LEARNING SCIENCE IN "REAL TIME"

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Abstract

This paper is an ethnographic/qualitative case study of Learning Gardens, an experiential life science educational program in three 6th grade South Bronx pubic school classes and local community gardens in South Bronx public schools. Classroom and garden lessons illustrate the stimulation of students' critical thinking and inquiry skills through experiential teaching methods congruent with individual learning styles. The program's success refutes school policies unduly focused on standardized testing, where failure results in closing and privatizing public schools, replacing them with charter schools. Learning Gardens gives hope to children who attend public schools and want to and can learn despite their families' poverty and their inner city, concrete neighborhoods.

Key words: experiential learning, community gardens, science education, environmental education

Introduction

This paper is an evaluative composite case study of a 6th grade experiential life science educational program in public school classrooms and community gardens in the South Bronx. Learning Gardens (LG), a program of the City Parks Foundation (CPF), a non profit organization is conducted in collaboration with 15 public schools and 50 classes in NYC's disadvantaged neighborhoods. The South Bronx is the poorest urban district in the nation where more than a quarter-million people live below the poverty level. Children are worse off: almost 50% live in poverty. A large population of first and second generation immigrant students resides in the South Bronx. Sixty percent of the population is Latino and 39% is Black, i.e., African American, Caribbean and African.

The primary objectives of this evaluation were to assess LG's effectiveness on students': (1) knowledge about life science, environmental issues/stewardship; (2) interest in and comfort with learning science; (3) engagement/re-engagement in learning; and (4) key aspects of social development (communication, team work, decision-making, leadership). Other objectives included identifying structural, curriculum-related, professional development, teacher engagement, and LG staff and program-related issues that support or hinder program success.

Theoretical Framework

Theoretically, we had thought to return to classic statements in experiential education such as Dewey's observation: "[g]ive the pupils something to do, not something to learn; and the doing is of such a nature as to demand thinking; learning naturally results." However, the following quote effectively highlights the tension between experiential learning in the LG program and today's, unfortunate, more dominant didactic pedagogy: "…experiential learning is not an alternative approach, but the most traditional and fundamental method of human learning… the current perception of experiential education as 'different' is probably less due to new developments in experiential learning than it is to the normalization of didactic teaching as the mainstream educational methodology. (http://wilderdom.com/experiential/ May 6, 2010).

Methods

Program documentation and past years' LG-administered surveys and curriculum were reviewed. Qualitative data were obtained through observations of the LG program in school classes and community gardens over seven months in 2011. In-depth interviews were conducted with the Director of Education, CPF, LG educator staff, participating public school administrators, teachers and a sample of 6^{th} grade students from 3 classes. Focus group interviews were conducted with a sample of students. Teacher and student (n=69) surveys were administered. An SPSS database was developed with all survey data entered and subject to descriptive statistical analysis. Bloom's taxonomy of learning was used as a theoretical framework (Bloom et al., 1956).

Analysis

Qualitative methods were used to analyze naturally occurring data, i.e., talk, text, interactions obtained through intensive observations in classrooms and garden. Analysis was by direct interpretation. Findings were modified by repeated rethinking, triangulated by multiple methods and a search for disconfirming evidence (Stake, 1995). Findings were presented back to teachers, LG's program Director and staff and validated as their interpretations of the data. Few discrepancies arose, mostly related to additional contextual information that the evaluator did not have. Appropriate modifications were made. Qualitative data were supplemented by quantitative data derived from survey and interview responses. Key themes, terms, and science-related processes and activities that correspond to Bloom's taxonomy were identified. These quantitative data were considered on a relational basis as to how the ideas and concepts. Multiple data sources were triangulated.

Literature Review

Nationwide, school gardening curricula have been primarily used in schools having gardens on school grounds. LG is one of the few educational programs to incorporate experiential science learning in community rather than school-based gardens. Quantitative studies show that school gardening programs have positive effects on students' science achievement and behavior (Blair, 2009). Qualitative studies identify a broad range of positive social/environmental student outcomes: increased motivation and enthusiasm, improved sense of self, teamwork, community involvement (Faddegon, 2005). Teachers' and administrators' survey responses provide positive attitudes about school gardens as ways to improve student learning (Skelly and Bradley, 2000). Whether structure in a gardening program is related to improved cognitive or emotional development has not yet been studied (Blair, 2009). LG, however, is a structured classroom/community garden science educational program. LG's curriculum, in contrast to most school gardening programs, coheres with and expands NYC's public school standards for life science curriculum. Multiple intelligence and experiential learning research is critical to the theoretical underpinnings and pedagogy of LG. (Gardner, 1982). Students learn when teachers are trained and use music, cooperative learning, art, role play, multimedia, etc. (Armstrong, 2009). LG offers professional development to teachers of participating classes, encouraging them to incorporate experiential pedagogies into teaching. Students can experiment and learn science in community gardens that can be a "scientifically enriching experience" (Falk and Dierking, 2010). LG is on the cutting edge in NYC schools, shifting science education from lecture to hands-on learning that better meets the needs of a substantial proportion of disadvantaged school students. Waliczek, Logan, & Zajicek's research shows that school gardening helped students to learn math and science at the lower levels of Bloom's taxonomy and that they were thinking at higher levels (2003). LG's evaluation, similarly, analyzed qualitative data to assess student learning within Bloom's framework.

Results and Discussion

COMMUNITY GARDEN

Gene Grabiner

Javier's class is digging dirt in the community garden by P.S. 198 in the Bronx
And Javier says: why am I digging dirt, I haven't done anything wrong?
He knows that men from Forrest Ave., from the *barrio,* maybe from the block go to jail
go to prison.
He knows that men from the block wear orange vests; paint benches, bag weeds in black
plastic in the park, dig dirt—this is called community service.
Will ten-year-old Javier get warm soil under his fingernails, sow zinnias,
smile
at their rainbow heads?

This poem was inspired by a child who had just learned that his class would participate in a 14-week innovative science-based classroom/community garden educational program in the South Bronx. His name, school, and address of the school are pseudonyms. In asking his innocently honest, socially complex question, Javier reasoned from his own experience living in the South Bronx where adults do "community service" when sentenced by criminal courts. "Community service" for Javier, and most likely for his peers, initially, had a negative meaning.

LG Program

LG's curriculum integrates public school horticulture in nearby South Bronx local community gardens. LG's objectives include helping students to:

- understand processes, language, and skills involved in scientific thinking,
- gain basic science knowledge through experiential learning,
- discover the biodiversity that exists in their own inner city neighborhoods,
- re-engage disaffected school children in learning through pedagogy that activates and supports multiple intelligences,
- nurture a positive outlook toward science, and for learning in general.

Too many students emerge from elementary school "disdaining science as too dull and too hard to learn" (AAAS, 1990). By introducing entering middle school students to science through LG, students learn in a natural setting that science is a process of discovery. Such experiences contradict the common notion among students and some teachers, that science is an array of unconnected facts, concepts, and rules with correct answers rather than creative, dynamic ways of thinking about and solving real problems (Driver et al., 1996).

Actualizing Multiple Intelligences

Our schools and culture focus attention almost entirely on linguistic and logical-mathematical intelligence (Gardner 1985). Yet, many individuals, who improve the world in different ways, excel in other intelligences (artists, musicians, naturalists, therapists, etc.). Children with these intelligences often do not receive reinforcement for them in school. LG is designed to expand and stimulate each student's intellectual capabilities and skills through a wide variety of experiential or hands-on teaching methods.

LG's teaching methods and tools for learning exceed conventional lecture, textbook, formulae methods. Model construction, art, writing, body movement, planting, using garden tools, and collaborative learning are integral to LG's pedagogy.

Students were observed dissecting plants, identifying their parts, and drawing them in their science journals. They asked and answered questions, individually and as a group, to understand the function of each plant part in the life cycle. Students learned through experimentation about; pollination, fertilization, plant reproduction, and the life cycle of plants and small garden animals. They also learned about different soil types, the Sun's role as the major source of energy; and the effects of light, water, and soil on plants and animals. Each class had a living caterpillar garden. Students observed complete butterfly metamorphoses. They released their butterflies into the gardens, watching as they drank nectar and pollinated flowers.

Invoking Inquiry, Observation, and Participation Skills through Experiential Learning

Committed to helping students understand that inquiry is at the heart of science and scientific ways of knowing, LG educators consistently ask and answer students' questions to stimulate critical thinking and illuminate ideas and concepts.

"I try to get students to come to answers and ideas on their own with some guidance in the right direction. If my questions are precise and interesting…then, they will inspire more curiosity about concepts....the better the questions, the better supported students are in activating prior knowledge. If my questioning is thought-provoking and causes strong responses…they are more likely to make connections.

"Correct responses are not always the main goal of questioning, rather it is to get a sense of the ideas these questions push students to generate…modeling [inquiry] questioning by asking questions aloud prepares students to formulate their own questions. As they respond and begin asking their own questions…discussion about major concepts begins and later deepens."

LG educators provide feedback to students by asking questions prompting their consideration of different problem-solving strategies. This is enhanced through combinations of inquiry-based strategies, e.g. designing and conducting experiments and observation; encouraging students to generate scientifically-oriented questions, ensuring that they share ideas and knowledge, etc. Sequential lessons are taught, building learning from the previous class or garden lesson in preparation for the next.

Winter 2011-In the Classroom

During winter, lessons are taught in the classroom where students perform experiments, dissect plants, touch small animals, and learn about scientific processes. February: 4 inches of snow has fallen in the South Bronx. An LG lesson in a 6th grade classroom in a small middle school is being observed. The room is light and airy. Student mobiles and atom constructions are suspended from the ceiling. A chart of photosynthesis is displayed on a front wall. Many books are available containing pictures and information about animals. There is goldfish tank; plants are growing under grow lamps. Students are greeted with a large sign in front of the room promoting questioning and inquiry as the basis of science and scientific thinking: **REAL SCIENTISTS ASK HOW AND WHY** The classroom's environment is an antidote to this school building's maze of halls running into other halls, with few outside windows.

Friday, March 25th 11:30am: Science Thinking and Inquiry

Each LG lesson has a hands-on experiment and/or involves systematic observation by the students, e.g.., dissecting flowers and beans, soil texture and properties, the function of worms, and pill bugs as decomposers, constructing a plant maze, etc. The LG educator actively engages students by asking and refining questions, having thoughtful interaction with real materials, and using diverse hands-on activities to fortify the science lesson. Questioning and eliciting responses from individual students and as a group provides them with opportunities to display prior knowledge. They answer questions by applying knowledge about one aspect of life science to a different sphere, and/or thinking about (analyzing) the question and arriving at (generating) some conclusion. Students' need not always be correct or fully accurate. It is the thinking process that is really encouraged. The group or another student may have varied responses or the LG educator may provide an explanation.

The Class Begins

The LG educator draws a lima bean on the board, names its parts and describes their functions. She then asks questions of the students geared to encourage their thought about the relationship between seeds and human embryos.

"*What do you think the outer part of the lima bean does? It's very thick?*"
Students do not respond.
She then suggests that the thick outer layer of the bean protects the embryo from bacteria or too much water which could drown the seed.
She refers to the uterus in women in which the human embryo grows and is nourished.
The LG educator continues drawing and discussing each part of the lima bean and its "job."
She then asks students to come to the board and identify the parts of the lima bean as they describe the function of each part. Each student is a volunteer. If they forget the part or function, the LG educator asks the class to help, **reinforcing group learning**. Then, she distributes a lima bean to each student.

Dissection: The students begin dissecting lima beans. Now, there is lots of discussion going on in class. The LG educator and classroom teacher each dissect a lima bean, demonstrating the method and talking students through each part of the bean as they go further inside. Several students show each other the parts of the lima bean as they dissect them, identify their names and compare the parts with the illustration on the board. The LG educator and the teacher move about the class ensuring that the students have dissected the specific parts.

Illustration: After completing their dissections, students draw and label the parts of the lima bean in their journals. One student had been totally uninterested in the lesson with his head down for most of the class. Yet, when asked to illustrate the parts of the bean in his journal, he became animated. He produced a large drawing that he wanted to display on the classroom wall. His drawing was detailed and he seemed proud of his work.

Asking and Answering Questions About a Natural Phenomenon

After the dissection class, the students discussed photosynthesis, setting the background for a lesson on the scientific method. The major learning goals relate to the concept that plants react to changes in their environment in specific ways and that an inorganic entity, the sun, is required for plants to make food for growth. This lesson helps students develop scientific habits of thinking, asking, and responding to questions. In each lesson on photosynthesis, scientific method, extended inquiry, and constructing a plant maze, the LG educator builds new concepts on previous ones.

In the following classroom dialogue, supportive and guided communication by the LG educator is highlighted. This communication method generates purposeful, coherent, and productive group discussion, supporting the process of a learning community (McConachie & Petrosky, 2010).The LG educator models communication skills and science literacy. She responds to students by asking questions that encourages them to consider different problem-solving strategies or generalizations. Students learn the core concepts and practice ways of thinking (Ibid.)

Experimentation Incorporating Problem Solving & Inquiry

Many students in this class are reading at a 2nd grade level.

LG educator:	Who can remind us of the question that we were investigating the last time I was here? **(Repetition of key ideas and concepts)**
Marcos:	How do plants grow?
LG educator:	Why do you say that?
Marcos:	We learned that plants move to the sun to get food.
LG educator	Right, Marcos, **is there also a larger question that we are looking at?**
Nelly:	Plants need the sun to make food?
LG educator	Yes, that's *important.* Is there any **other question we were investigating?** Silence We want to know how a living organism might respond, if their environment changed. I'd like you to think about **why we do science experiments.**
Amarantha:	To learn about something.
Dolly:	To understand.
LG educator:	**Did everyone hear that?** The scientific method is a way to ask and answer scientific questions. How?
Shaquan	By looking at something.
LG educator	Yes, good, that is one way to answer a scientific question: by making observations; and also doing experiments. **Today, we all are scientists.** Writes on the board: **HERE'S WHAT SCIENTISTS DO**: **Steps of the scientific method**: **Ask a Question -- Do Research -- Create a hypothesis. What's a hypothesis?**

	No response
LG educator:	It's an idea about how to answer a scientific question. Then, you test the hypothesis by doing what?
Damian:	An experiment.
LG educator	Yes, that's very good. **Can you repeat that please for the class?**
Damian	An experiment.
LG educator	Then, scientists analyze the information obtained from the experiment and come to a conclusion about if the hypothesis is correct. How can you use this method to understand science and our environment?
Simone:	Ask questions.
LG educator	Yes, thank you —**Who would like to add to that?**
Leandro :	Experiment.
LG educator	Yes – you test the idea – the answer you think is correct about the question.

The LG educator and students work together to define various terms: observation, prediction, and hypothesis. The LG educator gives examples of each. Classroom dialogue illustrate how LG educators stimulate students' critical thinking and inquiry skills through hands-on, experiential learning. The use of supportive and challenging communication promotes focused and fruitful discussion, underscoring the importance of a "learning community."

Extending Inquiry: Respecting and Building on Students' Knowledge

LG educator:	Let's think about a question: Where do you get energy to grow, run, live?
Gianni	From food.
LG educator	Where do plants get energy?
Jose-Juan	From food.
LG educator	Where do plants get food?
	No response.
Class teacher:	Look at the posters and think about the question and try to suggest an answer?
Adam	I've got it: they get their food from sunlight.
LG educator	So you are saying, plants get food from sunlight? Is there another process? What else do plants need to make food?
Adam	Water.
LG educator:	What else?
LG educator	Plants make food from air, water, sunlight.
Bianca	Shyly raises her hand and says *that's photosynthesis.*
LG educator:	**Could you repeat that, Bianca?**
Bianca	Photosynthesis.
LG educator	Take your time, Bianca, say more?
Bianca	Photosynthesis is how plants make food from the sun.
LG educator	**Can we all say photosynthesis---again once more**
	She holds up the poster and then distributes a fact sheet to each student about photosynthesis
Classroom Teacher	Distributes the students' science journals
LG educator	Asks the students **to draw or write their hypothesis** about how plants grow and what they do to get sunlight. What's another name for asking questions?
Leandro:	**Inquiry**
LG educator:	**Yes, that is right—can everyone say Inquiry**
Students	INQUIRY
LG educator	Yes, inquiry; yes, that is the heart of science, that is the very core of what scientists do**---inquire, ask questions, come up with answers.** Test answers by what?
Students	Experiments.

LG educator That's right, testing their answers by doing experiments. And you are testing your question by looking at what the plant does to get sunlight? You are doing science.

Students draw in their journals referring to fact sheets and large visual posters. They are animated in talking about what they are doing.

The Plant Maze: Experimentation, Hypothesis Testing, Problem Solving

The students conduct an experiment exploring their developing questions about plants, sun, and photosynthesis; they use the scientific method. They construct a plant maze, grow plants inside of this dark maze with only one opening for sunlight, and observe what happens. They test the hypothesis that the plant will move toward the grow lamp. Students talk excitedly together as the LG educator and classroom teacher distribute the materials to make the mazes: small pots for planting a seed, soil, poster board sheets, scissors, pencils, etc. experiment worksheets, and a sample of the maze. Students work in groups at tables.

The LG educator takes the sample maze around the class explaining its basic structure and how to construct it to function as an experiment. For some students, it is difficult to assemble. Students are encouraged by explaining how and why, and asking them questions. The LG educator and classroom teacher suggest that students question each other about the maze and photosynthesis – "see if you can come up with good questions that you want answers to."

Unifying Scientific Method and Science Inquiry

LG educator: "What will happen to the plant in the dark? Write down what you think will happen to the plant on your worksheet.

Draw your maze on the worksheet and show where the plant will grow.

Will the plant be able to work its way through the maze toward the light?

How long do you think it will take? How long will it take to reach certain points along the way? When you have completed your group maze and your worksheets,

you can plant a seed in your container, and put your mazes with the seed planted under the grow lights in the back of the room. You must open your maze twice a week to water the plants."

Weekly, students observe and record the plant's growth in their maze boxes by measuring height, noting how it appears, and if it looks healthy or not. They must explain their observations. By having students measure the growth and direction of their group's plant, they have opportunities to learn science both concretely and as a process of inquiry. This involves observation and reasoning about what they are studying.

In this snapshot of these 6th grade classes, students are using SCIENTIFIC INQUIRY to determine How Plants Grow?—a scientific question. To practice this they: built a maze, conducted an experiment, gathered and analyzed the evidence in groups, and were asked to develop explanations based on what they observed in that experiment.

The classes described above combine in a conceptually coherent sequence of lessons building on one another. The children are also learning the content of science (e.g., photosynthesis) as scientists would—using scientific processes, a teaching method based on research about how students learn science (National Research Council, 1999).

The Importance of Community Gardens for Urban Students

Middle school teachers and administrators consistently stated that their students either know nothing about nature or they have very limited life experiences. Some students, however, are reminded of the countries from which they emigrated-- where gardens are part of life. Teachers stressed the importance of the community garden as a place for students to interact with nature; a place that mostly is absent from their lives in the South Bronx. In NYC, past generations played in empty lots, grew "victory gardens," chased, collected butterflies, gathered wildflowers – normal, everyday opportunities to experience nature--directly involved with the green world. In 2011, South Bronx school children would never have these experiences except for LG.

In the fall and spring, LG moves to nearby community gardens where students participate in a variety of activities. They identify and touch small animals, conduct soil experiments, prepare soil for planting, choose planting beds, hoe, plant, weed, water and transplant.

It is spring. Students are gardening; LG educators engage them in discussions about the relationships among scientific processes, thinking, and abstract concepts learned during the winter. Climate change, recycling, the water cycle, soil, and the role of environmental stewardship were discussed as the students worked in the gardens. Onaje remarks,

"I didn't realize that killing bees would have a bad effect on the garden or that it means that fewer plants would be pollinated and grow."

Movement-Based Activities: Active Group Learning, Illustrating Important Concepts

On a hot Friday afternoon in mid-June, 33 students are escorted by their science teacher to the garden. The LG educator started the class with a movement-based activity:

> Using cards with names of inorganic elements needed for growth (sun, water, soil, air); producers (plants, flowers,) and consumers (mouse, squirrel, worm), students are divided into groups. They are instructed to tag each group needed by the plant or animal that they represent. This activity re-emphasizes the idea that consumers and producers need energy and how they function in the life cycle. The activity encourages students to remember (repeat) what they learned in the classroom through a group physical activity that is fun, intellectually stimulating, and establishes groundwork to find, identify and observe life forms in the garden.

Teachers and administrators report that the LG curriculum complements the New York City public school science standards for the 6th grade. LG lessons strengthen knowledge of the key ecological concepts of interdependence, energy transfer and life cycle transformation.

"Curiosity is a fundamental driving force of science; it is dynamic and on-going" (Meichtry, 1999). LG spurs students' curiosity as it helps them link science learned in classroom lessons and science rooted in their experience, bolstering observational skills and spurring further questions.

Hunting Decomposers in the Garden

Following the ecology activity, students are divided into groups. Garden tools and gardening gloves are distributed:

Several of the 6th grade girls are weeding with rakes and their hands.
One shouts out: *"Look at the worm!"*
Three girls run away, but soon return, drawn by the others' interest and excitement.
The students are finding more worms and handing them gently to each other.
A young woman from this class collects 5 worms.
Njeri asks, "*Can I take this one home*?"
The LG educator replies: "*It's best to place them in the soil where they live. If you take it home, it will die and won't be able to continue to enrich the soil.* "

In the garden, these girls overcome their fear of touching worms, suggesting that participation in science as equals with boys helps to reject stereotypical gender behavior. Excitement overflows. One of the boys shows the LG educator a tiny brown spot on his hand, after handling a worm.

"It's excrement, she says".

"Wow," they shout in unison and all move forward to examine the specimen closely.

Another boy sifts soil through his fingers and finds and picks up a "Rolly Poly."

"What is another term for a Rolly Poly?" [bolsters the use of scientific terms]

"A pill bug, says the finder."

"What does the pill bug do in the soil?"

"Decomposer" says another.

Children appear proud of their science knowledge. A discussion ensues about the role of decomposers and specifically of the pill bugs that eat decaying leaves, etc. to make rich soil. A student asks, "*do decomposers bring back the dead to life?"* This is a profound question in that the dead, as particular individuals, are not restored, but the general life process is restored and renewed in the garden through the help of the decomposers.

During this session in the garden, a bird caught and ate a worm and the students observed it. The LG educator explains: *Animals eat worms and excrete minerals that go back into the soil and enable plants to grow and the life cycle begin all over again.*

Garden Tools are Learning Methods

Other students are in a group raking and hoeing to make mounded rows of soil preparing a plant bed. Another group is mulching and sprinkling "vitamins" for seeds already planted. Students are measuring and spacing to have their plants fit well and survive. Eventually, the students plant sunflower seeds in rows they hoed. Students write their name on a small stick and place it deeply in the ground next to their seed—a demonstration of self-expression and creativity.

These examples illustrate the benefits of experiential learning in a garden by providing meaningful and tangible ways for students to understand science-related concepts. They emphasize science processes: a question is asked, students observe and interpret what they see, and come to conclusions.

Julio's transformation: Not all the students were initially enthusiastic about touching soil or getting dirty. For most was their first experience in a garden environment. Some were reluctant to learn science in the community garden. By spring, however, these students are seen eagerly preparing the soil, planting flowers and herbs; specifically looking for/observing the behavior of small animals.

Julio, a mainstreamed 6th grade special education student, began using his sleeve to touch soil for a classroom science experiment. In the garden, however, Julio plants marigolds in soil without using gardening gloves. His teacher remarks:

"….. My student… [who] *had a lot of trouble focusing in the traditional classroom…*
sustained attention for quite a long time when he was planting… in the garden."

Julio expresses kinesthetic intelligence as he masters his body and learns how to prepare the ground and plant in the garden. According to his teacher, this hands-on experience of learning how to properly plant and becoming involved in the life cycle of plants was crucial to capturing his interest. Use of different teaching modalities and hands-on activities by LG educators increases access to new information in ways that address the capabilities and needs of particular students.

Last Day in the Community Garden

On the last day in the garden, students excitedly eat the lettuce they planted and gather strawberries from plants beginning to ripen. They water plants, mulch, and weed their plots. During the summer months, the LG educator will be in the garden and students are invited to return to continue learning and having fun. They will return in the fall to harvest pumpkins and other vegetables that they planted.

The evaluator asks a student, if she has learned science through the LG program. Maritza replies: *"When you just read it, it's hard to understand. It's hard to see it in your head.*
Here, you can see it—you can see plants move up towards the sun."

Gilbert, a small, quiet boy, is listening to Maritza's explanation. He approaches the evaluator and says, *"We saw the caterpillars that Learning Gardens gave us become chrysalis and then we saw that they turned into butterflies. Even the one that fell off the top of the box became a butterfly. Miss J [the teacher] put it on the bottom of the box and we thought its wing would be broken like Miss X said [the LG educator]. But it flew away with them all. It landed on a rose near the fence – it was pollinating like we learned."*

As a 6th grade science teacher remarked: LG reinforces science concepts in real time so that students connect them to content and it's not only in their minds.

> "*In real time--- that's the key to the success of the Learning Gardens program in helping students learn—in REAL TIME!"*

How Do Teachers Know if Students Learn ?

The 6th grade classroom teachers concurred that their LG students engaged in the following scientific processes most of the time: observation, listening, exploring, labeling, identifying, or some of the time: investigating, analyzing, making, planting, demonstrating, solving, and experimentation. A teacher stated: *"One ELL student who is often frustrated in the classroom showed an increased enthusiasm for learning science. It has increased her confidence in her ability to do science. She is more willing to participate in class as a result of LG.'"*

Teachers identified specific skills acquired by their students from the LG program:

Problem solving: "*When students were building the plant maze, they had to solve the problem of how to build the barriers and prevent initial exposure to light, securing the maze to the different structures of the pot."*

Abstract concepts:" *How plants are fertilized and the roles of pollen, stamen, and how the pollen is able to fertilize the eggs in the ovary of the plant—by dissecting the plant and seeing the parts."*

Students Talk about Their LG Experience

Many students reported in surveys that the best thing about LG was planting flowers and vegetables, watching them grow, and observing worms and small insects. Others said that watching the metamorphosis of caterpillars into butterflies and releasing them in the garden was the best thing. Some emphasized dissecting a plant and life cycle experiments in groups to make "our own plant maze and look at the way plants get light."

"Planting in the garden helps me learn science" (reported by 75% of 69 students who completed a survey)

*"I better understand how science is part of everyday lif*e" (85%)

"It makes it easier to learn science" (75%)

"I am getting better grades on science tests" (92% agreed a lot and somewhat)

Rakeem, a tall, thin boy told the evaluator: *"It's a beautiful thing, you know, I got affection for the sweet potatoes I planted, it's beautiful*."

Between 60-95% of student's survey responses identified the core features of scientific inquiry they learned, asking questions, observing, exploring, labeling, identifying (i.e., knowledge acquisition), demonstrating or constructing, solving problems (i.e., applying knowledge), experimenting, investigating and analyzing (i.e., analysis).

The students engaged directly and actively with phenomena, (identifying parts of plants by dissecting them and planting and measuring their patterns of growth). This is a more thoughtful and beneficial method of learning than the traditional lecture, read, worksheet approach. Students reported that LG helped them to "understand how science is part of everyday life."

Changes in Students' Attitudes and Perceptions

Most students surveyed reported that by participating in LG, they developed: a positive attitude toward science and greater knowledge in science, horticulture, or the environment, increased enthusiasm for learning science, confidence in their ability to do science, understanding of issues that affected their community, such as recycling, are more willing to participate in regular classes and would like to continue to learn science through gardening.

Conclusions

As this study illustrates, several important educational objectives are being met by the LG program. Educational benefits for students derive from linked classroom/garden experiential, science-based learning and activities in 6 categories of Bloom's educational taxonomy: knowledge, comprehension, application, analysis, synthesis and evaluation (Bloom, 1956). The triangulation of all evaluation data related to the 6th grade middle school LG program leads to the conclusion that students learned. Based on Bloom's taxonomy, they learned in higher learning categories, and they used creative and critical thinking skills.

Bloom's Taxonomy	Activities	LG Activities
Knowledge gained	Observing, participating, investigating, exploring, identifying, labeling.	Dissecting lima beans, flowers, labeling parts and learning their function
Comprehension:	Describing, expressing understandings, creating, planting, drawing what they see and learn.	Finding pill bugs, describing their function as decomposers
Application	Experimenting, investigating through dissection, using prior knowledge to predict and generalize what is needed.	Predicting flower reproductive organs from knowledge of human reproductive organs
Analysis	Experimenting	Measuring plant growth in mazes under grow lamps.
Evaluation and Synthesis	Testing	Deciding about appropriate soil for specific plants, seeds.

These findings support research that found outdoor experiences aid in problem solving skills as well as in learning at Bloom's taxonomy levels (Waliczek, Logan, & Zajicek, , 2003; Stetson, 1991).

1. The LG approach uses good teaching practices to **communicate to students that** science is not a list of unconnected facts and concepts, but rather a process to generate and test knowledge. Scientific inquiry is learned through practice including observation, recording, analyzing, predicting, coming to conclusions that are continually reinforced. LG students have "real" science experiences connecting the process of doing science with what they learned about science: including creating models, dissecting in class, and practicing science in the gardens.

2. LG provides substantial benefits to students: They learned concepts of life science, became generally re-engaged learners, and increased in social development

3. The variety of instructional methods used by LG educators engage students who are

passively involved or unfocused in regular classes to become enthusiastic, active participants in their own learning about science and scientific practices. They listened, questioned, answered, hypothesized, dissected, drew, labeled, wrote, prepared the ground, planted and cared for plants in the garden. They worked individually and in groups. And they enjoyed learning core science concepts and began, perhaps for the first time, to develop and practice their abilities to use scientific thinking and evidence-based explanations.

4. The program offers sustained opportunities to close the gap between nature and those students who live in urban communities with few opportunities for outdoor activities. Children whose only exposure to plants and animals is from vegetable stands in supermarkets, and, perhaps a family pet, are involved in planting, growing, and harvesting vegetables and flowers and handling worms and pill bugs as they come to understand how science and stewardship of nature are critical for the health of the natural world.

5. Students show curiosity-- a mainstay of science-- in their garden work by asking to take home plants in order to watch them grow and thrive. These are signs of self-expression and creative enjoyment. They touch and fondle worms that they have found, asking to take them home because they are experiencing pleasure in caring for nature and are connecting to it emotionally.

6. Students expressed pleasure and excitement about their classroom/gardening experiences, using the natural environment as a sensory experience and interacting with it. Their enthusiasm shows that they considered learning science to be fun. This type of educational process can offer proper motivation for students to learn more and may foster a broader commitment to learning science.

7. LG exposed students, like Javier, to different ways of learning and social experiences that: can improve the environment of the community in which they live, cultivate imagination, increase awareness and caring for the environment, and reinforce understandings about the relationship between science and everyday life.

8. LG' success refutes educational policies that fetishize standardized tests and scapegoat public school teachers' unions for the low academic scores of poor, educationally disadvantaged students. LG's success challenges the educational policy of closing and privatizing public schools, replacing them with charter schools. LG gives hope to disenfranchised children who attend the nation's public schools, and want to and can learn despite their families' poverty and growing up in inner city, concrete neighborhoods.

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