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**Garden-based education in school settings: The effects on children's vegetable
consumption, vegetable preferences and ecoliteracy**

A Dissertation

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Abstract

The primary objective of this study was to evaluate the potential of school garden programs to address important issues related to childhood nutrition and environmental problems. A secondary objective was to develop a comprehensive theoretical framework specifically for garden-based education in school settings.

Students at two sites in the San Francisco Unified School District were taught science and health lessons utilizing the school garden. Activities included planting, tending, harvesting, consuming garden-grown produce, and participating in community events, for an average of thirty minutes a week for 4 months. A control school did not participate in gardening activities. As part of a pre-post panel study, 236 sixth-grade students completed the Garden Vegetable Frequency Questionnaire, and 161 completed a taste test. Twenty-eight students participated in one of eight group interviews.

Additionally, 14 personal interviews were conducted with key informants, teachers, school principals, a district garden-curriculum coordinator, citywide advocates, and a statewide leader in the garden-based learning movement.

Results indicate that gardening influenced factors that may predict or affect children's vegetable consumption, including improved recognition of, attitudes toward, preferences for, and willingness to taste vegetables. Gardening also influenced factors associated with vegetable consumption, including increased variety eaten as measured by self-reported monthly consumption, and consumption of different vegetable varieties at school. Results further demonstrate that the hands-on experiences in the school garden led to increased ecological knowledge, and performance of environmentally responsible behaviors, but no improvements in ecological attitudes. A synthesis of research findings together with a review of the literature led to the development of the Model for Garden Based Education in School Settings, a framework for developing and evaluating theoretically driven, behaviorally based school garden programs.

Future research is needed to understand what aspects of garden based learning experiences are most effective at facilitating positive knowledge, attitude and behavior changes. Studies should explain the effects of participating in school garden programs on different populations including young children, high school students, and adults.

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CHAPTER 1: INTRODUCTION

I. Statement of purpose and significance

Historically, the popularity of school garden programs has ebbed and flowed based on perceived societal needs, the potential for gardens to meet those needs, and changing teaching philosophies [1, 2]. For example, during WWII school gardening was primarily seen as a contributor to national security because gardens contributed to the food supply [2]. During the 1970's, when environmental degradation problems were paramount, school gardens were seen as an obvious way to connect kids with nature and engender an environmentally conscious populace.

Today, the number of school gardens is again on the rise, in part due to the interests of diverse groups who utilize outdoor classrooms to address multiple social issues related to health, economic and personal development, urban violence, environmental degradation, food security, and education. Because of the increased time and resource investment in school gardens, it is important to know if, and how, garden-based education may address these multiple and often interrelated issues.

The primary objective of this project was to evaluate the potential of school garden education interventions to address important issues related to childhood nutrition and environmental problems. A second objective was to develop a theoretical framework for school garden programs that would further improve program development and evaluation.

This chapter outlines the childhood nutrition and environmental degradation problems that inspired the research. It then describes the primary research question

and hypothesis. The final sections describe the theoretical framework that informed these hypotheses and the activities to refine and further develop a conceptual framework for garden based education.

A. Childhood Nutrition Problems

The percentage of overweight children in the U.S. is at an all time high, yet diets of many of them are nutritionally sub-optimal [3]. While health benefits of a diet rich in a variety of fruits and vegetables are widely known, children in the U.S. consume less than half the recommended number of fruit and vegetable servings [4-6]. Of those they do consume, fruit juice accounts for approximately 40% of fruit servings, and fried potato products account for approximately 20% of vegetable servings [7]. Diets that rely on fruit juices and fried potatoes to meet the recommendations are likely low in fiber, high in fat, and lack the variety of phytochemicals, vitamins and minerals needed for optimum health [8].

B. Environmental Problems

The United States has come a long way in the past 30 years towards addressing environmental problems such as polluted air, water, and soil. Yet without alteration of current trends in population and consumption, humanity may significantly alter or destroy almost every remaining natural ecosystem on Earth within a few decades [9]. This is significant because we are destroying ecosystem services for which we have no substitute, such as the climate, clean water and clean air [9]. For these reasons, it is important to promote an ecoliterate populace, one

that is knowledgeable about environmental issues, cares about the environment and will act in environmentally responsible ways [10, 11].

C. Childhood as an ideal time to promote lifelong healthy nutrition behaviors and promote ecoliteracy

Childhood is an ideal time to address nutritional and environmental issues. Developmental, social and physical changes affect eating behaviors and long-term health [12]. Children begin to exert some control over the foods they select and consume, especially in the upper-elementary school grades [13], eating behaviors practiced during childhood tend to carry over into adulthood [14], and childhood is a critical time in life for the development of positive attitudes and behaviors towards the environment [15, 16]. Since behavioral patterns are established in childhood, the study of educational interventions that seek to influence life-long practices supportive of personal health and the health of the environment is important.

II. Hypotheses

This project sought to evaluate five hypotheses that relate to vegetable consumption and ecoliteracy:

Hypothesis 1: Youth who participate in a garden-based learning experience in which they taste vegetables they have grown *will increase their ability to correctly identify vegetables* compared to a group that has had similar content instruction but no gardening experience.

Hypothesis 2: Youth who participate in a garden-based learning experience in which they taste vegetables they have grown will *increase their preferences for vegetables*, when compared to a group that has had similar content instruction but no gardening experience.

Hypothesis 3: Youth who participate in a garden-based learning experience in which they taste vegetables they have grown will be *more willing to taste vegetables* they have not grown, when compared to a group that has had similar content instruction but no gardening experience.

Hypothesis 4: Youth who participate in a science class that includes a garden experience will *increase their consumption of vegetables* more than a group that has had similar content instruction but no gardening experience.

Hypothesis 5: Youth who participate in a science class that includes a gardening experience *will increase their ecoliteracy* more than a group that has had similar content instruction but no gardening experience.

III. Theoretical framework used to test hypothesis

The theoretical framework that initially informed this research is found in Social Cognitive Theory (SCT) constructs, which posit that behavioral, personal and environmental influences interact continuously in a reciprocal manner, and additional model building research to further explain fruit and vegetable consumption in children [17, 18]. Applying these constructs to a school garden context, garden-based education may be an effective way to improve children's knowledge, attitudes and behaviors associated with vegetable consumption.

Specifically, these programs may alter a school's environment in ways that increase availability of vegetables, and opportunities to both model food preparation and consume vegetables. They also provide opportunities for delivering engaging, hands-on nutrition education. These changes in the schools' environment may affect students' personal and behavioral factors both directly and indirectly. It is hypothesized that personal factors affected include attitudes and preferences towards vegetables and knowledge of them. Behavioral factors include both students' willingness to taste vegetables, and their overall consumption of them.

While the SCT is used to design successful educational interventions that positively influence children's health behaviors, it is also a good theoretical framework for influencing ecoliteracy because the constructs are congruent with current thought on factors associated with effective environmental education programs. A meta-analysis of environmental behavioral research identified the following variables as associated with environmentally responsible behaviors: attitudes, locus of control, personal responsibility, action skills, knowledge of action skills, knowledge of issues, and situational factors [19]. These factors readily fit into the SCT's behavioral, personal and environmental constructs.

IV. Additional development of a conceptual framework to explain garden-based education

The SCT provided a useful starting place for explaining the effects of gardening on children's knowledge, attitudes and behaviors related to vegetable consumption and ecoliteracy. During the course of this study, however, it became

apparent that in order to more fully explain and harness the potential of school garden programs, a more comprehensive framework for garden-based education was needed. The development of a conceptual framework for garden-based education is summarized below and discussed in greater detail in chapter 3 and chapter 6:

1. A literature review identified potential areas of influence of school garden programs, and categorized these for school garden programs.
2. A brief review of existing theories identified complementary theoretical frameworks that help explain the observed influence of garden-based learning experiences.
3. A framework was proposed to describe how school gardens affect the outcomes of interest, and to suggest the mechanisms by which program elements achieve a variety of outcomes on several levels of society.
4. Qualitative data was gathered to explore the usefulness of the model in explaining garden-based education in a school setting.
5. Focus groups were convened to determine the validity of the proposed model and to help inform the final presentation of it.

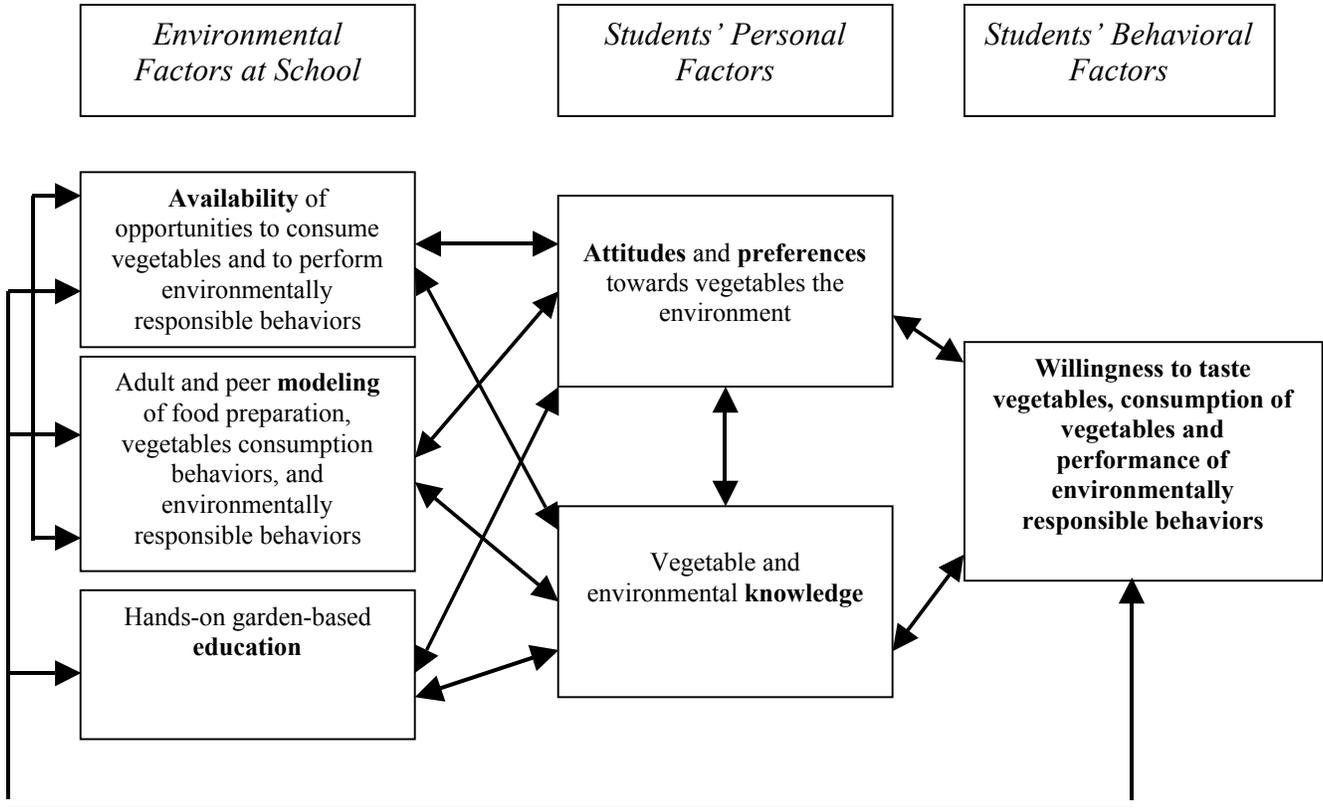
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Figure 1: How Social Cognitive Theory (SCT) constructs may apply to the reciprocal relationships among the variables in this study.



CHAPTER 2: REVIEW OF THE LITERATURE

I. Introduction and scope of review

This literature review serves two purposes. First, it takes a broad look at the school garden literature for the purpose of developing the Model of Garden Based Education, described in Chapter 6. Second, it takes a detailed look at the literature directly related to the hypotheses of the studies described in Chapters 4 and 5.

The literature review is organized as follows. Section II reviews evidence of the effect of school garden programs on the school environment. Section III reviews the observed outcomes of garden-based education on individuals. Then in Section IV, a detailed review of experimental studies on the effects of school gardens on children's knowledge, attitudes, and behaviors associated with vegetable consumption and ecoliteracy is provided because these studies most directly relate to the hypotheses of the studies described in Chapters 4 and 5. Section V reviews the observed outcomes on the community and bioregional levels. Section VI summarizes what is known about the causal relationships between program elements and observed outcomes, including empirical and theoretical support.

The search criteria for the literature review were broad, because no single body of literature describes what is known about school gardening. Articles on garden-based education can be found in literature on health and nutrition behavior, environmental education, horticultural therapy, youth development, place-based education, and plant-based studies. A limitation of this literature is that most studies of the effects of garden-based education are qualitative program evaluations, case studies, or anecdotal accounts. These factors taken together have contributed

to the widespread, and not unreasonable, claim that there is a “lack of research” regarding the effects of garden-based education [1]. What are missing from the literature related to school gardening are multiple studies on specific populations, studies that are rigorously quantitative or mixed-method, longitudinal studies, and studies with sample sizes that are adequate to answer the question asked.

Because the experimental literature on garden-based learning is limited, this literature review includes studies that represent a range of methods, including case studies, anecdotal reports, and experimental studies. Literature pertaining to school gardening, naturalized school grounds, and farm-to-school programs, an emerging component of food and garden-based education in schools, was gathered from multiple fields of study. A study that evaluated the effect of using the environment as an integrating context for education is also included, because gardening is considered one form of using the environment as an integrating context [2].

II. Program elements of garden-based education

The effect of the program on a school’s environment is frequently characterized as a program outcome. In this chapter, however, changes in the school environment are classified as ‘program elements,’ because without these environmental changes, individual and community outcomes would not occur.

The literature indicates that garden-based education programs may affect a school’s curricular, physical, and social learning environments. School garden programs may affect the curricular learning environment by increasing or enhancing opportunities for hands-on, place and project-based education. The

progressive activities of planning, planting, tending, harvesting and consuming produce alter the curricular learning environment by collectively engaging youth and adults in on-going processes [3-6]. In these ways, school gardens provide a real world context for learning that is distinguishable from typical hands-on learning activities in the classroom, which tend to simulate real-world experiences. Gardens may also affect the learning environment by providing a context for integrating curriculum from all classes and grade levels. Currently educators use garden-based pedagogy in all areas of basic education and subject areas including science, math, social studies, language arts, environmental studies, nutrition, physical education, and agricultural studies [2, 7]. These integrated learning experiences naturally reinforce content and abstract ideas that students read about. Garden-based learning activities may also engage students' multiple intelligences [8-10].

School garden programs may also affect the physical learning environment. Naturalized school grounds generally improve physical living conditions, particularly in urban areas, as they mitigate the "cold" city climate, making the school surroundings setting more attractive and hospitable. Green schoolyards may also improve the environmental quality of urban areas by increasing shade, decreasing storm run-off, and improving air quality [11, 12]. Further, the produce, flowers, herbs and other plants grown in school gardens encourage multi-sensory experiences by providing an array of tastes, fragrances, and textures [13-16]. Gardens and naturalized school grounds may also increase the diversity of vegetation, providing more diverse habitats for wildlife [11, 17]. Varied types of vegetation may also increase the number of different types of developmentally

appropriate learning and play opportunities [11]. The physical attributes of school gardens naturally reinforce learning by providing multiple exposures to and visual reminders of lessons [18]. Gardens provide youth and adults with places of refuge, safer after school environments, and a physical location where they can connect with nature and nurture living things [19, 20].

Gardens have been observed to affect a school's social learning environment in ways that may fundamentally alter the school culture and identity [21, 22].

Starting and maintaining a school garden necessitates collaboration between youth and adults and among peers, both within the school and in the broader community. As a result, gardens increase the involvement of caring adults in education, health, youth, environmental and/or community issues and activities, much the way athletics do, but in a more nurturing, less competitive environment [7]. Engaging parents in school garden programs fosters family relationships [23]. School gardens and school-based community garden programs also provide opportunities for multi-cultural exchange and intergenerational mentoring [24]. This increases children's exposure to diverse role models, often from different walks of life [20], and allows for peer and adult modeling of desired behaviors [25]. Participation in schoolyard naturalization projects has also been described as a valuable opportunity for youth to participate in democracy [26] and community [27].

III. Effects of garden-based education on individuals

Garden-based learning experiences may affect children's content- and skills-based knowledge, academic and cognitive skills, social and moral development, and

their attitudes and preferences toward fruits and vegetables and the environment. Hands-on experiences in gardens, or using the environment as a context for learning, may increase students' knowledge of specific content areas, including math and science [28-31], agriculture [30], botany and horticulture [32, 33], ecological principals [30], nutrition [34, 35], and food systems issues [30, 34]. Garden-based learning experiences have also been shown to increase children's knowledge and development of life skills, including those needed to perform health and environmentally responsible behaviors, including skills related to healthy eating, composting, and recycling [18, 25, 30]. Garden programs have also been used to provide job training for adolescents [19].

In addition to facilitating knowledge acquisition, studies have shown that garden-based learning may enhance academic skills and cognitive development, including processing and inquiry skills, such as the ability to observe, communicate, compare, relate, order and infer [36]. Learning in the outdoor classroom has also been associated with increased student motivation [20], willingness to stay on task, and adaptability to various learning styles [10].

Garden-based learning experiences affect participants' social and moral development in ways that are supportive of positive youth development. Among factors associated with that development are civility [10], communication [10, 37, 38,39], cooperation [20], decision making [38], delayed gratification [20], engagement [10], enthusiasm [20, 37], independence [20], nurturing [20], ownership [10, 23], patience [20, 39], pride [20, 37, 40], responsibility [23, 41], self

esteem [19, 23, 37], self -understanding [38], self-confidence [37], self-discipline [10], self-efficacy [25], sense of place [30], and teamwork [37, 38].

Coupling nutrition education with gardening experiences, where students taste food they have grown has been shown to increase their preferences towards fruits and vegetables [35, 42, 43], and to improve their attitudes towards healthy foods, including minimally cooked whole grains and vegetables [25, 44]. These experiences have also been shown to influence the meanings students attach to foods [13, 21, 45].

Garden-based education may also affect students' attitudes towards school, science and learning [31, 41, 46]. Students' attitudes towards the community, including their social concern, may be affected through school garden activities that involve community members in creating projects or through service-learning programs [47]. Hands-on experiences in nature affect students' environmental attitudes, including their concern, awareness, and appreciation of the environment, as well as their environmental ethics [30, 31, 48-50].

Experiences in a school garden program may affect participants' academic achievement and increase their performance of health- related and environmentally responsible behaviors. Research on garden-based learning and schools that use the environment as the integrating context for education have found that these pedagogies may increase students' achievement test scores and GPA, and lead to a decrease in discipline problems and absenteeism [6, 10, 28, 30, 51, 52]. Additionally, garden-enhanced education has been shown to positively affect students' health behaviors.

Studies have shown that after participating in a garden-based learning program, students increased their consumption of fruits and vegetables, willingness to try vegetables, healthy snacking behaviors, and physical activity patterns [18, 30, 43, 53, 54]. School gardening experiences were also found to increase students' performance of environmentally responsible behaviors including, composting, recycling and starting gardens at home [15, 20].

IV. Evaluation-based interventions that combine nutrition education or environmental education and garden-based learning

Only a handful of empirical reports detail evaluation-based interventions that combine nutrition and/or environmental education and gardening to increase upper-elementary and middle school aged students' knowledge, attitudes, and behaviors related to vegetable consumption and ecoliteracy. The *Nutrition in the Garden Program*, a 16-week nutrition and gardening program for 3rd and 4th grade students, used a questionnaire to measure changes in students' attitudes and preferences for fruits and vegetables. Vegetable consumption was measured through a 24-hour dietary recall workbook. Compared to a control, students in the garden group's attitudes toward vegetables and their preferences for fruit and vegetable snacks improved significantly, but there was no significant increase in their produce consumption [42].

A study of approximately 200 4th grade students evaluated the effectiveness of a 10-lesson, garden-enhanced nutrition education program called *Nutrition to Grow On* [55]. A nutrition knowledge questionnaire and a vegetable preferences

survey were developed to evaluate the curriculum. Researchers found that the garden-enhanced curriculum increased 4th grade students' nutrition knowledge and ability to correctly name some vegetables that they grew. Further, students in the garden group increased their preferences for several vegetables, including carrots, broccoli, snow peas and zucchini. Since zucchini was not grown in the school garden, these findings suggest that the intervention may have improved students' preferences for vegetables to which they were not directly exposed. Students in this program retained their preferences for broccoli, snow peas and zucchini 6 months after the intervention [35]. Participants also significantly increased their consumption of vegetables at home, and their willingness to both eat them as a snack and to ask a family member to buy them. Follow-up measurement indicated that students' willingness to eat vegetables as snacks also remained significantly higher six months following the intervention [56].

To determine the effects of garden experiences on 3rd through 5th graders' nutrition knowledge and preferences for fruit and vegetables, Poston et al. (2005) compared two groups of students who participated in after school nutrition education programs. One group was taught lessons from Professor Popcorn, a standard nutrition education program from the United States Department of Agriculture, and the other participated in eight garden-enhanced nutrition lessons from the Junior Master Gardener [57]. Neither group showed significant improvements in nutrition knowledge scores, or preferences for fruits and vegetables. However, pretest knowledge scores and preferences for fruits were already high for both groups. The study had a limited sample, however (n=29) [57].

McAleese and Rankin (2007) evaluated a 12-week nutrition education program for sixth-grade students that included garden-based activities. Ninety-nine sixth-grade students at three elementary schools made up two treatment groups and one control group. In this study, students in one school received nutrition education, students in a second school received nutrition education plus gardening experiences, and students in the third school served as a control. Students in all three groups completed pre and posttest fruit and vegetable preference questionnaires and 24-hour food recall workbooks. Based on results from the questionnaire, students in the garden program did not significantly increase their preferences for fruit or vegetables. Analyses of the food workbooks, however, found that students in the garden group increased their servings of fruits and vegetables more than those in the group that participated only in nutrition education and more than the control group. Significant increases were also found in vitamin A, vitamin C, and fiber intake for those students who participated in the garden activities as compared to the group that participated only in nutrition education and the control group [58].

Murphy et al. (2003) reported the findings of an evaluation of the Edible School Yard in Berkeley, California. The Edible School Yard is a garden-based learning program that is integrated into the curriculum and cafeteria, and emphasizes cooking. As measured by interviewer-assisted 24-hour dietary recall, sixth grade students who significantly increased their ecoliteracy scores also significantly increased the number of fruits and vegetable servings they reported eating, when compared to a control group of students did not have gardening experiences. Additionally, analysis of students' grade-point-averages and

experiential assessment activities found that students who participated in the Edible Schoolyard showed significantly greater gains in test scores for science generally, and a better understanding of garden cycles and sustainable agriculture, when compared to a control school [30].

Smith and Motsenbocke (2005) evaluated the use of four chapters of the Junior Master Gardener Handbook (Level One) on 119 fifth grade students at three schools. Each of the three schools had both experimental and control classes. Experiential classes participated in Junior Master Gardening Activities once per week for 2 hours over a 14-week time period. Control classes did not participate in any aspect of them. Results from paired t-test analyses indicate that students in the experimental groups significantly improved science achievement as assessed by pretest and posttest scores. Results from ANOVA, however, showed no significant difference in the experimental classes' pretest and posttest scores. Further, no significant difference was found between the experimental and control classes due to treatment [51]. The facts that those who taught these garden activities lacked prior teaching experience, and that the garden curricula were not integrated into the classroom may account for these findings.

Using a mixed methods approach, Dirks and Orvis (2005) also evaluated aspects of the Junior Master Gardener Program on 277 third grade students from 11 schools in Indiana. Based on matched pairs t-tests, a significant increase in students' knowledge and attitudes towards both science and agriculture was found between pre and post program scores. Qualitative results indicate that the program

positively influenced many students' attitudes towards plants, environmental actions and the community [31].

In a study of 647 3rd through 5th grade students, Klemmer et al (2005) found significant improvement in students' science achievement after participation in a program that combined science classes with gardening activities when compared to students in a control group [29].

V. Effects of garden programs on the broader community

School garden and farm-to-school programs may affect community and bioregional level variables. They may promote public health, ecosystem health, local economic development, and social capital [5, 59-61]. Numerous examples demonstrate that school garden programs that involve students, their families, and neighbors in projects contribute to the well being of their communities [23]. Community integration activities include creating schoolyard wildlife habitats, school-based community gardens, service learning projects, and farm-to-school programs [17, 45, 62, 63].

These types of projects may improve public health by promoting fruit and vegetable consumption and physical activity [45, 64, 65]. They may affect ecosystem health by enhancing the livability of urban ecosystems for humans and other flora and fauna [11]. Further, pairing school gardens with farm-to-school programs encourages environmentally responsible, socially just, local economic development. These programs further seek to improve the health of both individuals and the ecosystem, increase community food security, and promote social capital

[66-68]. While studies have not yet quantified the possible effects of gardens at the bioregional level, such an effect is hypothesized in the literature [69]. It may be that gardens affect bioregional level variables by virtue of their association to community level variables.

VI. Relationships between program elements and observed outcomes

Research on school gardens has not, to date, provided a strong empirical basis for direct causal relationships between program elements and student or community level outcomes. It is most likely that causal linkages are not well documented both because of the difficulties of conducting research in this field and because it has not been an area of interest until relatively recently [70, 71]. However, other fields of study have described causal relationships between similar program elements and observed individual and community outcomes. For example, research on place-based education links this pedagogy with the creation of learning environments that support positive behavior change, improve students' motivation, and increase community participation in students' learning [72].

In addition to empirical evidence from other fields, there is also a theoretical basis to support the expectation that the program elements described above may result in the observed individual and community outcomes. Several theories and conceptual frameworks that are applicable to a range of disciplines, including psychology, sociology, and youth development, account for some of the observed outcomes of school garden programs [73, 74], although no single theory

adequately explains or predicts the full range of effects of garden-based education programs on multiple variables described above.

We have identified just one recent publication that has sought to develop a conceptual framework to specifically address school garden programs [74]. Ozer's (2006) conceptual framework theorizes that the garden hands-on curriculum, and parental and community involvement in the school has short and long-term effects on the student, school, family, and community levels.

Ozer's model development process started from a theoretical standpoint informed by a social ecological-transaction perspective and includes the ecological principal of interdependence. In other words, the model recognizes a child's development as the result of their on-going interactions with school, family, and community environments, such that changes in one area may influence the others. Using the keywords, "school" and "garden," and "community" and "garden" to search electronic databases and online search engines to identify studies on the effects of garden experiences on students' physical health, mental health, or academic performance published prior to July 2005, Ozer identified five separate studies. These findings informed the model variables. Case study descriptions of school garden curricula and process studies of attitudes towards the curricula that did not assess health, mental health, or academic outcomes were excluded from her review, and hence excluded from her model [74].

The model is limited because it does not include all program elements or outcomes at the individual, community, and bioregion levels found in the literature. Therefore, while there is some support, both empirically and theoretically, for

causal links between program elements and outcomes, further research and theoretical development is needed.

VII. Conclusion

While empirical evidence remains limited, the literature suggests that there is a potential value for garden based education in schools. Because of the increased time and resource investment in school gardens, it is important to know if, and how, garden-based education works. Therefore, this dissertation research seeks to address several gaps in the literature that describes the effects of participating in school gardens on children's knowledge attitudes, and behaviors related to vegetable consumption and ecoliteracy. A theoretical framework will enable more rigorous research and evaluation of garden programs at a time when there is increased funding for these programs.

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CHAPTER 3: METHODS

This study employed a mixed-methods approach that included a quasi-experimental pre-post panel design with a non-randomly assigned control group. The Tufts University Institutional Review Board and the San Francisco Unified School District's Office on Human Subjects approved this study. This chapter describes the survey instruments and procedures for collection and analysis of the quantitative and qualitative data used to test the study hypotheses and develop a model for garden-based education.

I. Quantitative data

A. Quantitative survey instruments

To explore the effects of participating in a hands-on gardening experience on adolescents' knowledge, attitudes and behaviors associated with vegetable consumption and ecoliteracy, two paper and pencil survey questionnaires and one taste test were developed.

1. Garden Vegetable Frequency Questionnaire

A survey instrument, the Garden Vegetable Frequency Questionnaire (GVFQ), was created to measure consumption of and preferences for a variety of vegetables that are typically grown in school gardens and likely to be consumed by an ethnically and culturally diverse population (Appendix 1). The GVFQ, a paper and pencil survey, assesses (1) the variety of vegetables consumed the day prior to

taking the survey, (2) the frequency with which each variety is typically consumed, and (3) preferences for each one. The GVFQ takes approximately 15 minutes to complete and can be simultaneously administered to all study subjects, thus decreasing study resource needs and minimizing disruption to class time.

The self-administered instrument shows pictures and names of twenty-two vegetables and provides two additional blank response boxes to accommodate other vegetables that the student may have consumed. The vegetables listed in the GVFQ are: beets, bell peppers, bok choy, broccoli, Brussels sprouts, cabbage, cauliflower, carrots, chard, collards, corn, eggplant, fava beans, kale, lettuce, peas, potatoes, radishes, spinach, string beans, squash, and tomatoes. For each vegetable, subjects are asked to indicate if they consumed the food the day prior to taking the survey (“yes”, “no”, “I don’t know”), if they like the food (“yes”, “no”, “I don’t know”), and to indicate how often they eat it (“once a month or less”, “more than once a month”, “never”). The questionnaire was developed through an iterative process involving vegetable lists from ethnic cookbooks, gardening manuals, and a focus group with high school aged students who have younger siblings in the target age range. The high school students were asked what foods and specific vegetables their caregivers prepared and younger siblings regularly consumed.

The vegetable consumption component of the questionnaire was pre-tested with fifty-three youth in the target age range, who completed both the GVFQ and a 24-hour recall personal interview. Based on random assignment, half of the subjects took the GVFQ first, while the other half completed the interview first. Those who took the GVFQ first reported consuming an average of 1.8 (\pm 1.9)

vegetables, while those who completed the 24-hour recall first reported consuming an average of 1.8 (\pm 1.6) vegetables Table 1. While results from the two methods appear to agree, they are not identical. A frequency distribution of the difference scores indicates exact agreement between the two methods for only 64% of the pilot test population, while 81% of the respondents had a difference score of plus or minus one vegetable. Further, the GVFQ may be a more sensitive measure since students reported consuming higher total number of vegetables based on that method regardless of whether they took the survey before or after the recall. Based on these pre-test findings, the GVFQ is comparable to the recall from a practical (clinical) standpoint and, for the purposes of this study, considered a reasonable measurement tool to assess vegetable consumption.

A limitation of the GVFQ is that it does not assess the amounts of vegetables consumed. Therefore it is not possible to assess either the number of servings or the nutrient intake from the vegetables.

2. Food Preference Taste Test

The methodology for collection of food preference data through a taste test used in this study was adapted from a previously validated method [1, 2]. Food preference data were collected through a self-administered taste-test and accompanying form used to record subjects' responses. As part of the taste test, students were asked to name, taste and rate their preferences for five vegetables.

Students were not forced to taste any vegetable. Those who did were asked to indicate their preferences on a five-point scale. A five indicates "I really liked it a lot"; 4 indicates "I liked it a little"; 3 indicates "It was OK"; 2 indicates "I did not

like it”; and one indicates “I really did not like it”. Face icons were inserted next to each preference statement as a visual reinforcement of the opinion category and to aid in the ease of completing the survey. For each of the five vegetables, students were also asked whether they had ever tasted this food before, whether they eat it at home or at school, and whether they have grown it either in a school or home garden. For each question, students were given the option to answer “yes”, “no”, or “I don’t know” (Appendix 2)

The five vegetables used in the taste test included string beans, Swiss chard, carrots, snow peas and broccoli. They were chosen based on the following criteria:

1. The vegetable grows well in the study site area.
2. The vegetable is readily available at grocery stores.
3. The vegetables can be served raw.
4. At least one vegetable chosen is very familiar (carrot) and one is very unfamiliar (Swiss chard).

Other considerations for the implementation of the taste-test included sanitation and minimizing peer influence. All vegetables were purchased pre-washed and cut from the grocery store and served in individual cups. In order to minimize peer influence, binders were given to each student to create a private space at their desk, or table, in which to participate in the taste test. In addition, students were instructed not to comment out loud on the food.

3. Ecoliteracy Survey Questionnaire

The ecoliteracy survey was adapted from an existing survey to conform more closely to the California Department of Education's Content Standards for Sixth-Grade Science Curriculum [3, 4]. The modified questionnaire was developed in a collaborative effort with students, teachers and ecoliteracy researchers. To inform the development of suitable survey questions and format, a focus group was conducted with 5 children in the target age range (11-13 years old) and 3 children, aged 14-16, who were their siblings.

The Ecoliteracy Survey contains questions regarding demographics, ecological actions, ecological attitudes, and ecological knowledge (Appendix 3). The survey asks demographic questions concerning parents' ethnicity and socioeconomic status.

The survey also asks ecological action questions regarding students' recycling and composting activities at school and home and their energy and water conservation behavior. For each ecological action students are asked to indicate if they do it "never", "sometimes", or "always." These ecological actions were selected because they are identified in the literature as environmentally responsible behaviors [5-7], because the focus group indicated that they are things that "environmentalists do", and because it is possible for sixth-grade students in the study area to perform them.

In addition, the Ecoliteracy Survey includes questions about students' ecological attitudes toward extinction, organic produce, water pollution, land conservation and littering, and energy and water conservation. These eco-attitudes

were identified by the focus group as “things environmental people care about,” and are conceptualizations of environmentally responsible behaviors found in the literature [8-11]. In total, seven attitudinal statements were included in a four point Likert-type scale.

Finally, six completion statements and five multiple-choice questions ask students about plant parts and their function, and about the food web. These ecological knowledge questions were taken directly from a widely used textbook and from questions provided by the California Department of Education’s Standardized Testing and Reporting (STAR) program [12, 13]. Interviews with a middle-school science teacher and an ecoliteracy researcher verified that the selected questions accurately encompass content that is taught during the school year and considered components of ecoliteracy.

B. Quantitative data collection and administration

The sampling universe was incoming sixth-grade students in science classes in the San Francisco Unified School District. Selection bias was largely accounted for in this sampling frame because school attendance is mandatory. Students are assigned to a school, some of which have gardens and some of which do not. Students in schools with gardens are required to participate in garden activities.

Sixth-grade students from three urban schools participated in the study. Two were garden sites and one was a control site. To be considered a garden-school site, a school garden program had to include activities where students plant, tend, harvest and consume vegetables they grew as part of the required science

curriculum for an average of at least thirty minutes a week over a four-month time period. Both garden-school sites grew the same vegetable varieties. The control site had no garden program, but provided the same health and science curriculum used in the garden-school sites. Table 2 provides a summary of the ethnic representation at both school garden and control school sites.

Strict criteria were established to minimize variation in exposure to garden-based learning experiences. The garden school sites grew the same vegetable varieties, used similar curriculum, and spent about the same amount of time in the garden. Implementation differed slightly between the two groups due to teachers' interest and available resources. These methodological challenges are common in research on youth gardening and field intervention trials [14]. Table 3 summarizes the sample of teachers and students in each site and in each class. Table 4 provides a comparison of garden-based learning activities at each garden school site.

To determine the feasibility of implementing survey instruments and a taste-test in a 45-minute time period, a group of 9 youth in the target age population were asked to complete pilot tests. They actually completed the surveys and taste test within 35 minutes, well within the constraints of one class period. The surveys and taste-test were administered to students at all sites as part of their regular sixth-grade science curriculum. Pre-surveys were administered in November 2003 and post-survey data were collected in May 2004. Directions for each survey were read aloud to the class, but the surveys and taste-test were self-administered.

Three-hundred-and-twenty students participated in the study. Of these, 84 were excluded from analysis of the GVFQ and the Ecoliteracy Survey, and 159

were excluded from analysis of the taste test. Students were excluded for lack of parental consent, absence during pre-survey questionnaire administration, incomplete survey questionnaire, or because they moved away from the study site. Table 5 summarizes the number of individuals who were excluded from the study and the reasons for exclusion.

In total, data from 236 students (n=137 from the garden group, and n=99 from the control group) were eligible for analysis of the GVFQ and the Ecoliteracy Survey. Data from 161 students (n=99 from the garden group, and n=62 students from the control group) were eligible for analysis of data from the Taste Test Survey Questionnaire.

C. Quantitative data analysis

The unit of analysis is the individual student. Samples size calculations were based on an estimated mean difference of 0.9 in preferences for vegetables, and a standard deviation of the differences of 1.55 [15]. The test of equality of the means was carried out at the 0.05 level of significance. A sample size of 50 provided a probability of 0.80 of rejecting the null hypothesis of equal means if the alternative is true [16]. However, due to the likelihood of a clustering effect, the estimated sample size of 50 was doubled to 100 per group.

To analyze the impact of the garden experience, independent samples T-tests were used to detect significant differences in the change (post-test minus pre-test) in vegetable knowledge, preferences, willingness to taste, and consumption between the garden and control groups. An independent samples T-test on the

difference scores was also used to measure significant differences in ecological knowledge, ecological attitudes and environmentally responsible behaviors of students who had participated in a gardening program and those who had not. All survey and taste-test data analysis was performed using SPSS v.12 and v.14 [17].

II. Qualitative data

A. Qualitative data collection

Qualitative data were collected in order to better understand school gardening, and to determine the relevance of the proposed Model for Garden-based Education to explain these programs. Data collection activities included interviews with adults and youth. For example, the principal investigator co-taught in the school garden, volunteered with other garden related activities on the city and state levels, and made field notes of these experiences. Objective interpretation was sought through group reflection of field notes. Field notes were reviewed weekly and discussed with other school garden educators and researchers.

The initial interview sample included only teachers who directly implemented the garden-based programs. These interviews, however, quickly identified the complexities of forces that influence teachers' implementation of garden programming, and ultimately the impact of the experience on children. More specifically, it became clear that in addition to specific people and resources that affect individual garden-based learning programs, broader social forces also affect school sites. Therefore, additional interviews were sought with informants who are

considered leaders of the school garden movement within the school district, the city and the State of California [18].

A total of 14 interviews were conducted with teachers, school principals, the district garden-curriculum coordinator, citywide advocates, and a statewide leader in the garden-based learning movement. Based on repetition of comments, theoretical saturation was achieved [18]. Prompting questions used in the adult in-depth personal interviews included:

1. What do you think about school gardening?
2. Does gardening with the kids work? What works? What doesn't work?
3. Describe a time in the garden when you thought, "this is going really well."
4. Describe a time in the garden when you thought, "this is going really badly."

Student focus groups were also conducted. A purposeful sample was initially chosen for the focus groups based on the level of engagement in the program. However, since only 28 of the 170 students returned parental consent forms, all of these students were included in group interviews. Interview groups of 3 to 6 students were segregated by gender. Prompting questions used in these focus group interviews included:

1. What do you think about school gardening?
2. What did you like best? What didn't you like?
3. Why do you think your teacher took you out in the garden for class?

4. What do you think we should we do more of in the garden next year?
5. What do you think we should we do less of in the garden next year?

The Principal Investigator conducted all interviews and focus groups, which were audio recorded and then transcribed.

B. Qualitative data analysis

Using recognized qualitative analysis procedures and N-Vivo 2.0, interviews were analyzed numerous times based on a progression of inquiry including grounded hermeneutics and theory analysis approaches [19-23]. Grounded hermeneutics analysis was used to develop codes, categories, and themes that reflected study subjects' words and meanings [21]. Different meanings were then determined by arranging and rearranging the data according to theoretically derived categories [24]. The two theoretical frameworks used to create categories were Social Cognitive Theory (SCT) [25] and the Resiliency Model (RM) [26]. As noted in Chapter 1, the SCT, the theoretical framework that informed this study, describes a dynamic relationship between environmental, personal and behavioral influences. The RM was chosen to inform additional analytic categories because it is consistent with and complementary to the SCT, but also builds on the explanatory power of the SCT in the school garden context. An in depth description and analysis of the applicability of the SCT and RM to school gardening is provided in Chapter 6.

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Table 1: Comparison of number of vegetables consumed as reported on the Garden Vegetable Frequency Questionnaire (GVFQ) and the 24-hour recall personal interview.

Order in which information was collected	Number of vegetables consumed as reported on the GVFQ Mean \pm SD	Number of vegetables consumed as reported on the 24-hour recall Mean \pm SD
GVFQ first N=28	1.8 \pm 1.9	1.6 \pm 1.3
24-hour recall first N=25	2.4 \pm 2.6	1.8 \pm 1.6
Total N=53	2.2 \pm 2.3	1.7 \pm 1.4

Table 2: Summary of ethnic representation at each study site.

Ethnicity	Garden Site #1 N = 100	Garden Site #2 N = 90	Control Group N = 194
	Ethnic representation of total student body (%)		
African American	20.8	23.8	21.0
American Indian	0.2	0.7	1.5
Asian American	24.6	44.8	18.0
Filipino American	12.9	11.3	2.1
Hispanic or Latino	34.8	15.2	39.4
Pacific Islander	3.3	2.6	1.5
White (not Hispanic)	3.3	1.3	7.2
Other	0.2	0.2	5.0

Table 3. The study sample.

Control School (1 School Site) N = 99		Garden Schools (2 School Sites) N = 137		
2 Teachers No Treatment		Garden School Site #1 1 Teacher	Garden School Site #2 2 Teachers	
Teacher A N = 61	Teacher B N = 38	Teacher C N = 61	Teacher D N = 37	Teacher E N = 39

Table 4. Hands-on garden-based learning experiences at Garden School Site #1 and #2.

	<i>Garden School Site #1</i>	<i>Garden School Site #2</i>
Average Dose	<ul style="list-style-type: none"> • 1 hour/week for four months 	<ul style="list-style-type: none"> • 1 hour/week for four months
Planting Activities	<ul style="list-style-type: none"> • Each student planted seeds, transplanted starts, and planted mature plants at least four times • Students planted flowers, herbs and vegetables 	<ul style="list-style-type: none"> • Students planted flowers, herbs and vegetables by transplant and seed
Tending Activities	<ul style="list-style-type: none"> • Students watered during class at least 5 times over 4 months • Students are permitted to water the garden without direct teacher supervision if they have completed the required class assignments satisfactorily • Students weeded during class at least 5 times – please summarize. If they did each thing five times over four months organize it that way. • Students dug new beds at least 5 times • Students covered garden paths with mulch at least 5 times • Students mixed compost with soil to prepare beds at least 3 times • Students also watered, prepared beds and paths before and after school during unstructured time 	<ul style="list-style-type: none"> • Students watered during class at least twice • Students weeded during class at least twice • Students dug new beds at least once • Students covered garden paths with mulch at least once • Students mixed compost with soil to prepare beds at least once • Students also picked up garden area, watered, prepared beds and paths before and after school during unstructured time
Harvesting Activities	<ul style="list-style-type: none"> • Students collected seeds for next year • Students harvested, washed and prepared garden grown vegetables at least 4 times 	<ul style="list-style-type: none"> • Students harvested washed and vegetables at least 4 times
Consuming Activities	<ul style="list-style-type: none"> • Students ate vegetables raw from the garden at least 3 times • Students prepared and cooked ethnically diverse meals in class utilizing garden grown produce at least 4 times 	<ul style="list-style-type: none"> • Students ate vegetables raw from the garden at least four times
Garden size	<ul style="list-style-type: none"> • 1500 square feet 	<ul style="list-style-type: none"> • 1 acre
Subjects taught	<ul style="list-style-type: none"> • Science, health, community service 	<ul style="list-style-type: none"> • Science, health, language arts
Volunteer help	<ul style="list-style-type: none"> • Community volunteers • Teachers, parents, students, administrators 	<ul style="list-style-type: none"> • Elderly Neighbors • Conservation Corps • Teachers, parents, students, administrators
Community events	<ul style="list-style-type: none"> • Students hosted a ‘salad day’ where they served 75 heads of lettuce that they grew to the entire student body • Saturday garden Work party, with over 50 participants of families, friends, administrators, teachers, and students 	<ul style="list-style-type: none"> • 1 Saturdays Garden Workday, approximately 5 students participated with over 50 community volunteers

Table 5. Rationale for exclusion of study subjects from analysis of the Garden Vegetables Frequency Questionnaire (GVFQ), the Ecoliteracy Survey Questionnaire and the taste test.

Reason for exclusion	Garden Schools (Intent to treat N= 170) GVFQ N= 137 Taste test N= 99	Control School (Intent to treat N= 150) Final GVFQ N= 99 Taste test N= 62	Total percentage of study population (Intent to treat N= 320) GVFQ N= 236 Taste Test N= 161
Lack of parental consent for GVFQ and ECO	N= 15 (8%)	N= 25 (17%)	N= 40 (13%)
Lack of parental consent for taste test	N= 48 (28%)	N= 61 (41%)	N= 109 (34%)
Absent at pre-survey	N= 10 (6%)	N= 14 (9%)	N= 24 (8%)
Incomplete survey	N= 3 (2%)	N= 5 (3%)	N= 8 (3%)
Moved	N= 5 (3%)	N= 7 (5%)	N= 12 (4%)

CHAPTER 4 – ARTICLE #1

The impact of school garden experiences on middle school aged students' knowledge, attitudes and behaviors associated with vegetable consumption.

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Abstract

The objective of this study was to determine the effects of garden-based learning experiences on sixth-grade students' knowledge of, preferences for and consumption of vegetable varieties that were and were not grown in a school garden. Students at two sites in the San Francisco Unified School District were taught science and health lessons utilizing the school garden. Activities included planting, tending, harvesting, consuming garden-grown produce, and participation in community events, for an average of thirty minutes a week for 4 months. A control school did not participate in gardening activities. As part of a pre-post panel study, 236 sixth-grade students completed the Garden Vegetable Frequency Questionnaire, and 161 completed a taste test. Independent samples T-tests were conducted on the mean change in the outcomes measures. Results indicate that participation in school gardens can increase students' ability to identify vegetables, the variety that they eat, and their consumption of them at school. Future research should explore whether the effects of garden-based learning experiences persist over time. Additional studies are also needed to distinguish which aspects of garden based learning experiences are most effective at facilitating positive knowledge, attitudinal and behavioral changes.

Keywords: school garden, vegetable consumption, food preferences

Introduction

Garden-based education, a potentially successful strategy for developing innovative health interventions with urban youth, offers a number of advantages over other types of nutrition programs. It is relatively inexpensive; it can be implemented at school sites; it can be integrated into and enhance existing curriculum; support other environmental intervention strategies; and address multiple, interrelated issues associated with health and education (Alexander, North, & Hendren, 1995; Andrews, 2001; Bachert, 1976; Braun, Kotar, & Irick, 1989; Canaris, 1995; Lineberger & Zajiceck, 2000; Morris, Briggs, & Zidenberg-Cherr, 2000).

Generally, school garden programs consist of classroom instruction in one or more subject areas combined with garden-related activities, where students plant, tend, harvest and / or consume garden-grown produce. Educators use garden-based pedagogy in subject areas including science, math, social studies, language arts, environmental studies, nutrition, physical education, and agricultural studies (Desmond, Grieshop, & Subramaniam, 2002; Graham, Lane Beall, Lussier, McLaughlin, & Zidenberg-Cherr, 2005).

Since interest in school garden programs is on the rise, it is important to know if, and how, this intervention strategy might be effective at improving children's health behaviors (Graham et al., 2005). There are few reports of evaluation-based interventions that combine nutrition education and gardening to increase upper-elementary and middle school aged students' nutrition knowledge, preferences for and consumption of vegetables. The *Nutrition to Grow On*

curriculum was found to increase 4th grade students' nutrition knowledge and their ability to correctly name some vegetables that they grew. Students in the garden group also increased their preferences for several vegetables, including carrots, broccoli, snow peas and zucchini. Zucchini was not grown in the school garden, and these findings suggest that the intervention may have improved students' preferences for vegetables to which they were not directly exposed. Students in this program retained their preferences for broccoli, snow peas and zucchini 6 months after the intervention (Jennifer L. Morris & Sheri Zidenberg-Cherr, 2002). Further, participants significantly increased their consumption of vegetables at home, their willingness to ask a family member to buy them, and to eat them as a snack. Follow-up measurement indicated that willingness to eat vegetables as snacks remained significantly higher six months following the intervention (J.L. Morris & Sheri Zidenberg-Cherr, 2002).

An evaluation of the *Nutrition in the Garden* program, a 16-week nutrition and gardening program for 3rd and 4th grade students, found that while students' attitudes toward vegetables significantly improved, as did their preferences for fruit and vegetable snacks, their produce consumption did not change significantly (Lineberger & Zajicek, 2000). A 12 week nutrition education program for 6th grade students that included garden-based activities found that students who gardened did not increase their preferences for fruits or vegetables, but did increase the number of servings they consumed (McAleese & Rankin, 2007). Finally, an evaluation of an integrated school garden program, the *Edible Schoolyard* in Berkeley, California found that some of the participating 6th grade students

significantly increased the number of fruits and vegetables they reported eating (Murphy, 2003).

This paper addresses four gaps in the literature. First, it reports the effects of participating in a school garden program on 6th grade students' ability to correctly identify vegetables. Second, it describes the effect of growing vegetables on middle school aged students' preferences for them. Third, this paper explains the impact of participation in a garden-based learning program on students' willingness to try a variety of vegetables. Evidence suggests that willingness to try vegetables may predict future vegetable consumption (LL Birch, McPhee, Shoba, Pirok, & Steinberg, 1987). Fourth, this paper reports the direct effect of the gardening experience on overall consumption of different vegetable varieties.

The framework for this research is found in Social Cognitive Theory (SCT) constructs, which posit that behavioral, personal and environmental influences interact continuously in a reciprocal manner (Bandura, 1986). Applying these constructs to a school garden context helps understand and predict how school gardens may engender dynamic interactions between behavioral, personal, and environmental factors. For example, garden programs offer educators opportunities to teach math, science, art and language arts through hands-on experiences that simultaneously teach behavioral skills needed for growing, harvesting, and preparing produce for consumption. These experiential learning opportunities may directly influence children's behaviors because they increase opportunities to consume vegetables. These experiences may also influence students' knowledge, behavioral capability, cognitive skills, self-efficacy, attitudes, and preferences,

because they provide numerous occasions for observational learning, reinforcement, and adult and peer modeling of vegetable consumption.

Methods

This study employed a quasi-experimental, pre-post panel design with a non-randomly assigned control group. Sixth-grade students from three schools in the San Francisco Unified School District participated. Two schools were garden sites and one was a control site. In the intervention schools, the garden program was one in which students planted, tended, harvested and ate vegetables they grew as part of the required science curriculum for an average of thirty minutes a week over a four month period. Both garden-school sites grew the same vegetable varieties. The control site, which was located in the same school district as the garden-school sites, had no youth garden program but provided the same health and science curriculum.

Knowledge, attitudes and behaviors towards vegetables were measured through two self-administered surveys: the Garden Vegetables Frequency Questionnaire (GVFQ), and the taste test. The GVFQ was created to measure consumption of and preferences for a variety of vegetables that are typically grown in school gardens and likely to be consumed by an ethnically and culturally diverse population. It is a self-report, paper and pencil survey that assesses the types of vegetables consumed the previous day, the frequency with which they are typically consumed, and preferences for each one. The GVFQ takes approximately 15 minutes to complete and can be administered in the classroom.

The GVFQ shows pictures and names of twenty-two vegetables and provides two additional blank response boxes to accommodate other vegetables that a student may have consumed. The questionnaire was developed through an iterative process involving vegetable lists from ethnic cookbooks, gardening manuals, and a focus group, drawn from a convenience sample, with high school aged students who have younger siblings in the target age range. The high school students were asked what foods and specific vegetables their caregivers prepared and younger siblings regularly consumed.

The vegetable consumption component of the questionnaire was pre-tested with fifty-three youth in the target age range, who completed both the GVFQ and a 24-hour recall personal interview. Based on random assignment, half of the subjects took the GVFQ first, while the other half completed the interview first. Those who took the GVFQ first reported consuming an average of 1.8 (\pm 1.9) vegetables, while those who completed the 24-hour recall first reported consuming an average of 1.8 (\pm 1.6) vegetables. While results from the two methods appear to agree, they are not identical. A frequency distribution of the difference scores indicates exact agreement between the two methods for only 64% of the pilot test population, while 81% of the respondents had a difference score of plus or minus one vegetable. Further, the GVFQ appears to be a more accurate measure since students reported consuming higher total number of vegetables based on that method regardless of whether they took the survey before or after the recall. Based on these pre-test findings, the GVFQ is comparable to the recall from a practical

(clinical) standpoint and, for the purposes of this study, considered a reasonable measurement tool to assess vegetable consumption.

The methodology for collection of food preference data through a taste test used in this study was adopted from previous work on children's food preferences (LL. Birch, 1990; Jennifer L. Morris & Sheri Zidenberg-Cherr, 2002). Food preference data were collected through a self-administered taste-test and accompanying form used to record subjects' responses. As part of the taste test, students were asked to name, taste and rate their preferences for five raw vegetables, carrots, string beans, snow peas, broccoli, and Swiss chard. They were also asked whether they ate them at school and home. If they tasted the vegetable, they were asked to indicate their preferences on a five-point Likert type scale. The five vegetables were chosen because they grow well in the study site area, are readily available at grocery stores, and can be served raw. One was chosen because it was considered very familiar to the student (carrot) and one because it was quite unfamiliar (chard).

In total, three hundred twenty students at the garden and control sites completed the GVFQ and the taste test in November 2003 (pre-test) and in June 2004 (post-test). Of these, 26% were excluded from analysis of the GVFQ, and 49% students were excluded from analysis of the taste test. Students were excluded for lack of parental consent, absence during pre-survey questionnaire administration, incomplete survey questionnaire, or because they moved away from the study site.

In total, data from 236 students were eligible for analysis of the GVFQ, 137 from the garden group, and 99 from the control group. Data from 161 students were available for analysis of the taste test data, 99 from the garden group and 62 students from the control group. To analyze the impact of the garden experience, independent samples T-tests were used to detect significant differences in the change (post-test minus pre-test) in vegetable knowledge, preferences, willingness to taste, and consumption between the garden and control groups. The Tufts University Institutional Review Board and the San Francisco Unified School District's Office on Human Subjects approved this study.

Results

Ability to correctly identify vegetables: After the gardening experiences, children in the garden group increased the number of different vegetables that they correctly identified significantly more than those in the control group ($p < .05$) (Table 1).

Preferences for vegetables: As measured by the GVFQ, students who participated in hands-on garden-based learning experiences significantly increased their preferences for vegetables generally ($p = .029$) and for those that were specifically grown in the school garden ($p = .017$). There was no significant difference between the two groups in preferences for vegetables that were not grown in the school garden ($p = .23$) (Table 2). Results from the taste test indicate that there was no significant difference in students' preferences for vegetables between the garden and control groups (Table 1).

Willingness to taste vegetables: Results from the GVFQ demonstrate that after their experiences, students in the garden group reported having tried significantly more varieties of vegetables than those in the control group ($p < .001$) (Table 3). They were more willing to try both those that were grown in the school garden ($p < .001$) and those that were not ($p = .025$) (Table 3). Based on self-reported behaviors measured by the taste test, there was no difference between the two groups willingness to taste the vegetables (Table 1).

Variety of vegetables consumed more than once a month: Based on responses to the GVFQ, students in the garden group significantly increased the average number of vegetable varieties they consumed more than once a month ($p < .001$), and for both those they grew and those they did not ($p < .05$), compared to the control group (Table 4).

Consumption of vegetable varieties at school and home: Findings from the taste test indicate that after the gardening experience, children in the garden group ate a significantly greater variety of vegetables at school than those in the control group ($p < .05$) (Table 1). There was no significant difference between the two groups in the number of varieties they reported consuming at home (Table 1).

Discussion

This research adds to the growing literature on the positive effects of garden-based education on students' knowledge, attitudes and behaviors associated with vegetable consumption. Results from this study indicates that hands-on garden-based learning experiences can increase students' ability to identify

vegetables correctly, increase the variety that they eat, and their consumption of different vegetable varieties at school.

Findings differed between the two survey instruments for students' preferences for vegetables and the variety of vegetables they were willing to try. The GVFQ identified significant differences between the groups, but the taste test did not. It may be that the fewer number of vegetables on the taste test, and smaller sample size of respondents who took it, explain this difference.

Increased consumption may have been influenced by the increased availability of vegetables provided by the school garden program. However, the fact that students also increased their consumption of vegetable varieties not grown in the school garden indicates that the changes are likely also due to the effects on students' willingness to taste and eat more vegetables outside the school setting.

The study did not measure where within the school environment students consumed the vegetables. The increase in the number of vegetable varieties students reported consuming at school may have been due to either lunchtime consumption, consumption during garden activities, or both. In addition, students did not increase the number of vegetable varieties they consumed at home. This may be because the vegetables were not available at home, or if they were, they may have been prepared in a way that the children would not eat.

A limitation of this study is that the number of different vegetable varieties consumed was measured, but not the actual amounts. Therefore it is not known if the garden-based learning experiences increased the number of vegetable servings that students' consumed.

Implications for Future Research

Future research should explore whether the observed effects of participating in garden-based learning experiences on middle school aged students' preference for and consumption of vegetables persist over time, and if garden experiences affect the amount of vegetables that children consume. It will also be important to investigate whether changes in children's behavior affects the behavior of their parents.

Additional studies are needed to distinguish which aspects, including scale and scope, of garden based learning experiences are most effective at facilitating positive knowledge, attitudinal and behavioral changes. Comparison studies among different kinds of school gardens will greatly aid in the determination of what constitutes a successful program. The GVFQ presented in this study provides a helpful tool to use in comparison studies. It is available on request from the corresponding author.

Implications for Practitioners

Since garden-based learning experiences increase students' knowledge of vegetables, their willingness to taste them, and their consumption of them at school, educators should pair hands-on experiences in the garden with other environmental interventions that increase the availability of fresh produce in schools. In addition, experiences in gardens have also been found to promote academic achievement, ecoliteracy and youth development (Alexander et al., 1995; Andrews, 2001; Armstrong, 2000; Bradley, 1995; Harmon, 2001; Murphy, 2003; Wals, 1994).

These additional findings, when coupled with the comparatively low costs of starting and implementing these programs, make school gardens a particularly appealing intervention strategy for health educators to partner with teachers from diverse fields to leverage resources for delivering effective integrated programs.

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Table 1. Taste test results. Increase in students' ability to correctly identify five vegetables, their willingness to taste them, preferences for them, and consumption of them at school and home. The five vegetables are carrots, broccoli, snow pea, green beans, and Swiss chard.

	Garden Group Mean change \pm SD N = 99	Control Group Mean change \pm SD N = 62	P-Value
Ability to correctly identify vegetables	0.6 \pm 1.4	-0.03 \pm 1.2	.002*
Willingness to taste vegetables	-0.2 \pm 1.3	-0.4 \pm 1.3	.286
Preferences for vegetables	0.4 \pm 1.0	0.2 \pm 0.8	.279
Consumption of vegetables at school	0.5 \pm 2.1	-0.3 \pm 1.7	.010*
Consumption of vegetables at home	0.1 \pm 1.6	-0.3 \pm 1.8	.122

* An asterisk within a row indicates statistically significant mean change differences between the garden and control groups based on Independent samples T-test ($p < .05$)

Table 2. Increase in preferences for vegetables (post-test minus pre-test).

Change in the number of positive preferences for vegetables	Garden Group Mean change \pm SEM N = 137	Control Group Mean change \pm SEM N = 99	P-value
All GVFQ Vegetables (out of 24)	0.7 \pm 0.3	-0.2 \pm 0.3	.029*
Vegetables grown in the school garden (out of 11)	0.5 \pm 0.2	-0.1 \pm 0.2	.017*
Vegetables not grown in the school garden (out of 13)	0.2 \pm 0.2	-0.1 \pm 0.2	.23

* An asterisk within a row indicates statistically significant mean change differences between the control and garden groups based on independent samples T-test ($p < .05$)

Table 3. Increase in the number of vegetables that students were willing to taste (post-test minus pre-test).

Vegetables student were willing to taste	Garden Group Mean change \pm SEM N = 99	Control Group Mean change \pm SEM N = 62	P – value
All GVFAQ Vegetables (out of 24)	1.9 \pm 3.5	-0.1 \pm 3.7	<.001*
Vegetables grown in the school garden (out of 11)	1.5 \pm 0.2 *	0.2 \pm 0.2 *	<.001*
Vegetables not grown in the school garden (out of 13)	0.4 \pm 0.2 *	-0.3 \pm 0.2*	.025*

* An asterisk within a row indicates statistically significant mean change differences between the control and garden groups based on independent samples T-test (p<.05)

Table 4. Increase in the number of vegetable varieties students consumed once a month or more (post-test minus pre-test).

Vegetables consumed more than once a month	Garden Group Mean change \pm SEM N = 99	Control Group Mean change \pm SEM N = 62	P – value
All GVFQ Vegetables (out of 24)	1.1 \pm 4.1	-0.9 \pm 4.6	.001*
Vegetables grown in the school garden (out of 11)	0.5 \pm 0.2	-0.3 \pm 0.2	.005*
Vegetables not grown in the school garden (out of 13)	0.5 \pm 0.2	-0.6 \pm 0.3	.001*

* An asterisk within a row indicates statistically significant mean change differences between the control and garden groups based on independent samples T-test ($p < .05$).

CHAPTER 5 – ARTICLE #2

School garden experiences increase sixth-grade children’s environmental knowledge, attitudes, and behaviors.

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Abstract

This study compares the environmental knowledge, attitudes and behaviors of urban sixth-grade students who participated in garden-based learning programs as part of their regular science classes with those of students who were exposed to similar curriculum content without the gardening experience. Quantitative results indicate that hands-on garden experiences are generally a successful pedagogy for increasing environmental knowledge and behaviors. Qualitative data suggest that gardening experiences may affect children’s environmental attitudes and behavioral intentions. Future research should distinguish the relative effectiveness of the several components of garden programs, the synergies among them that may increase effectiveness, and whether observed changes persist over time.

Key Words: Garden-based education, children, ecoliteracy

Introduction

The United States has made considerable progress in the past 30 years toward addressing problems of polluted air, water and soil. Yet if current population and consumption trends continue, humans may significantly alter or even destroy almost every remaining natural ecosystem on Earth within a few decades (Daily, 1997). This is significant because we are destroying ecosystem services for which we have no substitute, such as the climate, clean water and clean air (Daily, 1997). To control this trend will require an ecoliterate population, one that knows and cares about environmental issues and will act in environmentally responsible ways. “Ecoliteracy” is used to include three components (1) knowledge of the principles of ecology, (2) positive ecological attitudes, and (3) the practice of ecological values (Fritjof, 1993; Golley, 1998).

This paper examines the potential of school garden programs to promote ecoliteracy in children. There are several reasons to do this. First, childhood is a critical time for developing an environmental ethic, positive attitudes towards the environment, and for influencing precursors to environmentally responsible behavior (Bunting & Cousins, 1985; Glazer & Glazer, 1998). Second, most children in the U.S. attend school until the age of sixteen. Third, since the number of garden-based educational programs in schools is increasing (Klemmer, Waliczek, & Zajicek, 2005), it is possible to reach more and more students with ecoliteracy programming. These three factors create an opportunity for implementing targeted environmental educational interventions with high levels of participation.

A limited number of studies have evaluated the effects of school garden experiences on middle school aged students' environmental knowledge, attitudes and behaviors. Murphy et al. (2003) reported the findings of an evaluation of the Edible School Yard in Berkeley, California. The Edible School Yard is a garden-based learning program that is integrated into all aspects of the school. As measured by analysis of students' grade-point-averages, a survey questionnaire, and experiential assessment activities, they found that students who participated in the Edible Schoolyard showed significantly greater gains in test scores for science generally, and a better understanding of garden cycles and sustainable agriculture, when compared to a control school (Murphy, 2003).

Smith and Molsenbocke (2005) evaluated the use of four chapters of the Junior Master Gardner Handbook (Level One) on 119 fifth grade students at three schools. Each of the three schools had both experimental and control classes. Experiential classes participated in Junior Master Gardening Activities once per week for 2 hours over a 14-week time period. Control classes did not participate in any aspect of the Junior Master Gardening lessons. Results from paired t-test analyses indicate that students' in the experimental groups improved science achievement, as there was a statistically significant difference between the experimental classes' pretest and posttest scores. Results from ANOVA, however, showed no significant difference in the experimental classes' pretest and posttest scores. Further, no significant difference was found between the experimental and control classes due to treatment (Smith & Molsenbocker, 2005).

Using a mixed methods approach, Dirks and Orvis (2005) also evaluated aspects of the Junior Mater Gardener Program on 277 third grade students from 11 schools in Indiana. Based on matched pairs t-tests, a significant increase in students' knowledge, and attitudes towards both science and agriculture was found between pre and post program scores. Qualitative results indicate that the program positively influenced many students' attitudes towards plants, environmental actions and the community (Dirks & Orvis, 2005).

In a study of 647 3rd through 5th grade students, Klemmer et al (2005) found significant improvement in students science achievement after participation in a program that combined science classes with gardening activities when compared to students in a control group (Klemmer et al., 2005).

Based on this promising, but limited number evidence, additional research on the effects of garden based education on children's ecoliteracy is warranted. The research presented here asks whether hands-on learning experiences in a garden are more effective at improving children's ecoliteracy than non-experiential education. Specifically, the hypothesis tested whether youth who participate in a science class that includes gardening experiences would increase their environmental knowledge, and improve their attitudes towards the environment and performance of environmentally responsible behaviors more than a group who have the same classroom curricula without the gardening experiences.

The framework for this research is found in Social Cognitive Theory (SCT) constructs, which posit that behavioral, personal and environmental influences interact continuously in a reciprocal manner (Bandura, 1986). Applying these

constructs to a school garden context helps understand and predict how school gardens may engender dynamic interactions between behavioral, personal, and environmental factors. For example, garden programs offer educators opportunities to teach math, science, art and language arts through hands-on experiences that simultaneously teach behavioral skills needed for cultivating a garden. These experiential learning opportunities may directly influence children's environmentally responsible behaviors because they increase opportunities to perform ecological actions such as planting and composting. These experiences may also influence students' knowledge, behavioral capability, cognitive skills, self-efficacy, attitudes, and preferences, because they provide numerous occasions for observational learning, reinforcement, and adult and peer modeling of environmentally responsible behaviors. Figure 1 illustrates of the application of SCT constructs to hands-on garden-based education.

Methods

This study employed a mixed-methods, quasi-experimental, pre-post panel design with a non-randomly assigned control group. Sixth-grade students from three schools in the San Francisco Unified School District participated in the study. Two schools were garden sites and one was a control site. To be considered a garden site, a school garden program had to include activities where students plant, tend, harvest and consume vegetables they grew as part of the required science curriculum for an average of at least thirty minutes a week over a four-month time

period. The control site had no youth garden program and provided the same science curriculum used in the garden sites.

Students' environmental knowledge, attitudes and behaviors were measured through a self administered, paper and pencil, ecoliteracy survey questionnaire. The ecoliteracy survey was adapted from an existing survey to conform more closely to the California Department of Education's Content Standards for Sixth-Grade Science Curriculum . The modified questionnaire was developed in a collaborative effort with students, teachers and ecoliteracy researchers. To inform the creation of suitable survey questions and format, a focus group was also conducted. The focus group, drawn from a convenience sample, consisted of 5 children in the target age range (11-13 years old) and 3 children, aged 14-16, who were their siblings.

The Ecoliteracy Survey contains questions regarding demographics, ecological actions, ecological attitudes, and ecological knowledge. The survey asks demographic questions concerning parents' ethnicity and socioeconomic status. The survey also asks ecological action questions regarding students' recycling and composting activities at school and home, and their energy and water conservation behavior. For each ecological action students are asked to indicate if they do the action "never", "sometimes", or "always." These ecological actions were selected because they are identified in the literature as environmentally responsible behaviors (Ramsey & Hungerford, 1989; Ramsey, Hungerford, & Tomera, 1981; Vaske & Kobrin, 2001), because the focus group indicated that they are things that "environmentalists do", and because it is possible for sixth-grade students in the study area to perform them.

In addition, the ecoliteracy survey includes questions about students' ecological attitudes toward extinction, organic produce, water pollution, land conservation and littering, and energy and water conservation. These eco-attitudes were identified by the focus group as "things environmental people care about," and are conceptualizations of environmentally responsible behaviors found in the literature (Bunting & Cousins, 1985; Jaus, 1982, 1984; Skelly, 2000). In total, seven attitudinal statements were included in a four point Lickert scale.

Lastly, six fill in the blank and five multiple-choice questions ask students about plant parts and their function, and about the food web. These ecological knowledge questions were taken directly from a widely used text book and questions provided by the California Department of Education's Standardized Testing and Reporting (STAR) program (California Department of Education, 2003; Exline et al., 2001). Interviews with a middle-school science teacher and an ecoliteracy researcher verified that the selected questions accurately encompass content that is both taught during the school year and is considered components of ecoliteracy.

Three-hundred-and-twenty students participated in the study. Of these, 84 were excluded from analysis for lack of parental consent, absence during pre-survey questionnaire administration, incomplete questionnaire, or because they moved away from the study site. Data from 236 students (137 from the garden group, and 99 students from the control group) were eligible for analysis. Table 1 summarizes the number of individuals who were excluded from the study and the reasons why.

Students at both the garden and control sites completed the ecoliteracy survey questionnaire in November 2003 (pre-test) and in June 2004 (post-test). To measure the impact of the garden experience assessed by the ecoliteracy survey questionnaire, independent samples T-tests were used to detect significance differences between the groups in mean change (post-test minus pre-test) in the dependent variables.

In order to understand more fully the impact of the garden experiences, personal interviews were conducted with the three teachers who administered the school garden programs and with 28 of the students in eight focus groups. The focus groups were held at the end of the school year. Initially, a purposive sample was chosen for the student focus groups based on their level of engagement in the program; however, since only 28 students returned parental consent forms, all of them were included. Focus groups were separated by gender, and consisted of three to six students per group. Table 2 includes the personal interview questions used with teachers and the focus group discussion guide used with students.

The Principal Investigator conducted all personal interviews and focus groups, which were audio recorded and then transcribed. Using qualitative analysis procedures and N-Vivo 2.0, coded transcript segments were repeatedly sorted and summarized until coherent themes about the impact of school gardening experiences on students' environmental knowledge, attitudes, and behaviors emerged. The Tufts University Institutional Review Board and the San Francisco Unified School District's Office on Human Subjects approved this study.

Results

Students who participated in hands-on garden-based learning experiences increased their overall environmental science knowledge score significantly more than those who had similar instructional content but no garden experience ($p < .001$). Those in the garden group also showed significantly greater increases in their scores on those questions that specifically conform to the California State Standards for Sixth-grade Science ($p < .05$) and those that pertain to plant identification ($p < .05$) (Table 3).

There was a small, non-significant difference in changes in environmental attitudes between the garden and control groups (Table 3). However, qualitative data from teachers at both garden school sites suggested that students who participated in school gardening changed their attitudes toward the environment in regard to insects. For example, one teacher stated that, “not all the kids want to make their hands dirty, but...they got used to it and [then]...they wanted to touch the worms and the slugs.” Two teachers thought that students became “more insect friendly”, because the school gardening experiences created a situation in which students had to “interact with nature and come to terms with it.”

Based on self-reported behavior, students who participated in garden-based learning increased their frequency of ecological behaviors that they “sometimes” perform more than the control group ($p = .001$) (Table 3). Additional qualitative data suggests that the garden-based experience may have had an impact on their behavioral intentions as well. For example, when students were asked, “What would you like to do more of next year?” they replied that if given an opportunity,

they would participate in the environmentally responsible behaviors of “planting trees”, “composting”, “re-using materials”, “picking up litter”, and “teaching others about how to treat plants well.”

Discussion

This study adds to the growing body of literature on the effects of garden-based education by utilizing SCT constructs to describe the effect of the experience on middle-school-aged students’ environmental knowledge, attitudes and behaviors. Quantitative results indicate that hands-on garden-based learning experiences are generally a successful pedagogy for increasing environmental knowledge and behaviors. These results are consistent with previous findings showing that integrated school garden programs may improve students’ academic achievement and increase their performance of environmentally responsible behaviors (Murphy, 2003). This study also quantifies the impact of the experience on standardized test questions from the California Department of Education. These findings suggest that garden-based pedagogy could be an effective method to improve standardized test scores for science.

Qualitative data from this study suggest that participating in hands-on experiences in a garden while living in an urban setting may affect children’s environmental attitudes and behavioral intentions because it allows them a unique opportunity to interact with nature. Further, it is possible that the ways in which students engaged in changing the physical landscape through gardening allowed them to envision other ways to improve their environment. For example, after the

gardening experience, students identified several activities they wanted to do, such as planting trees and picking up garbage, activities that would further improve the school's physical environment. Since follow-up behavior was not measured, it is not known whether and to what extent students followed through on their behavioral intentions, and if so, whether they did it on their own, or only when presented with an opportunity to do it during class time.

One of the seemingly inconsistent results of this study is that while environmental knowledge and behaviors improved significantly, the scope of improved attitudes towards the environment was limited. These findings are contrary to the assumption that positive environmental attitudes are a necessary precursor to the performance of environmentally responsible behaviors. The SCT offers a framework for understanding this apparent incongruity. It may be that participation in school gardens lead directly to behavioral change by altering the environment and providing opportunities to perform these behaviors without intervening changes in the personal factors of knowledge and attitudes. Results from this study suggest changes in behavior were not mediated by changes in attitude, lending further support to the use of the SCT in the development and evaluation of school garden programs.

Implications for Future Research

Future research should distinguish what aspects of garden based learning programs, including types and duration of learning activities, are most effective at facilitating positive knowledge, attitudinal and behavioral changes. Studies should

also explore the influence of garden based learning experiences on personal attributes that may be predictors or mediating factors of environmentally responsible behaviors. Finally, future research needs to explore whether and to what extent short-term changes persist over time.

Implications for Practitioners

Even a successful environmental education intervention can have an impact only if it is adopted. School gardens offer a number of practical benefits that increase the likelihood that they will. They are relatively inexpensive and can be integrated into and enhance the existing curriculum. Some evidence suggests that they can have a positive effect on academic achievement, health, and youth development (Alexander, North, & Hendren, 1995; Andrews, 2001; Desmond, Grieshop, & Subramaniam, 2002; Lieberman & Hoody, 1998; Morris, Briggs, & Zidenberg-Cherr, 2000). These additional advantages increase the appeal of school gardens as an intervention strategy. They provide an opportunity for environmental educators to partner with teachers and community members with diverse interests to leverage resources to achieve both their unique and their shared goals.

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Figure 1: How Social Cognitive Theory (SCT) constructs may apply to the reciprocal relationships among the variables in this study.

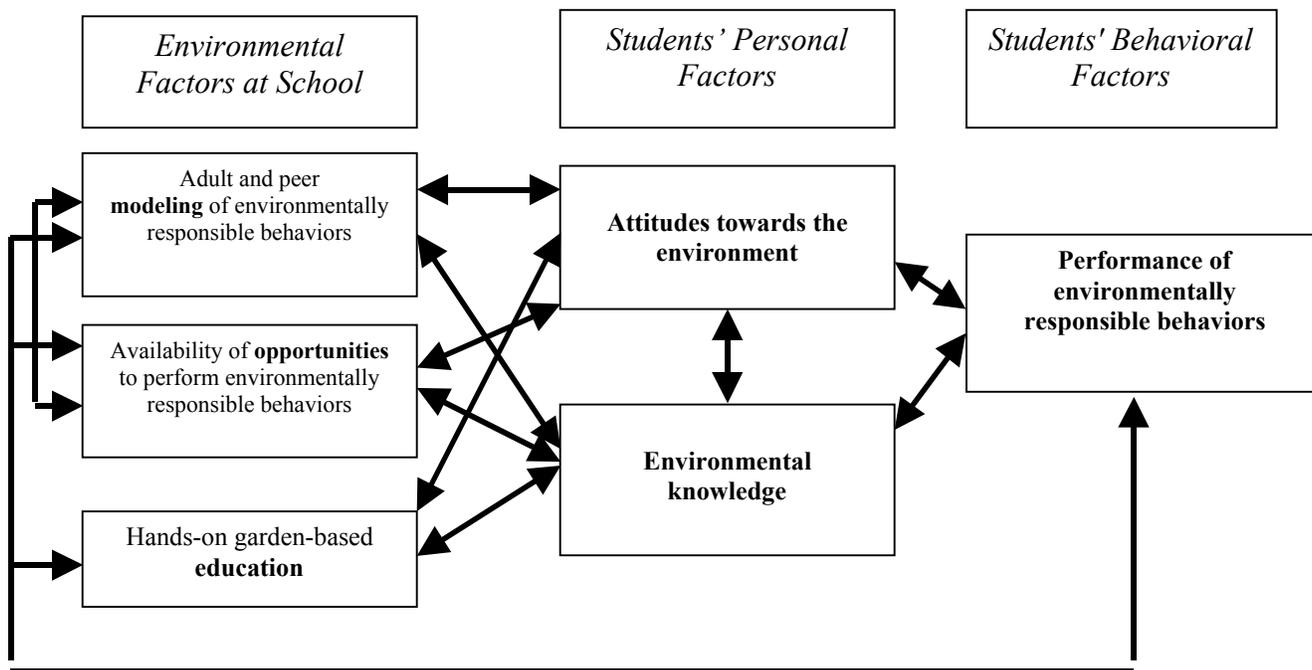


Table 1: Rationale for exclusion of study subjects from analysis.

Reason for non-response and subsequent exclusion from the study	Garden Group Intent to treat n = 170 Final n = 137	Control Group Intent to treat n =150 Final n = 99	Total study population Intent to treat n = 320 Final n = 236
Lack of parental consent	8% (15)	17% (25)	13% (40)
Absence at pre-survey questionnaire administration	6% (10)	9% (14)	8% (24)
Incomplete survey questionnaire	2% (3)	3% (5)	3% (8)
Moved from the study site	3% (5)	5% (7)	4% (12)

Table 2. Prompting questions used in teacher interviews and student focus groups

Teacher in-depth personal interviews

1. What do you think about school gardening?
2. Does gardening with the kids work? What works? What doesn't work? Why?
3. Describe a time in the garden when you thought, "this is going really well."
4. Describe a time in the garden when you thought, "this is going really bad."

Student Focus groups

1. What do you think about school gardening?
 2. What did you like best? What didn't you like?
 3. Why do you think your teacher took you out in the garden for class?
 4. What do you think we should do more of in the garden next year?
 5. What do you think we should do less of in the garden next year?
-

Table 3. Increase in students’ environmental knowledge, attitudes, and behaviors.

	Garden Mean change \pm SD N = 137	Control Mean change \pm SD N = 99	P – value
Environmental knowledge			
All Ecological Knowledge Questions (out of 12)	1.2 \pm 2.5	-0.1 \pm 2.6	.000*
California state standards for 6 th grade Science (out of 6)	0.7 \pm 1.5	0.1 \pm 1.7	.003**
Plant identification (out of 6)	0.4 \pm 1.9	-0.1 \pm 1.9	.04**
Environmental attitudes			
Agree with ecological attitudes (out of 9)	0.6 \pm 2.0	0.4 \pm 1.9	.64
Environmental behaviors			
Change in number of environmentally responsible behaviors student reported performing “sometimes” (out of 7)	0.8 \pm 1.9	0.03 \pm 1.5	.001*

* Significant at the $p < .001$ level, ** Significant at the $p = .05$ level based on

Independent samples T-tests.

CHAPTER 6 – ARTICLE #3

A Model for Garden-Based Education in School Settings: Development of a conceptual framework to improve children’s academic achievement, ecoliteracy, health and wellness while enhancing schools, communities and bioregions.

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Abstract

An integrated theoretical framework would foster the design of successful school garden programs, promote the development of a coherent research and evaluation literature, and capitalize on the heightened interest in and funding for these programs. The Model for Garden-based Education (MGBE) describes how school gardens work and suggests the mechanisms by which program elements achieve a variety of outcomes at several levels of society. Development of the MGBE was informed by existing theory, previous literature, and original qualitative research. Future research on the MGBE should test the causal linkages between and among construct variables. Educators from diverse fields may use the MGBE as a tool to develop and evaluate theoretically driven, behaviorally based school garden programs.

Keywords: Garden-Based Education, Conceptual Framework , Social Cognitive Theory, Resiliency Model, school gardens

Introduction

The number of school-garden related programs is increasing across the country, and these programs are beginning to be institutionalized throughout school districts, universities and states. In 2006, for example, the California Legislature appropriated 15 million dollars to support a “garden in every school” [1]. While each school garden program is unique to the place and people who run it, they generally pair classroom instruction with garden-related activities, where students plant, nurture, harvest and often consume garden-grown produce.

The motivation for developing these programs usually is to promote one or more of the following four outcomes for students: increased academic achievement, improved healthy behaviors of increased fruit and vegetable consumption and physical activity, improved ecoliteracy, or positive youth development. The most recent trend is to develop programs that will simultaneously achieve gains in each of these four areas and at the same time, enhance more distal goals, such as positive outcomes for the whole community [2].

It is likely that simply having a school garden will not lead to knowledge, attitude and behavior changes. Even when educational programs are associated with changes in participants’ knowledge and attitudes, they are not generally associated with behavior change [3, 4]. There is evidence that programs based on theory are more likely to be effective at changing individuals’ behaviors. The use of theory helps explain how an intervention may work, and allows for efficient program implementation [4]. A theoretical framework for school garden programs would contribute to the design of more consistently successful programs, and to the

development of a more coherent research and evaluation literature. To the extent that a framework fuels rigorous research and evaluation of garden programs, it may also help capitalize on the current increased funding for these programs [5].

We have identified just one recent publication that has systematically sought to develop a conceptual framework for school garden programs that could explain their potential to maximize students' development of healthy lifestyle behaviors [5]. Ozer's (2006) conceptual framework theorizes that the garden, hands-on curriculum, and parental and community involvement in the school has short and long-term effects on the student, school, family, and community levels [5].

Ozer's model development process started from a theoretical standpoint informed by a social ecological-transaction perspective and includes the ecological principle of interdependence. In other words, the model recognizes a child's development as the result of their on-going interactions with school, family, and community environments, and that changes in one area may influence the others. Using the keywords, "school" and "garden," and "community" and "garden" to search electronic databases and online search engines to identify studies on the effects of garden experiences on students' physical health, mental health, or academic performance published prior to July 2005, Ozer (2006) identified results from five separate studies. These findings informed the model variables. Case study descriptions of school garden curricula and process studies of attitudes towards the curricula that did not assess any health, mental health, or academic outcomes were excluded from her review, and hence from her model.

The model has two limitations. First, the model does not include all of the program elements or the outcomes at the level of the individual, community, and bioregion found in the literature. Since the experimental literature is limited, and goals for school gardens differ, it makes sense to identify potential variables from numerous sources and from as broad an interdisciplinary view as possible. Second, the model was not field tested to ensure its usefulness for studying interventions and to further explore the predictive value of the various components in the model, or to increase its usefulness in designing interventions. Developing a model for school garden researches and practitioners that includes a broader range of potential variables and is understandable to a wide range of audiences could have far reaching implications for practice and the research and evaluation literature.

This paper proposes a broader conceptual framework for garden based education in school settings. As a first step we revisited the literature to establish a theoretical starting point for development of such a model. In addition, we explored the relevance of our proposed model to explain garden based education in a school setting, and tested it in focus groups with multiple audiences. The final model categorizes all the known elements of garden programs; incorporates individual, school, community, and bioregional levels of program influence; and addresses cognitive, physical, behavioral and social outcomes for each of those levels. Finally, the model hypothesizes causal relationships between program elements and outcomes.

This paper is organized as follows: Part I introduces the proposed Model for Garden-based Education in school settings (MGBE). Part II describes the empirical

and theoretical basis that informed the creation of the MGBE. Part III presents qualitative research that explores the applicability of the MGBE to describe a school garden program. Part IV concludes with a discussion of the strengths and weakness of the proposed MGBE, suggests directions for future research and the relevance of the model for practitioners.

PART I - A Proposed Model for Garden-based Education

The Model for Garden-based Education in school settings (MGBE) is presented in Figure 1 and 2. It posits that a garden-based education program directly affects a school's learning environments in ways that may *directly* and *indirectly* affect students' personal characteristics and improve their academic achievement and health-promoting and environmentally responsible behaviors. It may also, affect broader community level factors, such as public health and environmental quality. These relationships between schools' learning environments, individuals' personal characteristics and behaviors, and community level factors are hypothesized to form positive feedback loops. For example, positive changes in students' personal characteristics are hypothesized to lead to positive changes in their behaviors, or in the school or community environment. Finally, the cumulative impacts on the community are hypothesized to have an impact at the bioregional level, with a positive feedback loop between community and bioregion. Bioregion is a system of related, interconnected ecosystems characterized by a combination of broad biological, social, and geographic criteria. The remainder of this section

provides detailed conceptualizations of the main MGBE constructs and potential relationships among them.

Influences on the school's learning environments

The construct that specifies the potential effects of garden-based education programs on the school's learning environment is at the top of the model because it is hypothesized to be the "trigger" or driving force. The MGBE predicts that these impacts on schools' learning environments may affect both personal and behavioral factors, as well as community level factors.

The MGBE predicts that a school garden program may enhance or improve the curricular, physical, and / or social learning environments. A school garden may shape the *curricular learning environment* by increasing or enhancing opportunities for (a) hands-on, project-based, and placed-based education, (b) engaging youth and adults in real, on-going processes, (c) integrating curricula across disciplines and grades, (d) reinforcing concepts and abstract ideas through experiential learning opportunities, and (e) engaging multiple intelligences. A school garden may alter the *physical learning environment* by enhancing or increasing the (a) quality of the environment including the visual and sensory aesthetics, (b) diversity of environments in which students play and learn, (c) perception of safe places in the school and / or community, and (d) opportunities for visual reinforcement of learning, consuming vegetables, performing environmentally responsible behaviors, finding refuge, connecting with nature, and nurturing living things. A school garden may influence the *social learning*

environment by affecting the school culture and identity, and increasing opportunities for (a) fostering relationships between youth and adults and among youth; (b) cultural exchange; (c) intergenerational mentoring through increased parental and community involvement; (d) modeling of behaviors by peers and adults; (e) practicing democracy; and (f) meaningful participation in school and community for both youth and adults.

Influences on the development of the whole child

The MGBE predicts that changes in the learning environment described above will directly and indirectly affect participants' personal characteristics. The terminology "development of the whole child" is used in the MGBE to capture the wide variety of characteristics affected by garden-based learning experiences, including (1) knowledge acquisition (2) development of life skills, (3) academic and cognitive skills, (4) social and moral development including social competence, autonomy, problem solving, and sense of purpose, and (5) positive attitudes and preferences towards fruits and vegetables, and toward the school, community, and the environment.

Influences on academic achievement, and health related and environmentally responsible behaviors

The MGBE predicts that the changed learning environments and resulting effects on the development of the child will result in improvements in the following outcomes: (1) academic achievement including science and math test scores, grade

point average (GPA), discipline, and absenteeism; (2) health related behaviors including fruit and vegetable consumption, willingness to try vegetables, snacking behaviors, and physical activity patterns; and (3) environmentally responsible behaviors including composting and recycling. Further, based on findings in the nutrition literature, the MGBE also predicts an association between health related behaviors and academic achievement [6, 7].

Influences on the community and bioregion

The MGBE predicts that school gardens may affect community level outcomes of (1) public health, (2) ecosystem health, (3) local economic development, and (4) social capital directly through their influence on participating community members, and indirectly through youth and adults behaviors within the community. As more communities gain improvements in these areas, the cumulative effects may influence bioregional level variables.

Reciprocal relationships between model constructs

The MGBE predicts a dynamic relationship between the school's learning environment, students' personal characteristics and behavior, and the community, and posits that changes in one area may set in motion positive feedback loops among and between constructs. The MGBE predicts that changes in the school's environment will directly affect students' personal factors, behavioral factors, and community; the model also predicts that the effects on personal factors will in turn positively affect the school environment, behavioral factors, and the community.

Similarly, positive changes in behavioral factors or in the community will have positive effects on the other model constructs. For example, the MGBE predicts that changes in the school environment will increase the personal factor of social competence of the child. Students with increased social competence may in turn influence the school's social learning environment and the community as the student engages more meaningfully with peers and adults. Improved social competence may also affect the student's academic achievement and lead to increased positive health related behaviors.

PART II – How the MGBE was derived

The MGBE was developed through an iterative process that involved an analysis of the literature on a range of factors related to garden based education and a review of relevant theoretical frameworks.

1. Review of the literature

To build the model for school gardens, we reviewed the literature to identify potential program elements and outcomes of garden-based education. Since the purpose was to build an interdisciplinary model for garden-based education, we considered literature applicable if it pertained to school gardening or naturalized school grounds or farm-to-school programs, an emerging component of garden-based education in schools. One study that evaluated the impact of using the environment as an integrating context for education is included since gardening is considered one form of using the environment as an integrating context [8]. We

gathered literature from multiple fields of study, including health and nutrition behavior, environmental education, horticultural therapy, and plant-based studies. Because the experimental literature on garden-based learning is limited, and since the purpose was to build a comprehensive model, studies were included that represent a range of methods, including case study, anecdotal reports, and experimental.

A review of the literature found that garden-based education programs affect cognitive, physical, social and behavioral outcomes at the individual, school, community and, potentially, bioregional levels. The effect of the program on a school's environment is frequently characterized as a program outcome. In this paper, however, we classify changes in the school environment as 'program elements', because we hypothesize that, without these environmental changes, individual and community outcomes would not occur. In other words, the environmental changes are the necessary driver of the observed individual and community outcomes. However, the MGBE also posits that individual and community outcomes can in turn lead to positive effects on the school's environment, and in this sense we view changes in a school's environment as program outcomes.

This section describes the changes in the school environment identified in the literature and observed individual and community level outcomes. It also summarizes what we know about the causal relationships between program elements and observed outcomes.

1a. Program elements of garden-based education

The literature indicates that garden-based education programs may affect a school's curricular, physical, and social learning environments. Garden programs may affect the curricular learning environment by increasing or enhancing opportunities for hands-on, place and project-based education. The progressive activities of planning, planting, tending, harvesting and consuming produce alter the curricular learning environment by collectively engaging youth and adults in on-going processes [9-12]. In these ways, school gardens provide a real world context for learning that is distinguishable from typical hands-on learning activities in the classroom, which tend to be simulations of real-world experiences. Gardens may also affect the learning environment by providing a context for integrating curriculum from all classes and grade levels. Currently educators use garden-based pedagogy in all areas of basic education and subject areas including, science, math, social studies, language arts, environmental studies, nutrition, physical education, and agricultural studies [8, 13]. These integrated learning experiences naturally reinforce content and abstract ideas that students read about. Garden-based learning activities may also engage students' multiple intelligences [14-16].

School garden programs may also affect the physical learning environment. Naturalized school grounds generally improve physical living conditions, particularly in urban areas, as they mitigate the "cold" city climate, making the school surroundings setting more attractive and hospitable. Green schoolyards may also improve the environmental quality of urban areas by increasing shade, decreasing storm run-off, and improving air quality [17, 18]. Further, the produce,

flowers, herbs and other plants grown in school gardens encourage multi-sensory experiences by providing an array of tastes, fragrances, and textures [19-22]. Gardens and naturalized school grounds may also increase the diversity of vegetation, providing more diverse habitats for wildlife [17, 23]. Varied types of vegetation may also increase the number of different types of developmentally appropriate learning and play opportunities [17, 24]. In addition, the physical attributes of school gardens naturally reinforce learning by providing multiple exposures to and visual reminders of lessons [25]. Gardens also provide youth and adults with places of refuge, safer after school environments, and a physical location where they can connect with nature and nurture living things [26, 27].

Gardens have been observed to affect a school's social learning environment in ways that may fundamentally alter the school culture and identity [28, 29]. Starting and maintaining a school garden necessitates collaboration between youth and adults and among peers, both within the school and in the broader community. As a result, gardens increase the involvement of caring adults in education, health, youth, environmental and/or community issues and activities, much the way athletics do, but in a more nurturing, less competitive environment [13]. Engaging parents in school garden programs fosters family relationships [30]. School gardens and school-based community garden programs also provide opportunities for multi-cultural exchange and intergenerational mentoring [31]. This increases children's exposure to diverse role models, often from different walks of life [27], and allows for peer and adult modeling of desired behaviors [32]. Participation in schoolyard

naturalization projects has also been described as a valuable opportunity for youth to participate in democracy [33] and community [34].

1b. The effects of garden-based education on individuals

Garden-based learning experiences may affect children's content- and skills-based knowledge, academic and cognitive skills, social and moral development, and their attitudes and preferences toward fruits and vegetables and the environment. Evaluations of hands-on experiences in gardens or of using the environment as a context for learning have found that they increased students' knowledge of specific content areas, including math and science [35-38], agriculture [37], botany and horticulture [39, 40], ecological principals [37], nutrition [41, 42], and food systems issues [37, 41]. Garden-based learning experiences have also been shown to increase children's knowledge and development of life skills, including those needed to perform health and environmentally responsible behaviors, including skills related to healthy eating, composting, and recycling [25, 32, 37]. Garden programs have also been used to provide job training for adolescents [26].

In addition to facilitating knowledge acquisition, previous findings demonstrate that garden-based learning may enhance academic skills and cognitive development, including processing and inquiry skills, such as the ability to observe, communicate, compare, relate, order and infer [43]. Learning in the outdoor classroom has also been associated with increased student motivation [27], willingness to stay on task, and adaptability to various learning styles [16].

Garden-based learning experiences affect participants' social and moral development in ways that are supportive of positive youth development. Among factors associated with that development are civility [16], communication [16, 44, 45] [46], cooperation [27], decision making [45], delayed gratification [27], engagement [16], enthusiasm [27, 44], independence [27], nurturing [27], ownership [16, 30], patience [27, 46], pride [27, 44, 47], responsibility [30, 48], self esteem [26, 30, 44], self -understanding [45], self-confidence [44], self-discipline [16], self-efficacy [32], sense of place [37], and teamwork [44, 45].

Coupling nutrition education with gardening experiences, where students taste food they have grown has been shown to increase their preferences towards fruits and vegetables [42, 49, 50], and improved their attitudes towards healthy foods, including minimally cooked whole grains and vegetables [32, 51]. These experiences have also been shown to influence the meanings students attach to foods [19, 28, 52]. Garden-based education may also affect students' attitudes towards school, science and learning [38, 48, 53]. Students' attitudes towards the community, including their social concern, may be affected through school garden activities that involve community members in creating projects or through service-learning programs [54]. Hands-on experiences in nature affect students' environmental attitudes, including their concern and appreciation and awareness for the environment, as well as their environmental ethics [37, 38, 55-57].

Experiences in a school garden program may affect participants' academic achievement and increase their performance of health- related and environmentally responsible behaviors. Research on garden-based learning and schools that use the

environment as the integrating context for education have found that these pedagogies may increase students' achievement test scores and GPA, and lead to a decrease in discipline problems and absenteeism [12, 16, 35, 37, 58, 59].

Additionally, garden-enhanced education has been shown to positively affect students' health behaviors. Studies have shown that after participating in a garden-based learning program, students increased their consumption of fruits and vegetables, willingness to try vegetables, healthy snacking behaviors, and physical activity patterns [25, 37, 50, 60, 61]. School gardening experiences were also found to increase students' performance of environmentally responsible behaviors including, composting, recycling and starting gardens at home [21, 27].

1c. The effects of garden programs on the broader community

School garden and farm-to-school programs may affect community and bioregional level variables including, promoting public health, ecosystem health, local economic development, and social capital [11, 62-64]. Numerous examples demonstrate that school garden programs that involve students, their families, and neighbors in projects contribute to the well being of their communities [30]. Community integration activities include creating schoolyard wildlife habitats, school-based community gardens, service learning projects, and farm-to-school programs [23, 52, 65, 66]. These types of projects may improve public health by promoting fruit and vegetable consumption and physical activity [52, 67, 68]. They may also affect ecosystem health by enhancing the livability of urban ecosystems for humans and other flora and fauna [17]. Further, pairing school gardens with

farm-to-school programs encourages environmentally responsible, socially just, local economic development. These programs further seek to improve the health of both individuals and the ecosystem, increase community food security, and promote social capital [69-71]. Lastly, while previous research has not yet quantified the effects that gardens may have at the bioregional level, such an effect is hypothesized in the literature [72]. Gardens may affect bioregional level variables by virtue of their association to community level variables.

Id. Causal Relationships between program elements and observed outcomes

Research in the field of school gardens has not, to date, provided a strong empirical basis for direct causal relationships between program elements and student or community level outcomes. It is most likely that causal linkages are not well documented in this literature both because of the difficulties of conducting research in this field and because it has not been an area of interest until relatively recently [73, 74]. However, other fields of study have described causal relationships between similar program elements and observed individual and community outcomes. For example, research on place-based education links this pedagogy with the creation of learning environments that support positive behavioral change, improve students' motivation, and increase community participation in students' learning [75].

2. Existing theories that predict the observed outcomes based on program elements

While several distinct theories and conceptual frameworks account for some of the observed outcomes of school garden programs [5, 76], no single theory adequately explains or predicts the range of effects of garden-based education programs on multiple variables (including cognitive, psychosocial and behavioral), nor does one theory address the mechanisms by which garden programs affect outcomes at different levels: individual, school, community, and bioregion. This section describes the SCT and RM and demonstrates how a synthesis of the two provides the best model of garden-based education in a school setting. Figure 3 provides an overview of the SCT, RM and MGBE.

2a. The Social Cognitive Theory (SCT)

The SCT posits that behavioral, personal and environmental influences interact continuously in a reciprocal manner [77]. The SCT has been widely used to develop interventions that positively influence health behaviors in children [77-79] [77, 80]; however, the constructs are also congruent with current thought on what predicts effective environmental education programs [81].

The SCT may be applied to a school garden context to understand, predict and influence children's health related and environmental knowledge, attitudes, and behaviors. As predicted by the SCT, changes in the school's learning environments may engender dynamic interactions between behavioral, personal, and environmental factors. Specifically, garden programs offer educators opportunities to teach math, science, art and language arts through hands-on experiences that

simultaneously teach behavioral skills needed for growing, harvesting, and preparing produce for consumption, and for performing environmentally responsible behaviors. These experiential learning opportunities may directly influence children's behaviors because they increase opportunities to consume vegetables, be physically active, and perform environmental actions. These experiences may also influence students' knowledge, behavioral capability, cognitive skills, self-efficacy, attitudes, and preferences, because they provide numerous occasions for observational learning, reinforcement, and adult and peer modeling of behaviors. These personal outcomes may in turn influence academic achievement, healthy behaviors, and environmentally responsible behaviors. Additionally, performance of many of the environmental actions, such as composting, may in turn enhance the influence of the garden on the school's learning environments.

The SCT predicts many, but not all, of the outcomes found in the garden literature. For example, the self-efficacy concept in the SCT does not fully address the 20 youth development assets attributed to garden-based learning experiences. The behavioral construct does not predict students' academic achievement or adequately explain the varied community level outcomes that appear in the garden-based education literature. The RM addresses these gaps.

2b. The Resiliency Model (RM)

Broadly speaking, the RM states that external developmental supports may lead to improved behavioral outcomes directly, or indirectly through support of the development of personal resiliency traits. External developmental supports include

caring relationships for youth and adults, high youth-centered expectations, and opportunities to participate meaningfully in the school and the community. The four personal resiliency traits include social competence, problem solving, autonomy, and sense of purpose. The behavioral outcomes for individuals and / or communities include academic achievement, improved health, and success in life [82].

As applied to a school garden context, the RM helps explain the observed influence of the garden on factors related to youth development, students' academic achievement, and community level variables. Specifically, it predicts that if a garden program contains 'meaningful opportunities to participate in the school and community' and 'opportunities to develop caring relationships with others,' it will lead to positive youth development and academic achievement. Based on the RM, these two program elements are also precursors to influencing community level variables attributable to public health and social capital [82]. In addition, the resiliency traits construct of the RM provides a comprehensive organizing structure to categorize the numerous youth development assets associated with social and moral development identified in the literature (Table 1).

In sum, the synthesis of the SCT and RM provides theoretical support for the assertion that the observed cognitive, social and behavioral outcomes cited in the school garden literature are attributable to the effects of program elements on the schools' learning environments. While most of the variables can be reasonably included within one of the constructs in this model, it still does not include the community level variables of ecosystem health and economic development, and the

bioregional level construct. For this reason, these two variables are also specified in the model.

PART III - Model Evaluation

As discussed above, the proposed MGBE was derived from existing literature on garden-based education and theoretical frameworks that explain findings in the literature. This section presents qualitative research conducted to empirically explore the applicability of the MGBE as an organizing framework for school garden programs.

Methods

Qualitative data were collected from students and teachers who participated in two school garden programs in the San Francisco Unified School District during the 2003-2004 school year. The programs combined classroom instruction with garden activities where students planted, tended, harvested and consumed vegetables they grew as part of the required science curriculum for an average of thirty minutes a week over four months. Each garden program had at least one community event, including weekend garden work parties. One school hosted a ‘salad day’ during lunchtime, where students served their peers lettuce they had grown.

Data collection activities included focus group interviews with students and adults, and in-depth personal interviews with adults. Separate focus groups were held for male and female students. There were three to six students per group. In

total, 28 students participated in one of the eight group interviews that took place at the end of the school year. Additionally, fourteen in-depth personal interviews were conducted with adults, including key informants, teachers, school principals, a district garden-curriculum coordinator, citywide advocates, and a statewide leader of the garden-based learning movement. The questions used in the student focus groups and the adult in-depth personal interviews are presented in Table 2.

The Principal Investigator conducted all personal interviews and focus groups. The student focus groups and the interviews with adults were audio recorded and then transcribed. Using qualitative analysis procedures and N-Vivo 2.0, coded transcript segments were repeatedly sorted and summarized until coherent themes concerning the effects of school gardens on individuals, schools, the community, and the bioregion emerged. The Tufts University Institutional Review Board and the San Francisco Unified School District's Office on Human Subjects approved this study.

Results

Influences on the school's learning environments

In total, 32 thematic statements were identified regarding the influence of the garden programs on the schools' curricular, physical and social learning environments. Selected quotes presented below represent the major themes identified.

Curricular Learning Environment (11 thematic statements): Educators' and students' responses suggest that the school garden program influenced the curricular learning environment in the ways proposed in the MGBE. Teachers indicated that the garden created a “*living laboratory*” for “*hands-on learning*” that “*engages different learning modalities*”, provided opportunities to “*re-enforce abstract concepts youth read in books*”, and engaged students and adults in a “*real process*” [Educators, Interviews #16, #6, and #9]. The following two quotes illustrate that educators distinguish learning in the garden from classroom instruction and from other hands-on experiences, because it engages youth and adults in a real, ongoing process with other living things.

It is so fundamental that you grow these plants ...these are real [and you get] such an ownership that you just don't get from the regular classroom, no matter how classroom activity oriented it is...I do not think there is any way that something like that could be duplicated [School Principal, Interview #9].

There's not a separation in the human mind; the emotional part and the intellectual part work together. And if you're teaching to the intellectual part and you haven't engaged kids emotionally. Then the kids aren't engaged. That's why I think in things like gardening. There's an excitement...real plants are growing, real food... we're involved in a process [Science Teacher, Interview #8].

Students also distinguish garden-based education from classroom learning. Students in every focus group indicated garden-based education was “*fun.*” Although several equated learning in the outdoor classroom as “*play,*” they also noted that it was about “*learning more about the earth, flowers, atmosphere...instead of having to do... workbooks*” [Focus group #3]. Students also indicated that it was “*easier to learn outside than in the classroom*” because “*you are a part of it*” [Focus groups #3 and #2].

Physical Learning environment (11 thematic statements): As proposed in the MGBE, comments from students and teachers indicate that the garden enhanced the physical environment of the school. Participants characterized the urban environment where they live, work, and play as unsafe and full of “*lifestyle hazards*” due to high levels of “*crime and violence*” [Interviews #17 and #18]. Adults characterized the effects of the school garden on the physical environment as “*improving the urban aesthetic*” by making the school more “*appealing*” and “*inviting*”, and “*less like a prison yard*” [School Principal, Interview #9]. Students similarly commented, “*just the plants growing...made it look like our school was cleaner*” [Focus group #12]. Educators also noted that the gardens created an “*urban oasis*” for youth to “*connect to the earth*” [Educators, Interviews #14 and #7].

The main reason...why we need this garden, is that there has been a tremendous disconnect between the kids...[and] the earth...They are living in the asphalt jungle.... It is causing a lot of...behavioral problems, violence...[Educator, Interview #7].

The two quotes below demonstrate that the garden provided a place of refuge, and a safe alternative to going home after school for students.

I think it is just fun to have a garden, like when you are feeling upset you can go there and be with the flowers and trees [Student age 11, Focus group #5].

I would rather stay in the garden than go home because there is not that much at home. Even though lots of kids like to watch TV, it is fun doing gardening. It is nice being outside. You know how some people don't let you outside after school, so I like being at school more better than being at home... School is a safe environment [Student age 12, Focus group #5].

Social Learning Environment (10 thematic statements): Responses indicated that the garden program influenced the school's social environment in ways proposed in the MGBE. Educators noted that the garden provided much-needed opportunities for youth to participate meaningfully in the community and “do something that matters” [Science Teacher, Interview #8]. Principals noted that the garden provides opportunities for adults to participate meaningfully in their children’s education and for intergenerational mentoring.

In a neighborhood like ours where...a lot of the families are blue-collar workers and not college educated...they do not necessarily relate[school] to a warm...family kind of feeling. ...That Saturday that we did our garden thing... I did not see any other activity that we had that [school year with] that kind of percentage of parents. I know why they came, because... they could dig holes, they could help the kids,...they could-actually teach, and...feel like they were not being talked to... in language that they really don't relate to.... So [gardening] is a huge opportunity to involve the community [School Principal, Interview #9].

Two adults also indicated that the school gardening experiences provided opportunities for youth and adults to see each other differently and to develop collaborative relationships.

This is real, ...and when they can connect it to their regular education, and the people who are involved with their regular education, ...all of a sudden they have a different view toward us. ...It is something we are doing together. I think it is wonderful [School Principal, Interview #9].

The garden also changed the social environment for youth. Students acknowledged that it created a different space for them to work and play. Students also noted that the garden made them work with people they normally would not have worked with. They appreciated the inclusiveness and likened it to a family situation.

I think being in the garden it is lot easier and more funner to make friends and just talk about things about your life [Student age 11, Focus group #3].

When you have a garden everybody is a part of it, nobody is left out, and everybody is doing their thing. It is an ohana [Student age 11, Focus group #3]. Note: ohana means “family” in Hawaiian

Influences on the development of the whole child

Twenty-six thematic statements were identified that indicate the influence of garden-based educational learning experiences on students’ personal characteristics. Two of those statements indicated there were also personal benefits for the adults who work with youth in the garden. These included *patience, focus, respect for natural processes and other human beings, gentleness, behavioral capacity, teamwork, multicultural cooperation, self-efficacy, self-awareness, pride, ownership, happiness, sense of accomplishment, work ethic, cultural identity, and knowledge*. Table 3 categorizes these variables by the respective RM resiliency traits. The following student quotes illustrate ways they noticed gardening influenced them. They are coded in this study as responsibility and behavioral capacity.

I think [gardening] teaches you responsibility, like to water the plants. ...Because if you don’t they will die and then it would be your fault [Focus group #2]

I learned to cook...I got to learn a lot, a lot of new flavors, a lot of new recipes, like with carrots in the spaghetti, stuff like that [Focus group #1].

Adults identified personal characteristics affected by the gardening experiences, among them teamwork, empowerment, ownership and cultural identity.

I think school gardening is...an active empowerment for the kids...and also shows the teachers that they have ownership of the school. ...You have kids who normally would not work together....

They may come from different backgrounds, different ethnic groups, different social groups, but in the garden they work together and achieve a goal, and I like that. There is also the satisfaction, I think, on the part of the kids that this is their place [School Principal, Interview #16].

I had a Samoan boy who recently immigrated and his father died and he was in a catatonic sort of state, and I started taking some Samoan kids out during my free time and what happened? He got happy. ...I said you should go to college and study agriculture, and he said oh, I already know this, because back home we are farmers and he told me about his farm. He then kept getting better and better. ...He went from being catatonic to being a superstar [Science Teacher, Interview #15].

Five students made direct references to curriculum content, such as ‘*the water and carbon cycle*’ during the focus groups [Educator, Interview #12]. Additionally, one teacher noted that students appeared to remember some of the things they learned, and to be gaining knowledge of vegetables.

I was impressed...they remembered the food web exercise, and the afternoon class also remembered the word photosynthesis. They even remembered all the vegetables we have grown and cooked with [Science Teacher, Interview #13].

Growing food in the garden and cooking it also appears to have influenced students’ attitudes towards vegetables, and their perceptions of soil and garden-grown vegetables.

I like some of the vegetables more because... when you think of beans or...broccoli, you think they are all soggy and... disgusting and mushy like peas. But then when you cook them in a way that you don’t just go out in the store and...buy it, it feels more better. It just feels fresher [Focus group #4].

A number of students stated that after the gardening experiences they felt more comfortable both touching and eating vegetables, and they felt that garden produce

was fresher and nicer to eat than store-bought. In the conversation below, the adult interviewer (“A”) is conversing with a group of five youth (“Y”).

Y: At first [the garden] was all junky. And to eat it? I didn't want to put my hands on some dirty.

A: I am wondering if you didn't like it at first, what did you, or anyone else, think about vegetables at the end.

Y: I feel free to touch them now.

Y: And they aren't all moldy.

Y: In the beginning I wouldn't even try and eat those.

Y: I didn't want to go out there.

Y: Whatever they are called, fava beans. I wouldn't even touch those. Now they taste good.

Y: ...now that in the end, the vegetables are more cleaner so we will be able to touch them... [Focus group #12].

Influences on academic achievement, and health related and environmentally responsible behaviors

As postulated in the MGBE, the school garden program was perceived by teachers to influence both students' academic achievement and behaviors related to improved health and the environment. Educators also attributed improved academic performance of failing students to the garden program. One educator also hypothesized that the garden may decrease students' absenteeism.

I remember a few years ago...Home Depot came in, on their volunteer time...and brought us a whole bunch of...bags of soil...tools...their own expertise, and they started working with the kids on different projects. ...They said at the end of the day they were going to have awards for the students...and almost without exception, the students they picked [as winners] -they did not know anything about our students- were kids who had huge behavior problems at the school, and were not passing classes. -I stood back and watched myself and I agreed with them [School Principal, Interview #9]

“I think they like gardening, so they like school and their attendance will probably be a little better, not a lot better...” [School Principal, Interview #9].

During the focus groups, students attributed a total of 23 actions related to health and 32 actions associated with environmental responsibility to participation in a garden program. Students noted that because of the garden, they performed the health-related behaviors of ‘tasting’, ‘cooking’, ‘touching’, ‘cleaning’, and ‘trying new vegetables’ [Focus groups #1, #2, #4, and #11]. They also indicated that the garden increased their levels of physical activity because it provided opportunities for them to ‘run’, ‘carry buckets’ and do ‘work’ [Focus groups #3, and #4].

Most of us [students] only get one or two [physical] activities ...every month or so, but doing the garden we get like three or four or five [Focus group #3].

Environmental action students performed in the school garden program included mulching, ‘composting’, ‘picking up trash’ and ‘planting’ [Focus groups #2, #4 and #1].

Twelve participant statements indicated a desire to do things in the garden in the future. If carried out, these would constitute performance of health-related and environmentally responsible behaviors. For example, many students reported that they would like to “plant more so that they could harvest, cook and eat more fruits and vegetables” [Focus group #1]. These stated desires demonstrate that experiences in the garden influenced students’ behavioral intentions. In the conversation below, students indicate that next year they want to continue cleaning up the school area and taking responsibility for the garden.

Y: By just the plants growing in our school, made it look like our school was cleaner. ...Next year we should...go over there by Ms. Indy’s class...to clear out all the junk from there.
Y: Yeah, you got to clear all the junk out from there.

Y: Because when the garden was first there...it was all looking junky, and the kids were littering in there, and I would not do that because if...it was your garden and they were littering in it, wouldn't you want them to pick it up?

A: Do you feel like it is your school garden? Do you feel like it is yours? Mine?

Y: No. It is all of ours.

Y: Yeah. It is all of ours, so we need to clean it up and make it nicer.

Y: We need to be responsible for the garden [Focus group #12].

Influences on the community and bioregion

Participants' comments regarding community fall into three categories: the positive influence of the garden on the physical environment of the community, the social environment of the community, and students' behavior within the community. Fourteen thematic statements associated the school garden program with the larger community.

Students commented that the school garden physically improved their school, and they saw their gardening efforts as a meaningful contribution to the broader community.

We made our school garden look... greener. ...It is nice now. Now I am not embarrassed about coming to school [Focus group #12].

I am able to go to sleep at night knowing that I have helped my community and made my community a better place [Focus group #10].

Educators noted that the gardens created a focal point for the diverse urban community in which the schools are located. The gardens brought the community together by creating multiuse centers, and by allowing adults to see youth differently.

We have an old folk's home next door, they go and weed the garden. ...The bilingual class...of adults that meets in our building, they go

out into the garden and the teacher is able to teach them the English words for the plants... so it is a laboratory classroom for them [School Principal, Interview #16].

[School gardening] brings the community together. I think that a lot of times the community members see the kids as disruptive. They do not see kids as nurturing things, and so the garden gives an opportunity for the neighbors to see that kids can build and grow something, and work in positive ways. ...A lady drove by the other day and saw the kids out there working, so she went to the store and bought some plants, came back and gave them to the kids [School Principal, Interview #16].

Youth are also influencing the larger community by taking the skills they learn at school home with them. For example, two students indicated that they started gardens at home after learning how to do it at school, and after being given seeds that they then brought home to plant *[Focus group #4]*.

Relationships between model constructs

Seventy-eight thematic statements reflected a reciprocal relationship between the influence of the garden program on two or more of the environmental, individual, and / or community level constructs. The following quote illustrates the dynamic influences of the school garden on the school's learning environment, the community, and the student's personal characteristics and behaviors.

I learned [gardening] can be so beautiful. It can be healthy for you too. If you have no plants, then we can't live because they produce oxygen and we produce carbon dioxide. It makes you happy to take care of something, and when you are done you feel so happy about it that you just want to participate in what you are doing... We should [also] have more people working on gardens so people can live longer because if you eat vegetables you live longer. Then you get more energy and life and exercise more to lose weight. ...[And] ...I would like to see...more people working on gardens more than watching TV...so they would learn about it, and understand why you need vegetables and gardens in our lives [Focus group #4].

This quote suggests directional relationships for many of the variables in the model. For example, the student's comment that gardening made her feel happy, and that because she felt happy, she wanted to continue to participate in the garden indicates a reciprocal relationship between the learning environments and the students' personal characteristics. Additional causal relationships include the influence of the garden on the learning environments, and the resulting effects on the student's knowledge and attitudes. Her comments also indicate that community involvement in the school garden may lead to improved healthy behaviors. Based on her other statements, it is also possible that provided with additional opportunities to garden at school, the personal desire to continue gardening would result in further increases in physical activity, consumption of vegetables, and additional understanding of ecological processes. Further, this student's rationale for wanting to get other people away from the TV and into gardening supports school gardening as a compelling pedagogy for this population to learn about the connections among health, academics, and ecology.

Discussion and Conclusions

Based on analysis of these qualitative data, we conclude that the constructs and conceptualizations of the MGBE are useful to explain school garden program outcomes. All but one of the MGBE constructs were present in an actual program. No data confirm the inclusion of the proposed bioregional level construct, but this is not surprising since we did not look for it directly. The findings also support the inclusion of most variables within MGBE constructs, but did not speak to a handful

of conceptualizations. For example, while data suggest that the school garden experience may have affected some scholastic behaviors, such as grade point average and student attendance, we did not directly evaluate these outcomes. Further, as proposed, the MGBE represents potential outcomes. It is likely that not all garden programs will result in all outcomes. The effects of garden programs on individuals and the community will likely depend on the extent to which a program influences the learning environments.

In addition, the qualitative findings identified ‘behavioral intentions,’ a variable that was not discussed in the literature or predicted by the SCT or RM, and not included in the MGBE as first proposed. Since many youth said that they wanted to do more of certain activities, such as ‘cooking’, ‘planting’ or ‘harvesting,’ in the future, we include the variable ‘behavioral intentions’ in the MGBE as part of the behavioral factors construct.

Finally, a major challenge to developing a cross-disciplinary theoretical framework is that the final result needs to be meaningful to both practitioners and researchers across a number of disciplines and communicated in a language that they all understand. Once we determined that the proposed MGBE was robust, we asked elementary and middle school teachers, garden-based educators, and experts in the fields of education, nutrition, youth development and ecoliteracy for their input into the final model. Most teachers suggested that they would prefer a simpler version. Researchers and several teachers preferred a version that included all of the variables. To meet the needs of the different user groups, we have included both. Figure 1 is the MGBE for researchers and Figure 2 is for practitioners.

Part IV – Summary and implications for researchers and practitioners

Based on an analysis of the literature including that which describes relevant theories, and on qualitative research, we conclude that the MGBE is a cohesive framework for explaining and predicting the effects of garden-based education on children, schools, communities, and bioregions. The MGBE articulates a polytheoretical, behaviorally based model for garden-based education that may help define the discipline, inform practice, and contribute to the development of coherent research and evaluation literature.

The MGBE, which was built from a broad range of sources, extends the model first proposed by Ozer [5], but it has two limitations. First, personal and behavioral factors are presented in terms of effects of school gardens on children, because the literature is largely limited to discussion on the effects on children. However, it is likely that adults, including teachers, parents and community members' attitudes and behaviors may also be affected by participating in a school garden program. As research in this area progresses, the MGBE will likely evolve. Second, the community and bioregional level constructs require additional empirical support. There is limited literature on both.

Future research on the MGBE should also test the causal linkages between and among construct variables. Complex causal relationships between the school garden program, personal characteristics, and behavioral and community outcomes in a garden context need to be described in order to identify which program

elements are the most effective in creating the desired changes in knowledge, attitudes and behavior.

Practitioners from diverse fields may use the MGBE presented in Figure 2 as a guide to developing and evaluating theoretically driven, behaviorally based school garden programming. As educators plan the school year, curricular units, and individual lessons, the "Program Design" box offers a checklist to ensure the overall program enhances the school's learning environments in as many ways as possible. We hypothesize that the more program design elements a school garden program incorporates, the more positive effects will result. Educators can then use the "Program Outcomes" boxes to identify the desired impact of the garden program on students, the community and/or the bioregion. Once desired outcomes are identified, appropriate evaluation tools may be developed and used. In this way, the MBGE can act as a tool to systematically document what school garden programs entailed and what outcomes were achieved. These data are critical to the development and dissemination of successful programs...

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Figure 1: The Model for Garden-Based Education in school settings: A
 Research Tool

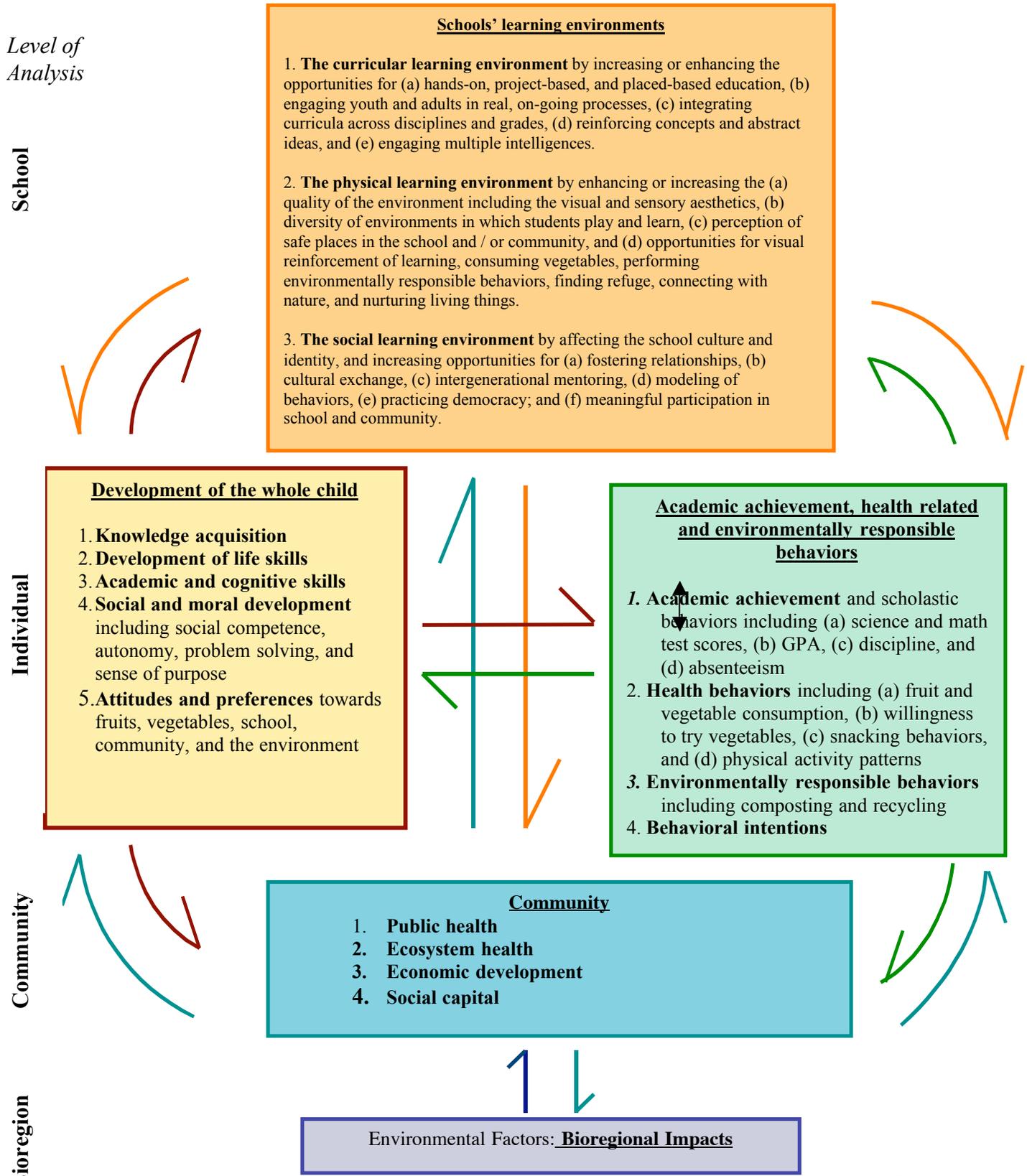


Figure 2. The Model for Garden-Based Education in school settings: A Tool for Educators

DIRECTIONS: Use this model to plan and evaluate your school garden program. As you plan your year, units and individual lessons, use the Program Design box as a checklist to make sure the overall program enhances the school's curriculum, physical and social learning environments in as many ways as possible. Then use the Program Outcomes boxes to identify the impact you want the program to have on students, the community and / or the bioregion. Check all boxes that apply, and specify where applicable.

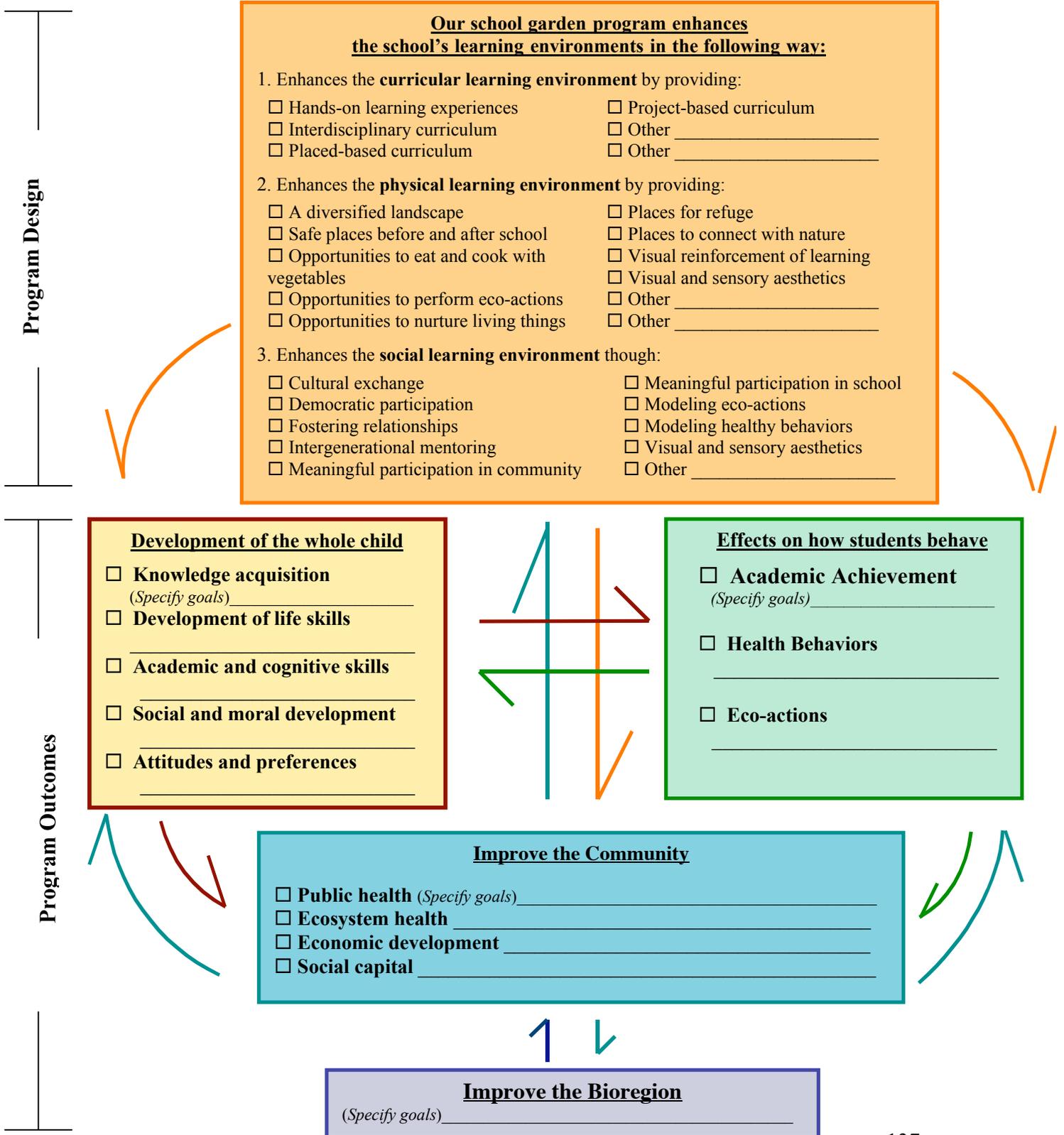


Figure 3. The Social Cognitive Theory (SCT) and Resiliency Model (RM) model constructs applied to garden-based education, and the Model for Garden-based Education in school settings (MGBE).

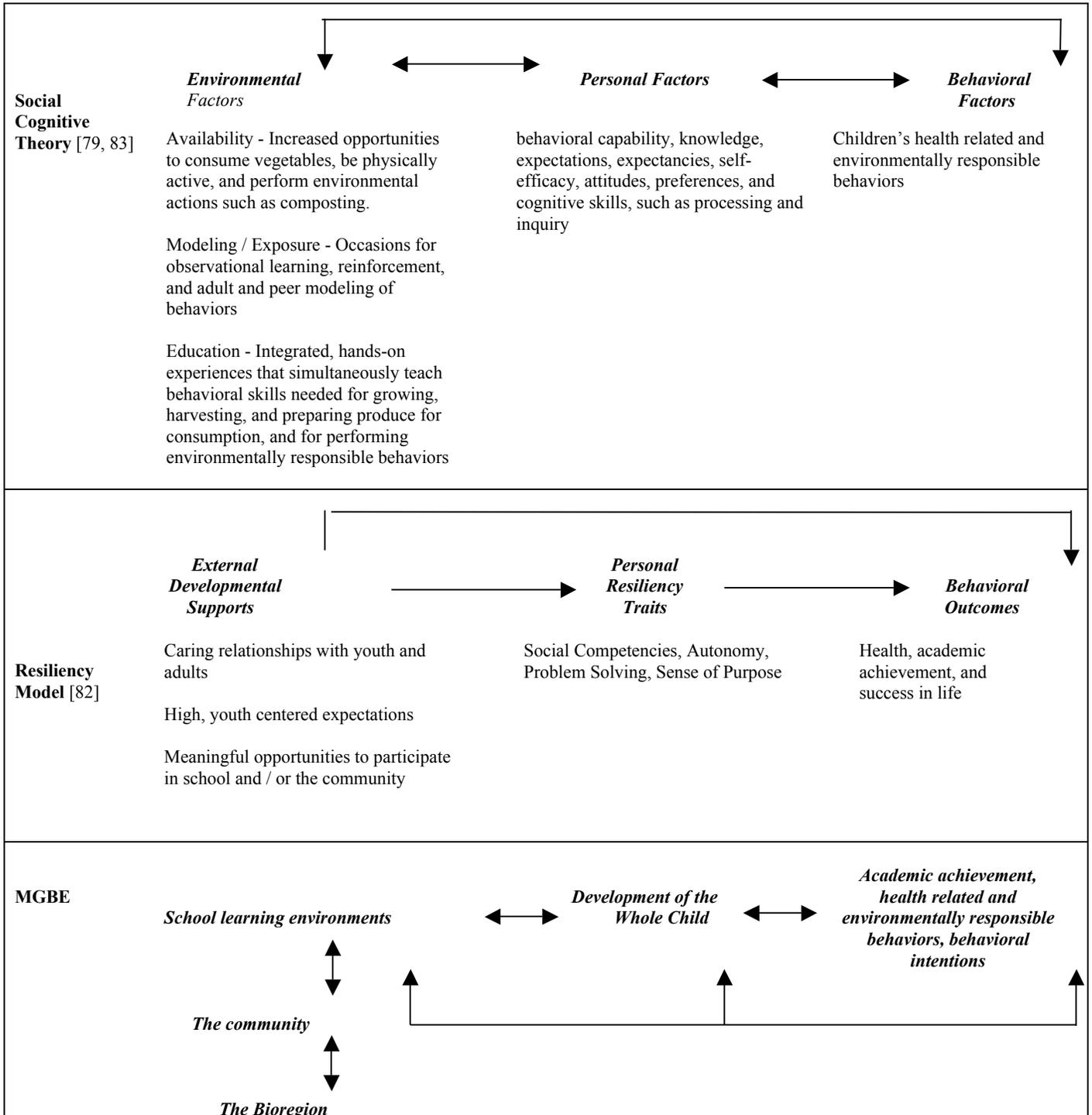


Table 1. Personal traits related to garden-based education organized into the Resiliency Model’s social competence, problem solving skills, autonomy, and sense of purpose constructs.

Resiliency Trait	Social Competence	Problem Solving	Autonomy	Sense of Purpose
Variables identified in the literature to have been affected by garden-based educational experiences	Civility [14] Communication [14, 42, 43] Cooperation [24] Delayed gratification [27] Engagement [16] Enthusiasm [27, 44] Nurturing [27] Patience [27] Responsibility [30, 48]	Decision making [45] Teamwork [44, 45]	Independence [27] Self esteem [26, 30, 44] Self esteem [27] Self -understanding [45] Self-confidence [44] Self-discipline [16] Self-efficacy [32]	Ownership [16, 30] Pride [27, 44, 47] Sense of place [37]

Table 2. Prompting questions for adult and student interviews

Adult in-depth personal interviews

1. What do you think about school gardening?
2. Does gardening with the kids work? What works? What doesn't work? Why?
3. Describe a time in the garden when you thought, "this is going really well."
4. Describe a time in the garden when you thought, "this is going really bad."

Student Focus groups

1. What do you think about school gardening?
 2. What did you like best? What didn't you like?
 3. Why do you think your teacher took you out in the garden for class?
 4. What do you think we should we do more of in the garden next year?
 5. What do you think we should we do less of in the garden next year?
-

Table 3. Personal factors affected by participation in garden-based educational experiences.

Resiliency Trait	Social Competence	Problem Solving	Autonomy	Sense of Purpose
Variables identified in this study to have been affected by garden-based educational experiences	<ol style="list-style-type: none"> 1. Citizenship Skills 2. Cooperation 3. Gentleness 4. Patience 5. Respect 6. Responsibility 	<ol style="list-style-type: none"> 7. Behavioral capacity 8. Decision making 9. Focus 10. Mastery of skills and knowledge 11. Multicultural cooperation 12. Teamwork 13. Work Ethic 	<ol style="list-style-type: none"> 14. Happiness 15. Self-awareness 16. Self-efficacy 	<ol style="list-style-type: none"> 17. Cultural Identity 18. Ownership 19. Pride 20. Sense of Accomplishment

CHAPTER 7: SUMMARY AND DISCUSSION

This dissertation project initially sought to explore the potential of hands-on learning experiences in a school garden to improve children's nutrition behavior and to prevent environmental degradation. As the study progressed, it became evident that in order for evidence-based interventions on school gardening to progress, a comprehensive conceptual framework was needed. This chapter summarizes the key findings of this project, discusses the implications of the results, and presents suggestions for future research needs.

I. Key findings and implications

A. Knowledge, attitudes, and behaviors associated with vegetable consumption

1. Findings

Ability to correctly identify vegetables: This study demonstrated that sixth grade students increased their ability to correctly identify vegetables. This finding is consistent with previous research with younger children [1]. Since knowledge is often associated with attitudes and is considered a necessary precursor to behavior change [2-4], an important implication is that increased knowledge about vegetables may lead to improvements in attitudes toward and consumption of them.

Attitudes towards and preferences for vegetables. Results from the Garden Vegetable Frequency Questionnaire (GVFQ) and qualitative data presented in this study indicate that the gardening experiences influenced students' attitudes towards and preferences for vegetables generally, and specifically for those they grew.

However, while previous research using a similar taste test methodology found an increase in students' preferences for vegetables after participation in garden-enhanced nutrition classes [5], the taste test survey used in this study found no statistically significant improvements.

Willingness to try vegetables. Results from the GVFQ demonstrate that after their experiences, students in the garden group reported having tried significantly more vegetable varieties, including both those that were and those that were not grown in the garden. As measured by the taste test, however, there was no statistically significant improvement in the garden groups' willingness to taste the vegetables. Again, previous research using a similar taste test methodology did demonstrate a significant increase in younger students' willingness to taste vegetables.

The inconsistency in preference and "willingness to try" results between the taste test and the GVFQ, and between the taste test and a previous study using similar methodology, may be due to differences in the vegetables used and the smaller sample size who completed the taste test in this study. It may be that the GVFQ is a more sensitive measure because it asks about a greater variety of vegetables.

Vegetable variety consumption. Based on self-reported consumption captured by the GVFQ, students who gardened significantly increased the average number of vegetable varieties they consumed more than once a month, both for those they grew and those they did not. Taste test results indicate they ate a significantly greater variety of vegetables at school, but not at home.

The observed increase in vegetable consumption may have been influenced by the increased availability of vegetables provided by the school garden program. However, the fact that students also increased their consumption of varieties not grown in the school garden indicates that the changes are likely also due to the effects on students' willingness to taste and eat more vegetables outside the school setting. Students did not increase the number of vegetable varieties they consumed at home, possibly because they were not available at home, or because they were prepared in a way that the children would not eat them.

2. Implications

The above findings have three important implications for policy and programming. First, the reauthorization of the 2004 Child Nutrition Act required all institutions participating in the federal school meal program to establish a local school wellness policy by the 2006-2007 school year [6]. As districts are now drafting the administrative directives that specify how those policies will be implemented, consideration should be given to the potential for school garden programs to contribute to the achievement of wellness policy goals. School gardens are a particularly appealing intervention strategy for carrying out wellness policy goals because they are relatively inexpensive programs, and have been found to promote academic achievement and to support positive youth development [7-13]. There are already a few examples of districts across the country utilizing garden programs to meet their wellness goals [14].

Second, the findings suggest that interventions that increase the availability of fresh produce in schools should be coupled with hands-on experiences in the garden. For example, in response to the obesity epidemic, numerous schools across the country are actively incorporating more fresh fruits and vegetables into school meals [15]. It is unlikely, however, that simply increasing vegetables in the cafeteria or classroom will lead to increased consumption [16]. Based on this study, a potentially more successful strategy may include providing opportunities for students to learn more about the produce and at the same time, to taste it through activities such as gardening.

Third, the finding that students' consumption of vegetables at home did not improve suggests that garden programs should consider how to include "home components." These may include providing fresh, garden grown vegetables directly to families, and/or teaching caregivers how to prepare them in ways that students prefer. School-site based Community Supported Agriculture (CSA) programs are one example of opportunities to increase families' access to garden grown produce. Other "home components" could include coupling existing school events, such as parent nights, with cooking demonstrations. Given the unique interests, expertise and resources available, decision-makers at individual school sites may be in the best position to determine how to incorporate more parental involvement in garden related activities. Again, the administrative directives of the wellness policies may be a good place to encourage schools to do so.

B. Knowledge, attitudes and behaviors associated with ecoliteracy

1. Findings

Ecological knowledge. Students who participated in hands-on garden based learning experiences significantly increased their overall environmental science knowledge score, including responses to questions that specifically conform to the California State Standards for Sixth-grade Science. These findings support previous research on school gardening and, more broadly, on using the environment, have found associations between such programs and improved academic achievement [13, 17].

Ecological attitudes. There was a small, but non-statistically significant improvement in students' environmental attitudes after participating in the garden program. Qualitative data from teachers at both garden school sites suggested, however, that the gardening experiences may have influenced students' attitudes towards soil and insects. The ecoliteracy survey questionnaire did not address these specific variables.

Environmentally responsible behaviors. Based on self-reported behavior, students who participated in garden-based learning significantly increased their frequency of ecological behaviors that they “sometimes” perform. These results are consistent with previous research that similarly demonstrated an increase in performance of ecological actions after participation in a school garden program [13].

These findings call into question the assumption that positive environmental attitudes are a necessary precursor to the performance of environmentally

responsible behaviors. Results from this study suggest changes in behavior were not mediated by changes in attitude. The Social Cognitive Theory (SCT) [18] and the Model for Garden Based Education (MGBE) offer a framework for understanding this apparent incongruity. Both predict that school gardens may directly lead to behavioral change by altering the environment and providing opportunities to perform these behaviors without changes in the personal factors of knowledge and attitudes. Results from this study suggest changes in behavior were not mediated by changes in attitude, lending further support to the use of the MGBE in the development and evaluation of school garden programs. In other words, the MGBE suggests that it is the *assumption* that is incorrect, not that the results are inconsistent with a predictive theory.

2. Implications

Two commonly cited barriers to implementing garden programs are that teachers are already over worked, and must focus on preparing students for the state tests. In this light, gardens are often viewed as an “add-on” that takes away from what is assumed to be more valuable instructional time. These results suggest instead that garden-based education is an effective method to improve students’ standardized test scores for science, and could replace classroom instruction time rather than be an addition to it.

The finding that a significant increase in environmental attitudes is not necessarily required to produce an increase in environmental behaviors is also important. As predicted by the MGBE, changes in the physical, social, or curricular

environment created by school-garden programs may lead directly to increased environmental behaviors. For example, changes in the physical environment may reduce barriers to performance of environmental behaviors, and therefore increase their performance. Improved behaviors may result because the student had a pre-existing positive attitude that was not altered by the school-garden program, or because the barriers have been reduced to the point where it is actually easier to undertake the environmental behavior than not. For example, students may increase how often and how much they compost if collection receptacles are clearly marked and conveniently located. Changes in the social environment, specifically changes in social behavioral norms, may also increase environmental behaviors without changing environmental attitudes. Students may decide to perform an environmental behavior such as composting, simply because their peers are doing it. Finally, change in the curricular environment, from classroom learning to hands-on learning, necessarily increases behaviors that are a part of the hands-on curriculum. While this seems obvious, the environmental impact is potentially profound. If every student in the United States composted scraps from their school lunch, the effects on waste disposal and soil health could be significant.

II. Model building: Summary and implications

1. Summary

In response to major gaps in the literature on garden based education, this dissertation presents a proposed Model for Garden-based Education (MGBE) in School Settings (see Chapter 6). The MGBE posits that a garden-based education

program directly affects a school's learning environments in ways that may *directly* and *indirectly* affect students' personal characteristics and improve their academic achievement and health-promoting and environmentally responsible behaviors. It may also, affect broader community level factors, such as public health and environmental quality. These relationships between schools' learning environments, individuals' personal characteristics and behaviors, and community level factors are hypothesized to form positive feedback loops. For example, positive changes in students' personal characteristics are hypothesized to lead to positive changes in their behaviors, or in the school or community environment. Finally, the cumulative impacts on the community are hypothesized to have an impact at the bioregional level, with a positive feedback loop between community and bioregion.

2. Implications

The development of the MGBE has important implications for practitioners and researchers. Educators from diverse fields may benefit from the MGBE through the development and evaluation of theoretically driven, behaviorally based school garden programming. The Program Design Checklist, detailed in Chapter 6, Figure 2, allows practitioners to develop school garden programs that are theoretically more likely to improve children's academic achievement, health and wellness. Until additional research demonstrates otherwise, it is most likely that the more program design elements a school garden program incorporates, the more positive effects will result. Educators can use the Program Outcomes boxes to identify the desired impact of the garden program on students, the community and /

or the bioregion. The identification of desired outcomes leads logically to the choice of appropriate evaluation tools. The MGBE may also promote research on garden based education because it provides a theoretical basis for measuring outcomes at multiple levels of analysis and specifies potential study variables at each level.

III. Future research

In addition to specific research needs identified in Chapters 4, 5, and 6, future inquiry into garden based education should continue in several areas. First, studies are needed to further understand the influence of participating in school garden programs on different populations. Specifically, research is needed to explain the effects of school gardens on very young children and high school aged students' knowledge, attitudes and behaviors related to vegetable consumption and ecoliteracy.

Second, research is needed to determine potential crossover effects for all student-age populations. The MGBE suggests that positive effects on participating students may also have positive effects on non-participating parents and siblings. The MGBE also suggests that the physical, social, and curricular environmental changes produced by school-garden programs may positively influence the adult teachers, parents, and community members who are directly involved in facilitating the programs. If programs incorporate "home components," as proposed, it will be increasingly important to know what effects *those* activities have on adults and the community.

Third, studies are needed to distinguish what aspects, including scale and scope, of garden based learning experiences are most effective at facilitating positive knowledge, attitude and behavior changes. To accomplish this, comparison studies among different kinds of school gardens are needed. The MGBE provides a useful organizing tool for comparing program elements and their effects. Improved comparisons will be achieved by using similar evaluation tools that have been adapted to the unique settings of school gardens. The GVFQ is one such tool. Another is the Science Achievement Evaluation Instrument for School Gardens developed by Klemmer et al. (2005) [19]. Additional work is needed to develop validated evaluation tools that measure multiple knowledge, attitudinal and behavioral outcomes at multiple levels of society.

Finally, longitudinal studies are needed to determine if observed effects on students, parents, teachers and other community members persist over time. Longitudinal studies are similarly needed to determine whether some aspects of garden-based learning experiences produce longer lasting effects than others.

IV. Conclusions

The primary motivation for this dissertation was to quantify the potential for school gardens to address important issues related to child nutrition and environmental problems. Generally, findings from the papers presented in chapter 4,5, and 6 indicate that school gardens are one avenue to improving aspects of children's health and wellness while promoting ecoliteracy and academic achievement.

Even if these results can be achieved through other activities, school gardens offer a number of benefits that may make them better choices. They are relatively inexpensive and they can be integrated into and enhance existing curriculum. Furthermore, successful garden-based education programs can be implemented in any school, in any region. Much of the garden-enhanced educational experience can be done in containers or in the classroom and supplemented with outdoor activities. In fact, of all the “barriers” to implementing these programs cited in the literature, climate and weather conditions do not appear even once [20, 21].

In addition, the nature of the pedagogy permits teachers with little to no gardening experience to learn alongside students. Garden programs also facilitate active involvement of families from diverse educational and socioeconomic backgrounds. Finally, perhaps the most distinctive characteristic of school garden programs is that they connect people with real, on-going natural processes. There is no substitute for learning while nurturing living organisms in the natural world. These factors, taken together, provide a compelling rationale for continuing to pursue the potential of school-garden programs.

It is unlikely, however, that simply having a school garden will result in all the desired outcomes. It is more likely that what we do in the garden matters. Therefore, more work is needed to determine what “dosage,” or rather, what scale or scope of school garden experiences is most likely to result in the desired outcomes. That is why the development of a theoretical framework for school garden programs that would further improve program development and evaluation was integral to this dissertation research.

Thirty years from now, it is possible that educators will look back and classify this time in the history of the school garden movement as a watershed moment. Whereas garden programs have historically have been primarily motivated by a desire to alleviate only one societal problem, such as environmental education, today we are seeing a plethora of programs designed to simultaneously address issues related to obesity, food security, environmental degradation, education, and economic and personal development. This trend provides an unprecedented opportunity for farmers, advocates and educators from diverse fields to leverage human, social and natural capital to successfully address interrelated issues associated with health, education, and the environment.

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APPENDIX A

Garden Vegetable Frequency Questionnaire

ID#	
PRE	POST

Name: _____

Date: _____

Are you: Male or Female? (Please circle one)

How old are you? _____

School Name: _____

Teacher's Name: _____

Fun Survey
THIS IS NOT A TEST!

DIRECTIONS.....

1. This is a survey about what you think about food.
2. For each food there are three questions.
3. There are no right or wrong answers.
4. If you want to change your answer, erase the circle you filled in and fill in another.
5. Have fun!

Thank you for your help!
Please turn the page and begin.

Beets			
1. Did you eat this food yesterday?	<input type="radio"/> YES	<input type="radio"/> NO	<input type="radio"/> I don't know
2. Do you like this food?	<input type="radio"/> YES	<input type="radio"/> NO	<input type="radio"/> I don't know
3. How often do you eat this food?	<input type="radio"/> More than once a month	<input type="radio"/> Once a month or less	<input type="radio"/> I have Never tried it

Cabbage			
1. Did you eat this food yesterday?	<input type="radio"/> YES	<input type="radio"/> NO	<input type="radio"/> I don't know
2. Do you like this food?	<input type="radio"/> YES	<input type="radio"/> NO	<input type="radio"/> I don't know
3. How often do you eat this food?	<input type="radio"/> More than once a month	<input type="radio"/> Once a month or less	<input type="radio"/> I have Never tried it

Carrots			
1. Did you eat this food yesterday?	<input type="radio"/> YES	<input type="radio"/> NO	<input type="radio"/> I don't know
2. Do you like this food?	<input type="radio"/> YES	<input type="radio"/> NO	<input type="radio"/> I don't know
3. How often do you eat this food?	<input type="radio"/> More than once a month	<input type="radio"/> Once a month or less	<input type="radio"/> I have Never tried it

Cauliflower			
1. Did you eat this food yesterday?	<input type="radio"/> YES	<input type="radio"/> NO	<input type="radio"/> I don't know
2. Do you like this food?	<input type="radio"/> YES	<input type="radio"/> NO	<input type="radio"/> I don't know
3. How often do you eat this food?	<input type="radio"/> More than once a month	<input type="radio"/> Once a month or less	<input type="radio"/> I have Never tried it

Chard ("Swiss Chard")			
1. Did you eat this food yesterday?	<input type="radio"/> YES	<input type="radio"/> NO	<input type="radio"/> I don't know
2. Do you like this food?	<input type="radio"/> YES	<input type="radio"/> NO	<input type="radio"/> I don't know
3. How often do you eat this food?	<input type="radio"/> More than once a month	<input type="radio"/> Once a month or less	<input type="radio"/> I have Never tried it

Collards (or Greens)			
1. Did you eat this food yesterday?	<input type="radio"/> YES	<input type="radio"/> NO	<input type="radio"/> I don't know
2. Do you like this food?	<input type="radio"/> YES	<input type="radio"/> NO	<input type="radio"/> I don't know
3. How often do you eat this food?	<input type="radio"/> More than once a month	<input type="radio"/> Once a month or less	<input type="radio"/> I have Never tried it

Corn (including polenta)			
1. Did you eat this food yesterday?	<input type="radio"/> YES	<input type="radio"/> NO	<input type="radio"/> I don't know
2. Do you like this food?	<input type="radio"/> YES	<input type="radio"/> NO	<input type="radio"/> I don't know
3. How often do you eat this food?	<input type="radio"/> More than once a month	<input type="radio"/> Once a month or less	<input type="radio"/> I have Never tried it

Eggplant			
1. Did you eat this food yesterday?	<input type="radio"/> YES	<input type="radio"/> NO	<input type="radio"/> I don't know
2. Do you like this food?	<input type="radio"/> YES	<input type="radio"/> NO	<input type="radio"/> I don't know
3. How often do you eat this food?	<input type="radio"/> More than once a month	<input type="radio"/> Once a month or less	<input type="radio"/> I have Never tried it

Fava Beans			
1. Did you eat this food yesterday?	<input type="radio"/> YES	<input type="radio"/> NO	<input type="radio"/> I don't know
2. Do you like this food?	<input type="radio"/> YES	<input type="radio"/> NO	<input type="radio"/> I don't know
3. How often do you eat this food?	<input type="radio"/> More than once a month	<input type="radio"/> Once a month or less	<input type="radio"/> I have Never tried it

Kale			
1. Did you eat this food yesterday?	<input type="radio"/> YES	<input type="radio"/> NO	<input type="radio"/> I don't know
2. Do you like this food?	<input type="radio"/> YES	<input type="radio"/> NO	<input type="radio"/> I don't know
3. How often do you eat this food?	<input type="radio"/> More than once a month	<input type="radio"/> Once a month or less	<input type="radio"/> I have Never tried it

Lettuce			
1. Did you eat this food yesterday?	<input type="radio"/> YES	<input type="radio"/> NO	<input type="radio"/> I don't know
2. Do you like this food?	<input type="radio"/> YES	<input type="radio"/> NO	<input type="radio"/> I don't know
3. How often do you eat this food?	<input type="radio"/> More than once a month	<input type="radio"/> Once a month or less	<input type="radio"/> I have Never tried it

Peas (including Snow Peas and Sugar Snap)			
1. Did you eat this food yesterday?	<input type="radio"/> YES	<input type="radio"/> NO	<input type="radio"/> I don't know
2. Do you like this food?	<input type="radio"/> YES	<input type="radio"/> NO	<input type="radio"/> I don't know
3. How often do you eat this food?	<input type="radio"/> More than once a month	<input type="radio"/> Once a month or less	<input type="radio"/> I have Never tried it

Potatoes (including French Fries)			
1. Did you eat this food yesterday?	<input type="radio"/> YES	<input type="radio"/> NO	<input type="radio"/> I don't know
2. Do you like this food?	<input type="radio"/> YES	<input type="radio"/> NO	<input type="radio"/> I don't know
3. How often do you eat this food?	<input type="radio"/> More than once a month	<input type="radio"/> Once a month or less	<input type="radio"/> I have Never tried it

Radish			
1. Did you eat this food yesterday?	<input type="radio"/> YES	<input type="radio"/> NO	<input type="radio"/> I don't know
2. Do you like this food?	<input type="radio"/> YES	<input type="radio"/> NO	<input type="radio"/> I don't know
3. How often do you eat this food?	<input type="radio"/> More than once a month	<input type="radio"/> Once a month or less	<input type="radio"/> I have Never tried it

Spinach			
1. Did you eat this food yesterday?	<input type="radio"/> YES	<input type="radio"/> NO	<input type="radio"/> I don't know
2. Do you like this food?	<input type="radio"/> YES	<input type="radio"/> NO	<input type="radio"/> I don't know
3. How often do you eat this food?	<input type="radio"/> More than once a month	<input type="radio"/> Once a month or less	<input type="radio"/> I have Never tried it

String Beans			
1. Did you eat this food yesterday?	<input type="radio"/> YES	<input type="radio"/> NO	<input type="radio"/> I don't know
2. Do you like this food?	<input type="radio"/> YES	<input type="radio"/> NO	<input type="radio"/> I don't know
3. How often do you eat this food?	<input type="radio"/> More than once a month	<input type="radio"/> Once a month or less	<input type="radio"/> I have Never tried it

Squash			
1. Did you eat this food yesterday?	<input type="radio"/> YES	<input type="radio"/> NO	<input type="radio"/> I don't know
2. Do you like this food?	<input type="radio"/> YES	<input type="radio"/> NO	<input type="radio"/> I don't know
3. How often do you eat this food?	<input type="radio"/> More than once a month	<input type="radio"/> Once a month or less	<input type="radio"/> I have Never tried it

Tomatoes (including pasta sauce, vegetable juice, or on a salad)			
1. Did you eat this food yesterday?	<input type="radio"/> YES	<input type="radio"/> NO	<input type="radio"/> I don't know
2. Do you like this food?	<input type="radio"/> YES	<input type="radio"/> NO	<input type="radio"/> I don't know
3. How often do you eat this food?	<input type="radio"/> More than once a month	<input type="radio"/> Once a month or less	<input type="radio"/> I have Never tried it

Can you think of any other vegetables you ate **YESTERDAY** that I did not ask you about? (Please write their names in the space below).

<i>NAME OF VEGETABLE</i> _____	<input type="radio"/> YES	<input type="radio"/> NO	<input type="radio"/> I don't know
1. Did you eat this food yesterday?	<input type="radio"/> YES	<input type="radio"/> NO	<input type="radio"/> I don't know
2. Do you like this food?	<input type="radio"/> YES	<input type="radio"/> NO	<input type="radio"/> I don't know
3. How often do you eat this food?	<input type="radio"/> More than once a month	<input type="radio"/> Once a month or less	<input type="radio"/> Never

<i>NAME OF VEGETABLE</i> _____	<input type="radio"/> YES	<input type="radio"/> NO	<input type="radio"/> I don't know
1. Did you eat this food yesterday?	<input type="radio"/> YES	<input type="radio"/> NO	<input type="radio"/> I don't know
2. Do you like this food?	<input type="radio"/> YES	<input type="radio"/> NO	<input type="radio"/> I don't know
3. How often do you eat this food?	<input type="radio"/> More than once a month	<input type="radio"/> Once a month or less	<input type="radio"/> Never

APPENDIX B

Taste Test

ID#	
PRE	POST

Name: _____

Date: _____

Are you: Male or Female? (Please circle one)

How old are you? _____

School Name: _____

Teacher's Name: _____

Fun Survey
THIS IS NOT A TEST!

DIRECTIONS.....

6. This is a survey about what you think about food.
7. It is OK to have answers that are different from other classmates.
8. If you do not know the answer to a question, mark "I don't know."
9. Have fun!

Thank you for your help!
Please turn the page and begin.

Please look at FOOD #1 in front of you and answer the following questions.

1. What is the name of this food? _____
 I don't know

2. A) Will you taste this food?
 Yes, I will taste this food. (Go ahead and taste the food now)
 No, I will not taste this food
B) If you tasted the food, what did you think of it?
 I really liked it a lot 😊😊
 I liked it a little 😊
 It was OK 😐
 I did not like it 😞
 I really did not like it 😞😞

3. Have you ever tasted this food before?
 YES NO I don't know

4. Do you eat this food at home?
 YES NO I don't know

5. Do you eat this food at school?
 YES NO I don't know

6. Have you grown this food in the school garden?
 YES NO I don't know

7. Have you grown this food in a garden at home?
 YES NO I don't know



Go on to Food #2.

Please look at FOOD #2 in front of you and answer the following questions.

1. What is the name of this food? _____

I don't know

2. A) Will you taste this food?

Yes, I will taste this food. (Go ahead and taste the food now)

No, I will not taste this food

B) If you tasted the food, what did you think of it?

I really liked it a lot 😊😊

I liked it a little 😊

It was OK 😐

I did not like it 😞

I really did not like it 😞😞

8. Have you ever tasted this food before?

YES

NO

I don't know

9. Do you eat this food at home?

YES

NO

I don't know

10. Do you eat this food at school?

YES

NO

I don't know

11. Have you grown this food in the school garden?

YES

NO

I don't know

12. Have you grown this food in a garden at home?

YES

NO

I don't know



Go on to Food #3.

Please look at FOOD #3 in front of you and answer the following questions.

1. What is the name of this food? _____

I don't know

2. A) Will you taste this food?

Yes, I will taste this food. (Go ahead and taste the food now)

No, I will not taste this food

B) If you tasted the food, what did you think of it?

I really liked it a lot 😊😊

I liked it a little 😊

It was OK 😐

I did not like it 😞

I really did not like it 😞😞

13. Have you ever tasted this food before?

YES

NO

I don't know

14. Do you eat this food at home?

YES

NO

I don't know

15. Do you eat this food at school?

YES

NO

I don't know

16. Have you grown this food in the school garden?

YES

NO

I don't know

17. Have you grown this food in a garden at home?

YES

NO

I don't know



Go on to Food #4.

Please look at FOOD #4 in front of you and answer the following questions.

1. What is the name of this food? _____

I don't know

2. A) Will you taste this food?

Yes, I will taste this food. (Go ahead and taste the food now)

No, I will not taste this food

B) If you tasted the food, what did you think of it?

I really liked it a lot 😊😊

I liked it a little 😊

It was OK 😐

I did not like it 😞

I really did not like it 😞😞

18. Have you ever tasted this food before?

YES

NO

I don't know

19. Do you eat this food at home?

YES

NO

I don't know

20. Do you eat this food at school?

YES

NO

I don't know

21. Have you grown this food in the school garden?

YES

NO

I don't know

22. Have you grown this food in a garden at home?

YES

NO

I don't know



Go on to Food #5.

Please look at FOOD #5 in front of you and answer the following questions.

1. What is the name of this food? _____

I don't know

2. A) Will you taste this food?

Yes, I will taste this food. (Go ahead and taste the food now)

No, I will not taste this food

B) If you tasted the food, what did you think of it?

I really liked it a lot 😊😊

I liked it a little 😊

It was OK 😐

I did not like it 😞

I really did not like it 😞😞

23. Have you ever tasted this food before?

YES

NO

I don't know

24. Do you eat this food at home?

YES

NO

I don't know

25. Do you eat this food at school?

YES

NO

I don't know

26. Have you grown this food in the school garden?

YES

NO

I don't know

27. Have you grown this food in a garden at home?

YES

NO

I don't know



You are done! Thank you! Please draw on the back of this sheet until everyone is finished.

APPENDIX C

Ecoliteracy Survey Questionnaire

ID#	
PRE	

Name: _____

Date: _____

How old are you? _____

Are you: Male or Female? (Please circle one)

School Name: _____

Teacher's Name: _____

Fun Survey
THIS IS NOT A TEST!

DIRECTIONS.....

1. This is a survey about you and your thoughts. You will be asked about what you think about food, yourself, the environment, and plants.
2. For each food item there are three questions.
3. If you do not know the answer to a question, mark "I don't know."
4. Have fun!

Thank you for your help!
Please turn the page and begin.

PART I. Questions About You

1. Were you born in the United States?

YES NO I don't know

2. Was your MOM born in the United States?

YES NO I don't know

If your MOM was NOT born in the United States, in what country was she born?

(Please fill in the blank) _____ I don't know

3. Was your DAD born in the United States?

YES NO I don't know

If your MOM was NOT born in the United States, in what country was she born?

(Please fill in the blank) _____ I don't know

4. Do you qualify for free or reduced lunch?

YES NO I don't know

5. When you were in 5th grade, did you garden with your school?

YES NO I don't know

6. When you were in 5th grade, did you garden at home?

YES NO I don't know

7. When you were in 5th grade, did you learn about pollution at school?

YES NO I don't know

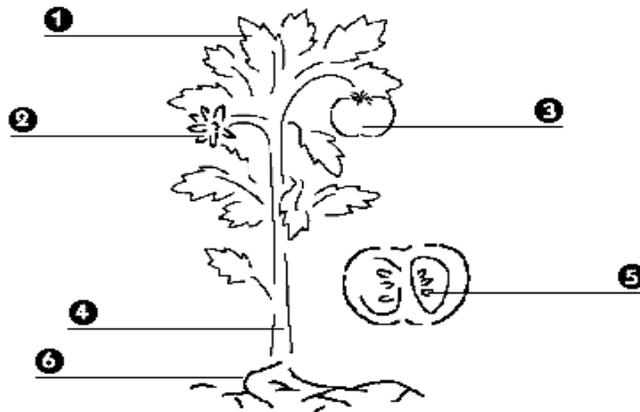
PART II – About the Environment

8. Do you recycle **cans or bottles** at HOME?
 Always Sometimes Never
9. Do you recycle **cans or bottles** at SCHOOL?
 Always Sometimes Never
10. Do you recycle **paper or magazines** at HOME?
 Always Sometimes Never
11. Do you recycle **paper or magazines** at SCHOOL?
 Always Sometimes Never
12. Do you put your food scraps in a **compost** at HOME?
 Always Sometimes Never
13. Do you put your food scraps in a **compost** at SCHOOL?
 Always Sometimes Never
14. Do you turn off the water when you are brushing your teeth?
 Always Sometimes Never
15. Do you turn off the light when you are not in the room?
 Always Sometimes Never
16. Do you shut down your computer when you are not using it?
 Always Sometimes Never

17. On a scale of 1 to 5, with 1 being "strongly agree" and 4 being "strongly disagree", how much do you agree or disagree with the following statements? (Circle your answer.)

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
	1	2	3	4	5
I am worried about animals that are going extinct.	1	2	3	4	5
Organic vegetables are dirty.	1	2	3	4	5
I think people should build more parks for animals.	1	2	3	4	5
I feel like there are many things I can do to protect the environment.	1	2	3	4	5
Trying to protect the environment is my responsibility.	1	2	3	4	5
I would come to school on a Saturday to plant flowers.	1	2	3	4	5
I think my own actions may harm the environment.	1	2	3	4	5
I would pay more for a CD if it were made in an environmentally friendly way.	1	2	3	4	5
Doing things to protect the environment is a waste of time.	1	2	3	4	5

18. What are the names of the different plant parts?



19. Where does photosynthesis happen? (Circle one)

LEAF ROOTS STEMS FLOWER

For questions 21 - 25, fill in the circle of the best answer.

21. Which of the following organisms are typical decomposers?

- grasses and ferns
- bacteria and mushrooms
- deer
- snakes

22. Which of the following is NOT recycled in an ecosystem?

- carbon
- water
- nitrogen
- energy

23. Organisms may be dispersed in all of the following ways EXCEPT by

- wind.
- temperature.
- water.
- other organisms.

24. Chlorofluorocarbons, or CFCs, are the main cause of

- ozone depletion.
- global warming.
- the greenhouse effect.
- ice ages.

25. Humans add greenhouse gases to the atmosphere in all of the following ways EXCEPT by

- driving a car.
- burning wood.
- planting a tree.
- using the computer.