING LIFE SCIENCE AFFECTS STUDENTS' ATTITUDES TOWARD THE ENVIRONMENT AND COLLABORATION

Abstract

Recently, schools nationwide have expressed a renewed interest in school gardens (California School Garden Network, 2006), viewing them as innovative educational tools. Most of the scant studies on these settings investigate the health/nutritional impacts, science learning potential, or emotional dispositions of students. However, few studies examine the shifts in attitudes that occur for students as a result of experiences in school gardens. The purpose of this mixed method study was to examine a school garden program at a K-3 elementary school. Results from pre/post tests, pre/post environmental and collaboration attitudes surveys, interviews, and recorded student conversations reveal a number of changes. Changes include student motivation, real-world experiences, science learning, and shifts in attitude toward the environment and the "21st Century Skill" collaboration.

My study sought to demonstrate the value of garden-based learning through a focus on measures of learning typically associated with the informal learning environment. These measures tend to take into account shifts in attitude which can be important factors in learning. In contrast, existing studies on school gardens that do examine learning emphasize individual learning of traditional school content (math, science, etc.) (Blaire, 2009; Dirks & Orvis, 2005; Klemmer, Waliczek & Zajicek, 2005a

& b; Smith & Mostenbocker, 2005). My results indicate positive shifts in attitude toward nature and working collaboratively with other students providing further support for school gardens as contexts for learning.

Objectives

Environmental issues gained a conspicuous position on the national policy agenda in the 1970s (Dunlap, van Liere, Mertig, & Jones, 2002). They have not lost standing, which is evidenced by the fact that President Obama has included environmental literacy in the U.S. Department of Education budget since 2010 (NCLI Coalition, 2010). The primary goal of environmental education is producing environmentally literate and responsible citizens (Knapp, 2000). One venue for environmental education is outdoor learning opportunities. Outdoor learning opportunities have many positive impacts, including improving students' attitudes about the environment (Dillon et al., 2006). In 2011, Senator John Reed of Rhode Island (D) initiated an amendment to the *Elementary and Secondary Education Act of 1965*, otherwise known as *No Child Left Behind*, called the *No Child Left Inside Act*. This environmental education bill supports states to develop environmental literacy programs and promotes professional development programs for teachers to incorporate outdoor learning opportunities into their practice.

Related to this national focus to the environment and environmental education is school gardens. Over 3,000 school gardens are being used across the country for educational purposes (National Gardening Association, 2010). Several research studies have shown that school gardens provide a variety of environmental stewardship opportunities (Alexander et al., 1995; Blair, 2009; Brunotts, 1998; Brynjegard, 2001; Canaris, 1995; Faddegon, 2005; Moore, 1995; Thorp & Townsend, 2001). School-based instructional strategies that use a garden of some kind as a teaching tool are often referred to as garden-based learning. Beginning in the mid-1990s, a number of researchers started to explore the effects of school garden programs. Most of the studies that have been conducted have been in the area of nutrition education and have been small-scale and quantitative in methodology. Evidence shows that school gardens can be used to improve nutritional habits by encouraging children to eat more vegetables (Lineburger & Zajiceck, 2000; Nanney, Johnson, Elliot, & Haire-Joshu, 2006). A small number of studies have explored how school gardens affect children's' environmental attitudes (Skelly & Zajicek, 1998; Waliczek & Zajicek, 1999) and social and emotional growth (Desmond et al., 2002; Waliczek, Bradley, Lineberger, & Zajicek, 2000). In addition, four studies have looked at learning by evaluating specific garden-based curricula and academic achievement by students in science (Dirks & Orvis, 2005; Klemmer, Waliczek & Zajicek, 2005a & b; Smith & Mostenbocker, 2005).

Although I found no studies on the use of school gardens for teaching 21st Century Skills, I argue that school gardens may be important vehicles for teaching skills necessary for students to succeed in the 21st century. In 2009, the New Jersey Core Curriculum was reviewed and updated according to the Standards Revision Project. According to the Partnership for 21st Century Skills (2010), "The key goal of the 2009 revision was to align state content standards with the knowledge and skills needed for post-secondary education and the 21st century workplace." (Fourteen other states also revised their educational standards to reflect such changes.) In addition to the core subjects (3 Rs), the following 4Cs were determined to be necessary skills in the 21st century: 1) critical thinking, 2) communication, 3) collaboration, and 4) creativity.

Arguably, these skills can all be developed through experiences in a school garden. My study focuses on the "21^{st} Century Skill" collaboration. Students need to develop the ability to "collaborate with others." Collaboration is defined as the ability to "work effectively and respectfully with diverse teams, exercise flexibility and willingness to be helpful in making necessary compromises to accomplish a common goal, and assume shared responsibility for collaborative work, and value the individual contributions made by each team member" (Partnership for 21^{st} Century Skills, 2010).

However, in spite of interest in exploring school garden programs and the push to develop students' "21^{st}-Century Skills," a connection between them is poorly understood. As I argue in Fisher-Maltese and Zimmerman, in review, I believe existing studies on garden-based learning approach learning through a school-based perspective, that is, they focus mainly on content learning. I believe this perspective on learning is unduly narrow and limits the conclusions that can be drawn about the benefits of these settings. In this paper I present evidence of the impact of a garden-based learning program on student environmental attitudes and collaboration skills, and argue that these are components often associated with informal learning contexts. This paper is part of a larger mixed method study that developed and assessed an elementary garden-based science curriculum on insects, which used a school garden as an informal learning setting. This paper focuses on the following research question: 1) Does involvement in a garden-based curriculum lead to shifts in students' attitudes toward the environment or collaboration? This examination of student attitudes provides a new and important contribution to the small, but growing, body of research on garden-based learning and provides further evidence of the benefits of these out-of-school settings (Dierking et al., 2003).

Background

Beyond science content learning, a variety of other aspects of learning are posited as outcomes associated with garden-based learning. These include, but are not limited to, shifts in attitudes toward the environment and collaboration.

Environmental Attitudes

Environmental attitudes are defined as "a psychological tendency expressed by evaluating the natural environment with some degree of favor or disfavor" (Milfont & Duckit, 2009). There is no gold standard for measuring environmental attitudes; however, direct, self-reporting techniques, such as scales and inventories, are the most widely used techniques (Milfont & Duckit, 2009). While many instruments designed to measure environmental attitudes are study specific, there are three widely used instruments (Dunlap & Jones, 2003): a) The Ecology Scale (Maloney & Ward, 1973), b) The Environmental Concern Scale (Weigel & Weigel, 1978), and c) The New Environmental Paradigm (NEP) (Dunlap & Van Liere, 1978). One of the significant challenges of assessing changes in *children's* environmental attitudes is finding an age-appropriate instrument. Manoli, Johnson & Dunlap (2007) modified the NEP, originally designed for adult populations, for use with children ages 10-12. After interviewing fifth-grade students, the authors found that reducing the number of items on the NEP to 10 from 15 and revising the wording made it appropriate for use with upper elementary students. (Manoli, Johnson, & Dunlap, 2007). However, instruments for measuring the environmental attitudes of very young children (younger than 10 years old) are project-specific and thus my study involved an instrument from a study with 236 sixth-grade students (Ratcliffe, 2007) that we modified for use by reducing the number of items and simplifying the language.

Another challenge in selecting and/or developing an instrument to measure environmental attitudes comes from the inherent complexity of the structure of environmental attitudes. Historically, environmental attitudes are described as containing three components: affect, beliefs, and behavior. However, contemporary studies on attitude structure demonstrate that affect, beliefs and behaviors interact with attitudes, rather than being their constituent components of attitudes (Milfont & Duckit, 2009). Accordingly, I treat environmental attitudes as a singular component and did not measure behavior. With the limitations noted above, my study was informed by research on studies of young peoples' environmental attitudes and the garden learning literature.

Fancovicova & Prokop (2011) conducted a study on 34 Slovakian fifth-grade students who participated in an outdoor education program. Comparing pre/post measures from 17 treatment and 17 control students, they found students' attitudes toward plants, as measured by the Plant Attitude Questionnaire (PAQ), shifted in a positive direction in the treatment group. Similarly, Carrier (2009) conducted a quasi-experimental pre/post study with four fourth- and fifth-grade classes who participated in a 14-week environmental education program in a Southeastern state in the U.S. The treatment group participated in outdoor activities while the comparison group participated in activities in their classrooms. Using the Children's' Attitudes Toward the Environment Scale (Musser & Malleus, 1994) they found interesting differences between boys and girls where boys increased their environmental attitudes when they participated in outdoor activities, while, girls scored the same in both settings. Smith-Sebasto & Cavern

(2006) measured the impact of adding pre/post in-class activities to a three-day environmental education program for 169 seventh-grade students. The Environmental Adaptation Environmental Trust and Pastoralism Subscales of the Children's Environmental Response Inventory (Bunting & Cousins, 1983) were used to measure changes in environmental attitudes. Students who received both pre- and post-activities had statistically significant gains on the Environmental Adaptation Subscale.

Only two research studies have investigated environmental attitude change in conjunction with school gardens, both employing the Project GREEN curriculum. Project GREEN (Garden Resources for Environmental Education Now) is a program that uses a garden to teach about the environment and sustainability (Skelly & Zajicek, 1998). Skelly & Zajicek(1998) surveyed second- and fourth-grade students (n=153) from four elementary schools in Texas who participated in the garden program in comparison to a control group (n=84) that did not participate in the garden program. Using the Children's Environmental Response Inventory, they found garden program students demonstrating more positive environmental attitudes (e.g., higher scores in pastoralism, or "enjoyment of the natural environment in an intellectual and aesthetic fashion," (Skelly & Zajicek, 1998, p. 579) than those students without the garden experience. Similarly, Waliczek and Zajicek (1999), in their study of 589 second- through eighth-grade students from seven schools in Texas and Kansas, found that environmental attitudes changed in a positive direction on a project-specific environmental attitudes scale called The School Garden Program Environmental Attitude Inventory after experiencing Project GREEN gardening activities. Together, these studies indicate a propensity for shifts in attitudes toward the environment for young children when they participate in outdoor or garden-based curriculum experiences, however, none of these projects studied children under the age of 10.

Collaboration

Hmelo-Silver (2004) explains that a “good collaborator means knowing how to function well as part of the team” (p. 241). Functioning well as part of a team involves knowing how to resolve disagreements and reach consensus (Barron, 2002). In order to achieve this, all of the team members need to participate and be able to express themselves openly (Cohen, 1994; Wenger, 1998). Becoming a good collaborator and learning collaboratively are often connected (Hmelo-Silver, 2004). Students working together in small collaborative groups is used in experiential approaches, such as problem-based learning (Hmelo-Silver, 2004). The goal of such an approach is that students are able to take on tasks that are much more mentally challenging as a group than they would alone; this is referred to in the literature as distributing the cognitive load (Hmelo-Silver, 2004; Pea, 1993; Salomon, 1993). Although the garden-based curriculum in this study did not use any formal techniques to establish collaboration, such as scripted cooperation or reciprocal teaching (O’Donnell, 1999; Palincsar & Herrenkohl, 1999), assigning the students a partner or small group was a choice I made to encourage collaboration.

Informal Science

My study comes at a time when there is growing interest in understanding how people learn science in informal settings. In the spring of 1999, the Board of the National Association of Research in Science Teaching (NARST) established an Ad Hoc committee focused on out-of-school science education. The consensus policy statement, issued after two years of collaboration, outlined several aspects of learning that directly connect to the categories of learning I documented in a school garden. For example, I found that learning was socioculturally mediated (Ash, 2003; Ash Crain, Brandt, Loomis, Wheaton, & Bennett, 2007; Bell, et al., 2009; Borun, Chambers, & Cleghorn, 1996; Dierking et al., 2003; Eberbach & Crowley, 2005; Rowe, 2002). More recently, the NRC released *Learning science in informal environments: People, places, and pursuits* (Bell, Lewenstein, Shouse, & Fedder, 2009) in which learning in informal science contexts is described as "learner-motivated, guided by learner interests, voluntary, personal, ongoing, contextually relevant, collaborative, nonlinear, and open-ended" (p. 11). In Fisher-Maltese and Zimmerman (in review) I argue that in order to understand learning in school gardens, researchers should approach these contexts from an informal learning perspective, a perspective that adopts a broad view of learning. This paper further refines the argument set out in Fisher-Maltese and Zimmerman (in review) and expands upon the work by analyzing a different school garden program. From these documents, and the associated research literature, I developed a framework for what I call an informal learning lens (see Table 8) (Fisher-Maltese & Zimmerman, in review). This framework guides my analysis of learning that occurs in a school garden. Of particular importance for this paper, I will be focusing on learning that is "socially mediated" and "life-long" (highlighted in blue), according to Dierking et al.'s (2003) definition.

Table 8

Informal Learning Lens

NARST Description of Learning in Informal Environment (Dierking et al., 2003)	Additional Research on Learning in Informal Environments
Socially Mediated	Bell, et al., 2009; Ash, 2003; Ash Crain, Brandt, Loomis, Wheaton, & Bennett, 2007; Borun, Chambers, & Cleghorn, 1996; Rowe, 2002; Eberbach & Crowley, 2005
Derived from Real-world Experiences in an Authentic Context	Bell, et al., 2009; Kisiel, 2003; Rennie, 2007
Self Motivated and Guided by Learner's Needs and Interests	Bell, et al., 2009; Informal Learning Environments Newsletter, May/June, 1998; Falk, 1999, 2001; Falk & Dierking, 2002
Voluntary	Bell, et al., 2009; Informal Learning Environments Newsletter, May/June, 1998; Falk, 1999, 2001, 2005; Falk & Dierking, 2002; Rahm, 2002; Bamberger & Tal, 2007
Life-long	Bell, et al., 2009; Informal Learning Environments Newsletter, May/June, 1998; Falk, 1999, 2001; Falk & Dierking, 2002; Rahm, 2002

In addition, I have created a conceptual framework that guides this study (see Figure 4). It is a conjecture map (Sandoval, in press). The map is read from left to right. It begins with a *high level conjecture* which describes the kind of learning I am interested in supporting. The conjecture becomes treated within the *Embodiment* of the design. *Embodiment* includes necessary tools and materials and task and participant structures. *Embodiment* generates certain *Mediating Processes* which lead to desired *Outcomes (Sandoval, in press)*.

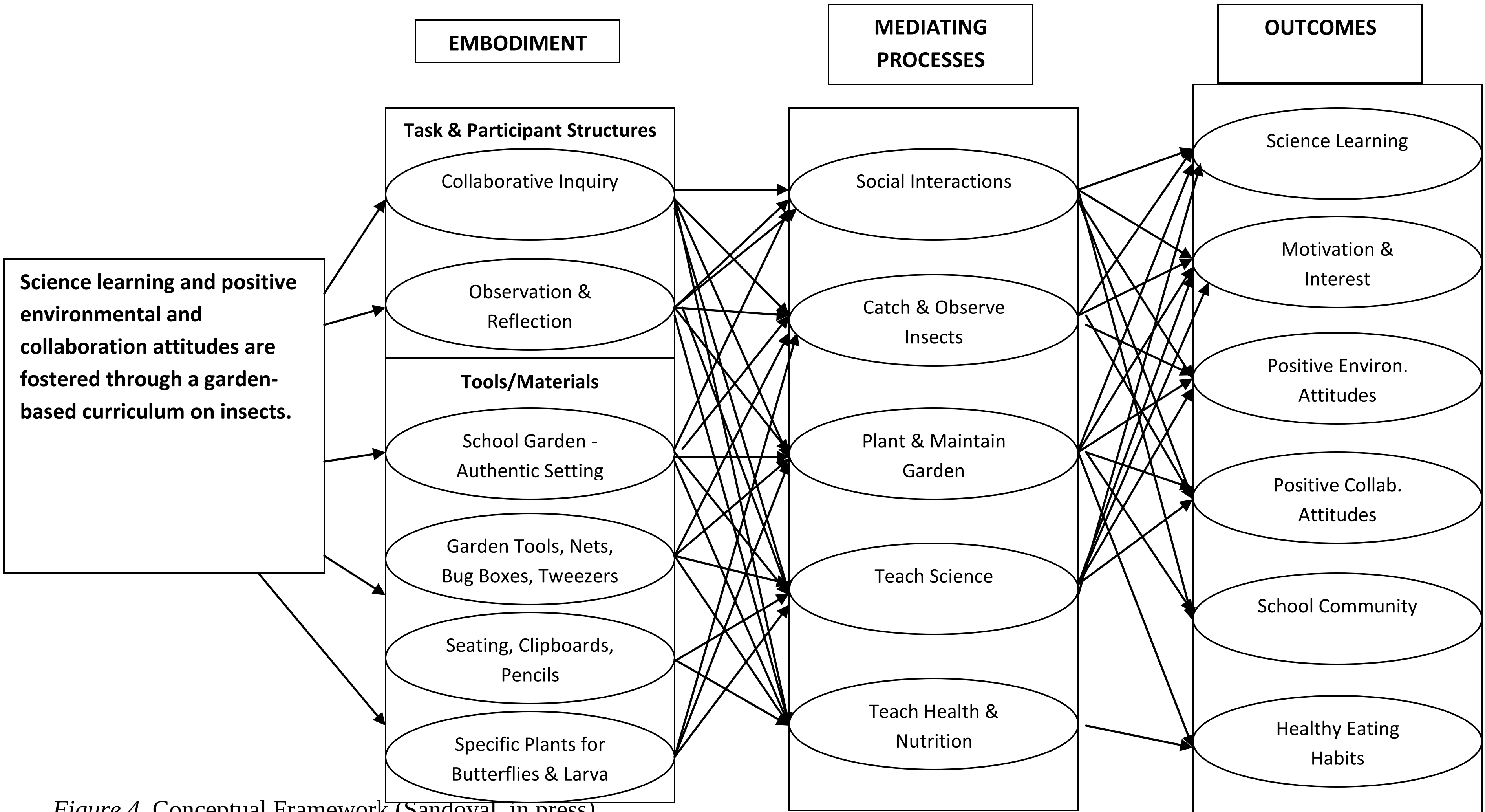

Figure 4. Conceptual Framework (Sandoval, in press)

Methods

This paper is part of a larger case study of a garden-based, science curriculum on insects, which uses a school garden as an informal learning setting.

Study Context

This study took place in four second-grade classrooms within a K-3 elementary school, located in an affluent, predominantly White (60%) and Asian (40%) school district in central New Jersey. Sixty-six second graders participated in the study, along with four teachers, and one principal (n = 71).

Garden-based Curriculum and Framework

The second-grade science curriculum at Penn's Neck Elementary School (a pseudonym) includes a unit on insects. Typically specimens are ordered from a science supply company and raised in the classroom to demonstrate their life cycle changes. Painted Lady butterflies are the most common insect observed in classrooms at the school. In an effort to connect the insect curriculum to the school garden, teachers from Penn's Neck chose ladybugs and praying mantises, in addition to Painted Lady butterflies, to study since they are beneficial to the garden and served as a practical means to connect the insect curriculum to the school garden. However, ladybugs pose a unique challenge to observing the different phases of the life cycle since most science supply companies will only ship adults, as larva are fragile and tend to die during transport.

Following a co-design approach (Penuel, Roschelle, & Shechtman, 2007), a four-week standards-based science curriculum on insects, which uses the school garden, was developed collaboratively with the four participating second-grade teachers. Each week, the students participated in insect lessons in the classroom and in the garden. The researcher facilitated lessons by supporting the teachers and co-teaching the lessons. The weeks' lessons had a given focus, including anatomy, life cycles, helpful and harmful insects, butterfly and larva identification, and designing a butterfly garden (see Table 9).

Table 9

Curriculum Overview

Lesson 1: Using the 5 senses to observe and explore the school garden	
Day 1:	What's a garden? How do I use my 5 senses to observe and explore?
Day 2:	Exploration in the school garden
Lesson 2: Arthropods and insects – Basic anatomy and life cycle	
Day 1:	What's an insect? What's an arthropod? Conduct an observation of a praying mantis Using a rubric in the classroom
Day 2:	Catch and conduct an observation of an

	insect in the school garden
Day 3:	Helpful and harmful insects

Lesson 3: Butterflies – A type of insect

Day 1:	How to identify butterflies
Day 2:	Conduct an observation of butterflies in the school garden
Day 3:	Identifying butterflies by their larva; Conduct an observation of caterpillars in the classroom

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Lesson 4: Designing a butterfly garden

Day 1:	What attracts butterflies to a specific habitat?
Day 2:	Butterfly life cycle
Day 3:	Plant nectar and host plants in the school garden

Role of the Researcher. Over the course of the study, my role as observer varied as direct observer and participant observer (Creswell, 2007). I had been a second-grade teacher at this school and led the initiative to plant the school garden described in the study six years ago. Due to my close connections to the teachers, school garden, and garden-based curriculum the teachers were implementing, I had to be aware of how my biases would affect this research. I took certain precautions to limit bias by asking peers and professors at the university to review the curriculum, instruments, and data. I also made a conscious effort to look for contradictory evidence. While bias is a limitation of my work, my connections to the study setting and participants lent themselves to certain affordances, namely access to the school, teachers, and students, and background knowledge of the teachers and principal that helped me to know where the participants were coming from and what was going on at the school. I facilitated lessons by supporting the teachers and co-teaching the lessons on several occasions. Throughout the study, I was cognizant about remaining objective and encouraged the teachers to take the lead so I could remain in the role of observer.

The curriculum was designed using a framework called Learning Across Contexts (LAC) (Zimmerman, 2005, 2009). LAC is a curriculum design framework that addresses the need to capture evidence of learning across the gaps between informal and formal science learning settings (Zimmerman, 2005, 2009). A goal of the curriculum was to provide evidence that students are learning concepts in the garden that are connected to and reinforced in the classroom. LAC involves a three-phase pedagogical model: (a) pre-visit preparatory activities including learning important terminology and content information, (b) activities and tasks during the field trip (or visit to the school garden), such as going out to the garden, seeing real-life examples of what students are studying in the classroom and recording observations, and (c) post-visit reflection activities, including writing in a science journal or completing a written assignments (e.g., making an insect life cycle timeline) (Zimmerman, 2005, in review). According to this framework, the informal learning experience, in this case lessons in the school garden, is viewed as an integral part of the curriculum, instead of a supplementary or disconnected activity (Zimmerman, 2005, 2009).

Data Sources

Over the course of the curriculum, several data sources allowed for the assessment of both the effectiveness of the curriculum and the knowledge gains by students. The research design and assessment protocols included comparisons within the student population. Data collection involved multiple forms of complementary data (a) field notes from curricular planning meetings, (b) pre-curriculum and post-curriculum semi-structured student interviews (audio recorded), (c) observations of the school garden in use: lessons in the garden and preliminary and follow-up lessons in the classroom (video recorded), (d) digital audio-recorded conversations of students during lessons in the school garden, (e) pre/post tests to assess science content knowledge, and (f) pre/post surveys to assess attitudinal shifts toward the environment (Ratcliffe, 2007) and collaboration (Neo, 2004). I conducted observations at the school garden site, as well as in the classrooms. Almost all of the curricular lessons were observed in all four classrooms. Field notes recorded in a research journal during the observations captured contextual information, such as teacher, setting, date and time, activity, dialogue, and included preliminary analysis. With students from three of the four classes, pre/post interviews were conducted with individual students. With Mrs. Captree's class, due to scheduling constraints, pre-curriculum interviews were conducted with individual students, but post interviews were conducted with one of the students individually, and the other three students as a group. Interviews were videotaped for accuracy. Pre/post tests included multiple choice and open-ended questions designed to elicit students' understanding of insect anatomy, life cycles, behavior, habitats, as well as attitudes toward the environment and collaboration.

Data analysis followed a multi-step process as quantitative and qualitative data were analyzed separately and then examined for triangulation purposes. Pre/post test data were analyzed using a rubric developed by the researcher. Inter-rater reliability was conducted and yielded 94% reliability. Paired sample t-tests were conducted using the statistical software, SPSS, on the pre/post tests and pre/post surveys. I used pre-existing survey instruments. One survey was designed to capture shifts in students' environmental attitudes (Ratcliffe, 2007) and the other shifts in attitudes towards collaboration (Neo, 2004) over the course of the curriculum. Ratcliffe's (2007) survey was selected because it was age-appropriate (although some language did have to be simplified since it was designed for sixth-grade students) and was previously used to measure changes in environmental attitudes as a result of a school garden experience. An abbreviated and modified version of Ratcliffe's (2007) Ecoliteracy Survey included statements about students' ecological attitudes toward extinction, organic produce, water pollution, land conservation and littering, and energy and water conservation. Ratcliffe (2007) explains, "These eco-attitudes were identified as 'things environmental people cared about' and are conceptualizations of environmentally responsible behaviors found in the literature

(Bunting & Cousins, 1985; Jaus, 1982, 1984)" (p. 78). In total, 7 attitudinal statements were included in a 5-point Likert scale (e.g., 1 = strongly agree, 5 = strongly disagree). Survey responses were scored on a 1 to 5 scale. For all but two of the statements (2 and 8), a 1, or strongly agree, was the most desirable response. For example, statement 1 read "I am worried about animals that are going extinct." For statements 2 and 8, the inverse was the most desirable response so the responses were re-coded for consistency (i.e., a 1 became a 5, a 2 became a 4, etc.). Responses were then added together to create an index (Index A = pre-test, Index B = post-test). Indices provided a general measure of environmental attitudes over time (i.e., from pre- to post-test). Interview and observational data (e.g., student conversations during lessons in the garden and classroom) were first transcribed and organized by data source and then examined and organized by research question. The third step involved describing the data set with several rounds of coding using a coding scheme developed to highlight examples of student learning and attitudinal shifts (see Table 10). Codes for environmental attitudes included "protect habitat," "fear of insects," and "want to protect insects/compassion towards." Codes for collaboration attitudes included "collaboration through teamwork" and "collaboration through socially mediated learning." Codes for engagement and motivation were also included.

Table 10

Coding Table

Code	Criteria	Example
Protect habitat	Demonstrated a desire to protect insects' habitat	"Yes, because they didn't harm you or anything and they didn't do anything to your place and now you should do something to help them because they need to have a habitat to survive."
Fear of insects	Demonstrated a fear of insects	"Yeah, because then like bees, if you ruin their home, they'll chase after you. But beware of killer bees because they might like, I think they might kill you because they're called killer bees."
Want to protect insects	Demonstrated compassion towards insects	"What? No! Don't hurt nature!"
Collaboration through teamwork	Demonstrated working together	"You can help each other." "I think…We got it! We got it! Go get the net house! We got a Cabbage White! You have to put it in here and close it."
Collaboration through socially mediated learning	Talking about science	"Guys! I think you caught a Mayfly. They only live for like 30 minutes."
Motivation/Interest	Demonstrated motivation or interest in garden or curriculum	"Mrs. F-M can you come next week and we can try to catch more butterflies? YAY!!!"

Results

Data from this study both support existing research on garden-based learning and reveal important new findings about learning in these settings. I first discuss students' collaboration skills and then environmental attitudes.

Collaboration Skills

In interviews (n = 16), students focus on the garden as an opportunity to collaborate, or engage in discussions about school content, methods, processes of science, etc., and work with their friends. They described different ways that they worked together and helped each other, such as while catching insects and butterflies and planting flowers. Second-grade student, Pamela Luther, in Mrs. Briarwood's class described,

> My partner and I helped each other out to catch that red ant. So whenever I'd find it, I'd tell her so she would be the one picking it up. I've got the good eyes so I'd always find it.

Carson Miller in Mrs. Captree's class described how he collaborated with his small group by experimenting with different methodologies for successfully catching butterflies,

> Well, we learned from the last time my group was doing the butterfly catching. We, like, decided to split up into two pairs and each cover one part of the garden. We finally caught it, but then it escaped. Then I saw that if we just be quiet and work together and just let one person get it, it might work better.

During interviews, I also directly asked students, "Do you like working as a team with other students?" in order to assess their attitudes towards collaboration. Student responses fell into one of three categories: Yes, No, and Sometimes (see Table 11). Students often qualified why they said Yes, No, or Sometimes and these reasons fell into five reasoning categories: Fun, Speed, Altruism, Work Load, Interpersonal (see Table 12).

Table 11

Students' Responses When Asked if They Like Working with Other Students

Response Category	# of Students (Pre)	# of Students (Post)
Yes	8	10
Sometimes	4	2
No	4	4

Table 12

Why Students Like or Dislike Working with Other Students

Student Reasoning	Response Category	Example Student Reasoning
Fun	Yes	"It's more fun to talk to your friends."
Speed (faster or slower)	Yes/No	"I get my work done faster."
Altruism	Yes	"You can help each other."
Work Load	No	"You don't have other people hogging the whole thing."
Interpersonal	No	"I like that there's not going to be fighting going on."

When comparing pre/post curriculum interview responses, most of the students' were consistent; however, two students changed their minds from only liking working as a team some of the time to all of the time by the end of the curriculum (a 30% improvement). I was pleasantly surprised by this result since the curriculum does not actively promote collaboration, other than providing the students opportunities to collaborate by having them work in pairs and small groups.

Collaboration as Teamwork. Audio-recorded conversations of students in the garden revealed students working together and talking about what they were seeing and doing, as seen in this example of Miranda and Diana in Mrs. Captree's class trying to catch a butterfly with butterfly nets and put it into a net house:

Miranda: C'mon I see one! Let's go! It's fast! (Running, out of breath) Diana, c'mon let's find another one.

Diana: A Cabbage White is hiding in there. Let's wait for it. There it is! (Runs) I got it! (Screams) I see it in the trees. That's where it likes to be.

Miranda: Let's go this way! Diana, I'll look down here. You go over there. It went in the garden!!! Over there! There it is! Careful, that's Poison Ivy over there.

Diana: It keeps flying away. Butterflies have compound eyes.

Miranda: (To a parent volunteer) I caught one, but it got away. I see one! It's over there! Go to the front!

Diana: Got it?

Miranda: I think…We got it! We got it! (shrieking) Go get the net house!

Diana: We got a Cabbage White! You have to put it in here and close it.

Miranda: It's under my net. Get ready to zip it closed. (Screams)

Diana: We got it, but it flew away! Did you see the eggs?

Miranda: Yes, I saw them. I know a better way to catch them. We put the nets in (the net house) and then quickly pull it out and zip it.

Diana: We have to find another one in 10 minutes! (Running)

In this example, Diana and Miranda are heard negotiating what is the best way to catch a butterfly and transfer it from their butterfly net to a net house.

Collaboration through Social Mediation. In another example, Archie and Kevin in Ms. Emilio's class catch an insect they do not recognize and go to show it to their friend, John.

Archie: It's in! We got something! (goes to show John)

Kevin: Me and Archie caught it (to John).

John: Guys! I think you caught a Mayfly. They only live for like 30 minutes.

Archie: We caught something! (to other students) I just went like this and it flew into my net! You okay little fella (to the insect)? Ms. Emilio, look we caught something!

Kevin: What is it?

Ms. Emilio: I don't know, but it looks cool.

Researcher: You caught a Lace Wing. Those are really beneficial for the garden. They eat aphids!

Archie: Should I let it go?

Researcher: Yeah, I would let it go.

Archie: There you go little buddy. He won't go out.

Researcher: Just put it upside down and shake it.

Archie: I don't want to hurt it!

Kevin: (To others pointing to Lace Wing) That can eat aphids!

Archie: Yeah, like the famous Ladybug!

In this example, John incorrectly identifies the insect that Archie and Kevin have caught, but also teaches them an interesting fact about Mayflies.

I interviewed a small subset of each class, however, all participants in the garden curriculum (n = 66) were asked to complete a collaboration attitudes survey. I received 63 pre-surveys, 55 post-surveys, and yielded a total of 52 repeated measures for this survey. The collaboration attitudes survey contained 11 statements about students' attitudes toward collaborating or working with a group of students at school versus working alone using a Likert scale response component. For example, items on the collaboration survey included statements such as, "I learn more when we work as a group than when I work alone," and, "I enjoy working as a team." Interestingly, in contrast to interview and student conversation data, pre/post survey analysis indicates no statistically significant change (Index A (pre) $M = 19.75$, $SD = 6.69$; Index B (post) $M = 19.83$, $SD = 7.95$, a lower number indicates a better score; paired t-test yielded $t(52) = -0.054$, $p=.957$). I believe I saw no change from pre- to post-survey because students' collaboration skills did not change very much. As mentioned above, the garden-based curriculum did not actively promote collaboration.

Environmental Attitudes

Several forms of data were used to assess if students' attitudes changed toward the environment through their use of the school garden: results from the pre/post environmental attitudes survey, responses to specific questions on the pre/post test, interviews, and student conversations in the garden. With regard to the interviews, overall, the staff at Penns Neck Elementary expressed the view that the school garden is a tool that helps the students shift their environmental attitudes, or develop a greater understanding and appreciation "of the importance of the earth and the environment," as expressed by the school principal, Mr. Agnosto.

The environmental attitudes survey contained eight statements about plants and animals, an expression of an environmental attitude toward protecting and cultivating them, and a Likert response component. For example, one statement from the survey was, “Trying to protect the environment is my responsibility.” Another statement was, “I think people should build more parks for animals.” Sixty-three students completed both the pre- and post-survey; only repeated measures were analyzed. Analysis of these pre/post surveys did not result in a statistically significant pre-post change (Index A (pre) M = 17.84, SD = 4.43; Index B (post) M = 17.81, SD = 4.86, a lower number indicates a better score; paired t-test yielded $t(63) = 0.076$, $p = .94$. While quantitative data (i.e., the environmental attitudes survey) show no statistically significant shift in attitudes, qualitative data collected for the study indicate otherwise. Specifically, responses to a question on the pre/post test, interviews, and student conversations, show a positive shift in environmental attitude.

Pre/post tests also included one question assessing students’ environmental attitudes towards butterflies and their habitats, q13: “Is there anything you can do to protect where butterflies live? Do you think this is important? If you do, why?” to assess how students’ environmental attitudes changed over the course of the curriculum, if at all. An answer to this question that included a pro-environmental behavior (e.g., plant plants with flowers from which butterflies obtain nectar, don’t pull important plants thought to be weeds, don't harm habitats) was coded as a “1,” which was considered the most desirable or “correct” response. If students provided some “other” response, it was coded as a “5,” and was considered “incorrect.” If students did not answer the question, it was coded as an “88.” While many students answered, “I don’t know” (n = 53) to q13 on the pre-test, post-test answers included a variety of responses. Many students had ideas for things they could do to protect where butterflies live (q13: n = 36 answered “1” for a positive behavior), such as “plant food for the butterflies to eat” and “ask my parents to stop spraying our lawn [with pesticides].” For the second part of the question, “Do you think it is important [to protect where butterflies live]?”, students answered either “yes” (coded as a “1”), “no” (coded as a “2”), or “I don’t know” (see Table 13)

Table 13

Responses to “Do you think it is important to protect where butterflies live?”

Response	Pre-Test	Post-test
Yes	17	25
No	1	1
I don’t know	48	40

For the third part of the question, “If you do, why?” students either provided a “good reason” (e.g., butterflies are helpful insects because they pollinate flowers, help plants grow, are living things), coded as a “1”, provided “not a good reason,” coded as a “2,” or answered “I don’t know,” coded as an “88” (see Table 14).

Table 14

Responses to “If you do [think it’s important to protect where butterflies live], why?”

Response	Pre-Test	Post-test

Good Reason	16	25
Not a Good Reason	7	7
I don't know	43	34

Teachers and students communicated in interviews that the garden teaches students to respect and protect nature in several ways. Sixteen students (four in each of the second-grade classes) were interviewed before and after the curriculum. Pre/post curriculum student interviews included the questions, "Do you think it's important to protect where insects live? If yes, why? How can you protect where insects live? Is there anything you can do?" In total, 6 out of 16 students' interview responses showed a positive shift in environmental attitudes from pre to post curriculum (see Table 15).

Table 15

Student Interview Responses to "Do You Think It's Important to Protect Where Insects Live?"

Student	Pre/Post	Response
Pamela	Pre	No. Because they eat our plants.
	Post	Some places like we don't need to protect where ants live. And other critters, but we do need to protect some of, ones that eat other insects and that don't do any harm to us.
Carson	Pre	Yeah, because then like bees, if you ruin their home, they'll chase after you. But beware of killer bees because they might like, I think they might kill you because they're called killer bees.
	Post	Yeah, because some are helpful so, like the ones that are

		helpful you would keep safe and then the ones that are not very helpful, you wouldn't.
Margaret	Pre	No.
	Post	Yeah, because insects are important to the world. You can't live without insects because some are helpful. For example, a dragonfly. Because mosquitoes bother people, but dragonflies eat mosquitoes and then there are less mosquitoes. And an example of a harmful insect is a killer bee.
Kyle	Pre	Yes, because if you hurt an insect, they'll hurt you back. Like if you hurt a bee, it will sting you.
	Post	Yes, because they didn't harm you or anything and they didn't do anything to your place and now you should do something to help them because they need to have a habitat to survive.
Isaac	Pre	Yes, otherwise you have another animal to add to the endangered species list. There are so many.
	Post	Yes, since most butterflies now are dying…because people are killing like, they're putting bug spray…and then they're well, they're searching for the habitat and [people are] building cities there.
Noah	Pre	Mm-hmm. Because they could become endangered and maybe even extinct. We need insects…I mean if we didn't have honeybees, there would be no such thing as honey, which never spoils.
	Post	Yes. Well, because not all of them are pests or harmful. They're helpful because they want to protect, and they help pollinate flowers.

Pamela and Margaret have a complete attitude change. They changed their attitude from "no, you should not protect where insects live" in the pre-curriculum interview to "yes, because some insects are actually helpful, and not all are harmful." Pamela, Carson, Margaret, and Noah all seem to regard insects favorably because some insects are helpful. Isaac and Noah do not change their opinion that insects' habitats should be protected, but their reasoning in the post-interview is much more sophisticated. Both explain that you should protect them in the pre-interview because you do not want more animals added to the endangered animals list. However, in the post-interview, Isaac explains how people are responsible for the butterflies dying through spraying pesticides and habitat destruction and Noah explains how insects are important for pollination. Carson and Kyle explain that you should protect where insects live for a different reason: fear that they will hurt you if you don't protect their habitat. In the post-curriculum interview, Carson expresses that you should protect the insects' habitats that are helpful. Kyle seems to have developed some compassion towards insects in that he thinks he should help them since they need a habitat to survive. At least three other students communicated a fear of insects in the pre-interview. Clearly, students had either been taught previously or learned through personal experience that insects are frightening. For example, Darren Ruiz in Mrs. Briarwood's class explained in an interview, "I don't like insects. Like I can draw an insect, but when people talk about them a lot, I start to shiver and then I feel like I have bugs and insects crawling on me." Darren refused to touch the plastic creatures I asked him to sort into two groups during the interview: insects and non-insects. He felt more comfortable pointing as I moved them for him into two different piles. Interestingly, Darren seemed to overcome or forget about his fear during the lesson (L2/D2) in the garden which involved catching insects with tweezers and nets and observing them in bug boxes. In the audio-recorded conversation between him and his partner he does not once express fear and seems engaged in the activity.

Student conversation data also provided support that students had a positive shift in attitude toward the environment. Students' comments fell into two categories:

expressing concern for insects and wanting to protect them and expressing excitement about catching insects as part of the curriculum (see Table 16).

Table 16

Student Voices from the Garden

Concern for Insects/Desire to Protect Them
We won't hurt you butterfly! (chasing a Cabbage White)
Robert, let it go. Let him go! There he goes. He jumped! There's Larry, the grasshopper. Don't touch him!
You have to learn to be gentle with that! (to others with nets)
Dude, don't do that. You're going to kill it.
Student 1: Look, there's a wood ant! Right there. Kill it! Student 2: What? No! Don't hurt nature! Student 1: I'm not. I'm just kidding.
Excitement About Catching Insects as Part of the Curriculum
Teacher: Group 1, you're going to look for insects. Students: Yes! (squeals)
I saw a really cool insect, Rohan. Somewhere…here. Get over here! Look at that one. Get it!
Student: Mrs. F-M can you come next week and we can try to catch more butterflies?" Researcher: Yes, we're going to do that. Student: YAY!!!

Teacher: Would you like to help me break the lumps [in the soil before planting flowers]?
Student: Sure, I'd love to!

Discussion

Surprisingly, the quantitative data for this study show no shifts in attitudes. This finding is in contrast to other findings that show positive shifts in environmental attitudes for students as a result of outdoor education programs generally (Carrier, 2009; Fancovicova & Prokop, 2011; Farmer, Knapp & Benton, 2007) and experiences in school gardens, in particular (Skelly & Zajicek, 1998; Waliczek & Zajicek, 1999). The question is "why?" Responses to the environmental attitudes survey did not show statistically significant student gains. With many environmental attitude research instruments being study specific, there is no gold standard for measuring environmental attitudes, which makes it difficult to make generalizations in the field (Milfont & Duckit, 2009). A review of instruments that are reliable and valid reduced my choice to only three instruments. However, only one of these had been modified for research of children's environmental attitudes (Manoli, Johnson & Dunlap, 2007). In addition, there are challenges to developing a good instrument for detecting changes in environmental attitudes (Johnson & Manoli, 2010). As previously mentioned, one challenge is the complexity and multidimensional structure of environmental attitudes (Milfont & Duckit, 2009). I believe I saw no change from pre- to post-survey because of the limitations of the instrument. While students' shifts in environmental attitudes were often about insects specifically, the survey questions were very general and did not match the specific curriculum content. Data suggest that perhaps another tool would have resulted in quantitative pre-post changes as found in other studies. For instance, a scale that included fear toward nature (i.e., insects) would have captured changes in the students' environmental attitudes.

However, in contrast to the quantitative data from this study, the qualitative data indicate a shift in attitudes toward a more empathic view of nature, making us question what is really going on for these students. Results from the pre/post test, interviews, and student conversations in the garden show positive shifts in student attitudes toward the environment (Patton, 2002). I organize my discussion of the qualitative data into two categories of shifting attitudes as a result of learning experiences, those that are socially mediated and those that are indicators of life-long learning (see Table 17).

Table 17

Informal Learning Lens and Data

NARST Description of Learning in Informal Environment (Dierking et al., 2003)	Fisher-Maltese & Zimmerman Study Data	Additional Research on Learning in Informal Environments
Socially Mediated	-Students discuss insects and plants in the school garden, which mediates science learning. -Students discuss how they worked together to catch insects and butterflies in the garden. - Majority of students report	Bell, et al., 2009; Ash, 2003; Ash Crain, Brandt, Loomis, Wheaton, & Bennett, 2007; Borun, Chambers, & Cleghorn, 1996; Rowe, 2002; Eberbach & Crowley, 2005

	that they like opportunity to work as a team with other students in garden. -Results to a pre/post collaboration survey are not statistically significant	
Life-Long	- Students discuss why they think it's important to protect where insects live (e.g., butterflies) and share ideas for how to do so. -Some students convey shift in attitude that all insects are bad and should be feared to some insects are helpful and some are harmful. -Results to a pre/post environmental attitudes survey are not statistically significant	Bell, et al., 2009; Informal Learning Environments Newsletter, May/June, 1998; Falk, 1999, 2001; Falk & Dierking, 2002; Rahm, 2002

Social Learning

I classify exploring students' shifts in attitudes toward collaboration, or working "effectively and respectfully with team members" (The Partnership for 21st Century Skills, 2010) as social learning. And, if science learning is "strongly socioculturally mediated" (Dierking et al., p. 109, 2003), it is not surprising then, that a setting that provides opportunities for students to work with partners and small groups is fertile ground for science learning (Fisher-Maltese & Zimmerman, in review). During data collection, I heard repeatedly from student participants that they enjoyed the opportunity to work as a team and help each other when out in the school garden. When Pamela describes how she worked with her partner to catch an ant or Diana and Miranda excitedly talk back and forth as they struggle to catch a butterfly, they speak directly to this point. Likewise, the conversation between Archie and Kevin is also an example of collaboration through social mediation. In the end, Kevin and Archie co-construct the notion that Lace Wings eat aphids, just like Ladybugs, and are therefore beneficial to the garden. This is not to say that simply because they want to work with their friends that the learning is socially-mediated per se, but it provides greater opportunities for discourse which may mediate learning (Fisher-Maltese & Zimmerman, in review). Several researchers have reported on the mediating role of discourse in informal settings. Though the discourse may not always be on topic, conversations in museums and other informal settings mediate the learning experience (Ash, 2003; Ash, Crain, Brandt, Loomis, Wheaton, & Bennett, 2007; Borun, Chambers, & Cleghorn, 1996). Therefore, if students enjoy using the garden because it allows them an opportunity to socialize, discourse in this setting may lead to science learning in unexpected ways (Zimmerman, 2010). For example, Zimmerman (2010) found students engaging in science-related talk during a visit to an aquarium. Though this talk was not the focus of the field trip exercise, the students, who were clearly friends, began a science-related conversation that led both students to verbalize science ideas. Often omitted in a school learning perspective, an informal learning context highlights the social learning opportunities that the school garden provides. Capitalizing on these opportunities through timely scaffolding may lead to deeper learning (Dierking et al., 2003).

The majority of students interviewed reported that they liked working collaboratively with other students, whether because “it’s more fun to talk to your friends,” or “you get your work done more quickly,” they expressed this is one aspect of working in the school garden that they like. All four of the teachers and the principal also reported that students felt excited, and/or enjoyed, learning in the school garden. In post-curriculum interviews, all of the teachers conveyed that they were pleased that their students seemed excited about learning over the course of the unit and three out of four were even surprised that their students learned as much as they did. In sum, my data from the garden-based curriculum reveal instances of the connection between motivation to learning in the school garden and emotional states (e.g., enjoyment, excitement); working collaboratively with other students seems to contribute.

Life-Long Learning

Life-long learning through the school garden is also revealed in shifts in attitude that are carried over from year to year. Dierking et al. (2003) explain,

> Rather, learning, in general, and science learning in particular, is cumulative, emerging over time through myriad experiences, including but not limited to experiences in museums and schools…The experiences children and adults have in these various situations dynamically interact to influence the ways individuals construct scientific knowledge, *attitudes* (italics added), behaviors, and understanding. (p. 109)

In general, some of the participating second-grade students from Penns Neck Elementary School seemed to undergo a shift in environmental attitudes. Perhaps in order to shift the majority of students’ attitudes, changes to the curriculum based on a better understanding of the complex structure of environmental attitudes would be necessary. Regardless, many students began the study fearing insects and having no idea why anyone would protect where they live. By the end of the garden-based curriculum, the majority of students understood that not all insects are harmful, and some are, in fact, helpful and interesting. This new understanding helped them view insects more favorably and compassionately. Darren Ruiz, from Mrs. Briarwood's class, was an illustrative example of this change in attitude. As Darren learned that not all insects are harmful, he shifted from being afraid to touch the plastic insects in the pre-curriculum interview to enthusiastically working with his partner to catch ants in the garden and observe them in his bug box. Most of the students also seemed to feel by the end of the curriculum that one *should* protect where insects live and had some ideas about how to do so. For example, they suggested during post-interviews, "not spraying the lawn" or" planting foods that the butterflies (or other insects) like to eat" (e..g., Milkweed for the Monarchs), which they got to experience during one of the garden lessons. Students' shifts in environmental attitudes toward insects are not unique to this study. Ratcliffe (2007) found that children who participated in school gardening shifted their attitudes toward the environment with regard to insects. For example, teachers from her study reported that students became "more insect friendly" and that "not all kids want to make their hands dirty, but…they got used to it and [then]…they wanted to touch the worms and insects " (Ratcliffe, p. 80, 2007).

Conclusion

This paper provides support of the use of mixed methods research techniques. While the qualitative data indicate positive shifts for students toward the environment and collaboration, the quantitative data show no statistically significant changes in attitude. There are advantages to both qualitative and quantitative methods being used; dual methodologies add to the richness of data analysis (Firestone, 1987; Fraser & Tobin, 1993; Orion & Hoftstein, 1994; Sieber, 1973). Fraser and Tobin (1992) explain the rationale for a combined method:

> …the complexity of qualitative observational data and quantitative data added to the richness of the data base as a whole…Through triangulation of quantitative data and qualitative information, greater credibility could be placed in findings because they emerged consistently from data obtained using a range of different data collection methods (p. 290)

In the case of this study, triangulation of the data show positive shifts in attitude that would have been missed if quantitative methods were used in exclusion. This work draws from a small sample of teachers, administrators, and students. Though limited in scope, this study provides a rich example of how a garden-based curriculum can shift student attitudes.

References

Alexander, J., North, M.W., & Hendren, D.K. (1995). Master gardener classroom garden project: An evaluation of the benefits to children. *Child Environments*, 12(2), 124-133.

Anderson, D., Lucas, K. B., Ginns, I. S., & Dierking, L. D. (2000). Development of knowledge about electricity and magnetism during a visit to a science museum and related post-visit activities. Science Education, 84(5), 658-679.

Ash, D. (2003). Dialogic inquiry in life science conversations of family groups in a museum. Journal of Research in Science Teaching, 40(2), 138-162.

Ash, D., Crain, R., Brandt, C., Loomis, M., Wheaton, M., & Bennett, C. (2007). Talk, tools, and tensions: Observing biological talk over time. International Journal of Science Education, 29(12), 1581-1602.

Bamberger, Y., & Tal, T. (2007). Learning in a personal context: Levels of choice in a free choice learning environment in science and natural history museums. Science Education, 91(1), 75-95.

Barron, B. (2002). Achieving coordination in collaborative problem-solving groups. *Journal of the Learning Sciences*, 9, 403-437.

Bell, P., Lewenstein, B., Shouse, A.W., & Feder, M.A. (Eds.). (2009). Learning science in informal environments: People, places, and pursuits. Washington, D.C.: National Academies Press.

Blair, D. (2009). The child in the garden: An evaluative review of the benefits of school gardening. *Journal of Environmental Education*, 40(2), 15-38.

Borun, M., Chambers, M., & Cleghorn, A. (1996). Families are learning in science museums. Curator: The Museum Journal, 39(2), 123-138.

Brown, A. (1992). Design experiments: Theoretical and methodological challenges in creating complex interventions in classroom settings. *The Journal of the Learning Sciences*, 2(2), 141-178.

Bunting, T.E., & Cousins, L.R. (1983). Development and application of the Children's Environmental Response Inventory. *Journal of Environmental Education*, 15(1), 3-10.

California Department of Education. (2010). *Catalogue listing of publications*. Retrieved October 25, 2010, from http://www.cde.ca.gov./re/pn/rc/ap/pubdisplay.aspx?ID=001512.

California School Garden Network. (2006). Gardens for learning: Creating and sustaining your school garden. Irvine, CA: California School Garden Network.

Canaris, I. (1995). Growing foods for growing minds: Integrating gardening into the total curriculum. Children's Environments, 12(2), 134-142.

Carrier, S. (2009). Environmental education in the schoolyard: Learning styles and gender. *The Journal of Environmental Education*, 40(3), 2-12.

Center for Ecoliteracy. (1999). The edible schoolyard. Berkeley, California: Learning in the real world.

Cohen, E.G. (1994). Restructuring the classroom: Conditions for productive small groups. *Review of Educational Research*, 64, 1-35.

Coleman, J.A. (1977). Differences between experiential and classroom learning. In M.T. Keeton (Ed.), *Experiential learning: Rationale, characteristics, and assessment* (pp. 49-61). San Francisco, CA: Jossey-Bass Publishers.

Creswell, J.W. (2007). Qualitative inquiry & research design: Choosing among five approaches. London, England: Sage Publications.

Desmond, D., Grieshop, J., & Subramaniam, A. (2002). Revisiting garden based learning in basic education: Philosophical roots, historical foundations, best practices and products, impacts, outcomes, and future directions. Prepared for IIEP/FAO, SDRE Food and Agricultural Organization/United Nations, Rome, Italy, UNESCO International Institute for Educational Planning, Paris, France.

Dierking, L.D., Falk, J.H., Rennie, L., Anderson, D., & Ellenbogen, K. (2003). Policy statement of the "Informal Science Education" Ad Hoc Committee. Journal of Research in Science Teaching, 40, 108-111.

Dillon, J., Rickinson, M., Teamey, K., Morris, M., Choi, M.Y., Sanders, D., Benefield, P. (2006). The value of outdoor learning: Evidence from research in the U.K. and elsewhere. *School Science Review*, 87(320), 107-111.

Dirks, A.E., & Orvis, K. (2005). An evaluation of the junior master gardener program in third grade classrooms. *HortTechnology*, 15, 443-447.

Driver, R., Leach, J., Milllar, R., & Scott, P. (1996). *Young people's images of science*. Buckingham, England: Open University Press.

Dunlap, R. E., & Jones, R. E.. (2003). Environmental attitudes and values. In R. Fernandez-Ballesteros (Ed.), *Encyclopedia of psychological assessment*, Vol. 1 (pp. 364-369). London: Sage.

Dunlap, R. E., & Van Liere, K. D. (1978). A proposed measuring instrument and preliminary results: The 'New Environmental Paradigm'. *Journal of Environmental Education*, *9*(1), 10-19.

Eberbach, C., & Crowley, K. (2005). From living to virtual: Learning from museum objects. Curator: The Museum Journal, 48(3), 317-338.

Faddegon, P.A. (2005). *The kids growing food school gardening program: Agricultural literacy and other educational outcomes.* Doctoral dissertation, Cornell University, Ithaca, NJ.

Falk, J.H. (1999). Museums as institutions for personal learning. Daedalus, 128, 259-275.

Falk, J.H. (2001). Free-choice science learning: Framing the issues. In: Falk, J., (Ed.), Free-choice science education: How people learn science outside of school (pp. 2-9). New York: Teacher's College Press.

Falk, J. H. (2005). Free-choice environmental learning: Framing the discussion. Environmental Education Research, 11(3), 265-280.

Falk, J.H., & Dierking, L.D. (1992). The museum experience. Walnut Creek, CA: AltaMira Press.

Falk, J.H. & Dierking, L.D. (1998, May/June). Free-choice learning: An alternative term to informal learning? Informal Learning Environments Research Newsletter (p. 2). Washington, DC: American Educational Research Association.

Falk, J.H. & Dierking, L.D. (2000). Learning from museums: Visitor experiences and the making of meaning. Lanham, MD: AltaMira Press.

Falk, J.H. & Dierking, L.D. (2002). Lessons without a limit: How free-choice learning is transforming education. Walnut Creek, CA: AltaMira.

Farmer, J., Knapp, D., & Benton, G. M. (2007). An elementary school environmental education field trip: long-term effects on ecological and environmental knowledge and attitude development. *The Journal of Environmental Education*, *38*(3), 33-42.

Firestone, W.A. (1987). Meaning in method: The rhetoric of qualitative and quantitative methods in classroom environment research. *Educational Researcher*, 16, 16-21.

Fisher-Maltese, C., & Zimmerman, T.D. (in review). Teaching science in a "living laboratory:" How an informal learning lens reveals new insights into the use of a school garden

Francovicova, J., & Prokop, J. (2011). Plants have a chance: Outdoor educational programmes alter students' knowledge and attitudes towards plants. *Environmental Education Research*, 17(4), 537-551.

Fraser, B. J., & Tobin, K. (1992). Combining qualitative and quantitative methods in classroom environment research. In B. J. Fraser & H. J. Walberg (Eds.), *Educational environments: Antecedents, consequences, and evaluation* (pp. 271-292). London: Pergamon Press.

Griffin, J., & Symington, D. (1997). Moving from task-oriented to learning oriented strategies on school excursions to museums. *Science Education*, 881, 763-779.

Hein, G. (1998). Learning in the museum. New York, NY: Routledge.

Hickling, A. K., & Gelman, S. A. (1995). How does your garden grow? Early conceptualization of seeds and their place in plant growth cycle. *Child Development*, 66, 856-876.

Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn?. *Educational Psychology Review*, *16*(3), 235-266.

Jaus, H. (1982). The development and retention of environmental attitudes in elementary school children. *Journal of Environmental Education*, 13(2), 12-18.

Johnson, B., & Manoli, C. C. (2010). The 2-MEV scale in the United States: a measure of children's environmental attitudes based on the theory of ecological attitude. *The Journal of Environmental Education*, *42*(2), 84-97.

Kisiel, J. (2003). Teachers, museums, and worksheets: A closer look at a learning experience. *Journal of Science Teacher Education*, 14(1), 3-21.

Klemmer, C.D., Waliczek, T.M., & Zajicek, J.M. (2005a). Development of a science achievement evaluation instrument of a school garden program. *HortTechnology*, 15, 433-438.

Klemmer, C.D., Waliczek, T.M., & Zajicek, J.M. (2005b). The effect of a school gardening program on the science achievement of elementary students. *HortTechnology*, 15, 448-452.

Kraft, R. J. (1990). Experiential learning. *Adventure Education*, 175-183.

Lave, J. & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge, England: Cambridge University Press.

LifeLab. (2006). *Garden based learning that promotes a sustainable future.* Retrieved July 31, 2008, from http://www.lifelab.org/about/index.html.

Lineberger, S.E. & Zajicek, J.M. (2000). School gardens: Can a hands-on teaching tool affect students' attitudes and behaviors regarding fruits and vegetables? Hortechnology, 10(3), 593-597.

Maloney, M. P., & Ward, M. P. (1973). Ecology: Let's hear it from the people. An objective scale for measurement of ecological attitudes and knowledge. *American Psychologist*, 28, 583-586.

Manoli, C., Johnson, B., & Dunlap, R. (2007). Assessing children's environmental world views: Modifying and validating the New Ecological Paradigm Scale for use with children. *Journal of Environmental Education*, 38(4), 3-13.

Milfont, T., & Duckit, J. (2009). The environmental attitudes inventory: A valid and reliable measure to assess the structure of environmental attitudes. *Journal of Environmental Psychology*, 30, 80-94.

Moore, R. (1995). Growing foods for growing minds: Integrating gardening and nutrition education into the total curriculum. *Children's Environments*, 12(2), 134-142.

Morris, J., & Zidenberg-Cherr, S. (2002). Garden-enhanced nutrition curriculum improves fourth grade school children's knowledge of nutrition and preference for some vegetables. *Journal of the American Dietetic Association*, 102 (1), 91-93.

Musser, L., & Malleus, A. (1994). The children's attitudes toward the environment scale. *The Journal of Environmental Education*, 23(3), 22-26.

Nanney, M., Johnson, S., Elliot, M., & Haire-Joshu, D. (2006). Frequency of eating home-grown produce is associated with higher intake among parents and their pre-school aged children in rural Missouri. Journal of the American Dietetic Association, 107(4), 577-584.

National Gardening Association. (2012). *GrowLab Curricula*. Retrieved November 29,

2012, from www.gardeningwithkids.org
National Gardening Association. (2010). Garden in every school registry. Retrieved April 23, 2010, from http://kidsgardening.com
Nguyen, S.P., & Rosengarten K.S. (2004). Parental reports of children's biological knowledge and misconceptions. *International Journal of Behavioral Development*, 28, 411-420.
Obama, M. (2012). *American grown: The story of the White House kitchen garden and gardens across America.* New York, NY: National Parks Foundation.
O'Donnell, A.M. (1999). Structuring didactic interaction through scripted cooperation. In
O'Donnell, A.M. and King, A. (eds.). *Cognitive Perspectives in Peer Learning*. Erlbaum, Mahwah: NJ, pp. 179-196.
Orion, N., & Hoffstein, A. (1994). Factors that influence learning during a scientific fieldtrip in a natural environment. *Journal of Research in Science Teaching*, 33(10), 1097-1119.
Palincsar, A.S., & Herrenkohl, L.R. (1999). Designing collaborative contexts: Lessons from three research programs. In O'Donnell, A.M. and King, A. (eds.). *Cognitive Perspectives in Peer Learning*. Erlbaum, Mahwah: NJ, pp. 151-178.
Patton, M.Q. (1990). *Qualitative evaluation & research methods*. Thousand Oaks, California: Sage Publications.
Pea, R.D. (1993). Practices of distributed intelligence and designs for education. In Salomon, G. and Perkins, D. (eds.), *Distributed Cognitions: Psychological and Educational Considerations*, Cambridge University Press: New York, pp. 47-87.
Penuel, W. R., Roschelle, J., & Shechtman, N. (2007). Designing formative assessment software with teachers: An analysis of the co-design process. *Research and Practice in Technology Enhanced Learning*, 2(1), 51-74.).
Pine, K., Messer, D., & St. John, K. (2010). Children's misconceptions in primary science: A survey of teachers' views. *Research in Science & Technological Education*, 19, 79-96.
Quay, J. (2003). Experience and participation: Relating theories of learning. *Journal of Experiential Education*, 26(2), 105-112.
Rahm, J. (2002). Emergent learning opportunities in an inner-city youth gardening program. Journal of Research in Science Teaching, 39(2), 164-184.
Ratcliffe, M. (2007). Unpublished doctoral thesis, Tufts University, Boston.
Rennie, L.J. (2007). Learning science outside of school. In: S.K. Abell & N.G. Lederman (Eds.), Handbook of research on science education (pp. 125-167). Mahwah, NJ: Lawrence Erlbaum Assoc., Inc.
Rowe, S. (2002). The role of objects in active, distributed meaning-making. Perspectives on Object-Centered Learning in Museums, , 19-35.
Salomon, G. (1993). No distribution without individual cognition: A dynamic interactional view. In Salomon, G. and Perkins, D. (eds.), *Distributed Cognitions: Psychological and Educational Considerations*, Cambridge University Press: New York, pp. 111-138.
Sieber, S. D. (1973). The integration of fieldwork and survey methods. *The American Journal of Sociology,* 78(6), 1335-1359.
Skelly, S.M. & Zajiceck, J.M. (1998). The effect of an interdisciplinary garden program

in the environmental attitudes of elementary school students. Hortechnology, 8(4). 579-583.

Smith, L.L., & Mostenbocker, C.E., (2005). Impact of hands-on science through school gardening in Louisiana public elementary schools. *HortTechnology*, 15, 439-443.

Smith, N. J., & Cavern, L. (2006). Effects of pre- and post-trip activities associated with a residential environmental education experience on students' attitudes towards the environment. *The Journal of Environmental Education*, 37(4), 3-17.

Waliczek, T.M., Bradley, J.C., Lineberger, R.D., & Zajicek, J.M. (2000). Using a web-based survey to research the benefits of children gardening. Hortechnology, 10(1), 71-76.

Waliczek, T.M., & Zajicek, J.M. (1999). School gardening: Improving environmental attitudes of children through hands-on learning. *Journal of Environmental Horticulture*, 17, 180-184.

Weigel, R. & Weigel, J. (1978). Environmental concern: The development of a measure. *Environment & Behavior*, 10, 3-15.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*, Cambridge University Press: New York.

Zimmerman, T.D. (2005). Unpublished doctoral thesis, University of California, Berkeley.

Zimmerman, T.D. (March, 2010). Paper presented at the National Association for Research on Science Teaching Annual Conference. Philadelphia, PA.

Zimmerman, T.D. (2011). In J.E. Katz. W. LeBrar & E. Lynch (Eds.), Creativity and Technology: Social Media, Mobiles and Museums. Museumsetc., Edinburgh.

CHAPTER 4

SUCCESSFUL IMPLEMENTATION OF A GARDEN-BASED SCIENCE CURRICULUM: A CASE STUDY

Abstract

The purpose of educational reform is to help schools be more effective in accomplishing their goals by replacing certain structures, programs, and/or practices with better ones (Fullan, 1991). The purpose of this paper is to use an intensive study of curriculum reform in one school to explore the issues of implementing effective practices in schools. Moreover, much research has been about failed implementation; this paper is about a success in implementing a garden-based science unit. Through observations and interviews with teachers and the school principal, I analyze the facilitators and barriers to implementing a garden-based science curriculum at a K-3 elementary school. Participants reported a number of implementation processes necessary for success: leadership, vision, and material, human, and social resources. However, in spite of facilitators, teachers reported barriers to implementing the garden-based curriculum, specifically lack of time and content knowledge.

Introduction

The purpose of educational reform is to help schools be more effective in accomplishing their goals by replacing certain structures, programs, and/or practices with better ones (Fullan, 1991). Over the last 100 years, there have been many attempts to improve schooling, most of which have been unsuccessful. A few examples include curriculum reforms, such as PSSC Physics, BSCC Biology, and MACOS Social Sciences

(Elmore, 1996). The garden as a type of curricular reform is not a new idea; school gardens have their roots in the earliest days of progressive education (Dewey, 1915). The philosophical background of garden-based education can be found in the writings of such progressive intellectuals as Jean-Jacques Rousseau, John Dewey, and Maria Montessori. In *Schools of Tomorrow,* John and Evelyn Dewey (1915) detail several experimental schools that incorporate active learning through working school gardens. School gardens were thought to be a means to incorporate best practice pedagogy into instructional practice and accomplish the goal of making school more applicable to real life (Dewey, 1916).

School gardens can be an important way to serve these important ends: improve student learning in science, encourage healthy eating habits, shift environmental attitudes in a positive direction, and build a sense of school community (Brynjegard, 2001; Faddegon, 2005; Graham & Zidenberg-Cherr, 2005; Skelly & Zajicek, 1998; Waliczek, Bradley, Lineberger, & Zajicek, 2000). This research program illustrates the value of gardens for those ends (Fisher-Maltese, 2013a; Fisher-Maltese, 2013b), but an otherwise great idea doesn’t mean much if it can’t be put into practice. The purpose of this paper is to use an intensive study of curriculum reform in one school to explore the issues of implementing effective practices in schools. Moreover, beginning with Berman & McLaughlin (1978), much research has been about failed implementation; this paper is about a success in implementing a garden-based science unit.

Implementing School Gardens

To begin the discussion of implementing this garden-based science unit, I first present the conceptual framework guiding the study and provide a rationale for why it is important to study school gardens. Next, I explore the literature on educational change because it provides important background information for how educational changes can happen in schools. Third, several resources are discussed because of the role they play in successful implementation. And, fourth, since leadership is a key component of curricular reform, literature on distributed leadership will be reviewed.

Several key factors determine the success or failure of the implementation of a curricular unit. The conceptual framework presented in this paper organizes the proposed key factors in four categories: leaders, implementation processes/facilitators, implementation enactment, and outcomes. The three implementation categories are the focus of this study; they are enclosed in a dotted-line box (see Figure 5). The fourth category, outcomes, is located outside of the box; it is a topic of great importance, but outside the scope of this paper (see Fisher-Maltese, 2013a; Fisher-Maltese, 2013b).

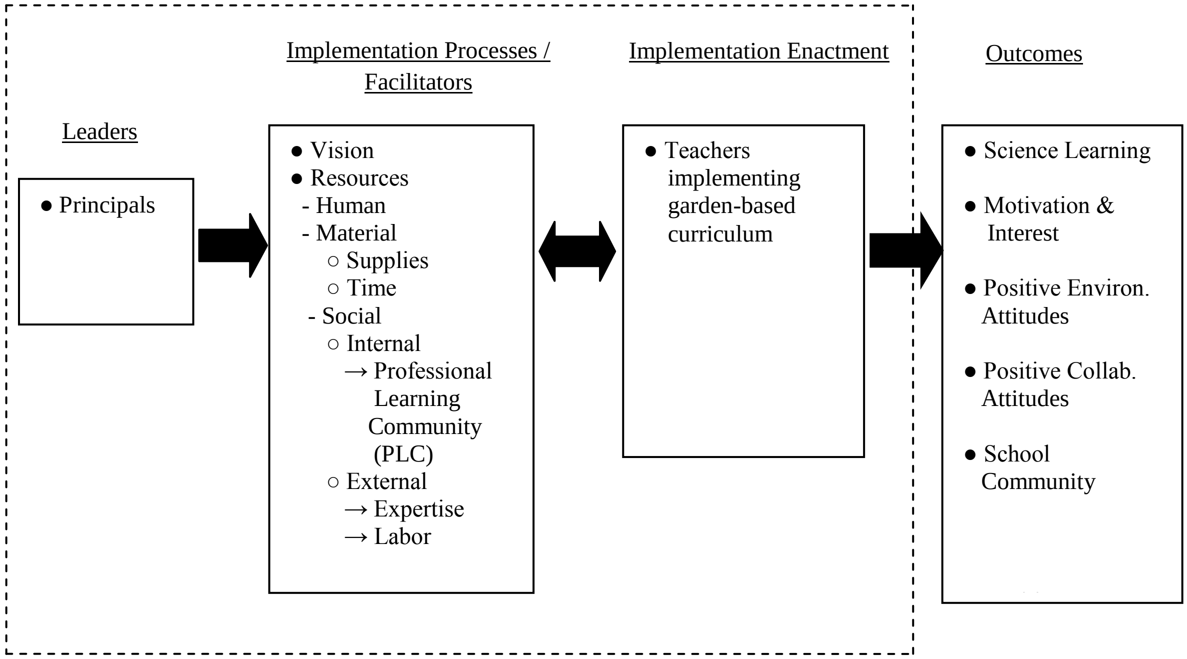

Figure 5. Conceptual Framework

This study uses views held by teachers and the principal on the implementation of a garden-based science unit and observations of the unit being implemented by teachers as a window into implementing effective practices in schools. The following research question frames this investigation: 1) What factors are necessary for successful implementation of a garden-based science curriculum?

Why Care About Gardens

Though growing in number nationally (National Gardening Association, 2010), research studies that examine the impacts of school gardens are limited and those that examine implementation processes are completely lacking from the literature. Most school garden studies focus on nutrition and health effects on children. Teachers, administrators, and students in school garden programs report that they can be used to improve nutritional habits since children who grow their own vegetables are more likely to eat them (Graham & Zidenberg-Cherr, 2005; McAleese & Rankin, 2007; Nanney, Johnson, Elliot, & Haire-Joshu, 2006). Evidence suggests students who learn in school gardens perform better academically through improved content knowledge and opportunities for active learning, especially in science (Faddegon, 2005; Klemmer, Waliczek & Zajicek, 2005; Smith & Mostenbocker, 2005). In addition, school gardens contribute to increases in children's environmental attitudes related to stewardship and awareness of nature (Brynjegard, 2001; Faddegon, 2005; Fisher-Maltese, 2013b; Skelly & Zajicek, 1998; Thorp & Townsend, 2001). Last, school gardens seem to contribute positively to social and emotional growth in children by building self esteem, leadership skills, and a sense of community (Brynjegard, 2001; Waliczek, Bradley, Lineberger, & Zajicek, 2000).

Educational Change Process

The educational change process consists of three phases: initiation, implementation, and institutionalization (Fullan, 2007). History illustrates that problems arise when one phase in the process is overlooked. For example, large-scale reform efforts in the 1950s and 1960s are thought to have been unsuccessful for the most part because they focused on the adoption or initiation phase of new projects, but virtually ignored the implementation of them (Fullan, 2000). By definition, "Implementation consists of the process of putting into practice an idea, program, or set of activities and structures new to people attempting or expected to change" (Fullan, 2007, p. 84). Even still, the typical tendency is to invest in people, time, and money most heavily in the innovation development and less so in the implementation of a change, thus creating an imbalance (Hall & Hord, 2006). Issues of implementation became the focus of education reform studies in the 1970s, as they were for so long ignored in seemingly well planned changes. Influential studies, such as the RAND Change Agent Study on the implementation of bilingual and literacy programs, found that federal education policies geared toward changing local educational practices basically ignored the complex contexts of schools, or “what economists called the ‘black box’ of local practices, beliefs, and traditions” (McLaughlin, 1990, p. 11). Essentially, schools are dynamic and complex places and linear views of the educational change process fall short.

Resources for Educational Change

Several resources are necessary for educational change to occur successfully: vision, and three more traditional resources, human, social, and material (Gamoran, Anderson, Quiroz, Secada, Williams, & Ashmann, 2003).

Vision

Initially, a leader of an educational change must have a vision, or big idea of what could be. In the case of a garden-based curriculum, a vision must be fostered of what the curriculum will look like, how the school garden will be used to teach the curriculum, and how it will ultimately benefit students. Successful principals are able to help teachers work toward a common vision (Gamoran, et al., 2003). “Shared vision or ownership (which is unquestionably necessary for success) is more of an outcome of a quality change process that it is a precondition for success” (Fullan, 2007, p. 41).

Resources

In contrast to what some believe, resources do matter (Greenwald, Hedges, & Laine, 1996). Parents, if they can, choose to live in neighborhoods with “good school districts,” or those with the most resources, to which to send their children. What is meant by resources goes beyond just money. Instead, it is really about how that money translates to supporting teachers so they can do their job well (e.g., allocating time, providing necessary tools and materials, and promoting professional learning communities) (Gamoran, et al., 2003). Human, social, and material resources are necessary to support more effective teaching practices.

Human. People within the organization who possess extensive content knowledge and enthusiasm are necessary for establishing professional development groups and fostering further exploration (Gamoran, et al., 2003).

Social. The presence of a community of practice is a type of internal social resource. In communities of practice, also known as Professional Learning Communities (Elmore & Burney, 1998), teachers together examine how their students are doing, they relate this to how they are teaching, and they make continuous refinements to their own teaching practices (Fullan, 1999). Teachers who work in a communal atmosphere and have the time and opportunity to work collaboratively are more likely to change their teaching practices (Elmore & Burney, 1998). Expertise from outside the school, such as an outside consultant, is often necessary to facilitate a new curriculum. Also when a new curriculum requires a teaching tool that requires maintenance and care, such as a garden, another type of external social resources is required: labor. Labor provided by parents and local community members is an important supplement for teachers who have limited time outside their regular responsibilities.

Material. Material resources include the supplies and objects necessary to implement a curriculum. Material resources require the money necessary to buy them initially and keep them in supply. Time is also a material resource. For example, time for teachers to work collaboratively to discuss students, curricula, and their practice is a resource.

Leadership

Leadership is a key variable in the success or failure of curricular reforms. The literature on distributed leadership is instructive in understanding the formal and informal leaders necessary for the implementation of a garden-based science unit.

Distributed Leadership

In contrast to the conventional principal-centric view of leadership in schools, leadership may be distributed among individuals (Prestine & Nelson, 2005). An alternate view is that it is the leadership functions that are distributed among individuals (Leithwood, et al. 2007). In fact, given the high demands of standards-based reform, school leaders only chance of succeeding may be to delegate and share responsibility (Elmore, 2004). In order for curricular reforms to be successful, teachers must share the vision, or buy into the reform. Teachers are more likely to support reforms and make efforts to change their practice if they feel a sense of ownership or that they have participated in the process. Distributed leadership occurs when people within the school are developed and empowered by school leaders (Knapp, 2003).

Leadership continues to be extremely important, but who carries out specific leadership tasks may be more fluid than originally thought (Heller & Firestone, 1995).

This is the case for implementing a garden-based curriculum. An effective leader is crucial to the success of the program, but whether this leader is a formal or informal one is less important. Depending on the school context and culture, the leader may be the principal, a teacher, a parent, or an outside consultant. In my experience, it follows a distributed model, with many of the leadership functions transferred to teacher leaders and outside consultants. In the following section, I look at a variety of leadership roles at the local level and how they play a part in enabling this type of curricular reform (Fullan, 1991).

The principal. The major agents of educational change (or blockers) are the principals and the teachers (Fullan, 1991). The school looks to the principal for a vision and support of a school reform. It is crucial that the principal have sufficient content knowledge about a curricular reform to explain the rationale behind it to everyone in the school community (teachers, parents, and administrators). The principal is usually responsible for organizing custodial support and allocating resources for the reform or assisting others in the process of acquiring necessary funds.

Teacher leaders. In some cases, a teacher leader may lead the initiative to implement a garden-based curriculum. The teacher is the main agent by which the reform reaches the students. Teachers need to have adequate content knowledge about the reform, sufficient professional development, and be involved in the process of interpreting the reform in the individual school context.

The consultant. An outside consultant provides necessary expertise for implementing a curricular reform. National organizations, such as the National Gardening

Association (NGA) and local resources, such as University Cooperative Extension Master Gardeners, can provide an individual with expertise who can help to implement a garden-based curriculum. In this study, I was the consultant. I assumed the roles of researcher, co-developer of the curriculum, garden and insect expert, and co-facilitator of lessons.

The parent and the community. In some situations, a parent or member from the local community can be instrumental in implementing an educational change. Parents can be very well suited for the activist role and often have the time to provide much-needed labor that teachers do not have. Local residents, such as senior citizens, high school students, and boy or girl scouts, often look for projects to perform community service hours and feel connected to the local community.

Methods

This paper describes a qualitative case study. A garden-based curriculum on insects and how it was implemented across four second-grade classrooms was the focus of the study and was treated as one bounded case.

Study Context

This study took place in four second-grade classrooms within Penns Neck Elementary (a pseudonym). In order to build a “complex, holistic picture” (Creswell, 1998, p. 15) of the case, I will describe the school context at both the district and school levels.

District Level

Central Winthrop Regional School District is a relatively large, suburban school district servicing two adjacent municipalities with approximately 9,500 students. The residents are predominantly affluent with only 3.69% students classified as low-income (New Jersey Department of Education, 2010). A high number of well-educated professionals reside in the area due to the close proximity of several leading pharmaceutical, technological, and financial companies, a private university, and convenient access to the direct train line to two major metropolitan centers. The district has “deep pockets” due to extensive subsidization from local, private corporation donations and high property taxes. The community is considerably diverse with a student body comprised of 47.9% Caucasian, 41.7% Asian, 5.2% African American, 5.1% Hispanic, and 0.09% Native American (New Jersey Department of Education, 2010). The diversity is unique with an almost 50:50 split between Caucasian and Asian students. Ten schools serve the students: four grades K-3 elementary schools, two grades 4-5 elementary schools, two middle schools, and two high schools.

Approximately 1,300 faculty members are employed by the district. The school district has a strong reputation. It is known to have a supportive administration, excellent benefits, cooperative students from supportive families, and extensive professional development opportunities for faculty, such as tuition reimbursement for Master's and doctoral programs in education at both public and private institutions. As a result, there is a long waiting list of qualified teachers who would like to teach at all of the district schools.

School Level

Penns Neck Elementary School is a 700-student K-3 school located in the most affluent part of the Central Winthrop District. Currently, the median income of residents is $131,347 with only 0.15% of students classified as low income (New Jersey Department of Education, 2010). The diversity of ethnicities is similar to the overall district with 52.4% Caucasian, 42.8% Asian, 3.2% Hispanic, and 1.7% African American students. Currently, there are about 60 faculty members with a student/faculty ratio of 12.5. Average class size is an impressive 18 students per class. Not surprisingly, in a school located in an affluent, highly educated area, the school made AYP for the 2010 year and the students showed a strong performance in both math and language arts according to the New Jersey Assessment of Skills and Knowledge for third-grade (NJASK3). For example, 71.8% scored proficient, 11.2% advanced proficient in LA; 34.4% scored proficient, 58.3% advanced proficient in Math (New Jersey Department of Education, 2010).

The school has had a school garden for the last six years. The garden consists of four large raised beds surrounded by mulched paths and a deer- and rodent-proof fence. Vegetables (e.g., peas, tomatoes, carrots, etc.), herbs (e.g., basil, dill), fruit (e.g., blueberries, strawberries), and flowers (e.g., zinnias, marigolds, cosmos) are typically grown. The fence is lined with an internal and external border of perennial plants. One section of the border contains perennial plants that are food sources for local butterflies. The school garden was initiated by a core group of teachers, including myself. It is used by the teachers at the school to teach lessons in different subject areas, especially science, across grade levels. The garden is used by teachers and students for lessons in science, math, health, and language arts. For example, the garden is used in the following science units: earthworms in first grade, insects in second grade, and plant growth and development in third grade. Some teachers also use the garden for measurement lessons in math and writing in language arts.

Study Participants

The study involved four teachers, their respective students (n = 66), and the school principal at the participating school as described in detail below (see Table 18).

Table 18

Adult Participants[1]

Mrs. Briarcliff is a White middle aged teacher who has been teaching second grade for seven years. She teaches the basic skills class which consists of students who have performed average or below average in first grade. She is energetic and heads several school-wide projects. She is a school garden advocate and co-wrote a successful grant which was used to buy supplies and learning materials for the garden.
Mrs. Captree is a White middle aged teacher who has been teaching second grade for 20 years. She was a member of the core group of teachers who started the school garden and has been a leader in the initiative since the onset. She will be teaching third grade for the first time next year so has decided to step down from her leadership position with the garden while she learns the new curriculum. She still plans to use the garden with her class, however. Mrs. Captree is warm and nurturing. She has several special education students in her classroom who are pulled out for special services.
Ms. Emilio is a White young teacher who has been teaching for three years. It is her first year teaching second grade; she taught first grade for two years prior. She is confident

and excited about trying new things. She has an apparent good rapport with her students since she taught many of them last year in first grade; many chose to stay with her when she moved to second grade.

Ms. Martin is a White young teacher who has been teaching for six years (four in this school district). She has taught third grade previously; this is her first year teaching second grade. Ms. Martin is conscientious and organized. She seems nervous about teaching the second-grade curriculum for the first time as well as the garden-based insect unit. Her students are labeled "gifted and talented" based on a standardized test they took in the first grade.

Mr. Agnosto is the principal at the school. He is White and middle-aged. This is his first year as principal of Penns Neck Elementary School, but has taught in the district for 19 years. He was previously a math supervisor and assistant principal. He is supportive of the school garden and shares that he is not as involved with it as he would like to be. He is open about feeling overwhelmed in his first year as being principal.

[1] All names are pseudonyms.

Garden-based Curriculum

The second-grade science curriculum at Penns Neck Elementary School includes a unit on insects. Typically, insect specimens are ordered from a science supply company and raised in the classroom to demonstrate their life cycle changes. Butterflies are the most common insect observed in classrooms at the school. In an effort to develop an insect curriculum that is connected to the school garden, teachers from Penns Neck chose ladybugs and praying mantises, in addition to Painted Lady butterflies which they normally use, to study since they are beneficial to the garden and served as a practical means to connect the insect curriculum to the school garden. The teachers have been committed to integrating the school garden into curricula since its inception. One year after its initiation (and five years before the implementation effort described here), a group of teachers participated in professional development over the summer to develop ties to several curricular areas to the garden across grade levels. The teachers also began the work of writing and replacing one of the science kits at each grade level with a garden-based science unit. They would still orders specimens from the science company to observe in the classroom, but omitted the rest of the science kits.

Following a co-design approach (Penuel, Roschelle, & Shechtman, 2007), a four-week standards-based science curriculum on insects, which uses the school garden, was developed collaboratively with the four participating second-grade teachers. Each week, the students participated in insect lessons in the classroom and in the garden. The weeks' lessons had a given focus, including anatomy, life cycles, helpful and harmful insects, butterfly and larva identification, and designing a butterfly garden (see Table 19).

Table 19

Curriculum Overview

Lesson 1: Using the 5 senses to observe and explore the school garden	
Day 1:	What's a garden? How do I use my 5 senses to observe and explore?

Day 2:	Exploration in the school garden

Lesson 2: Arthropods and insects – Basic anatomy and life cycle

Day 1:	What's an insect? What's an arthropod? Conduct an observation of a praying mantis Using a rubric in the classroom
Day 2:	Catch and conduct an observation of an insect in the school garden
Day 3:	Helpful and harmful insects

Lesson 3: Butterflies – A type of insect

Day 1:	How to identify butterflies
Day 2:	Conduct an observation of butterflies in the school garden
Day 3:	Identifying butterflies by their larva; Conduct an observation of caterpillars in the classroom

Lesson 4: Designing a butterfly garden

Day 1:	What attracts butterflies to a specific habitat?
Day 2:	Butterfly life cycle
Day 3:	Plant nectar and host plants in the school garden

Data Sources

Factors necessary for successful implementation of the garden-based curriculum, were derived from post-curriculum semi-structured interviews with the four participating teachers and the school principal and observations of lessons. Interviews were audio-recorded for accuracy. Field notes were recorded in a research journal during the interviews and captured contextual information, such as teacher, setting, date and time, and preliminary analysis. In situ data from video-recorded lessons from the garden-based curriculum provided important insights on how the teachers enacted implementation of the curriculum.

Data analysis followed a multi-step process. Interview and observation data were first transcribed and then examined for recurrent themes, such as level of dependence on the researcher-consultant relative to years teaching experience and presence of key resources (e.g., external expertise and labor, teachers at the school with extensive garden and science content knowledge). The data set was then described with several rounds of coding using a coding scheme developed to highlight examples of factors in the implementation of the garden-based curriculum, specifically facilitators and barriers to the implementation process.

Role of the Researcher

Over the course of the study, my role as observer varied as direct observer and participant observer (Creswell, 2007). I had been a second-grade teacher at this school and led the initiative to plant the school garden described in the study six years ago. Due to my close connections to the teachers, school garden, and garden-based curriculum the teachers were implementing, I had to be aware of how my biases would affect this research. I took certain precautions to limit bias by asking peers and professors at the university to review the curriculum, instruments, and data. I also made a conscious effort to look for contradictory evidence. While bias is a limitation of my work, my positive relationship with the participants lent themselves to certain affordances, namely access to the school, teachers, and students. Also, my background knowledge of the teachers and principal helped me to know where the participants were coming from and what was going on at the school (Patton, 1990). The teachers were willing to try the garden-based curriculum I created and entrusted me with co-teaching the lessons with them. Throughout the study, I was cognizant about remaining objective and encouraged the teachers to take the lead, whenever possible, so I could remain in the role of observer.

Findings

The following vignettes illustrate what implementation of the garden-based curriculum looked like. Overall, the teachers showed a willingness to try the curriculum; there was not a sense of dissonance or resistance. Across the sample of teachers, there was a range in levels of confidence with the garden-based curriculum and some notable differences in teachers' content knowledge about gardens and insects. The more independent use by the teachers of the garden-based curriculum demonstrates successful implementation. Level of independence with the garden-based curriculum seemed to be relative to years of teaching experience. The less experienced teachers, Ms. Emilio and Mrs. Martin, were more dependent on me, the researcher.

Teachers' Enactment of Garden

The first example is a lesson Mrs. Captree led when she and her class released the Painted Lady Butterflies they had raised in the classroom. She exemplifies independent use of the curriculum.

Mrs. Captree: Big circle everyone!

Students: Bye bye butterflies!

Mrs. Captree: Boys and girls, from what flower do Painted Ladies like to eat the nectar?

Rohan: Zinnias!

Mrs. Captree: Exactly, so please follow me over to the bed where you planted zinnias (she carries over the net house from the classroom containing four Painted Lady butterflies, the children form an oval around the flower bed, Mrs. Captree gingerly opens the net house and encourages the butterflies, one by one, to perch on her hand, she slowly transfers them to the flowers in the middle of the bed)

Brian: Can we catch them again?

Sophia: We can't catch the butterflies we just let go!

(2 butterflies stubbornly stay in net house, perched on the flowers in a small vase)

Mrs. Captree: These guys are having their last meal. They're definitely drinking. See the proboscis! (Mrs. Captree points to one of the butterfly's heads so the children will see its long tongue touching the flower. The children crowd in to see the butterflies more closely.)

Rohan: Just leave the cup out here so they can keep drinking! (Mrs. Captree takes the vase of flowers from the net house and sets it down in the middle of the garden bed.) There's Flappy! You're stepping on a flower Nicole! (Nicole jumps back)

Students: (The butterflies start flying from flower to flower) Bye Biggee! Bye Meaty! Bye Flappy!

Sophia: Look! One's on my shirt!

Mrs. Captree: That's amazing! They really love you guys!

Next is an example of Mrs. Briarcliff teaching a lesson on insect anatomy. She independently leads the lesson, though some limitations of her science content knowledge are evident as I need to interject with a description of insects' compound and simple eyes.

(Mrs. Briarcliff holds up big picture of a grasshopper. The students are gathered around her sitting on the rug).

Mrs. Briarcliff: What makes an insect an insect?

Keisha: (students raise their hands, Mrs. Briarcliff points to Keisha) 3 body parts?

Mrs. Briarcliff: Okay, they have 3 body parts. What are they?

Jacqueline: A head

Tommy: An abdomen

Mrs. Briarcliff: Yes, a head, an abdomen. The abdomen is like their tummy (patting her stomach). And they have what we call the thorax. They also have an exoskeleton. What's that? Who knows?

Josh: A skeleton?

Mrs. Briarcliff: Yes, a skeleton, that's good!

Pamela: But their skeleton is like outside of their body.

Mrs. Briarcliff: Good, yes, “exo” means outside and their skeleton is outside their body. They also have compound eyes. What do you think that means?

Kathy: It means they have 3 or 4 eyes.

Mrs. Briarcliff: No…They also have antennae. What are they? Can you show me what they look like? (Several students make their fingers look like they’re coming out of the tops of their heads.) Yeah! Peter? What did you want to say? Let him speak (to other students who are all talking at once, making their fingers look like antennae). Okay, 5-4-3-2-1, thank you. Peter?

Peter: They use them to feel.

Mrs. Briarcliff: Okay. (Researcher gestures to Mrs. Briarcliff)

Researcher: I just want to add something about insects’ eyes. They have two kinds of eyes: a simple eye and, as Mrs. Briarcliff said, they have compound eyes. It’s very interesting. Their compound eyes…I don’t know if you’ve ever looked through a prism, which makes you see many different images of the same thing. Well, that’s what an insect sees when it looks through its compound eye. It helps them sense movement. I don’t know if you’ve ever noticed when you try to swat a fly, they always fly away before you can swat them (some students nod “yes”). Now, they also have a simple eye. It’s where they sense light and dark. It’s much simpler than our eye because we can see color, depth…so they have two kinds of eyes: simple and compound eyes. It’s a neat thing.

Mrs. Briarcliff: Okay, well we kind of lucked out because today [the Researcher] brought us crickets to look at! Raise your hand if you know what a cricket is (all hands shoot up).

Kyle: They look like a grasshopper, but they’re brown.

Carrie: They make a chirping sound at night.

Mrs. Briarcliff: (Nodding “yes” and smiling at student volunteers, looks at the Researcher.)

Researcher: Okay, so with me today I have four bug boxes each with several crickets. You’ll all get a chance to observe them…

Next Ms. Emilio leads a lesson on conducting an insect observation. Ms. Emilio leads the lesson independently, although she is less confident than the first two teachers, which is evident when she checks in with me about where to release the insects after the students record their observations. I facilitate the lesson by walking around to individual students helping them to identify the insects they found using a field guide. Ms. Emilio told me before the lesson that she was not sure she would be able to identify the different insects her students would find.

(Students are sitting at picnic tables adjacent to school garden. Partners share a bug box with an insect that they found. Teachers and students refer to this space as the "outdoor classroom." Each student has a science journal, a clip board, a pencil, and a hand lens. Ms. Emilio is standing in between the tables so all of the students can see her. [The researcher] is walking around speaking to individual students. Students are talking to each other and looking in each other's bug boxes.)

Ms. Emilio: Alright! I want you to really use those 5 senses right now to *really* study that insect! Take notes on your next magnifying glass page (in their student science journals, each page has a picture of a magnifying glass where students should draw the insect and lines to write a description). Remember we observed the crickets and the caterpillar…(flipping through a student's journal) so on your next magnifying glass page, which looks like this (holding up journal page for students to see). Take some notes using your 5 senses observing these bugs. See if you can figure out what kind of insect it is, whether it's helpful or harmful, [the Researcher] and I can try to help you. Oh, you guys got some cool things! (to a particular student who shows her his bug box) I think that ladybug looks so cool because it doesn't look like the ladybugs we had in the classroom. Look how big its spots are! That's cool. And then you have a roly poly in there, too.

Researcher: (to a particular student) I think you found an earwig. Let's look up earwig in the field guide (showing student how she looks up earwig in the index and then flips to the page). Here it is! Is this what you found?

Vicki: It is!

Researcher: Great! Read this description and write some notes.

Ms. Emilio: Ms. Emilio's friends! You really only have about 5 more minutes so I need you to focus and take your notes so we can set these bugs free before we go back inside.

Researcher: (with a different student) Look at this picture of a weevil (in field guide). I think you actually found the larva, not the adult. What do you think?

Samit: Wow! Look, Yosh (his partner), I found a weevil larva!

Aide: Has anyone seen Mica's hand lens?

Kevin: I did in the garden?

Aide: You saw it in the garden? Then why didn't you pick it up? (To class) If you see something that belongs to someone, please pick it up and give it to a teacher!

Ms. Emilio: (walking around the different tables, stops to talk to a group of students huddled around an ant hill) I really need you to take some notes…Samit (who was unable to catch an insect), join a group that has an insect so you can take some notes.

Researcher: (showing some students the weevil larva) Look, it has 6 legs so you know it's an insect, right? It's pretty large so it's probably going to be a large adult.

Ms. Emilio: Boys and girls, 3 more minutes! You should be working on your observations. I should see something written and something drawn.

Researcher: (showing some different students a page in the field guide) You found an earwig. See. It has those pinchers (pointing to the large pinchers coming out of its abdomen). It could pinch you if you touch them (makes a pinching motion with fingers). (A different student comes up to her with a bug box) Ah! You found a roly poly. I'm not sure what its scientific name is so I'm having trouble finding it in my field guide.

Ms. Emilio: (to Researcher) Should we set the bugs free back in the garden?

Researcher: (To class) I would set them free as close to where you found them as you can. Like those ladybugs you found by the eggs, put them back by those leaves. Those are the mama ladybugs so you probably want to let them go by their eggs.

Ms. Emilio: Boys and girls, did we hear that! Okay, finish your last sentence. Friends, we are going to walk back into the garden with all of our materials. You're going to let your insect go as close to where you found it as possible. Once you take it out of the box to set it free, take all of your materials and line up. We're sort of in a rush because we gotta get to library so we need to do this quickly! Okay, go ahead!

Jessica: Whoa! The ladybugs are trying to get out! (looking at the ladybugs in bug box) Okay, let's go. I'll grab our clip boards (to partner).

Last, I lead a review lesson on butterfly/plant specificity with Mrs. Martin's class before the students rotate to different planting and watering stations. Mrs. Martin is open about her lack of confidence and garden content knowledge. Before this lesson she had indicated a preference that I take the lead on garden-based lessons.

Mrs. Martin: Boys and girls please sit down. Please listen and don't waste any time. Otherwise, you may not get to a station. Okay, listen up!

Researcher: Okay, let's see if you remember which plant is for which butterfly or caterpillar. These are marigolds (holding up tray of flowers). They come in yellow and orange. Which butterfly likes to eat the nectar from marigolds? (Students raise hands.)

Katie: The Monarch?

Researcher: No, but good guess.

Jonas: Red Admiral

Researcher: Yes, that's one. What's the other one?

Cassandra: Tiger Swallowtail

Researcher: No, Tiger Swallowtails love the butterfly bush, Buddleia. Can anyone help?

Ira: Great Spangled Fritillary

Researcher: Yes! It is the Great Spangled Fritillary! Now these are zinnias (holding up flowers in pots). Does anyone know which butterfly likes zinnias? Hint: it's the one you raised in your classroom (everyone's hand shoots up)

Several Students: It's the Painted Lady!

Researcher: We'll have to check to see if they go right to the zinnias when we release them.

Katie: Really? I hope they do! (speaking quietly to herself)

Researcher: Now these are cosmos (holding up tray of flowers). Which butterfly likes cosmos?

Allie: The Viceroy?

Researcher: It *is* the Viceroy. Remember the Viceroy and the Monarch look a lot alike. What's a way you can tell them apart?

Allie: The Viceroy is a bit darker than the Monarch (which is true in the photograph we looked at in the classroom).

Researcher: Sometimes they're darker, but there are some sure fire ways you can tell the difference. What are they?

Seamas: That stripe on the bottom…

Researcher: Yeah! That stripe that goes across the bottom of their hind wings. And there's another way you can tell!

Cece: The buckeyes under their wings!

Researcher: Yeah! Those buckeyes, or circles, on the underside, or ventral side, of their wings. Great.

Isabel: I know another way you can tell the Monarch and the Viceroy apart – by the plants they prefer!

Researcher: Yes! Of course, by the plants they prefer! (looking around at the different plants in flats and laughing) The Monarchs like the Purple Cone Flower and their larva love Milkweed. The Viceroys like cosmos and their larva like White Poplar. You guys remember a lot!

Facilitators and Barriers to Implementation

The following section is organized by facilitators and barriers to the implementation processes that led to enactment of this garden-based curriculum on insects. The following implementation processes are discussed: vision, resources, and leadership.

Vision

The vision the members of the school hold for the school garden is important background information for how this garden-based curriculum was implemented at the school. The history of the vision and the shared vision of the school garden are both discussed.

History

While a teacher at Penns Neck Elementary School, I initiated the school garden with the support of the principal of the time, Stu Feldman, and a core group of teachers who shared my vision. Toward the end of my first year teaching, Mr. Feldman set a goal for me to become more involved in school projects beyond my classroom walls the following year. Shortly thereafter, I approached him about the idea to start a school garden as a means to improve science instruction and a sense of school community, which had waned over the last few years. Over the following months, Mr. Feldman and I laid out the necessary steps to initially get the project off the ground: writing a formal proposal, presenting the idea at a whole-school staff meeting, starting a school garden committee, researching garden programs at other schools, and planning the space for the garden to be built. As an insider at the school, I had an integral understanding of the school culture and context (McLaughlin, 1990). I knew that the vision for the garden would be attractive to many of the other teachers so buy-in and acceptance became a facilitator to the change (Hall & Hord, 2006). The garden committee, consisting of teachers at the school and the principal, grew in number. Mr. Feldman agreed to fund the school garden from the activities budget, costing approximately $6,000. The committee made important decisions regarding the designing and building of the garden and how it would be used. Mr. Agnosto, the current principal when the study was conducted, describes his view of the change:

> I think any initiative that really builds from within is going to be the most successful. And what I mean by that is when you have a small group of teachers that start a project and then you have other teachers who are excited about it. Kids are excited. Parents are excited…then it's sort of contagious and other people want to find out about it, especially if it's something that appears to be successful. With this (the garden), people saw the long-term benefits of it and got excited

> about it. So that's how I think it grew and grew. A lot of people believed in it obviously.

Garden as a Real-World Experience

The main vision for the school garden, as expressed by all four of the teachers and the principal, is for the teaching of science curricula. The teachers and the principal reported that the garden is an authentic setting where students can observe real-life examples of what they are studying in the classroom. These reports were consistent with the initial vision for the school garden that I, along with the core group of teachers comprising the Garden Committee, shared. Mrs. Captree summarized the affordances she believes the garden lends in teaching science,

> That they get to see out in the actual real world what the insects need to live. And which insects are harmful and helpful, which is part of the curriculum. I think it's so beneficial for them to be able to go out there and, you know, see how the whole process works with the planting and how the insects correlate with the planting…I think to be able to see the insects out in nature really helps. It's just so isolated here in the classroom.

Similarly, Mr. Agnosto reported in an interview,

> It's actually, I mean obviously, more real life and authentic for kids to go through those experiences. To understand when they're studying insects to go out in the garden and find the type of insects that are important to the garden…It's authentic. It's real life. It's something we can just go out right to the backyard and walk to and learn about right here at the school.

Ms. Emilio and Mrs. Martin, respectively, reported their own surprise at how much their students learned during the garden-based curriculum.

> I thought it might be over their heads. Especially classifying the butterflies. I just…because it was hard for me to grasp. But then seeing the results like when you came in here with that caterpillar and they were just rattling things off and they remembered it. And when they were out in the garden identifying the

> different types of butterflies. It was really cool to see. So I think they got a lot out of it. And I learned a lot. So it's been neat to see them. And they've been bringing in all types of caterpillars and insects. And talking about their markings and everything. So they're excited about it!

> But the kids learned so much. I was amazed at what they remembered from the lessons and, as far as I know, I don't think any other second grade teachers go too much in depth. With the naming of the butterflies and different families of butterflies. But kids can do it. They learn it. Because I saw it! So I think overall it was really fun from start to finish. Finishing with the fourth lesson where you got to plant those specific flowers for the certain butterflies that they learned about and the caterpillars. So I really liked it.

Resources

The school has several resources, material, human, and social (Gamoran, et al., 2003), that facilitated the implementation of this garden-based science curriculum.

Material

First, Penns Neck is a well funded school and has the means to build a school garden and equip it with the necessary materials students and teachers need to maintain it and use it as setting for learning. Also, time is a material resource, or facilitator (Gamoran et al., 2003). Teachers at Penns Neck have been given professional time to work together to create a garden-based curriculum. They have been successful based on the fact that they have been able to replace a science kit at each of the grade levels with a garden-based curricular unit. It is unclear if this type of professional learning time has been ongoing or just a one-time occurrence.

Interestingly, time, while a material resource and change facilitator, is also a barrier to implementation. All four of the teachers interviewed reported that a lack of time because of competing demands was a major barrier to using the school garden.

Mrs. Briarcliff explained,

> I think part of the problem is that [the garden-based insect curriculum] is too close to the end of the year. That's a big problem because it took a little bit, it took more work from us, which we're always willing to do, but the timing on it. But the insect [unit] comes at the end of the year so it's hard…I don't know what the answer is, but I would have liked to have been able to put a little bit more effort into it. But I just, I only had so much time.

Mrs. Captree also shared how her schedule makes it difficult to get outside to the garden, but participating in the curriculum helped her to get out more,

> [Having this garden-based insect curriculum] helped us get out to the garden more, you know. To have it scheduled so many times with you, which is good, because it's hard…it's hard to get out there, you know. It's hard to fit it all in. But I definitely think it's worth it.

Mr. Agnosto explained how he tries to get buy-in from teachers who feel overburdened by explaining that the garden is not something extra, rather it's just a different way of teaching required content,

> I think it's important for people to see that it's not in addition, that it's replacing what you're already doing. We all have limited time to do a lot more than we have enough time to do. And, you can ask, but if it's something that really is important to somebody, you're going to find ways to make the time. And I think it's important to show teachers that you're still hitting these objectives in the curriculum, but you're doing it in a different way. So you don't have to do lesson 12-1, 12-2, 12-3, 12-4 in a science book, or whatever it is, because instead you're replacing those. So it's not in addition to. It's important to show people that it's not more work. It's just different work. It's a different way to teach the same objectives, the same big ideas, in an authentic manner, as opposed to just in the classroom.

More professional learning time to make additional curricular connections and time to train the teachers how to use the garden with their students may help the teachers achieve Mr. Agnosto's idea of using the garden to meet more standards (Knapp, 2003).

Human

Teachers at the school who have extensive content knowledge of science and gardens are considered human resources for the garden-based curriculum. For example, Mrs. Captree's knowledge and enthusiasm for nature and gardens made her a considerable resource and leader of the garden initiative. Other teachers, such as kindergarten teacher, Mrs. Kissane, and Reading Recovery teacher, Mrs. Schuster, also were resources for how to care for plants and maintain the garden at the school. Similarly, second-grade teacher, Mrs. Darby, was a science resource for other teachers with her twenty years of science teaching experience.

However, in spite of human resources within the school and their buy-in of the curriculum, the less experienced teachers at Penns Neck still felt their lack of content knowledge about gardening was a barrier to using the school garden. Mrs. Martin, shared in an interview,

> Some people, I guess, are more comfortable with it. I didn't use the garden that much to begin with because I don't have a green thumb, first of all, and I had to learn the curriculum and everything…At first it was very overwhelming to me. I was a little nervous. I knew just a little bit about plants and the garden from teaching third grade. And, like I said, I was happy when you took more control over some of the lessons because I would have butchered it. Because, I mean, I would have to learn it myself and that kind of stuff doesn't come easy to me.

Similarly, Ms. Emilio shared how she really needed an external resource, namely me, to implement the garden-based curriculum,

> I think for a lot of teachers it's, like for me when I first came in, I'm not a gardener. It can be a little intimidating. But if you team teach, or like we had help from you, it's a lot nicer and more hands on. The kids love it and they see the results from the fall to the spring and it's really interesting for them to see the changes.

Social

Another factor in successful implementation of this garden-based unit is social resources that are present at Penns Neck (Gamoran et al., 2003). According to teacher reports, a professional learning community (PLC), or community of practice, is already in place, which is additional facilitator to this change. Hall and Hord (2006) explain,

> In terms of the change process, when a school staff works collaboratively in a PLC culture, the outcomes for the staff are significant…In such a context, teachers make a commitment to making significant and lasting changes, and they are more likely to undertake fundamental, systemic change. (p. 28)

A PLC would supplement new teachers' limited content knowledge by providing opportunities for them to learn from the more experienced teachers. Mr. Agnosto, who recognizes that a lack of content knowledge is a barrier to garden use, also suggested team or buddy teaching as a way for teachers to overcome unfamiliarity with the garden. He explained,

> And the other thing would be to have that person buddy up with somebody who is more comfortable with it. If somebody feels like, I'm not a gardener myself, but if I saw kids excited about it and I saw the benefits of it, that's my own learning then, then what can I do? I could buddy up with a teacher who has more experience with it and feels more comfortable with it, and then I could plan on doing things with that class.

Another social resource that is present at the school is a large parent community who volunteers to assist with lessons and clean-up days throughout the school year and takes over the responsibility of care of the garden during summers. Parents sign up as an opportunity to support the school, participate in an activity with their child, and enjoy picking rights of any ripe fruit, vegetable, or herb in the garden during their volunteer week. School garden leadership organizes a sign-up schedule and trains parent volunteers before the summer recess. A garden-educator from the Northeast Farming Association (NOFA) for the first two years after the school garden was initiated and myself (a university-based researcher) over the course of the study provided external expertise. However, as was clear during teacher interviews, the less experienced teachers, Mrs. Martin and Ms. Esposito, were dependent on me in the implementation of the garden-based curriculum. This level of dependence begs the question, what happened after I left? Did these teachers continue to use the school garden to teach science or did they revert back to other classroom-based methods instead? Some schools with school gardens have addressed this issue by hiring a full-time garden coordinator to provide such support or build a relationship with Master Gardeners from university extension programs who need to fulfill volunteer hours to obtain their credential. Mrs. Briarcliff and Mrs. Captree mentioned to me that they were thinking about contacting the Master Gardeners for this reason at the end of the study.

Leadership

Leadership was an important factor in the successful implementation of this garden-based unit on insects. It was not only the leadership of the past principal, Mr. Feldman, and present principal, Mr. Agnosto, but the leadership of teachers that has made this curricular reform lasting. Although Hallinger and Heck (1998) report that in schools located in high socioeconomic (SES) areas, the impact of principals is virtually nonexistent in contrast to low SES or predominately African American schools. “When controlling for SES and ethnicity, however, the effects of principal leadership on reading and math outcomes tended to disappear in high SES or predominately Caucasian elementary schools" (p. 178). This may be the case in reading and math, but at Penn's Neck, the principal's leadership (both Mr. Feldman's and Mr. Agnosto's) contributed substantially to successful implementation of this garden-based science curriculum at Penns Neck Elementary. The principal at Penns Neck Elementary School oversees the use and maintenance of the school garden. He ensures that it is supported in the budget so teachers have the materials they need to use it in and it can be maintained.

Also, it was not the principals' "top-down leadership," a typical barrier to educational changes, that was a predictor of success, rather that they developed teacher leaders who led the initiative (Hall & Hord, 2006). Indeed, Hall & Hord (2006) tell us that teacher participation in project decisions is a facilitator to educational changes. The fact that the garden-based curricular reform was led by not only the school principal, but teacher leaders, is both a facilitator and a barrier to the change. It is a barrier because teachers come and go and have to balance a tremendous number of responsibilities (Fullan, 1991). As I learned in interviews, Mrs. Captree was stepping down as leader of the school garden because she was going to be teaching a new grade level the following year. As a garden leader, Mrs. Captree organized a maintenance schedule, parent volunteers for clean-up days and summer vacation, and a sign-up sheet for classes to use the garden so there was not overcrowding. She also led the Garden Committee who made collaborative decisions over grade level uses of the garden, including garden bed allocation and curricula connections. Who would lead the school garden the following year had not been determined at the conclusion of the study. However, Mr. Agnosto seemed confident that finding someone to step up would not be difficult. In recent years, the leadership role of the school garden now receives some financial compensation. Teachers who volunteer to lead the school garden receive a stipend from the district for their time and efforts, a facilitator to this educational change. In terms of leadership attrition, this garden has outlasted the turnover of one principal and the teacher leader who initiated it, which is further testament that it has been implemented well.

Conclusion

The garden-based curriculum at Penns Neck Elementary School is an example of successful implementation. The case indicates several factors important for successful implementation that are supported in the educational change literature. For example, a shared vision is an important resource. Effective leadership is integral. Not only strong principal leadership, but leadership by those on the ground floor using the innovation, the teachers. Use of the innovation must be tied to improved student learning. In this case, the school garden was primarily used to teach science. Several levels of resources are necessary for successful implementation: material, human, and social. Creating a professional learning community in which teachers are given time to work collaboratively on additional ties from the garden to curricula and standards and to be trained on how to use the garden with their students is essential. Although this case is limited in scope and only involved a small number of teachers and administrators, it is my hope that it will provide insights that can be used to improve existing school garden programs and those that have yet to be initiated.

References

Anderson, C. (2003). How can schools support teaching for understanding in mathematics and Science (pp. 3-21). In Gamoran, A., Anderson, C., Quiroz, P., Secada, W., Williams, T., Ashmann, S. (2003). *How schools and districts can support change in teaching math and science*. New York: Teachers College Press.

Berman, P., & McLaughlin, M. W. (1978). *Federal programs supporting educational change, Vol. VIII: Implementing and sustaining innovations*. Santa Monica, CA: Rand.

Brynjegard, S. (2001). School gardens: Raising environmental awareness in children. San Rafael, CA: School of Education, Dominican University of California. (ERIC Documentation Reproduction Service No. ED452085). Retrieved October 25, 2010, from http://edres.org/eric/ED452085.htm.

Creswell, J.W. (2007). Qualitative inquiry & research design: Choosing among five approaches. London, England: Sage Publications

Dewey, J., & Dewey, E. (1915). *Schools of tomorrow*. New York: E.P. Dutton.

Dewey, J. (1916). *Democracy and education*. New York: The Free Press.

Elmore, R.F. (2004). *School reform from the inside out*. Cambridge: Harvard Education Press.

Elmore, R.F. (1990). *Restructuring schools: The next generation of educational reform*. San Francisco: Jossey-Bass Publishers.

Elmore, R., & Burney, D. (1998). *Continuous Improvement in Community District# 2, New York City*. Pittsburgh, PA: High Performance Learning Communities Project, Learning Research and Development Center, University of Pittsburgh.

Faddegon, P.A. (2005). *The kids growing food school gardening program: Agricultural literacy and other educational outcomes.* Doctoral dissertation, Cornell University, Ithaca, NJ.

Fisher-Maltese, C. (2013). *Teaching science in an informal setting: Assessing a garden-based approach to teaching the life cycle of insects.* Unpublished doctoral dissertation, Rutgers, The State University of New Jersey—New Brunswick.

Fisher-Maltese, C. (2013). *How a garden-based approach to teaching life science affects students' attitudes toward the environment and collaboration.* Unpublished doctoral dissertation, Rutgers, The State University of New Jersey—New Brunswick.

Fullan, M. (1993). *Change forces: Probing the depths of educational reform*. London: The Falmer Press.

Fullan, M. (1999). *Change forces: The sequel*. London: The Falmer Press.

Fullan, M. (2000). The return of large-scale reform. *Journal of Educational Change*, 1, 5-28.

Fullan, M. (2007). *The new meaning of educational change. New York: Teachers College Press.*

Gamoran, A., Anderson, C., Quiroz, P., Secada, W., Williams, T., Ashmann, S. (2003). *How schools and districts can support change in teaching math and science*. New York: Teachers College Press.

Graham, H. & Zidenberg-Cherr, S. (2005). California teachers perceive school gardens as an effective nutritional tool to promote healthful eating habits. *Journal of the American Dietetic Association*, 105 (11), 1797-1800.

Greenwald, R.L., Hedges, V., & Laine, R.D. (1996). The effect of school resources on student achievement. *Review of Educational Research*, 66, 361-396.

Hall, G., & Hord, S. (2006). *Implementing change: Patterns, principles, and potholes.* Boston: Pearson.

Hallinger, P., & Heck, R.L. (1998). Exploring the principal's contribution to school effectiveness:1980-1995. School Effectiveness and School Improvement, 9(2), 157-191.

Heller, M., & Firestone, W. A.. (1995). Who's in charge here? Sources of leadership for change in eight schools. *The Elementary School Journal*, 96(1), 65-86.

Klemmer, C.D., Waliczek, T.M., & Zajicek, J.M. (2005). The effect of a school gardening program on the science achievement of elementary students. *HortTechnology*, 15, 448-452.

Knapp, M.S., Copland, M.A., & Talbert, J.E. (2003). *Leading for learning: Reflective tools for school and district leaders*. Seattle: University of Washington.

Leithwood, K.A., & Riehl, C. What do we already know about education leadership? In Firestone, W.A., & Riehl, C. (2005*) A new agenda for research in educational leadership.* (pp. 12-27). New York: Teachers College Press.

Leithwood, K., Mascall, B., Strauss, T., Sacks, R., Memmon, N., & Yashkina, A. (2007). Distributing leadership to make schools smarter: Taking the ego out of the system. *Leadership and policy in schools*, 6(1), 37-68.

McAleese, J. & Rankin, L. (2007). Garden-enhanced nutrition education affects fruit and vegetable consumption in sixth-grade adolescents. *Journal of the American Dietetic Association*, 107 (4), 662-665.

McLaughlin, M. W. (1990). The Rand change agent study revisited: Macro perspectives and micro realities. *Educational Researcher*, 19(9), 11-16.

Nanney, M., Johnson, S., Elliot, M., & Haire-Joshu, D. (2006). Frequency of eating home-grown produce is associated with higher intake among parents and their pre-school aged children in rural Missouri. Journal of the American Dietetic Association, 107(4), 577-584.

National Gardening Association. (2010). Garden in every school registry. Retrieved April 23, 2010, from http://kidsgardening.com

New Jersey Department of Education. (2010). New Jersey school report card. (2010-2011). Retrieved March 1, 2013, from http://education.state.nj.us

Patton, M.Q. (1990). *Qualitative evaluation & research methods*. Thousand Oaks, California: Sage Publications.

Prestine, N.A., & Nelson, B.S. How can educational leaders support and promote teaching and learning? New conceptions of learning and leading in schools. In Firestone, W.A., & Riehl, C. (2005) *A new agenda for research in educational leadership.* (pp. 46-60). New York: Teachers College Press.

Skelly, S.M. & Zajiceck, J.M. (1998). The effect of an interdisciplinary garden program in the environmental attitudes of elementary school students. Hortechnology, 8(4). 579-583.

Smith, L.L., & Mostenbocker, C.E., (2005). Impact of hands-on science through school gardening in Louisiana public elementary schools. *HortTechnology*, 15, 439-443.

Stein, M.K., & Nelson, B.S. (2003). Leadership content knowledge. *Educational Evaluation and Policy Analysis*, 25(4), 423-448.

Thorp, L., & Townsend, C. (2001, December 12). Agricultural education in an elementary school: An ethnographic study of a school garden. *Proceedings of the 28th Annual National Agricultural Education Research Conference in New Orleans*, *LA* (pp. 347-360). Retrieved from http://www.aaaeonline.org/conference_files/758901.

Waliczek, T.M., Bradley, J.C., Lineberger, R.D., & Zajicek, J.M. (2000). Using a web-based survey to research the benefits of children gardening. Hortechnology, 10(1), 71-76.

CHAPTER 5

CONCLUSION

School gardens are educational settings which integrate multiple academic disciplines, including science, math, reading, environmental studies, nutrition, and health. Garden-based learning is positioned amongst experiential learning theory and situated learning theory. The learning that takes place in them has the potential to be authentic, engaging, and meaningful. They have the power to shift attitudes (e.g., environmental). Working in a school garden fosters community and collaboration (California School Garden Network, 2006).

The learning that takes place in school gardens, as well as their other affordances, is only partially explored. My dissertation adds to the limited research base on garden-based learning by answering the following research questions. 1) How is student learning impacted when in the context of a school garden (Chapter 2)? Student science learning is impacted because they are motivated and engaged through the real-world experiences in a school garden. 2) Does involvement in a garden-based curriculum lead to shifts in students' attitudes toward the environment or collaboration (Chapter 3)? Yes, triangulation of the data suggests that involvement in this garden-based curriculum shifted students' attitudes toward the environment and collaboration in a positive direction. 3) What factors are necessary for successful implementation of a garden-based science curriculum (Chapter 4)? Participants in the study reported a number of affordances, including cross-curricular lessons in an authentic setting with real-life examples of what the students were studying, an opportunity to teach about the environment and healthy eating, and a sense of school community that was fostered. However, teachers also reported significant barriers to using the school garden, specifically lack of time and content knowledge.

Although this dissertation is limited in scope and draws from a small sample of teachers, administrators, and students, it provides a rich example of the ways an informal learning framework can shed light on the affordances of a garden-based learning curriculum that can frame larger garden-based learning studies. In particular, future research is needed on the social, motivational and real-world aspects of garden-based learning. Hopefully, researchers will utilize this work on garden-based learning using an informal learning lens to conduct studies on the effects of school gardens on student learning.

Without future research that examines school gardens' impacts on students, we will not truly understand the potential of these educational innovations. In addition, there will be little impetus to sustain the school gardens that currently exist. The appeal of school gardens is contagious as anyone who has been involved with them will tell you anecdotally. First Lady Michelle Obama's enthusiasm is testament to this. She writes in her book, *American Grown: The Story of the White House Kitchen Garden and Gardens Across America,*

> It is my hope that our garden's story—and the stories of gardens across America—will inspire families, schools, and communities to try their own hand at gardening and enjoy all the gifts of health, discovery, and connection a garden can bring. All across this great country of ours, something truly special is taking root (Obama, 2012, p. 19).

A school garden is not merely an educational or informal learning setting; they comprise a growing movement. They embody the kind of teaching and learning that leading theorists and pedagogues have espoused: John Dewey, Maria Montessori, James Coleman, Jean Lave, and Etienne Wenger. They offer a remedy to many of the criticisms of traditional schools. It is my hope that this dissertation will inspire others to explore this educational reform.

References

California School Garden Network. (2006). Gardens for learning: Creating and sustaining your school garden. Irvine, CA: California School Garden Network.

Obama, M. (2012). *American grown: The story of the White House kitchen garden and gardens across America.* New York, NY: National Parks Foundation.

BIBLIOGRAPHY

Alexander, J., North, M.W., & Hendren, D.K. (1995). Master gardener classroom garden project: An evaluation of the benefits to children. *Child Environments*, 12(2), 124-133.

Alston, J.M., Anderson, M.A., James, J.S., & Pardey, P.G. (2010). Persistence pays: U.S. agricultural productivity growth and the benefits from R&D spending. New York: Springer.

American Association for the Advancement of Science. (1993). *Benchmarks on-line.* Retrieved November 6, 2007, from http://www.project2061.org/publications/bsl/online/bolintro.htm

Anderson, C. (2003). How can schools support teaching for understanding in mathematics and Science (pp. 3-21). In Gamoran, A., Anderson, C., Quiroz, P., Secada, W., Williams, T., Ashmann, S. (2003). *How schools and districts can support change in teaching math and science*. New York: Teachers College Press.

Anderson, D., Lucas, K. B., Ginns, I. S., & Dierking, L. D. (2000). Development of knowledge about electricity and magnetism during a visit to a science museum and related post-visit activities. Science Education, 84(5), 658-679.

Ash, D. (2003). Dialogic inquiry in life science conversations of family groups in a museum. Journal of Research in Science Teaching, 40(2), 138-162.

Ash, D., Crain, R., Brandt, C., Loomis, M., Wheaton, M., & Bennett, C. (2007). Talk, tools, and tensions: Observing biological talk over time. International Journal of Science Education, 29(12), 1581-1602.

Bamberger, Y., & Tal, T. (2007). Learning in a personal context: Levels of choice in a free choice learning environment in science and natural history museums. Science Education, 91(1), 75-95.

Barron, B. (2002). Achieving coordination in collaborative problem-solving groups. *Journal of the Learning Sciences*, 9, 403-437.

Beatty, B. (1995). *Preschool education in America: The culture of young children from the colonial era to the present*. New Haven: Yale University Press.

Bell, P., Lewenstein, B., Shouse, A.W., & Feder, M.A. (Eds.). (2009). Learning science in informal environments: People, places, and pursuits. Washington, D.C.: National Academies Press.

Berman, P., & McLaughlin, M. W. (1978). *Federal programs supporting educational change, Vol. VIII: Implementing and sustaining innovations*. Santa Monica, CA: Rand.

Blair, D. (2009). The child in the garden: An evaluative review of the benefits of school gardening. *Journal of Environmental Education*, 40(2), 15-38.

Borun, M., Chambers, M., & Cleghorn, A. (1996). Families are learning in science museums. Curator: The Museum Journal, 39(2), 123-138.

Brunotts, C.M. (1998). School gardening: A multi-faceted learning tool. An evaluation of the Pittsburgh civic garden center’s Neighbors and Schools Gardening Together. Unpublished master’s thesis, Duquesne University, Pittsburgh, PA.

Brynjegard, S. (2001). School gardens: Raising environmental awareness in children. San

Rafael, CA: School of Education, Dominican University of California. (ERIC Documentation Reproduction Service No. ED452085). Retrieved October 25, 2010, from http://edres.org/eric/ED452085.htm.

Bunting, T.E., & Cousins, L.R. (1983). Development and application of the Children's Environmental Response Inventory. *Journal of Environmental Education*, 15(1), 3-10.

California Department of Education. (2010). *Catalogue listing of publications*. Retrieved October 25, 2010, from http://www.cde.ca.gov./re/pn/rc/ap/pubdisplay.aspx?ID=001512.

California Department of Education. (2010). *Catalogue listing of publications*. Retrieved October 25, 2010, from http://www.cde.ca.gov./re/pn/rc/ap/pubdisplay.aspx?ID=001512.

California School Garden Network. (2006). Gardens for learning: Creating and sustaining your school garden. Irvine, CA: California School Garden Network.

Canaris, I. (1995). Growing foods for growing minds: Integrating gardening into the total curriculum. Children's Environments, 12(2), 134-142.

Carrier, S. (2009). Environmental education in the schoolyard: Learning styles and gender. *The Journal of Environmental Education*, 40(3), 2-12.

Center for Ecoliteracy. (1999). The edible schoolyard. Berkeley, California: Learning in the real world.

Cohen, E.G. (1994). Restructuring the classroom: Conditions for productive small groups. *Review of Educational Research*, 64, 1-35.

Coleman, J.A. (1977). Differences between experiential and classroom learning. In M.T. Keeton (Ed.), *Experiential learning: Rationale, characteristics, and assessment* (pp. 49-61). San Francisco, CA: Jossey-Bass Publishers.

Creswell, J.W. (2007). Qualitative inquiry & research design: Choosing among five approaches. London, England: Sage Publications.

Crowhhurst-Lennard, S.H., & Lennard, H.L. (1995). *Livable cities observed*. Gondolier Press: Carmel, CA.

Desmond, D., Grieshop, J., & Subramaniam, A. (2002). Revisiting garden based learning in basic education: Philosophical roots, historical foundations, best practices and products, impacts, outcomes, and future directions. Prepared for IIEP/FAO, SDRE Food and Agricultural Organization/United Nations, Rome, Italy, UNESCO International Institute for Educational Planning, Paris, France.

Dewey, J. (1915). *Schools of tomorrow*. New York: E.P. Dutton.

Dewey, J. (1916). *Democracy and education*. New York: The Free Press.

Dierking, L.D., Falk, J.H., Rennie, L., Anderson, D., & Ellenbogen, K. (2003). Policy statement of the "Informal Science Education" Ad Hoc Committee. Journal of Research in Science Teaching, 40, 108-111.

Dillon, J., Rickinson, M., Teamey, K., Morris, M., Choi, M.Y., Sanders, D., Benefield, P. (2006). The value of outdoor learning: Evidence from research in the U.K. and elsewhere. *School Science Review*, 87(320), 107-111.

Dirks, A.E., & Orvis, K. (2005). An evaluation of the junior master gardener program in third grade classrooms. *HortTechnology*, 15, 443-447.

Driver, R., Leach, J., Milllar, R., & Scott, P. (1996). *Young people's images of science*. Buckingham, England: Open University Press.

Dunlap, R. E., & Jones, R. E.. (2003). Environmental attitudes and values. In R. Fernandez-Ballesteros (Ed.), *Encyclopedia of psychological assessment*, Vol. 1 (pp. 364-369). London: Sage.

Dunlap, R. E., & Van Liere, K. D. (1978). A proposed measuring instrument and preliminary results: The 'New Environmental Paradigm'. *Journal of Environmental Education*, *9*(1), 10-19.

Eberbach, C., & Crowley, K. (2005). From living to virtual: Learning from museum objects. Curator: The Museum Journal, 48(3), 317-338.

Elmore, R.F. (2004). *School reform from the inside out*. Cambridge: Harvard Education Press.

Elmore, R.F. (1990). *Restructuring schools: The next generation of educational reform*. San Francisco: Jossey-Bass Publishers.

Elmore, R.F., & Burney, D. (1998). *Continuous Improvement in Community District# 2, New York City*. Pittsburgh, PA: High Performance Learning Communities Project, Learning Research and Development Center, University of Pittsburgh.

Faddegon, P.A. (2005). *The kids growing food school gardening program: Agricultural literacy and other educational outcomes.* Doctoral dissertation, Cornell University, Ithaca, NJ.

Falk, J.H. (1999). Museums as institutions for personal learning. Daedalus, 128, 259-275.

Falk, J.H. (2001). Free-choice science learning: Framing the issues. In: Falk, J., (Ed.), Free-choice science education: How people learn science outside of school (pp. 2-9). New York: Teacher's College Press.

Falk, J. H. (2005). Free-choice environmental learning: Framing the discussion. Environmental Education Research, 11(3), 265-280.

Falk, J.H. & Dierking, L.D. (1998, May/June). Free-choice learning: An alternative term to informal learning? Informal Learning Environments Research Newsletter (p. 2). Washington, DC: American Educational Research Association.

Falk, J.H., & Dierking, L.D. (1992). The museum experience. Walnut Creek, CA: AltaMira Press.

Falk, J.H. & Dierking, L.D. (2000). Learning from museums: Visitor experiences and the making of meaning. Lanham, MD: AltaMira Press.

Falk, J.H. & Dierking, L.D. (2002). Lessons without a limit: How free-choice learning is transforming education. Walnut Creek, CA: AltaMira.

Farmer, J., Knapp, D., & Benton, G. M. (2007). An elementary school environmental education field trip: long-term effects on ecological and environmental knowledge and attitude development. *The Journal of Environmental Education*, *38*(3), 33-42.

Firestone, W.A. (1987). Meaning in method: The rhetoric of qualitative and quantitative methods in classroom environment research. *Educational Researcher*, 16, 16-21.

Fisher-Maltese, C. (2013). *Teaching science in an informal setting: Assessing a garden-based approach to teaching the life cycle of insects.* Unpublished doctoral dissertation, Rutgers, The State University of New Jersey—New Brunswick.

Fisher-Maltese, C. (2013). *How a garden-based approach to teaching life science affects students' attitudes toward the environment and collaboration.* Unpublished doctoral dissertation, Rutgers, The State University of New Jersey—New Brunswick.

Fisher-Maltese, C., & Zimmerman, T.D. (in review). Teaching science in a "living laboratory:" How an informal learning lens reveals new insights into the use of a school garden

Francovicova, J., & Prokop, J. (2011). Plants have a chance: Outdoor educational programmes alter students' knowledge and attitudes towards plants. *Environmental Education Research*, 17(4), 537-551.

Fraser, B. J., & Tobin, K. (1992). Combining qualitative and quantitative methods in classroom environment research. In B. J. Fraser & H. J. Walberg (Eds.), *Educational environments: Antecedents, consequences, and evaluation* (pp. 271-292). London: Pergamon Press.

Fullan, M. (1993). *Change forces: Probing the depths of educational reform*. London: The Falmer Press.

Fullan, M. (1999). *Change forces: The sequel*. London: The Falmer Press.

Fullan, M. (2000). The return of large-scale reform. *Journal of Educational Change*, 1, 5-28.

Fullan, M. (2007). *The new meaning of educational change. New York: Teachers College Press.*

Gamoran, A., Anderson, C., Quiroz, P., Secada, W., Williams, T., Ashmann, S. (2003). *How schools and districts can support change in teaching math and science*. New York: Teachers College Press.

Gee, J.G. (2007). Reflections on assessment from a sociocultural-situated perspective. *Yearbook of the National Society for the Study of Education*, 106(1), 362-375.

Graham, H. & Zidenberg-Cherr, S. (2005). California teachers perceive school gardens as an effective nutritional tool to promote healthful eating habits. *Journal of the American Dietetic Association*, 105 (11), 1797-1800.

Greenwald, R.L., Hedges, V., & Laine, R.D. (1996). The effect of school resources on student achievement. *Review of Educational Research*, 66, 361-396.

Griffin, J., & Symington, D. (1997). Moving from task-oriented to learning oriented strategies on school excursions to museums. *Science Education*, 881, 763-779.

Hall, G., & Hord, S. (2006). *Implementing change: Patterns, principles, and potholes*. Boston: Pearson.

Hallinger, P., & Heck, R.L. (1998). Exploring the principal's contribution to school effectiveness:1980-1995. School Effectiveness and School Improvement, 9(2), 157-191.

Heller, M., & Firestone, W. A.. (1995). Who's in charge here? Sources of leadership for change in eight schools. *The Elementary School Journal*, 96(1), 65-86.

Hein, G. (1998). Learning in the museum. New York, NY: Routledge.

Hickling, A. K., & Gelman, S. A. (1995). How does your garden grow? Early conceptualization of seeds and their place in plant growth cycle. *Child Development*, 66, 856-876.

Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn?. *Educational Psychology Review*, *16*(3), 235-266.

Jaus, H. (1982). The development and retention of environmental attitudes in elementary school children. *Journal of Environmental Education*, 13(2), 12-18.

Johnson, B., & Manoli, C. C. (2010). The 2-MEV scale in the United States: a measure of children's environmental attitudes based on the theory of ecological attitude. *The Journal of Environmental Education*, *42*(2), 84-97.

Kisiel, J. (2003). Teachers, museums, and worksheets: A closer look at a learning experience. *Journal of Science Teacher Education*, 14(1), 3-21.

Klemmer, C.D., Waliczek, T.M., & Zajicek, J.M. (2005a). Development of a science achievement evaluation instrument of a school garden program. *HortTechnology*, 15, 433-438.

Klemmer, C.D., Waliczek, T.M., & Zajicek, J.M. (2005b). The effect of a school gardening program on the science achievement of elementary students. *HortTechnology*, 15, 448-452.

Knapp, M.S., Copland, M.A., & Talbert, J.E. (2003). *Leading for learning: Reflective tools for school and district leaders*. Seattle: University of Washington.

Kraft, R. J. (1990). Experiential learning. *Adventure Education*, 175-183.

Lave, J. & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge, England: Cambridge University Press.

Leithwood, K.A., & Riehl, C. What do we already know about education leadership? In Firestone, W.A., & Riehl, C. (2005*) A new agenda for research in educational leadership.* (pp. 12-27). New York: Teachers College Press.

Leithwood, K., Mascall, B., Strauss, T., Sacks, R., Memmon, N., & Yashkina, A. (2007). Distributing leadership to make schools smarter: Taking the ego out of the system. *Leadership and policy in schools*, 6(1), 37-68.

LifeLab. (2006). *Garden based learning that promotes a sustainable future.* Retrieved July 31, 2008, from http://www.lifelab.org/about/index.html.

Lineberger, S.E. & Zajicek, J.M. (2000). School gardens: Can a hands-on teaching tool affect students' attitudes and behaviors regarding fruits and vegetables? Hortechnology, 10(3), 593-597.

Lopez, Russ, Campbell, Richard, & Jennings. (2008). The Boston schoolyard initiative: A public-private partnership for rebuilding urban play spaces. *Journal of Health Politics, Policy and Law*. 33, 617-638.

Louv, R. (2005). L*ast child in the woods: Saving our children from nature-deficit disorder*. Chapel Hill, NC: Algonquin Books of Chapel Hill.

Maloney, M. P., & Ward, M. P. (1973). Ecology: Let's hear it from the people. An objective scale for measurement of ecological attitudes and knowledge. *American Psychologist*, 28, 583-586.

Manoli, C., Johnson, B., & Dunlap, R. (2007). Assessing children's environmental world views: Modifying and validating the New Ecological Paradigm Scale for use with children. *Journal of Environmental Education*, 38(4), 3-13.

McAleese, J. & Rankin, L. (2007). Garden-enhanced nutrition education affects fruit and vegetable consumption in sixth-grade adolescents. *Journal of the American Dietetic Association*, 107 (4), 662-665.

McLaughlin, M. W. (1990). The Rand change agent study revisited: Macro perspectives and micro realities. *Educational Researcher*, 19(9), 11-16.

Milfont, T., & Duckit, J. (2009). The environmental attitudes inventory: A valid and reliable measure to assess the structure of environmental attitudes. *Journal of Environmental Psychology*, 30, 80-94.

Montessori, M. (1967). *The discovery of the child*. New York: Ballantine Books.

Moore, R. (1995). Growing foods for growing minds: Integrating gardening and nutrition education into the total curriculum. *Children's Environments*, 12(2), 134-142.

Morris, J., & Zidenberg-Cherr, S. (2002). Garden-enhanced nutrition curriculum improves fourth grade school children's knowledge of nutrition and preference for some vegetables. *Journal of the American Dietetic Association*, 102 (1), 91-93.

Musser, L., & Malleus, A. (1994). The children's attitudes toward the environment scale. *The Journal of Environmental Education*, 23(3), 22-26.

Nanney, M., Johnson, S., Elliot, M., & Haire-Joshu, D. (2006). Frequency of eating home-grown produce is associated with higher intake among parents and their pre-school aged children in rural Missouri. Journal of the American Dietetic Association, 107(4), 577-584.

National Gardening Association. (2012). *GrowLab Curricula*. Retrieved November 29, 2012, from www.gardeningwithkids.org

National Gardening Association. (2010). Garden in every school registry. Retrieved April 23, 2010, from http://kidsgardening.com

National Research Council. (1996). *National Science Education Council.* Washington, DC: National Academy Press.

New Jersey Department of Education. (2010). New Jersey school report card. (2010-2011). Retrieved March 1, 2013, from http://education.state.nj.us

Nguyen, S.P., & Rosengarten K.S. (2004). Parental reports of children's biological knowledge and misconceptions. *International Journal of Behavioral Development*, 28, 411-420.

No Child Left Inside (NCLI) Coalition. (2008). *The problem*. Retrieved on December 1, 2008 from http://www.cbf.org/site/PageServer?pagename=act_sub_actioncenter_federal_nclb_problem

Obama, M. (2012). *American grown: The story of the White House kitchen garden and gardens across America.* New York, NY: National Parks Foundation.

O'Donnell, A.M. (1999). Structuring didactic interaction through scripted cooperation. In

O'Donnell, A.M. and King, A. (eds.). *Cognitive Perspectives in Peer Learning*. Erlbaum, Mahwah: NJ, pp. 179-196.

Orion, N., & Hoffstein, A. (1994). Factors that influence learning during a scientific fieldtrip in a natural environment. *Journal of Research in Science Teaching*, 33(10), 1097-1119.

Palincsar, A.S., & Herrenkohl, L.R. (1999). Designing collaborative contexts: Lessons from three research programs. In O'Donnell, A.M. and King, A. (eds.). *Cognitive Perspectives in Peer Learning*. Erlbaum, Mahwah: NJ, pp. 151-178.

Pea, R.D. (1993). Practices of distributed intelligence and designs for education. In Salomon, G. and Perkins, D. (eds.), *Distributed Cognitions: Psychological and Educational Considerations*, Cambridge University Press: New York, pp. 47-87.

Patton, M.Q. (1990). *Qualitative evaluation & research methods*. Thousand Oaks, California: Sage Publications.

Penuel, W. R., Roschelle, J., & Shechtman, N. (2007). Designing formative assessment software with teachers: An analysis of the co-design process. *Research and Practice in Technology Enhanced Learning*, 2(1), 51-74.).

Pine, K., Messer, D., & St. John, K. (2010). Children's misconceptions in primary science: A survey of teachers' views. *Research in Science & Technological Education*, 19, 79-96.

Prestine, N.A., & Nelson, B.S. How can educational leaders support and promote teaching and learning? New conceptions of learning and leading in schools. In Firestone, W.A., & Riehl, C. (2005) *A new agenda for research in educational leadership.* (pp. 46-60). New York: Teachers College Press.

Quay, J. (2003). Experience and participation: Relating theories of learning. *Journal of Experiential Education*, 26(2), 105-112.

Rahm, J. (2002). Emergent learning opportunities in an inner-city youth gardening program. Journal of Research in Science Teaching, 39(2), 164-184.

Rennie, L.J. (2007). Learning science outside of school. In: S.K. Abell & N.G. Lederman (Eds.), Handbook of research on science education (pp. 125-167). Mahwah, NJ: Lawrence Erlbaum Assoc., Inc.

Rousseau, J. (1762). *Emile or on education* (introduction, translation, and notes by Allan Bloom, 1979). New York: Basic Books.

Rowe, S. (2002). The role of objects in active, distributed meaning-making. Perspectives on Object-Centered Learning in Museums, , 19-35.

Salomon, G. (1993). No distribution without individual cognition: A dynamic interactional view. In Salomon, G. and Perkins, D. (eds.), *Distributed Cognitions: Psychological and Educational Considerations*, Cambridge University Press: New York, pp. 111-138.

Sieber, S. D. (1973). The integration of fieldwork and survey methods. *The American Journal of Sociology*, 78(6), 1335-1359.

Skelly, S.M. & Zajiceck, J.M. (1998). The effect of an interdisciplinary garden program in the environmental attitudes of elementary school students. Hortechnology, 8(4). 579-583.

Smith, L.L., & Mostenbocker, C.E., (2005). Impact of hands-on science through school gardening in Louisiana public elementary schools. *HortTechnology*, 15, 439-443.

Stein, M.K., & Nelson, B.S. (2003). Leadership content knowledge. *Educational Evaluation and Policy Analysis*, 25(4), 423-448.

Thorp, L., & Townsend, C. (2001, December 12). Agricultural education in an elementary school: An ethnographic study of a school garden. *Proceedings of the 28th Annual National Agricultural Education Research Conference in New Orleans, LA* (pp. 347-360). Retrieved from http://www.aaaeonline.org/conference_files/758901.

Waliczek, T.M., Bradley, J.C., Lineberger, R.D., & Zajicek, J.M. (2000). Using a web-based survey to research the benefits of children gardening. Hortechnology, 10(1), 71-76.

Waliczek, T.M., & Zajicek, J.M. (1999). School gardening: Improving environmental attitudes of children through hands-on learning. *Journal of Environmental Horticulture*, 17, 180-184.

Weigel, R. & Weigel, J. (1978). Environmental concern: The development of a measure. *Environment & Behavior*, 10, 3-15.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*, Cambridge University Press: New York.

Whelan, D. L. (2008). Let them eat kale: With America's kids in danger of becoming obese, a growing number of schools are thinking outside the lunchbox. *School Library Journal*. 54(6), 44-49.

Zimmerman, T.D. (2005). Unpublished doctoral thesis, University of California, Berkeley.

Zimmerman, T.D. (March, 2010). Paper presented at the National Association for Research on Science Teaching Annual Conference. Philadelphia, PA.

Zimmerman, T.D. (2011). In J.E. Katz. W. LeBrar & E. Lynch (Eds.), Creativity and Technology: Social Media, Mobiles and Museums. Museumsetc., Edinburgh.